Inequality and Structural Violence in Archaic Athens: A Bioarchaeological Investigation of the Burial Ground at Phaleron (8th-5th century BCE)

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Thesis Submitted for the Degree of Doctor of Philosophy

2024

Abstract

This thesis aims to investigate the impact of inequality and structural violence on the lower socio-economic status inhabitants of Athens during the Archaic period (8^{th}-5^{th} century BCE). This period was characterised by social and political changes that set the foundation for greater political equality and democracy.

The Phaleron burial ground, excavated during the 2010s, significantly changed the known burial record for the Archaic period. The site differs from contemporaneous cemeteries due the diversity of burial practice, including simple pit burials and mass graves.

This study aims to identify health disparities between certain subgroups of the burial ground based on funerary practice. Multiple markers of physiological stress (cribra orbitalia, dental enamel hypoplasia, dental disease, periosteal new bone formation, trauma, and vertebral joint disease) were analysed and compared between those of different burial status. These pathological lesions were recorded through macroscopic examination of 206 individuals (normative burials: N=132, non-normative single burials: N=39, mass burials: N=35).

Despite some limitations due to preservation and size of the sample, a strong demographic bias towards young adult males in the mass burials was identified. A significantly higher level of physiological stress and trauma was identified in the normative burials, indicating high levels of physical activity and exposure to hazardous environments. The evidence was consistent with types of manual labour historically recorded for enslaved and other low-status people. When integrated with the historical evidence it is concluded that Phaleron was used for the burial of low-status labourers, potentially including enslaved individuals, as well as higher-status men in mass burials who might have been executed as political prisoners. In Athens, improved political equality did not translate into general economic or health equality, and large sections of society continued to be marginalised based on socio-economic status, gender, or citizenship.

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Statement of copyright

Acknowledgements

The PhD degree was incredibly rewarding but not always an easy journey, and I deeply appreciate all the support I received over the last four years.

First of all, I would like to thank my family for their love and unwavering support throughout my academic career. You never stopped believing in me and always provided me with encouragement when I needed it most.

My sincere gratitude goes to my supervisory team. I am indebted to Rebecca Gowland, who is a fantastic mentor and provided me with the highest level of support every step of the way. Your intellectual guidance and pastoral support throughout this entire process were of immeasurable value and kept me going through the most difficult phases of the PhD degree. I also want to extend my gratitude to Daniel Gaudio for his support and advice on the trauma analysis, and Jane Buikstra for providing me with the opportunity to study the Phaleron burial ground and for her insightful comments on my early drafts.

I would like to thank Tina Jakob and Anwen Caffell for everything they have taught me over the years, not only during my PhD studies but also during the MSc in Palaeopathology. I am sincerely grateful to you for always sharing your palaeopathology knowledge and for your guidance over the past years.

I am also incredibly thankful for the support and friendship I received from everyone at the Malcolm H. Wiener Laboratory for Archaeological Science at the American School for Classical Studies in Athens, especially Dimitris Michailidis, Zoe Chalatsi, Ioanna Moutafi, Voula Tritsaroli, and Takis Karkanas.

I would especially like to show my appreciation for Jessica Rothwell. I am truly grateful for your friendship, your support during the long months of data collection, and for helping me stay sane during the ups and downs of our PhD journeys.

Thank you to all members of the Phaleron Bioarchaeological Project, and especially to Aviva Cormier, Elizabeth Hannigan, Leigh Hayes, Anna Karligkioti, Marina Velegraki, Anna Lachana, Panagiotis Papavasileiou, Lefteris Kosmidis, and Foteini Diatsingou.

My deepest gratitude belongs to the wonderful friends I made during my time in Durham: Heidi Shaw, Friederike Schwelle, Ariadne Argyros, Brett Ostrum, Dominik Mitterer, and John Rayner. Thank you for the conversations, the laughs, and your emotional support over the last years. I truly could not have done this without you.

Finally, I would like to thank the UK Arts and Humanities Research Council who funded my PhD with a Northern Bridge DTP Studentship, and the Austrian Academy of Science for providing me with the financial support to work on the Phaleron Bioarchaeological Project before I started my PhD studies.

1. INTRODUCTION

1.1. Introduction – Athens during the Archaic Period

The first half of the first millennium BCE witnessed significant social and political changes in Greece. These centuries are associated with the 'rise of the polis', a political and social phenomenon that has been discussed and debated in numerous publications (e.g., Hall, 2007a; Osborne, 2007, 2009; Snodgrass, 1977). The Early Iron Age (1150-700 BCE) and the Archaic period (700-480 BCE) are important formative periods in the development of what is generally recognised as the world's first complex democracy, one of the most important legacies of Greek antiquity that still resonates in today's world. Archaeologists have drawn extensively on the burial record in order to explore these socio-political changes; although focus has been predominantly on funerary practices rather than bioarchaeological analysis (D'Onofrio et al., 2017; Doronzio, 2020; Morris, 1987, 1992; Whitley, 1991b).

The burial ground of Phaleron was located a few kilometres outside the ancient city limits of Athens and was used continuously as a burial ground between the 8th and the 4th century BCE with a main phase coinciding with the Archaic period. The site of Phaleron was named one of the 'Top 10 Discoveries of the Year' by Archaeology magazine in 2016 (Lobell, 2016). Of special interest was the discovery of a mass grave holding the skeletal remains of almost 80 individuals who were shackled at their wrists. A date based on two pottery vessels in the mid-late 7th century led to the interpretation that these men were victims of the political turmoil in the city due to elite rivalry for political power during the Archaic period, but connecting these findings to known historical events proves difficult (Rönnberg, 2023). The burial ground at Phaleron holds the potential to provide us with a previously undocumented perspective on

Athenian history. The burial evidence, which includes simple pit burials as well as mass burials, together with the size and location of the burial ground raises questions regarding the identity of the people buried, including socio-economic background and citizenship.

1.2. Aims and objectives

This thesis focuses on the evidence for social and health inequalities at Phaleron, during a period that tends to be celebrated as the stepping stone of democracy and equality. The project aims to investigate the lived experience of the population of Phaleron through the analysis of skeletal evidence of physiological stress and trauma, and integration with the historically understood socio-political framework of the Archaic period.

Socio-economic status and wealth inequality are the primary determinants of health today. The examination of the human skeletal remains from the Phaleron burial ground provides a unique opportunity for a bioarchaeological exploration of inequality in a period and place that is considered the birthplace of democracy, which is often synonymous with greater equality. Bioarchaeology can enhance our understanding of social differences that were a constant of life in antiquity but have not always been acknowledged in classical studies. Greek antiquity offers an abundance of archaeological, historical, and literary data that complements and enhances the data derived from bioarchaeological studies and, when integrated, allows us to gain deeper understanding of the past (Lagia and Voutsaki, 2024).

1.3. Research questions

This thesis addresses three main questions in order to gain insights into the lived experience of those buried at Phaleron and to investigate the presence and degree of inequality during the Archaic period in the polis of Athens:

(1) Are there any differences in health status between subgroups of the burial ground (as defined by funerary type), or is the health profile homogenous throughout? Were certain subgroups at a higher risk of morbidity and mortality, and what are the social implications of such differences?

(2) Is it possible to detect evidence for social control and oppression or structural violence through inequalities in health in those groups which the burial evidence suggests are of lower social status? Can any negative effects of multiple systemic inequality be identified that would be indicative of marginalised groups?

(3) Is there evidence that individuals or certain demographic or burial groups at Phaleron were enslaved or subjected to forced labour?

The first research question will investigate the social implications of differences in health status between different burial types and demographic groups. The presence of several large mass burials as well as the evidence of individuals buried shackled or with their limbs bound have been subject of wide interest (Ingvarsson et al., 2019; Lobell, 2016; Rönnberg, 2023). These burials are striking and contrast with the poorly furnished burials termed ‘normative burials’ that usually contain a single individual in a grave pit. Preliminary evaluation of the largest of the mass burials, which contained individuals who were evidently shackled at the time of interment, suggested a distinct demographic profile. This was skewed towards males younger than 35 years at the time of death. No evidence for females in the mass graves was identified (Ingvarsson et al., 2019). While the mass burials have received wide interest from the media, these individuals only make up a comparatively small section of the cemetery population (183 individuals out of 1797 excavated individuals were buried in mass burials) with most buried in normative circumstances. Who were these majority of people who were buried at Phaleron? Skeletal analysis, including demographic profiles as well as palaeopathological data, in combination with the excavation data will provide further insights into differences in living conditions between those buried in different ways. This will provide us with a deeper understanding of who was buried at Phaleron.

Research questions 2 and 3 aim to investigate the presence of structural violence and enslavement in the burial ground population. The funerary evidence suggests that Phaleron was used to bury individuals of lower socio-economic status. However, a more detailed investigation of the burial ground population is required to examine this in more detail. In theory, democracy gives every citizen the opportunity to partake in elections both as a voter and as a candidate. However, political equality did not extend to women, nor were all men included as it was dependent on citizenship and socio-economic status (Kellogg, 2021).

Classical archaeology has long focused on material culture associated with elite status by researching palaces, sanctuaries with abundant votive offerings, and wealthy burials. The elite are also much better represented in the written record available today. Research focus has shifted in more recent years, and historical studies have started to explore the evidence for lower social status groups, including the enslaved (see for example Bradley and Cartledge, 2011; Finley, 1968; Forsdyke, 2021; Hunt, 2018b; Thompson, 2003). A bioarchaeological analysis will allow a more comprehensive picture of the lives of the non-elite population. This includes the poor working class as well as the enslaved. A systematic analysis of the human remains from Phaleron has the potential to reveal the lived experience of the wider population during these formative centuries whose life stories remain undocumented in established historical traditions.

The research sample includes a broad cross-section of the burial ground that includes different burial types. Chronological differences were considered when possible. The health status of individuals was examined using traditional markers of physiological stress, trauma, and disease. The data from the palaeopathological analysis will be compared to data sets from historical cemetery sites elsewhere in Greece as well as burial grounds known to be associated with structural violence (e.g., cemetery sites from the US and South Africa that were used to bury enslaved individuals and low-status labourers). In combination with historical data, these comparisons will allow an exploration of the complex interactions of biological and cultural factors that shaped the lives of those buried at Phaleron.

1.4. Structure of the thesis

The thesis is structured in nine chapters. Chapter 2 presents the historical setting of the research project, focusing on the polis of Athens, and the historical, political, and social developments that took place during the Early Iron Age and Archaic period. This chapter also discusses how these changes affected those from a lower socio-economic background. Chapter 3 provides an overview of indicators of physiological stress that were used in this thesis. Additionally, it gives a brief review of bioarchaeological studies that employed indicators of physiological stress to explore living conditions in the Greek world during antiquity. Chapter 4 presents the theoretical foundation of the bioarchaeological study of inequality and structural violence. Chapter 5 introduces the burial ground of Phaleron, the skeletal sample used in this thesis, as well as the methods applied. Chapter 6 presents the results of the study, including burial category, biological sex, and age-at-death, along with palaeopathological indicators of stress. In addition to the population data, Chapter 7 introduces a focused evaluation and discussion of four individuals in the form of osteobiographies. Chapter 8 is structured around the research questions and will discuss the data obtained from the population-based analysis as well as the osteobiographies within their archaeological, socio-political, and cultural setting. Finally, Chapter 9 will briefly summarise the results in reference to the research questions. The limitations, future research, and the significance of the current study are also discussed.

Not all data could be included in the main body of the dissertation. Additional information in form of further tables as well as a catalogue of the study sample are presented in Appendix I and II.

2. SETTING THE STAGE: THE HISTORIC BACKGROUND

2.1. Introduction

This chapter sets the stage for the bioarchaeological analysis of the remains excavated at the Phaleron burial ground in Athens. The chapter will focus on the history of Athens and Attica during the Early Iron Age (EIA) (1150-700 BCE) and Archaic period (700-480 BCE), which is the main period of use of the Phaleron cemetery. The preceding centuries of the EIA, for which there is only limited evidence at the Phaleron burial ground, are important in order to understand to provide some context for the historical developments of the Archaic period. These centuries can be considered a key period in the history of Greece as they witnessed significant formative political, social, economic, and religious developments cumulating in the establishment of the first complex democracy during the Classical period (480-323 BCE). This chapter will provide an overview of historical developments and emergence of crucial institutions that provided the basis for democracy.

The wealth of archaeological and historical records for Greece and especially for Athens allows us to draw upon various lines of evidence. Many primary sources are available from the Classical period onwards, which are important for the reconstruction of chronology and historical events. In contrast, historical accounts for the EIA as well as the Archaic period are more limited and fragmentary, and the use of Classical and Hellenistic sources is necessary to complete the picture. However, the potential inaccuracies of documents written centuries later than the period in question has been topic of scholarly discourse (Anderson, 2003; Charalambidou and Morgan, 2017; Dickinson, 2019; Hall, 2007a: 22-27; Osborne, 1989; Papadopoulos, 2021).

Some of the first written sources we have are the works of Homer and Hesiod. These works are fictional and, thus, must be interpreted through this lens, but they can give some idea of the social and moral code of conduct of the EIA (Martin, 2000: 43-45; Raaflaub and Wallace, 2007). Epigraphic sources may provide direct evidence for individuals buried during this time, but this line of evidence is scarce for the Archaic Period and can be fragmented or altered. Specifically for burial ground at Phaleron, no epigraphic evidence or inscriptions are available. Our understanding of this important period of Athenian history is therefore strongly reliant on the archaeological record (Hall, 2007a: 27-28).

The place of focus for this thesis is Athens and Attica, and this chapter aims to provide a brief history of this region, rather than attempt an overview of developments spanning the entire Greek world. Athens does however present a unique case, and it cannot necessarily be compared directly to other settlements or regions, as extensive regional variation has been identified (Whitley, 2001: 165). In addition, the archaeological record for Ancient Greece does contain well known biases towards certain sites (e.g., Athens, Delphi, or Olympia), as well as towards particular forms of archaeological evidence (e.g., public buildings, temples, and tombs) (Dickinson, 2019; Whitley, 2015).

2.2. The Early Iron Age and Archaic period

Athens has been continuously inhabited since the Bronze Age, which is unusual given that many sites were abandoned after the collapse of the palatial system in the Late Bronze Age (LBA). The continuous settlement of the city provides some disadvantages in that evidence of earlier inhabitation of the area has sometimes been erased as the city developed (Dickinson, 2019). After the fall of the Mycenaean palace system of the LBA around 1200 BCE, the social structure of communities changed significantly. The political organisation of the small communities of the following centuries differed drastically from the clear hierarchical structures of the LBA palatial regimes. Smaller settlements had a limited need for political organisation and authority beyond their wider kin groups (Whitley, 2020). Communities were minimally ranked and organised as low-level chiefdoms ruled by a leader ('big men', chief, or *'basileus'*). Power was obtained through competition and was based on charisma, personal prowess, or displays of wealth. These chiefdoms appear to have been functional and served the requirements for social organisation and government on a very small scale; however, leadership was also inherently unstable, and power was not usually passed on to descendants over more than two generations (Donlan, 1997; Hall, 2007a: 120-127).

Political complexity re-emerged during the EIA and Archaic period from these ranked societies, but the new societal order – a community of equal citizen men – differed significantly from the LBA political organisation (Whitley, 2020). The political situation of Classical Athens can be identified as the first democracy, and the emergence of democracy was historically specific and routed in the mentalities and practices of the preceding centuries (Raaflaub and Wallace, 2007).

During the 7th century BCE, the polis was ruled as an oligarchy, and political participation was in the hands of an aristocratic elite ('*eupatridae*'). The power held by aristocratic rulers was dependent on birth and wealth and was inherited within the family. When looking at Athens specifically, the evidence suggests that a restricted version of democratic government had been established by the late 7th century BCE. Despite a hereditary system of power, the state apparatus in the early polis still consisted of elected magistrates, a council, and an assembly. These institutions likely had limited power and were mostly procedural. The early states did not strive to develop a progressive and egalitarian society, but politics was used to pursue power and the private interests of the elite. Like chiefdoms, this form of political organisation was inherently unstable and characterised by a continuous change of leadership (Anderson, 2005; Donlan, 1997; Hall, 2007a: 123).

The changes in political leadership during the 7th and 6th century were often accompanied by interpersonal violence, but not all political conflict was violent. Political violence appears to have been part of the Archaic political culture. Attempts to seize power by force, assassinations, or sending political opponents into exile were accepted during the Archaic period in a manner not possible during Classical times. Instances of violent claims for political power are, for example, known for Kylon, Peisistratides, Isagoras, and Kleisthenes. The 'Kylonian Conspiracy' likely marks the culmination of violent power struggles during the 7th century. Kylon was a member of the aristocratic elite and a successful Olympic athlete; after gaining support from a group of elite men, he attempted to seize power by occupying the Athenian Acropolis. Kylon and his men were unable to hold the Acropolis, and the coup failed. Consequently, Kylon was banned from Athens, while his supporters were executed (Stahl and Walter, 2009).

The continuous changes in leadership during the Archaic period indicate high levels of intra-elite rivalry, and political instability, which would have impacted society as a whole (Anderson, 2005). The introduction of Drako's law in 621/0 BCE clearly demonstrated the need for codified regulations of political life. These laws aimed to regulate retaliation after political homicides through institutional actions rather than individual authorities. The introduction of such a law suggests a highly aggressive and unstable political climate (Osborne, 2009: 186-188; 2023: 167-169; Wallace, 2007). Drako's laws were considered drastic in terms of punishments, including the death penalty and exile, and they were adjusted in later times; however, they were a clear step towards equal justice by regulating elite power and limiting the unpredictability of judicial sentencing (Wallace, 2007).

During the late 7th and early 6th century BCE, Athens faced an economic crisis that threatened the survival of the polis. Causes of the crisis are debated and likely manifold such as population increase or overuse of agricultural land. The exploitation of the lower socio-economic class by elite rulers caused major economic, political, and social problems, and the economic pressure forced independent farmers into dependency and slavery (Forsdyke, 2006; Wallace, 2007). This precarious situation threatened the stability of the polis and called for significant reforms, which were tasked to Solon. While the existence of Solon as a single individual has been debated in recent scholarship, the laws attributed to Solon had a significant impact (Blok and Lardinois, 2006). The introduction of Solon's reforms in the early 6th century BCE formed an important historical milestone in the establishment of democracy. Solon's constitution provided the basic structure for the Athenian laws of the Classical period. The reforms brought new laws that promoted social order and a constitutional reform. It divided the citizen body into different classes by wealth, established public authorities and offices, election by lot, and formalised the people's assembly, thus empowering the citizen body ('*demos'*) (Osborne, 2023: 169-175; van Wees, 2006; Wallace, 2007). One crucial aspect of these reforms was the outlawing of debt slavery, which had become common practice during the 7th century. Small independent farmers progressively accumulated debt towards a rich elite minority. As a result, farmers lost their land, income, and freedom, and were subjected to debt slavery, which made the differences between social strata (rich vs. poor) even more pronounced (Harris, 2002; Kyrtatas, 2011; Osborne, 2007; Wallace, 2009). It has been argued that the abolition of debt slavery paved the way for chattel slavery, which became more dominant during the late Archaic and Classical period (Finley, 1968; Lenski and Cameron, 2018). In contrast to lesser forms of dependency such as debt bondage from which the enslaved could theoretically free themselves, chattel slavery regarded the enslaved individuals as property, with all rights denied. The abolition of debt slavery meant that polis citizens of lower socio-economic status would not become permanent dependents of the elite anymore. Nevertheless, the aristocratic elite remained wealthy and in powerful positions. In theory, men of lower socio-economic standing were given their freedom and the opportunity to participate politically, but in reality, most political power was still in the hands of a small elite (van Wees, 2006; Wallace, 2007).

In the 6th century BCE, conflict between aristocratic families was ignited again as three major elite families – the Alkamaionidai, the family of Lykourgos, and the Peisistratids – competed for political power. Peisistratus seized power in 546 BCE and established a tyranny in Athens (Camp, 2001: 28). Defining the Archaic *tyrannis* is difficult, but the state form of tyranny might be considered a transitional stage in the political development from aristocracy to democracy. As a state form, the tyranny only existed in the Archaic period, and later accounts are likely not a reliable source for understanding the rule of the tyrants (Anderson, 2005; Camp, 2001: 28-39). The term 'tyrannos' is problematic as there used to be and occasionally still is a tendency to interpret these rulers based on the modern meaning of the term 'tyrant' which suggests illegitimacy (Hall, 2007a: 137-143; Parker, 2007). It is unclear how the Archaic people distinguished between *tyrannoi* and other forms of rulership, but there does not appear to be a significant difference in leadership between tyrants and other elite leaders (Anderson, 2005). Tyrannies might have started as popular dictatorships as the tyrant had to be supported by the *demos*, and tyrants were successful in establishing power because they regarded the needs of the Athenian citizen body. For example, Kylon's coup failed because the population of Athens did not back up his claim to power (Raaflaub and Wallace, 2007; Wallace, 2007). The relative stability under the tyrant rule of the Peisistratids permitted the strengthening of the political institutions, and the lack of elite conflict allowed the polis of Athens to prosper economically. During the second half of the 6th century, large scale building activity including monumental buildings, temples, and infrastructure can be noted for Athens. Additionally, the Panhellenic festivals were created, and cults established. The large-scale investment in the polis required wealth as well as a strong centralised authority in order to succeed (Camp, 2001: 28-39; Stahl and Walter, 2009; Wallace, 2007).

In common with previous types of leadership, the Archaic tyrannies were not a form of government that lasted over extended periods of times. Commonly, after one generation the leaders faced resistance and were overthrown. Towards the end of the 6th century, the rule of the Peisistratids became oppressive and violent, and the people of Athens disposed of their tyrants by assassination and exile (Camp, 2001: 39-40; Forsdyke, 2005; Raaflaub and Wallace, 2007). After the end of the Peisistratid rule, aristocratic rivalry and civil instability returned to Athens. After several years of struggle and exile, Kleisthenes gained political control with the support of the Athenian people. His main contributions were the establishment of a constitution in 508/7 BCE and social reorganisation of the polis. Kleisthenes developed a system that broke the power of the old aristocratic families and constituted the foundation of the democracy of the Classical period. Political power was moved into to the hands of the tribes, who made up the newly defined council of 500 (*boule*), rather than aristocracy. It was likely that the aristocratic and noble men still were the main speakers in the assembly, but the power of decision making lay with the council (Camp, 2001: 39-47; Forsdyke, 2005; Stahl and Walter, 2009; Wallace, 2007).

During the 5th century, the harbour of Athens was moved from Phaleron to Piraeus (see also Figure 5.1. showing the location of Phaleron and Piraeus in relation to the ancient city limits of Athens), and under the threat of Persian invasion, the monumental

Themistoklean wall was constructed for fortification. In 480/79 BCE, the Athenian fleet was defeated by the Persians in the battle at Thermopylai. The Persians seized Athens, plundered the city, and burned down the Acropolis. The almost complete destruction of the Acropolis and lower city marks a significant event in the history of Athens and now defines the start of the Classical period, during which the Athenian citizens faced a long drawn-out conflict with Sparta (Camp, 2001: 47-58, 294-299).

2.3. Settlement development during the Archaic period

The archaeological evidence for the settlement of Athens during the Archaic period is scarce and reconstruction of the living conditions is severely constricted by the lack of evidence thus creating a hiatus in our knowledge of the settlement history of Athens. This is partially due to the wide-spread destruction of the city by the Persians in 480 BCE and the subsequent rebuilding activities by the Athenians (Dimitriadou, 2019: 182). Furthermore, outside of the Acropolis and the area of the Agora, most archaeological evidence comes from rescue excavations. These only provide small and incomplete windows into the settlement history, and due to the constraints of rescue excavations, they are often poorly published. This lack of published data further limits our knowledge of the Archaic settlement, especially for earlier excavations in the 20th century, resulting in an underrepresentation of this period in archaeological research (Rönnberg, 2021a: 128-130).

The lack of evidence for a city wall during the Archaic period does not allow us to draw conclusions about the settlement area and its borders. The earliest evidence for a city wall is known from the early Classical period, the Themistoklean Wall. The complete lack of any archaeological evidence for such a monument during the Archaic period might be considered evidence that previous to the Classical period, only the Acropolis was enclosed by walls while the rest of the settlement appears to have been unprotected, but this lack limits the reconstruction of the settlement boundaries during earlier centuries (Rönnberg, 2021a: 141-142).

During the 7th century, an increase in sites dedicated to cultic activities evidenced by votive objects and temples on the slopes of the Acropolis and in the area of the Agora can be noticed as well as evidence for housing, workshops, and commerce (Dimitriadou, 2019: 182-183; Rönnberg, 2021a: 141). The changes in location of cemeteries from small burial plots in various locations throughout the later settlement area of Athens to larger cemeteries located on the outskirts of the settlement as defined by the fortification wall of the Classical period might allow some inferences about the settlement development. It has been suggested that this change was brought about by an increasing fear of the dead and associated pollution (Sourvinou-Inwood, 1983) and a functional differentiation of space in the settlement (Morris, 1989). These are factors that might be associated with an increasing urbanisation and potentially population increase, but these larger processes cannot be fully understood based on the evidence available to date (Rönnberg, 2021a)

The decline in archaeologically visible structures in the periphery of the settlement in combination with the increase in cultural and public monuments around the Acropolis and Agora indicate an intensification of settlement activity in this area (Rönnberg, 2021a: 141). The evidence for housing structures is highly fragmentary, but some remainders of housing structures have been identified on the Northwest, West, and South slopes of the Acropolis, the Agora, Areopagus hill, and in small plots in the areas North and South of the Acropolis (for a detailed account see Dimitriadou, 2019: 166-176). The ground plan of houses changed from oval structures or apsidal buildings during the Geometric period to rectangular buildings that appear in the 8th and 7th century. The apsidal houses and early rectangular houses mostly consisted of one room that functioned as a multipurpose room. During the early Archaic period, however, houses became larger with separate rooms that served different functions. These changes in housing structures might be connected to social changes associated with the polis development. For example, the new social structures might have put an increased importance on communal feasts in the private context (Rönnberg, 2021a: 150-155). However, these larger houses in close proximity to the Acropolis likely do not provide insight into the living conditions of the broader population.

The largest number of archaeologically visible structures are wells that are scattered around the settlement site. These have long been thought to belong to private houses but are now more commonly associated with workshops such as pottery or iron workshops that existed in the Agora from the 8th century BCE onwards (Dimitriadou, 2019: 182-183). In the course of the 7th century, a large number of wells in the Agora were abandoned, which has been interpreted as the result of persisting droughts (Camp, 1977: 50-52) or as a shift of workshops to the periphery of the settlement (Étienne, 2004: 31). However, new wells were built in the Agora in the 7th century suggesting that the Agora was not abandoned but rather continuously used for commercial and private activities. Multiple pottery workshops were identified, and some were also used for the distribution of the goods and accommodation of craftsmen working in the workshops. Furthermore, other workshops such as blacksmiths co-existed in the area of the Agora. It is possible, that the wells were not only used by the workshops, but some were also associated with private houses (Dimitriadou, 2019: 189-192). Living conditions for those working and living in the workshops were potentially hazardous as they would have been exposed to crowded living conditions and potentially poor air quality (e.g., dust) in addition to the risks they were exposed to in their working environment. The presence of workshops and private housing in close proximity might have impacted living conditions for the general population but likely not to the same extent. The wells allowed for easy access to water for private use as well as in workshops, but the manufacturing processes might have had an impact on water quality and created refuse and dump sites close to private housing. The abandonment of wells during the 6th century has been interpreted as indicative of the gradual transformation of the Agora into a publicly used space that necessitated the relocation of workshops and private houses from some areas of the Agora (Dimitriadou, 2019: 189).

The limited archaeological evidence makes it difficult to fully comprehend the development of the settlement and to gain an understanding of the living conditions during the Archaic period. This is especially true for those sections of society who might have lived in the outskirts of the city or in smaller hamlets in the surrounding areas. Nevertheless, there appears to be a shift from scattered villages during the preceding centuries to a more nuclear settlement with the Acropolis and the Agora as its political, cultural, religious, and commercial centre. The multifaceted use of the area around the Agora and Acropolis as living quarters as well as manufacturing might have impacted the living conditions for the entire population by pollution of air and water, but those working in the workshops would have been disproportionally affected in addition to likely crowded living conditions in communal accommodations associated with workshops. However, due to the incomplete evidence, it is not possible to draw general conclusions about living conditions in the entire settlement.

2.4. ‘Polis’: State, city, and community

The rise of the polis was the result of major social and political transformations. The process of state formation cannot be dated precisely but it is suggested to have begun during the 8th century BCE. The emergence of city states and new social organisation during the EIA and Archaic period was connected to population growth, concentration of settlements, and the development of a political identity. Regional differences have to be considered when exploring political changes. The polis phenomenon spans centuries and covers a large geographical area, so it is valid to question whether it was a uniform system or whether there were temporal and geographical differences within this state form (Davies, 1997, 2018; Hall, 2007b; Hansen, 2006; Morgan, 2003; Papadopoulos, 2014: 186-187; Snodgrass, 2006; Whitley, 2001: 165-166; 2020). Athens poses a clear example of a polis, which will be the focus of this section.

The term 'polis' is commonly translated as 'city-state', a translation from the German '*Stadtstaat'* (Hansen, 1998:15). As a minimal definition given by Snodgrass (1977) the polis is characterised as an autonomous political unit consisting of a town and its territory forming an inseparable unit. The terminology itself is ambiguous as 'polis' means both the urban centre with its surrounding countryside and the social unit of the community living in said settlement (Hall, 2007b; Whitley, 2001: 165-166). Historical sources suggest that the term was used for the urban centre before it was extended to the political community (Hall, 2007b). Runciman (1990: 348) used the term 'citizen state' rather than 'city state'. These citizen states are defined as juridically autonomous, and they had a stratified population that differentiates between citizens and non-citizens. It is argued that the formation of a state represents the development of an ideology of citizenship rather than a physical state (Whitley, 2001: 167).

Citizenship is an important structure in modern states and politics. Many rights as well as protection depend on citizenship and being without citizenship (stateless) is considered an anomaly affecting only a minority of people globally. Like democracy, citizenship is a legacy of ancient Greece. Most Greek states – both poleis and ethne – were citizen states (Runciman, 1990). Hansen (2003: 265) defines the polis as 'a community of *politai*. […]; functionally, the *politai* were the adult male citizens. As a community the Archaic and Classical polis was primarily a political and a military organisation, a male society, from which women and children were excluded, not to speak of foreigners and slaves. […] Political activity was a fundamental aspect of the community'. Within this definition, the polis is profoundly linked with the concept of citizenship, which was vital for political participation.

The first definition of 'citizenship' can be found in Aristotle's *Politics*, but as a later source it cannot be transferred directly to the Archaic period. During the Classical period, access to citizenship was regulated by written laws and procedures, but less is known about the concept during the Archaic period. The definition of 'citizenship' was likely more fluid and subject to change as it was a new concept (van Wees, 2018). For the Classical period, citizen status is thought to have afforded an individual certain legal privileges, that were not given to non-citizens. These rights included attending the assembly, holding offices, partaking in civil religion, and having access to the juridical system, but it also required a citizen – at least certain socio-economic groups – to partake in war and to pay taxes. However, non-citizens – women, children, foreigners, and resident aliens (*metics*) – were still considered a legal group with some rights and duties. Citizenship was inherited with only a few exceptions, which means that only sons of citizen men were included as citizens in the community (Duplouy, 2018).

The citizen body was emerging during the Archaic period, and this development went hand in hand with the development of more democratic structures. For the Archaic period especially, it was important to distinguish 'citizens' from any other status or demographic groups such as women, foreigners, or enslaved people. The exclusion of certain groups allowed the citizens to develop a common identity (Duplouy, 2018). The origins of the polis and democracy might be debated, but the importance of citizenship and community identity for both appears undisputed (van Wees, 2018). While citizenship in modern times is defined more broadly and more inclusively, certain elements of exclusion (e.g., foreigners), rights (e.g., voting), and duties (e.g., military service) can still be observed.

Military participation and citizenship appear closely related in the Archaic period; additionally, property class played a role in the level of military duty, and a differentiation based on economic wealth appears to have determined the military status of citizen-soldiers (‘hoplites’) (van Wees, 2018). The ‘hoplite revolution’ or ‘hoplite reform’ as a theory for the development of the polis was introduced in the early to mid-20th century (Andrewes, 1956; Nilsson, 1929). This theory suggests that changes in military equipment and the introduction of an equal fighting style in a close-order formation in the 7th century BCE played an integral part in introducing social change. This fighting style required a larger army meaning that all free men (citizens) regardless of socio-economic background were welcome to join the military forces, but it also relied on group solidarity. Rather than aristocrats fighting in heroic duels as described by Homer, the burden of fighting battles was divided more equally, thus creating a group identity. These developments eventually led to a demand for political participation that ended elite domination (Krentz, 2007; Pritchard, 2021; Raaflaub, 1997; Raaflaub and Wallace, 2007). The aristocratic power was challenged by the hoplites who developed as a distinct social and economic middle class between the two extreme ends of socio-economic status ('middling ideology' see: Kistler, 2004; Morris, 1996, 2000). The concept of political participation of a broader citizen body and equality supposedly lay in the emergence of this middle class (Donlan, 1997). However, this theory was challenged early on (Snodgrass, 1965). Instead, it was argued that notions of equality were present before the hoplite reform and that while military factors did play a role, they were not the principal driver for social and political change. Lower property classes had a different military status than elite soldiers and did not necessarily serve as hoplites at least in the Classical period. While there was a conscription system for members of wealthier classes, men who fell below that threshold might have owned hoplite equipment but entered the military service voluntarily. This system changed with the increasing need for hoplites in the course of the fifth century (van Wees, 2018). Raaflaub (1997) suggests an interactive model in which land-owning men, who participated in military actions as hoplite fighters to defend their territory, also joined the polis's decision-making process as part of an assembly. Landowners had a stake in the settlement or polis with respect to retaining their territory or even gaining more, but during the Archaic period, fewer wars were fought for the purpose of territory acquisition. The emergence of political participation of a wider population does not mean, that there was an absence of a stratified elite or aristocracy. However, the hoplite fighting style reflects egalitarianism and a sense of community that was not based on birth or wealth, and which also formed the basis of democratic politics (Raaflaub and Wallace, 2007).

Whitley (2001: 168-178) argues that the process of state formation and the origin of urbanism should be treated separately from one another, as these processes are not necessarily connected. While large temples and fortifications built around 700 BCE are considered an indicator of urbanisation (see De Polignac, 2005; Snodgrass, 2006), these structures do not necessarily make a settlement into a polis. For example, during the EIA both Corinth and Athens consisted of small settlements that were loosely connected around a fortified acropolis, but Athens stands out due to its larger population and can, therefore, be considered more urban than Corinth. Extraurban sanctuaries might have been used to mark the territory borders of an urban centre (De Polignac, 2005).

One important step in polis formation was the reintroduction of an alphabet between 950 and 750 BCE. Trade connections with the East and other forms of contact are visible in the archaeological record of artistic influence and the reintroduction of an alphabet. For the first time, reading and especially writing was not limited to a certain class of scribes who served the elite ruling class. Instead, it became accessible to a broader section of the population (Osborne, 2009: 161-169; Papadopoulos, 2014; Steele, 2020). The reintroduction of literacy allowed for written laws which played a significant role in the development of equality and democracy (Duplouy, 2018; Wallace, 2009).

A further vital development in the Archaic period were changes in metal use and the introduction of silver coinage. Bronze was the main metal used during the Bronze Age, but iron was fully adapted as the main metal by 900 BCE. Most of the archaeological knowledge for metal use comes from burials and sanctuaries resulting in some biases. Metal objects of daily use could be recycled while the votives and grave goods remained undisturbed within their context. Iron was more readily available in Greece than copper and tin for bronze. It is unclear how much social impact the introduction of iron had. Imported technology was developed further and might have allowed increased agricultural activity as well as more dispersed production sites. While iron became more readily available, the process of working iron was more difficult and thus likely not cheap (Morgan, 2009; Whitley, 2001: 80-84). A main use of metal was for military purposes enforcing the importance of warrior status to an aristocratic elite. This can for example be seen in the warrior and panoply burials (Morgan, 2001, 2009). Both bronze and iron played an important economic role, but the introduction of silver as a measure of value might have had an even bigger societal impact. Silver is increasingly used for coinage during the 6th century BCE with every polis minting their own coinage. The creation of coins as a means of payment instead of weighed silver pieces might have had a stronger impact on polis and politics than iron. Silver played a vital role in the rise of Athens as one of the wealthiest poleis (Papadopoulos, 2014; Schaps, 2004; van Wees, 2013; Wallace, 1987).

2.5. Burial practices in Early Iron Age and Archaic Athens

The archaeological record demonstrates changes in burial practice during the Archaic period. These include changes in burial location, grave type, and grave goods (Kurtz and Boardman, 1971; Prevedorou et al., 2024; an extensive overview can be found in Rönnberg, 2021a). Whether these changes were a distinct reflection of socio-political developments taking place during the EIA and Archaic period has been the subject of broad scholarly debate. Furthermore, some variability in burial customs such as the concurrent use of inhumations and cremations as well as variation in grave types were present in Archaic Attica (Alexandridou, 2016, 2020; Rönnberg, 2021a: 167-191) and even within single cemeteries (Doronzio, 2018). However, while the picture might be diverse to a certain degree, some trends in burial practice are observed. This section aims to provide a brief overview of the major developments in funerary practice during the EIA and Archaic period.

For the 9th century BCE, only a small number of archaeologically visible burials are available, but these increase during the 8th century BCE before decreasing again sharply around 700 BCE. A rise in burial visibility is again observed for the 6th and 5th centuries BCE (D'Onofrio, 1997; Dimitriadou, 2019; Houby-Nielsen, 1992; Morris, 1987; Osborne, 1989; Rönnberg, 2021b). The changes in burial numbers are attributed to population fluctuation (Camp, 1979; Snodgrass, 1977; Snodgrass, 1980) or interpreted as a reflection of social complexity (Morris, 1987, 1992, 2000). Morris (1992) argued that the right to a formal burial was linked to citizenship, and changes in burial numbers reflect the extension of this right to the lower socio-economic strata of society. This then can be considered a manifestation in the archaeological record of the 'middling ideology' that is central to the development of equality and democracy. However, Morris's interpretation of the burial record as a reflection of a more egalitarian society has been contested (D'Agostino and D'Onofrio, 1993; Houby-

Nielsen, 1992, 1995; Kistler, 2004; Osborne, 2009: 68-75; Papadopoulos, 1993; Patterson, 2006). It is difficult to extract population numbers and trends from burial numbers alone and other factors impacting the visibility of burials (burial treatment, changes in mortality and fecundity, etc.) should be taken into consideration in any interpretation. Trying to quantify these changes is not straight forward and different interpretations have to be considered (Scheidel, 2004). The discovery of the burial ground at Phaleron has changed the archaeologically known burial record for Athens significantly. The burial ground not only increased the number of known burials drastically, but it also added burials of non-elite and potentially marginalised people that have long been invisible in the burial record.

The location of burials also changed during this period from small intramural burial plots to larger extramural cemeteries. The process of state formation in Attica is associated with urbanism as smaller settlements coalesced into larger and more urbanised areas during the 8th century. The existence of larger cemeteries during the EIA might be considered an indicator that Athens did not consist of small hamlets but rather had a clear urban nucleus with the Acropolis as its centre (Hall, 2007b; Papadopoulos, 2021). A shift from using intramural burial plots, favoured during the EIA, towards large cemeteries outside the city boundaries potentially was part of city planning and the reorganisation of public spaces around the acropolis (Dimitriadou, 2019: 210-222; Papadopoulos and Smithson, 2017; Rönnberg, 2021b). By the end of the 6th century, clusters of burials were present along major roads just outside the city limits. For example, the Kerameikos cemetery was located directly outside the later city walls along the Sacred Way (*Iera Odos*) and the Northern cemetery was located close to the Acharnian Gate of the Themistoklean Wall. We have many permanent funerary monuments from the Classical period, but these were sparser in the Archaic period. The funerary monuments were rarely set on top of the burial itself but were rather located along the major roadways through the cemeteries. The location of burials and burial markers along important roads allowed for monuments to be seen by passersby and gave easy access for families (Shea, 2021).

Changes can also be observed in the burial types and practice. During the LBA, multiple burials (commingled contexts) were standard, so the shift towards single burials in the succeeding centuries is significant. In the early first millennium BCE, cist burials were commonly used for inhumations, while at the same time cremations became more prevalent. Remains from secondary cremations were sometimes placed in pottery or metal urns, but un-urned cremation burials are also known. Cremation as the predominant burial form was replaced by inhumations around 800 BCE (Doronzio, 2020; Houby-Nielsen, 1992; Kurtz and Boardman, 1971: 73-75; Morris, 1987: 21). Inhumations were never completely abandoned, and especially for infants and children this was always the dominant burial form, often in cists, pits, or jars (*enchytrismos*) (Vlanti, 2020). Both in the Kerameikos and other cemeteries in Athens, pit burials become the most common type of inhumation during the 8th century BCE for adults, and by 700 BCE inhumations had become predominant. In regard to burial position, stretched supine was the most standard form in Athens, but elsewhere (e.g., Salamis and Eleusis: Cavanagh (1977)) flexed or contracted positions are also present. *Enchytrismoi* for infants and children were common in all of Attica; in contrast, only a small number of burials in pots or jars is known for adults (Rönnberg, 2021a: 180-181, 185).

Wealth disparities can be traced through burial practices from the EIA to the Archaic period. During the EIA, cemeteries close to the Athenian Acropolis appear organised by kinship groups. An increase in burial goods during this period, including weapons (‘warrior burials’), suggests a highly stratified society. Burials with exclusive grave goods were not limited to males as evidenced by rich female burials (e.g., ‘Tomb of the Rich Athenian Lady': Smithson (1968)). Noticeable are a number of imported grave goods such as jewellery (Papadopoulos, 2021; Rönnberg, 2021a: 175-178). This feature gradually disappears during the early Archaic period. The decline of these richer burials thus coincides with the development of a more egalitarian society. In the 7th century BCE, most burials are only furnished with pots, and rich aristocratic burials appear absent from the archaeological record (Rönnberg, 2021a: 181; Whitley, 2001: 185-188). Morris (2000) argues that the increase in simple inhumation burials with few to no grave-goods was also a manifestation of the beginnings of the middling ideology, which is tied to political equality and the idea that all citizen men were allowed to participate in political decision making regardless of socio-economic status. This increased political equality has been thought to be reflected in the burial record as a larger proportion of the population was now granted access to formal burials. The lack of rich female burials in the Archaic period might be an indicator of sex discrimination in aristocratic social strata (Houby-Nielsen, 1992), but this theory has also been contested more recently (Doronzio, 2020). It should also be considered, that bioarchaeological analysis of human remains was not done routinely in the past, and assignment of biological sex was often based on grave goods rather than the osteological evidence thus creating an implicit scholarly bias. More generally, the changes in grave goods might be an overall indicator of structural changes within society (Rönnberg, 2021a: 167-191). At the same time as burial goods decline, offering places and trenches appear in some cemeteries in Attica. The offering trenches are linked to elaborate funeral rites that included the offering and burning of small objects and animals. The trenches become more common during the 7th and 6th century BCE, apparently as a replacement of grave goods that were placed inside the grave, and they have been interpreted as a reference to a banquet service meant to recall the lifestyle of the deceased. The most prominent example of offering trenches can be found in the

Kerameikos cemetery in Athens (Alexandridou, 2015; Houby-Nielsen, 1996; Kistler, 1998; Kurtz and Boardman, 1971: 75-76).

Overall, it can be argued that the changes in burial practice are reflective of larger socio-political changes taking place during the EIA and Archaic period. The diversity in burial forms suggests a heterogenous society that afforded archaeologically visible burials to people from all socio-economic classes.

2.6. The marginalised population of Athens

2.6.1. Enslavement and forced labour practices

Archaeological and historical research has long focused on the material culture and textual evidence of the elite population. It has been acknowledged, that the success of the Athenian polis was in part dependent on the low status work force that included both non-elite citizens and enslaved people. These marginalised sections of society have only become the subject of in-depth research in more recent years (Forsdyke, 2021; Hunt, 2018b; Sulosky Weaver, 2022; Taylor, 2017).

Slavery is found globally from prehistoric to modern times and in different cultural contexts. Enslavement can take on different forms, but at its core is characterised by dehumanisation, loss of freedom, and exploitation, and it is an inherently inhumane system. We do not have clear definitions of what constituted slavery in the ancient Greek world, and modern definitions have been subject to debate and evolution in order to recognise the continuing existence of slave-like conditions in the modern world, despite the formal abolition of slavery. More recent definitions include the forceful control of a person regardless of legal ownership. This would include slave-like practices such as forced labour or debt bondage, even if they do not involve legal ownership. In 1956, the United Nations enacted the ‘Supplementary

Convention on the Abolition of Slavery, the Slave Trade, and Institutions and Practices Similar to Slavery', which included debt bondage, serfdom, servile forms of marriage as well as exploitation of children. Additionally, in 1989 the United Nations enacted a resolution on child labour and in 2000 on child prostitution and human trafficking (Forsdyke, 2021: 18-19). The definition of slavery by Patterson (1982: 13) as 'the permanent, violent domination of natally alienated and generally dishonored persons' was highly influential. Slaves are deprived of most legal and political rights and experience desocialisation and depersonalisation ('social death'). Stripped of their individual social identity, they become a commodity (Kamen, 2013: 9). This definition recognises legal ownership as a cultural mechanism rather than being essential for identifying slavery. This acknowledgment is crucial for new definitions of modern slavery, and this also has implications for the study of enslavement in the past. It is well attested for ancient Greece, that chattel slaves were considered property, but one can argue that other slave-like practices such as debt-bondage, child labour or serfdom should also be considered as forms of slavery (Forsdyke, 2021: 20-22).

Finley (1968; 1980, 1999) argued that there is a binary between a true 'slave society' and a 'society with slaves'. In a 'society with slaves' enslaved people are present but not instrumental to the success of the society. Based on Finley's (1980) definitions of a slave society, enslaved individuals must constitute a certain percentage of the population, play a significant economic role, and slavery as an institution must be culturally significant. The terminology has been widely used but also criticised (Forsdyke, 2021: 48-50; Harper and Scheidel, 2018; Lenski, 2018b). Finley's definition of slave society provides a broad framework for the comparison of practices of enslavement in different geographical, temporal, and cultural settings. This framework, however, will be used with caution in this thesis, because it might not be appropriate to understand the more nuanced dimensions of enslavement, and it has the potential to diminish the experience of enslaved people.

Finley (1980) identified Classical Greece and Athens as a slave society. Despite clear steps towards political equality during the Archaic period that culminated during the Classical period in what is nowadays known as the first democracy, Classical Athens was heavily reliant on slave labour. Finley argued that in ancient Greece, paradoxically, the political freedom and strides towards equality for citizens of lower socio-economic status went hand in hand with a higher demand for chattel slaves to compensate for the loss of low-status work force. Athens was the most advanced democracy in the Greek world but was at the same time one of the most developed slave economies. It is estimated that chattel slaves made up between 15-35% of the total population of Classical Athens (Kellogg, 2021). Estimates of the numbers of enslaved people in ancient Athens range from 30,000 to 250,000 (Hunt, 2018a). Different mechanisms could cause a person to become enslaved. People could be captured in raids and sold into slavery, taken prisoner during war, born into slavery through forced reproduction and rape, or were enslaved as legal penalty (Braund, 2011; Forsdyke, 2021: 53-69).

Enslaved people were stripped of all legal and political rights. The lack of any social status rendered them vulnerable to physical and sexual violence (Kellogg, 2021). Chattel slaves were denied most rights and privileges and were 'socially dead'. They occupied the lowest status in the Athenian society and had extremely limited opportunities to move up the social ladder (Kamen, 2013: 8-18).

As slavery is also a phenomenon in non-democratic societies, the correlation between changes in political system and increase in slave labour is likely not clear cut (Lenski, 2018a). The Athenians were not split into two distinct status groups – enslaved versus free – rather status can be viewed as a spectrum with free people also participating in manual labour alongside enslaved people (Kamen, 2013). Nevertheless, slavery played a vital role in the economic system of Athens, and it had a profound impact on the socio-political system and culture (Hunt, 2018a). In addition, unskilled wage labour performed by members of lower socio-economic status still formed an essential part of the Athenian economy. Poverty forced men and women to undertake hard manual labour and exposed them to exploitation. It is estimated that approximately 20% of citizens did not own any land and, therefore, had to earn an income as peasant farmers or manual labourers. Foreigners who resided in Athens (*metics*) could also be found in the ranks of unskilled labourers. While all foreigners probably encountered some degree of prejudice, poor foreigners who engaged in menial labour were likely exposed to more discrimination than wealthy immigrants (Sulosky Weaver, 2022: 51-61). Poverty does not only have an economic component but also encompasses social and ideological aspects. In addition to a lack of material wealth, poverty is also a socially constructed category that is maintained by inequalities and reinforced by marginalisation and othering of the poor. Poverty existed on a spectrum and might have been experienced differently based on different facets of identity such as gender, age, or ethnicity (Taylor, 2017:16-17).

Slavery and forced labour practices are difficult to capture using historical and archaeological methods. It has proven difficult to discern socio-economic status from the burial record alone without the inclusion of skeletal data (Sulosky Weaver, 2022: 178-183), and it is, for example, not possible to conclusively identify slave quarters in the archaeological record of ancient Greece. Enslaved people can primarily be traced through literary and iconographic evidence as well as inscriptions. Historians and archaeologists have relied on indirect and textual evidence such as philosophy and law treatise to gain insights into the lived experience of slaves as direct archaeological evidence is limited (Forsdyke, 2021: 12-17; Hunt, 2011). Nevertheless, it has proven more difficult to archaeologically identify poor citizens than the elite.

2.6.2. Unskilled labour and slavery occupations

Slave labour and other forms of forced or low-status labour permeated all aspects of the Greek world. Enslaved people and people of low socio-economic status worked in many different occupations, and their lived experience would have differed significantly depending upon this. The four main occupations that relied on a low-status work force were agriculture, manufacturing, mining or quarrying, and domestic labour, but slaves also worked in banking, commerce and state bureaucracy (overviews are provided by Forsdyke, 2021: chapter 3; Lewis, 2018: chapter 8).

Agriculture was one of the main areas that was dependent on low-status work force. Slaves worked on small and large farms, but for larger agricultural estates, it is likely that labour division and specialisation was present, potentially creating a hierarchy amongst the enslaved. Agricultural work included ploughing, sowing, planting, harvesting, and manuring as well as building terrace walls and was physically demanding. Animal husbandry was also practiced in agricultural estates, and slaves would also have worked as specialised herdsmen (Forsdyke, 2021: 103-109; Kyrtatas, 2011).

Slaves and citizens of low socio-economic status also worked in manufacturing and skilled trades. They worked alongside other skilled labourers in metalworking, carpentry, pottery production, and stone masonry. Inscriptions suggest that citizens, free non-citizens, and slaves worked in the same environment and were also paid the same wages. However, it is likely that the wages of enslaved people went directly to the slave owner rather than to the enslaved themselves. Literary sources such as Xenophon tell us about the detrimental effects of labour in manufacturing workshops for health. Workers were exposed to hazardous environments with extreme temperatures, toxic fumes (e.g., metal working and pottery workshops), or unhygienic conditions (e.g., tanning). Heavy lifting of raw materials (e.g., stone or clay) would also have been harmful to the body. Additionally, physical abuse including whipping and shackling as well as emotional abuse in form of degradation were likely common in some workshops as suggested by one letter written by Lesis, who was working in a foundry (Harris, 2004). It is, however, not possible to generalise the working conditions as they likely varied between workshops and were dependent on the type of labour (Forsdyke, 2021: 110-116; Kyrtatas, 2011). Enslaved women worked in wool manufacturing, but it has been theorised that some of these women might have also worked as prostitutes (Forsdyke, 2021: 117-118; Wrenhaven, 2009).

Working in mines and quarries was the most physically demanding occupation. While quarrying was also undertaken by both free and enslaved people, mining was almost exclusively labour performed by enslaved. During the Classical period, an estimate of 10,000 to 30,000 slaves worked in Laurium, the mining district in southern Attica at any given time (for estimates see: Thompson, 2003: 148). Slaves were also often leased to work in the mines and some slave owners had several hundreds of slaves working the mines. In addition to work in the silver mines, ore-processing in workshops from grinding and washing to smelting was also slave dominated labour. Unskilled as well as skilled labour in the process of metal extraction and processing was physically demanding and unhealthy (high temperatures and toxic fumes) and, therefore, mostly performed by slaves. Mining overall was extremely hazardous and exposed miners to risk of injury and death, and slaves working in mines had the highest mortality rate. In addition to the inherent dangers of ore-processing, physical abuse was also present in the mines, and it is possible that some slaves died of exhaustion as the result of the gruelling conditions (Forsdyke, 2021: 16-17, 119-125; Kyrtatas, 2011). Evidence for slave revolts is limited for the Greek world but were reported for slaves working in mines (Thompson, 2003: 245-248).

Another setting that depended heavily on slave labour was domestic labour, including food production and serving, childcare, cleaning, and wool or cloth production. While some slave occupations were male dominated, both male and female slaves worked in domestic settings. Household labour was certainly less dangerous than working in mines or manufacturing, but domestic slaves were also subjected to physically demanding labour and abuse. As part of childcare duties, enslaved women were tasked with breastfeeding the master's children, which could potentially create strong bonds between the children and their carer. In the household setting, female slaves were also in danger of being sexually assaulted and exploited by their master (Braund, 2011; Forsdyke, 2021: 125-133).

In addition to occupations that required heavy manual labour, enslaved people also worked in civic administration, banking, prostitution, and warfare. Slaves working in banking and business were likely in a slightly more privileged situation. It was easier for these individuals to move within the social structures and gain freedom and potentially even citizenship. Publicly owned slaves performed different civic tasks ranging from upkeep of buildings and streets to keeping public records as scribes and accountants. In contrast to privately owned slaves, they were allowed to keep their earnings and may have been able to live independently. Undertaking administrative tasks meant that these slaves would have been literate and numerate, and considerable trust was granted. However, public slaves were branded with a public mark, that was meant to provide protection against the stealing of public slaves. In addition to the direct physical pain of the branding, this would also have been a very visible marker of their slave identity (Forsdyke, 2021: 133-150).

Prostitution was an occupation that was dominated by female slaves and former slaves, but male prostitution was also commonly associated with slavery. Their work allowed them to socialise with leading citizens and potentially granted them some social mobility. However, gaining independence was not the norm for sex workers in ancient Athens. Most would have remained enslaved in the brothel, and masters of slaves working in prostitution could make considerable profit (Forsdyke, 2021: 150-154; Kyrtatas, 2011; Wrenhaven, 2009).

2.6.3. Lived experience of forced labour

The lived experience of slavery and unskilled labour was not only dependent on the type of labour performed, but also on sex and gender, age, or ethnicity. Regardless of demographic factors, loss of freedom and identity has a significant impact resulting in physical and psychological trauma. Athens was a prominent slave market in antiquity, and slaves would be auctioned based on ethnicity, gender, age, or skills. In the case of foreign slaves, cultural dislocation was inevitable, but the sudden change in status would have been a shocking adjustment for both foreign and Greek enslaved people (Braund, 2011; Forsdyke, 2021: 70-89).

The majority of enslaved people were of non-Greek origin and the slave population of Athens likely had a diverse ethnic profile. The gap between the birth culture and the culture of the slave society might have been traumatic to an enslaved person. Cultural assimilation is dependent on the birth culture, and the number of slaves of same ethnicity in the community would have affected the lived experience. However, it is impossible to draw any definite conclusions about the ethnic make-up of the slave population of Athens based on historical sources other than that the population was of a diverse ethnic background (Braund, 2011; Forsdyke, 2021: 92-98).

In terms of gender and age, it might be expected that adult male slaves were more in demand than any other demographic groups. However, women and children were frequently enslaved during raids or warfare, while males were often executed instead of enslaved. In addition, there is also evidence documenting the sale of women and children as slaves showing that there was a demand. Female slaves could be as expensive as male slaves suggesting that they were valued at the same worth. The historical record might be biased towards male slaves as they appear in different contexts, such as mining or warfare, than women. It is likely that male and female slaves were more balanced in terms of numbers than the historical record might suggest (Forsdyke, 2021: 98-100; Kyrtatas, 2011).

2.6.4. Summary: The marginalised population of Athens

During the Archaic and Classical period, Greek economy was highly dependent on a low status work force that included non-elite citizens and enslaved people. The abolition of debt-slavery might have increased the need for chattel slavery; however, the development of democracy and citizen equality did not translate into economic equality and unskilled wage labour performed by citizens of lower socio-economic status still formed an essential part of the Athenian economy. Enslaved people and free unskilled labourers worked often side by side in different occupations including agriculture, quarrying and construction, as well as manufacturing. These occupations were physically demanding and exposed the workers to hazardous environments putting them at high risk for injury and other health insults. The individual lived experience would have been dependent on various axes of identity including sex, age, or ethnicity. A certain gendered labour division is known, but men and women both were required to perform strenuous labour. Loss of freedom has a significant impact resulting in physical and psychological trauma, and forced displacement of foreign slaves would have been additionally traumatic.

2.7. Summary

The EIA and Archaic period are of vital importance for our understanding of the history of Athens, and the use of the Phaleron burial ground coincides with this highly formative period. During these centuries, major political, social, and religious developments took place, including the introduction of governmental institutions, codification of written laws, and definition of citizenship. During the EIA and Archaic period political power shifted from a small number of elite members to the citizen body of the polis. Despite large steps towards equality, institutionalised hierarchy and sanctioned physical violence especially against the enslaved remained part of the political system. Violence against the enslaved is attested through literary sources including comedic theatre for example by Aristophanes and Menander, as well as Xenophon's *Memorabilia*, in which the beating of slaves, withholding of food, and chaining is portrayed as normal and accepted practice (Hunt, 2016). The societal and political changes that allowed people of lower socio-economic status to gain more freedom promoted chattel slavery, and Athens can be considered economically dependent on slave labour in the Classical period. Strides towards political equality for male citizens did not translate into economic equality, and the lower socio-economic class was still forced to earn a living performing manual and unskilled labour. While historical sources can tell us about politics and significant events, the archaeological record can be employed to look at different social developments and lived experiences regardless of social status during life.

3. Skeletal Indicators of Physiological Stress

3.1. Introduction

This chapter aims to provide an overview of the study of physiological stress in bioarchaeological research and the clinical and theoretical foundation for the study of stress including the Developmental Origins of Health and Disease Hypothesis (DOHaD) and systemic stress. Furthermore, the chapter briefly discusses the skeletal indicators of non-specific physiological stress used in this thesis. Different external and internal factors can cause high levels of physiological stress that will leave evidence in the skeletal remains. The integration of demographic data and multiple indicators of physiological stress allows us to investigate exposure to stress on an individual as well as on a population level. The chapter aims to discuss the potentials and limitations of bioarchaeological studies of physiological stress including issues of sample bias, preservation, and recording standards. In addition, a brief overview of bioarchaeological research in Greece will be given. This section focuses on studies that employed indicators of physiological stress to investigate temporal and regional variation as well as the impact of biological and social factors such as biological sex or social status on health and exposure to physiological stress.

3.2. Palaeopathology - The study of health and disease

Defining 'health', 'disease' as well as 'physiological stress' is not straightforward as these terms encompass an array of different factors. The World Health Organisation defines health as 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (WHO, 1946), but it is not possible to consider all these factors in archaeological contexts. The research field 'palaeopathology' is comparatively young (Buikstra and Roberts, 2012; Grauer, 2018) and is considered a subdiscipline of biological anthropology. It is the science of disease visible in human and animal remains as first described by Robert Wilson Shufeldt (Cook, 2012) and Sir Marc Armand Ruffer in the early 20th century (Ruffer, 1920). Palaeopathology examines origin, evolution, and progress of disease throughout history (Roberts and Manchester, 2005). In its approach, it is highly multidisciplinary drawing from different sources of evidence including clinical data, archaeological evidence from skeletal or mummified remains, and contemporaneous written and artistic records of disease. The 'bioarchaeological approach' developed by Buikstra (1977) combines biological and cultural data, therefore, interpreting lesion types and frequencies within a particular cultural context. The bioarchaeological approach aims to understand why and how disease affects different populations in different times and circumstances and how humans adapted to changes in their environment (Roberts et al., 2005).

The study of palaeopathology has several limitations that need to be considered in any interpretation of skeletal data. Samples from burial grounds are inherently biased as they will only ever present a subsection of a once-living population. Normal attritional mortality samples are subject to a biological bias known as the osteological paradox (DeWitte and Stojanowski, 2015; Wood et al., 1992). Such samples represent a population over an extended period of time and are usually characterised by high infant mortality, low numbers of adolescents and an increase in mortality throughout adulthood into older age. In contrast, catastrophic mortality samples caused by short-term crises such as epidemics or warfare should reflect the population composition more accurately as all age cohorts are exposed to the same elevated risk of mortality (Gowland and Chamberlain, 2005).

In addition, differential mortuary practices based on age-at-death, gender, social status, or cause of death can produce a biased representation within a cemetery. Taphonomic processes may result in an environmental mortality bias due to differential preservation and recovery of skeletal remains (Saunders and Hoppa, 1993).

Furthermore, living bone can only react in a limited number of ways to different disease processes. Differential diagnosis, including the characteristics and distribution of lesions in reference to clinical data, is essential when interpreting skeletal remains. In many cases, it is not possible to identify specific diseases, but a disease process can usually be classified in a broader disease category (e.g., infectious disease, metabolic disease, etc.) (Roberts et al., 2005).

However, despite all these limitations, palaeopathology provides the most direct evidence of disease in the past available and can, therefore, be considered the most unbiased account of population health.

3.3. The study of physiological stress

A general definition of physiological stress is the disruption of physiological homeostasis, but the term ‘stress’ has become widely used in bioarchaeological research, which has led to a diffusion of its meaning. The reality of stress is more complex, and individuals and populations cannot be defined in simple categories (Temple and Goodman, 2014). Different forms of physiological stress such as malnutrition, infectious disease, climatic stress, or poor environmental conditions, as well as psychological and emotional stress can have a negative effect on health and normal development (Barker, 2007; Barker et al., 1991; Barker and Osmond, 1986; Blackwell et al., 2001; Saunders and Hoppa, 1993; Temple and Goodman, 2014). For bioarchaeological studies it is important to acknowledge, that health is a highly complex system and associated with an individual perception of well-being (Temple and Goodman, 2014).

3.3.1. Developmental Origins of Health and Disease Hypothesis

The Developmental Origins of Health and Disease (DOHaD) hypothesis (originally 'Barker Hypothesis') argues that physiological stress experienced during early development can negatively affect health status during adulthood (Barker, 2007; Barker and Osmond, 1986; Blackwell et al., 2001; Rodney and Mulligan, 2014). Individuals who were exposed to stressors such as infectious disease, parasitic infection, malnutrition, or poor living conditions during development are more susceptible to disease and at higher risk of mortality during adult life. Especially the first 1000 days of life (counted from conception) are a sensitive time of developmental plasticity. A life-course approach is important to understand how chronic morbidity develops in later life as this might be the cumulative effect of health insults experienced in-utero or early childhood (Blackwell et al., 2001; Gowland and Caldwell, 2023). Several long-term studies have investigated the impact of low birth weight and illness during infancy and childhood on adult mortality and morbidity in the 20th century (Barker, 2007; Barker et al., 1991; Barker and Osmond, 1986; Blackwell et al., 2001). It is clear from such studies that the identified risk factors such as inadequate housing and overcrowding as well as poor nutrition mostly affect people from lower socio-economic backgrounds.

As archaeological populations often faced worse living conditions than the population of the 20th century did, it can be assumed that factors such as poor nutrition during pregnancy and childhood, infectious disease, inadequate housing, and crowded living conditions would have had an impact on population health in the past. The impact of environmental factors on gene expression (epigenetics) is one important mechanism acting on developmental plasticity. The potential impact of intergenerational adversity on frailty needs to be taken into consideration (Gowland and Caldwell, 2023; Kuzawa, 2005; McPherson, 2021). Bioarchaeological studies aim to identify the effect of stress during development on different populations as well as sex differences, differences in exposure to stress based on social status and social inequality, or the impact of cultural change on population health (e.g., Bourbou, 2005; DeWitte, 2009; Godde et al., 2020; Moles, 2023c; Quade and Gowland, 2021; Watts, 2015; Yaussy et al., 2016).

3.3.2. Systemic stress in bioarchaeological research

When exposed to a stressor, the body preferentially uses available resources to maintain essential functions, rather than investing energy in growth, and it initiates a stress response to preserve homeostatic functions (Armelagos et al., 2009; Klaus, 2014; Steckel et al., 2002a; Watts, 2015). Stress may be identified as the product of three key factors: environmental constraints, cultural systems, and host resistance (Figure 3.1). The systemic stress perspective is a model adapted for interpretation of stress indicators in palaeoepidemiological research (Goodman and Armelagos, 1989; Goodman and Martin, 2002; Goodman et al., 1984). It aims to identify stress in the skeletal and dental remains from archaeological contexts on an individual and population level. The model emphasises the role of environment, but also includes the influence of cultural systems as protective buffers (Larsen, 2015: 7).

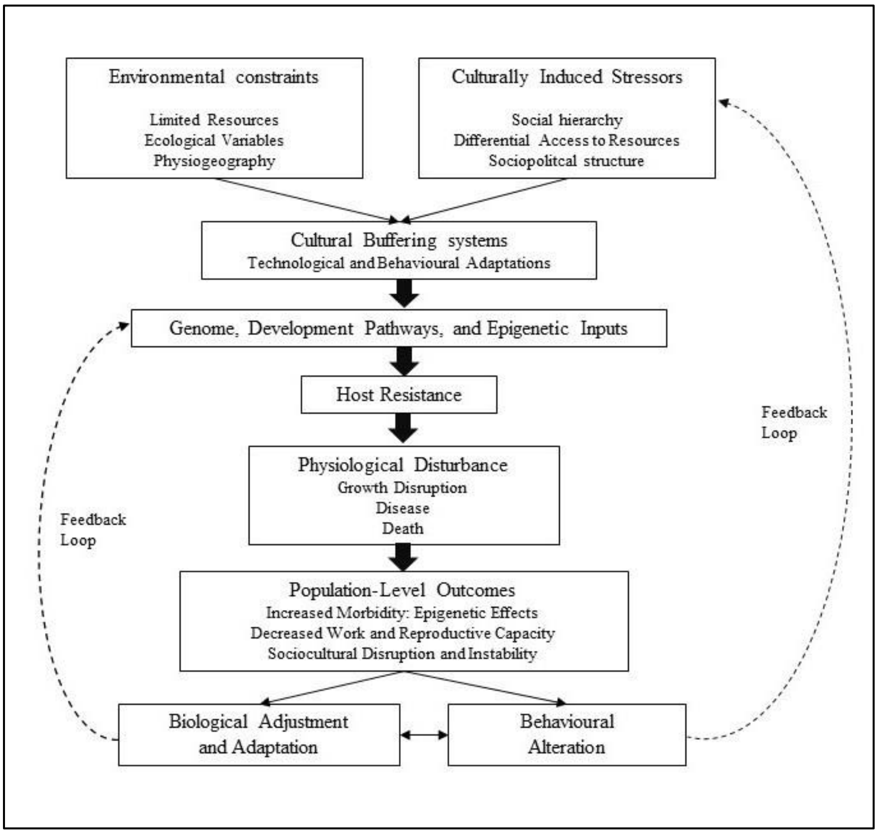

Figure 3.1: The Biocultural Model based on the 'Systemic Stress Perspective' model for the interpretation of stress in archaeological populations (after Larsen, 2015: 8, fig. 2.1)

Stressors accumulate throughout the life course and can cause a gradual decline in health. Environmental constraints can interact with cultural buffering systems, which can reduce external stress but also introduce new stressors. If the cultural system cannot provide an effective buffer for stress, the individual level of adaptation and host resistance become essential (Goodman et al., 1984). Genetic adaptation on a population level is possible but rare (e.g., sickle-cell anaemia providing resistance to malaria) (Goodman and Martin, 2002). A population can react to reduce certain aspects of stress which in turn would have an impact on the environment and the socio-cultural system itself. If many people within a community are affected by physiological stress impacting work capacity, fertility, morbidity, and mortality, this could potentially cause disruption of social, political, and economic structures of societies. Ultimately the survival of a population depends on its capacity to mitigate stress, which has implications for behaviour and the functioning of society (Goodman and Armelagos, 1989; Goodman and Martin, 2002; Larsen, 2015:7).

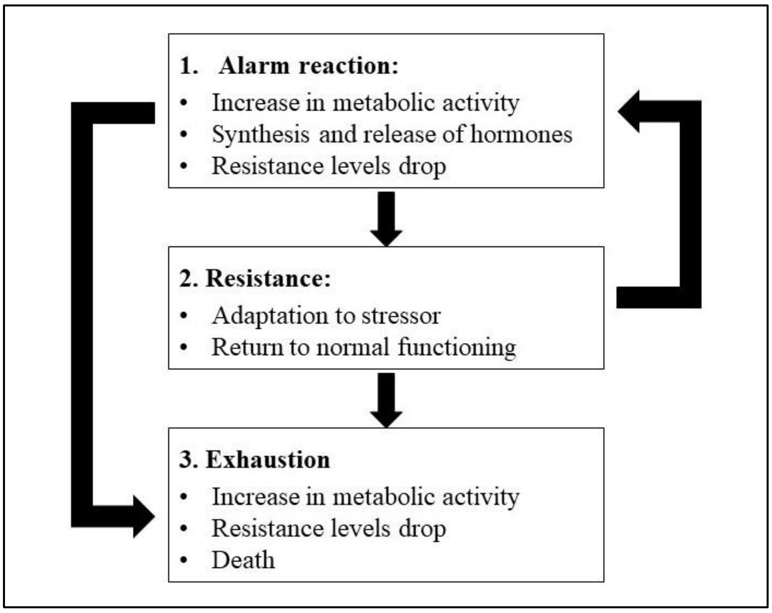

Figure 3.2: The General Adaptation Syndrome (Watts, 2015: 570, fig. 1)

The stress response – 'general adaptation syndrome' – involves the secretion of so called stress-hormones such as cortisol and adrenaline, which are distributed throughout the entire body (Figure 3.2) (Selye, 1946, 1950). During brief periods of stress, this can help provide energy for an immune reaction. The reaction is only effective for a short time, and chronic or repeated episodes of stress can damage the immune reaction resulting in slower or less powerful responses to future stressors. Chronic stress might impact development and can result in decreased health and nutritional status. Poor health status will in turn expose an individual further to new stressors (Goodman and Martin, 2002; Temple and Goodman, 2014; Watts, 2015).

Different factors such as infectious disease, nutrition, or environmental influences can lead to physical stress. For the purpose of bioarchaeological research, focus on specific aetiologies is not constructive as stress is often the result of a combination of interactive forces (Saunders and Hoppa, 1993). The systemic stress perspective argues for a greater interest not in specific agents but severity, duration, and cause of the disruption of normal physiological processes. The skeleton has limited options to react, and essentially pathological reactions can result in bone formation, bone loss, or a combination of both, which are largely considered non-specific. By focusing on the skeletal expressions of physiological stress, health status and functional impairment can be assessed on a population level. This approach allows us to examine broader social, economic, and political factors that impact and determine population health and mortality (Goodman and Martin, 2002).

Palaeopathological research treats several skeletal lesions as results of exposure to different stressors (see section 3.3.3.). Contrary to archaeological populations, stress in living individuals can be measured through various means such as hormone levels (e.g., cortisol). These data are not available for skeletal remains (but see Quade et al., 2021). In contrast, the evidence we have available to identify periods of stress in archaeological populations is largely indirect (Weston, 2012: 505).

3.3.3. Indicators of physiological stress

Chronic stress can manifest in the human body and become visible as so-called skeletal indicators of stress. Pathological lesions commonly interpreted as indicators of non-specific stress are cribra orbitalia (CO), dental enamel hypoplasia (DEH), decreased stature, periosteal new bone formation (PNBF), joint disease and trauma. Additionally, various forms of dental disease including caries, periapical lesions, and ante-mortem (AM) tooth loss are considered indicators of oral health that are also influenced by and have an impact on general health. CO, DEH, and short stature are indicative of adversity during infancy and childhood, while PNBF, dental disease, joint disease, and trauma are cumulative, and inform about stress and disease experienced over the life course including adulthood (Steckel et al., 2002a; Steckel et al., 2002b).

The biological data need to be interpreted within the site-specific context, but they can provide an estimate of population health and standard of living for different populations.

The utilisation of multiple skeletal indicators recognises that health is a composite of different aspects of life history. This approach allows for a more comprehensive understanding of health and acknowledges that stress represents a continuum (Larsen, 2015:7-8). The osteological paradox (DeWitte and Stojanowski, 2015; Wood et al., 1992) has to be taken into account when interpreting these lesions as heterogeneity in frailty can lead to selective mortality. Individuals who present with visible skeletal markers of stress have overcome and survived periods of severe stress; therefore, these individuals might be more resistant to adverse conditions than individuals with no skeletal evidence of stress who may have succumbed quickly to any external insult and, therefore, appear healthier skeletally. Skeletal indicators of stress do not provide any precise indicator of the cause. A succession of acute illnesses or a specific long-lasting disease cannot be diagnosed directly but these can result in skeletal indicators such as dental enamel hypoplasia or stunted growth. The age-of-onset and the duration of the disease or adversity is usually not possible to determine (Steckel et al., 2002b).

3.3.3.1. Orbital Lesions – Cribra orbitalia

Porotic changes of the orbital roofs (cribra orbitalia) are commonly observed archaeologically (Figure 3.3). Welcker (1888) was the first to fully describe these cribrous lesions of the cranium using the term 'cribra orbitalia', also noting the co-occurrence of porotic lesions in the orbits and the ectocranial surface of the parietal bones which were later termed 'porotic hyperostosis' (Angel, 1966). For the purpose of this thesis, only CO was used as the clear differentiation between slight expression of porotic hyperostosis and ectocranial porosity caused by other factors such as inflammation proved difficult in the sample. Both cranial cribrous lesions traditionally have been linked with anaemic conditions (Angel, 1964, 1966, 1967, 1972, 1978; Stuart-Macadam, 1987), but the causes of cribra orbitalia have been subject of discussion (Cole and Waldron, 2019; McIlvaine, 2015; Oxenham and Cavill, 2010; Rothschild, 2012; Walker et al., 2009).

Anaemia generally describes pathological abnormalities of red blood cells or haemoglobin resulting in decreased oxygen circulation in the body (Quintó et al., 2006). Several causes can lead to anaemic conditions including excessive red blood cell loss caused by parasitic or bacterial infection, injuries, or childbirth, insufficient or abnormal production of red blood cells due to nutritional defects, genetic haemolytic disorders, or red blood cell destruction (e.g., malaria infections) (Grauer, 2019).

Figure 3.3: Examples of porotic changes of the orbital roofs (cribra orbitalia). Left: right orbit with porosity (5_167); Right: left orbit with porosity (IV_180)

Clinically, most cases of anaemia are acquired due to nutritional deficiencies caused by insufficient intake or malabsorption. In a healthy individual the production and destruction of red blood cells is balanced and requires a number of key nutrients such as essential amino acids, vitamins A, B12, B6, folic acid, and iron (Larsen, 2015:31; Walker et al., 2009). The most common form of acquired anaemia is caused by iron deficiency, which affects a significant proportion of the global population nowadays and is considered a major public health problem by the World Health Organisation (2001) especially affecting people in underprivileged environments and of low socio-economic status (Kassebaum et al., 2014; Lopez et al., 2016) . Only few clinical cases of iron deficiency also present porotic cranial changes and no relationship between the severity of the condition and bone changes have been observed in clinical studies (Agarwal et al., 1970; Lanzkowsky, 1968). Archaeologically, hereditary forms of anaemia such as sickle-cell anaemia or thalassaemia have also been associated with CO (Angel, 1966; Hershkovitz et al., 1997; Lagia, 1993; Lagia et al., 2007a; Lewis, 2012), and more recently a link to malaria has been suggested (Gowland and Western, 2012; Rabino Massa et al., 2000; Smith-Guzmán, 2015a, b).

While nutritional deficiencies certainly posed a health risks in the past, the presence and identification of anaemic conditions in the archaeological record is complex. Bone lesions associated with clinical cases of genetic or acquired anaemia are due to compensatory marrow hyperplasia, which leads to an expansion of the marrow cavity (Tyler et al., 2006). Marrow hyperplasia as a result of increased haematopoietic activity might result in enlarged diploe with reduced trabeculae, which puts pressure on the cortical bone leading to thinning and progressive destruction of the external table (Brickley, 2018; Grauer, 2019; Tyler et al., 2006). Due to the anatomic differences, anaemic conditions would likely be more visible in the skeletons of children than in adults due to higher haematopoietic activity in non-adults and, therefore, porotic changes in the cranium are commonly interpreted as evidence of a childhood condition (Stuart-Macadam, 1985).

Iron deficiency anaemia has been proposed as cause of CO in several archaeological studies (for example El-Najjar et al., 1975; Lovell, 1997a; Mensforth et al., 1978); however, the iron deficiency anaemia theory has also been challenged over the years and has been subject of discussion. In addition to iron deficiency, other causes such as parasitic infection and megaloblastic (chronic vitamin B12 or folic acid deficiency) or haemolytic anaemias as well as co-morbidities should be taken into consideration when interpreting cranial porotic lesions (McIlvaine, 2015; Oxenham and Cavill, 2010; Rothschild, 2012; Walker et al., 2009). Furthermore, infection, inflammation, osteoporosis, or haemorrhage (e.g., due to scurvy) may lead to porosity affecting the orbit (Brickley, 2018; Cole and Waldron, 2019; Wapler et al., 2004), and it has also been suggested that porosity of the orbital roof without changes to the normal curvature might be developmental rather than pathological (Cole and Waldron, 2019). The importance of taphonomic changes and post-mortem damage when interpreting porotic lesions also needs to be emphasised.

The wide range of potential aetiologies hinders the identification of a single specific cause and co-morbidity of different nutritional deficiencies has to be taken into consideration. The aetiology is still the subject of discussion in bioarchaeological research, and differential diagnosis with a focus on lesion distribution throughout the entire skeleton as well as unambiguous terminology are essential (Brickley, 2018; Klaus, 2017). In more recent studies, CO has been used as a non-specific indicator of frailty with no regards to aetiology (e.g. Yaussy et al., 2016). Contextual evidence for environmental stress may vary between sites and specific circumstances for anaemia may be regionally specific and range from parasitism (e.g., hookworm), infectious disease (e.g., diarrheal infections), malnutrition, to lead poisoning. The aetiology of cranial porotic lesions is multifactorial and complex and generalised comments about health stress are usually all that is possible (Larsen, 2015:35-38).

CO is highly age-specific and active lesions are mostly found in non-adults. Generally cranial porotic lesions are considered non-specific indicators of disease, and healed lesions can be used as an indicator of poor health during childhood including various aetiologies. In addition to issues around lesion aetiology, problems with standardisation of lesion observations require more rigor in terms of both recording and in the provision of a differential diagnosis (Klaus, 2017; McFadden and Oxenham, 2020). This thesis does not attempt to identify specific causes of CO. Instead, the presence of these lesions is used to identify physiological stress experienced during early life.

3.3.3.2. Dental Enamel Hypoplasia

Dental enamel hypoplasia (DEH) occurs due to stress during the time of tooth development; therefore, these defects are commonly used to examine patterns of development and stress during infancy and childhood (Goodman and Rose, 1990; Hillson, 2005: 155-159).

Enamel is formed by ameloblasts from the tip of the crown towards the cementoenamel junction, and under normal circumstances, the enamel is smooth, white, and translucent. Dental development is highly controlled by genetics and effects of poor environmental circumstances on tooth development are generally limited when compared to the skeleton. However, systemic changes and severe physiological stress can cause a disruption of normal enamel formation (Boldsen, 2007; Geber, 2014; Hillson, 2005: 155-168). Three types of developmental defects are distinguished: hypoplasia, hypocalcification, and discolouration (Hillson, 1996: 165-177; Hu et al., 2007). Only enamel hypoplasia is used as an indicator of stress in this thesis and, therefore, discussed in more detail.

Figure 3.4: Examples of linear dental enamel hypoplasia (DEH). Left: IV_701; Right: IV_378.

The term 'dental enamel hypoplasia' describes a disturbance in the enamel production leading to a local deficiency in enamel thickness (Figure 3.4). The defect extends around the entire crown and follows the line of the perikymata. Often, the defect can be matched at several teeth forming at the same time, and if only one or two teeth in the entire dentition are affected by DEH, other reasons such as injury or local disturbance (e.g. infection) should be taken into consideration (Hillson, 2005: 169-171). DEH may appear as pits, furrows, and plane-form disruptions, but furrows (linear enamel hypoplasia) are most commonly encountered (Hillson, 1996: 165-167). The chronology of dental development is well known; therefore, defects of the enamel can be associated with specific ages. However, such an approach assumes that standards of dental development were the same in the past as they are now and no inter- or intrapopulation variation is considered (Roberts and Manchester, 2005: 75-77). It has been argued that the magnitude of the enamel defect may reflect the severity of the stress insult or stress duration. However, enamel does not grow at a constant rate, so the size of the hypoplastic defect is not necessarily a good indicator of stress duration. Furthermore, a purely macroscopic approach will introduce a certain bias as this approach cannot consider differences on the level of perikymata. Differences in spacing or number of involved perikymata can only be observed microscopically, and some questions regarding the impact of severity and duration of a stressful event on the laying down of perikymata is still unanswered (Hillson, 2008; 2014: 167).

Studies in modern developing countries have shown that diet is a major contributing factor to the formation of DEH (Mellanby, 1934; Roberts and Manchester, 2005: 75-77), but other stressors such as poor hygiene, illness, and possibly weaning can also result in enamel deficiencies (Kreshover, 1960; Larsen, 2015: 50-51). However, clinical studies have often concentrated on deciduous teeth and only few clinical studies have included permanent dentition, while archaeological research has focussed predominantly on the permanent dentition (Hillson, 1996: 165-167; 2005:175).

Research into enamel defects has a long history and can be traced to the 18th century (Goodman and Rose, 1990). Several studies in recent years have used DEH as an indicator of early life exposure to stress. The leading causes of these defects are thought to impact an individual's frailty and put them at higher risk for morbidity and early mortality later in life (Lorentz et al., 2019; Temple, 2014). Enamel defects have also been used to identify inequality based on differences in stress exposure related to socio-economic status or sex and gender (DeWitte and Wood, 2008; Pilloud and Schwitalla, 2020; Redfern and DeWitte, 2011a, b; Yaussy et al., 2016).

3.3.3.3. Stature

Metric skeletal data is routinely recorded in archaeological populations. In contrast to early studies, which operated under the assumption that genetics are the main factor determining bone size and shape, it is now widely accepted that stature also has a strong environmental influence during development. A combination of genetics and different environmental and social factors determines adult stature (Goodman and Martin, 2002; Gowland and Walther, 2018; Steckel et al., 2002b).

Stature can be inferred from skeletal remains and different methods have been employed in archaeological studies (Goodman and Martin, 2002; Gowland and

Walther, 2018; Hughes-Morey, 2016; Vercellotti et al., 2014; Watts, 2011). Two general methodological approaches for estimating stature from skeletal remains exist, the anatomical and the mathematical method. The anatomical method includes measurements of all skeletal elements contributing to height. To account for soft tissue, a correction factor is used (developed by Fully, 1956; refined by Raxter et al., 2006; Raxter et al., 2007). This methodological approach provides a good approximation of actual living height, but the method is not ideal for archaeological remains due to incomplete preservation of remains. The mathematical method on the other hand uses regression formulae based on known collections to calculate adult stature from single long bone measurements. While different population-specific formulae have been developed, the regression formulae commonly used were developed by Trotter and Gleser (1952, 1958). As the mathematical method only requires measurement of at least one complete long bone, it is widely applicable, less dependent on preservation, and much quicker to apply than the anatomical method (Gowland and Walther, 2018). Accuracy is affected by intra- and interpopulation differences, and there is an argument for the importance of population-specific regression formulae. The accuracy of a calculated estimate is affected by genetic similarity and body proportions. If the sample population is not consistent with the population, which was used to calibrate the regression formulae, the estimates can be of poor accuracy (Gowland and Walther, 2018; Nikita and Chovalopoulou, 2017; Vercellotti et al., 2009).

Temporal trends show that average adult stature increases with economic and nutritional improvement and declines in periods of deprivation (Larsen, 2015: 15-16). Over the last decades, there has been a growing interest in stature research in the social sciences (for a summary see Steckel, 2009). If all conditions are favourable and no growth disruptions occur, an individual can fulfil their genetic potential and reach full height. Several intrinsic and extrinsic factors such as nutrition, disease, or socio-economic status, however, can impact and disrupt growth and result in short adult stature (Steckel, 2009). Therefore, stature that is considered short for age is generally considered indicative of poor living conditions during childhood and development, and it is associated with a compromised immune system and increased mortality risk (Vercellotti et al., 2014). Nutrition and disease have a strong impact on stature: poorly nourished infants and children are more susceptible to infection, while infections can reduce an individual's ability to absorb nutrition. Children with smaller stature sometimes show a high frequency of stress indicators, such as enamel defects or porotic hyperostosis (Larsen, 2015:9-11). The association between reduced growth and increased risk of mortality might not be causal, but both are the result of processes triggered by adverse conditions (Saunders and Hoppa, 1993). A further important factor which determines growth success, is the mother's health during pregnancy. Chronic malnutrition during pregnancy can cause poor foetal nutrition which in turn leads to low birth weights, decreased growth after birth, and increased risk of mortality during infancy. The association between low birth weight and increased neonatal morbidity and mortality is well-established (see also DOHaD). Infants with low birth weight due to insufficient foetal nutrition have a lowered immune system and are, therefore, more susceptible to infections (Kuzawa, 2007; Kuzawa and Quinn, 2009; Newman and Gowland, 2015; Saunders and Hoppa, 1993; Steckel, 2009).

Stature that is lower than expected for the individual's age can be used as a non-specific and cumulative indicator of stress during development (Goodman and Martin, 2002; Steckel et al., 2002b). However, in contrast to dentition, where any disruption will remain visible throughout the entire life, skeletal elements have the potential for 'catch-up growth'. If the detrimental conditions are only temporary and nutritional and environmental conditions improve, an individual can experience a period of accelerated growth or delayed maturation. However, prolonged and severe stress will likely result in reduced stature (Gowland and Walther, 2018; Steckel et al., 2002a). Growth during infancy and early childhood is more sensitive to disruption than during adolescence, when the genetic component is stronger. Therefore, poor living conditions and stress during early life will have a more pronounced impact on adult stature than during adolescence (Larsen, 2015: 9-10). The potential for catch-up growth underlines the importance of distinguishing between non-adult and adult stature. Non-adult measurements can provide a more sensitive measure of population stress than adult stature, but the sample is inherently biased. Such a sample only includes non-survivors and, therefore, the frailest individuals within a population. Differences between non-adults likely reflect immediate changes in conditions, while variation in adult stature is more likely due to chronic conditions (Goodman and Martin, 2002; Saunders, 2008:133-134).

The osteological paradox is also relevant as it is crucial to consider the variety of factors influencing stature. The inherent problem of using adult stature as indicator of stress is that the most severely stressed individuals likely died in infancy and childhood. Any catch-up growth experienced by those who reached adulthood will inevitably mask stress induced growth retardation. Short stature is correlated with poor health and, therefore, indirect selection would eliminate individuals with short stature within a population meaning that the stature distribution of survivors might not be representative of the entire population. Higher levels of stress increase the probability of mortality for frailer individuals and result in a higher average adult stature. During periods of decreased stress and reduced selection pressure, more stature variation can be observed within a population (Vercellotti et al., 2014). Stature can be informative for examining development and stress, but these limitations show the importance of using a multiple-indicator approach. Despite clear limitations, stature has been used as a measure of socio-economic status and inequality in both modern and archaeological samples (for example DeWitte, 2009, 2018; Godde et al., 2020; Hughes-Morey, 2016; Vercellotti et al., 2014; Vercellotti et al., 2011).

3.3.3.4. Dental disease

Dental disease is amongst the most common pathological lesions seen in human remains. In addition to developmental defects (DEH), the dentition can be affected by dental caries, calculus, periodontal disease, attrition, or trauma. While developmental defects give insight into early development, these forms of dental disease accumulate over the life course. The different dental disease processes are related to each other and interlinked. Different patterns of dental disease within a population can give insight into diet and subsistence strategy, and dental disease can be used to understand social differences and inequality within a population. However, different methods of recording dental disease as well as differential preservation of dentition might limit comparability between different studies and populations.

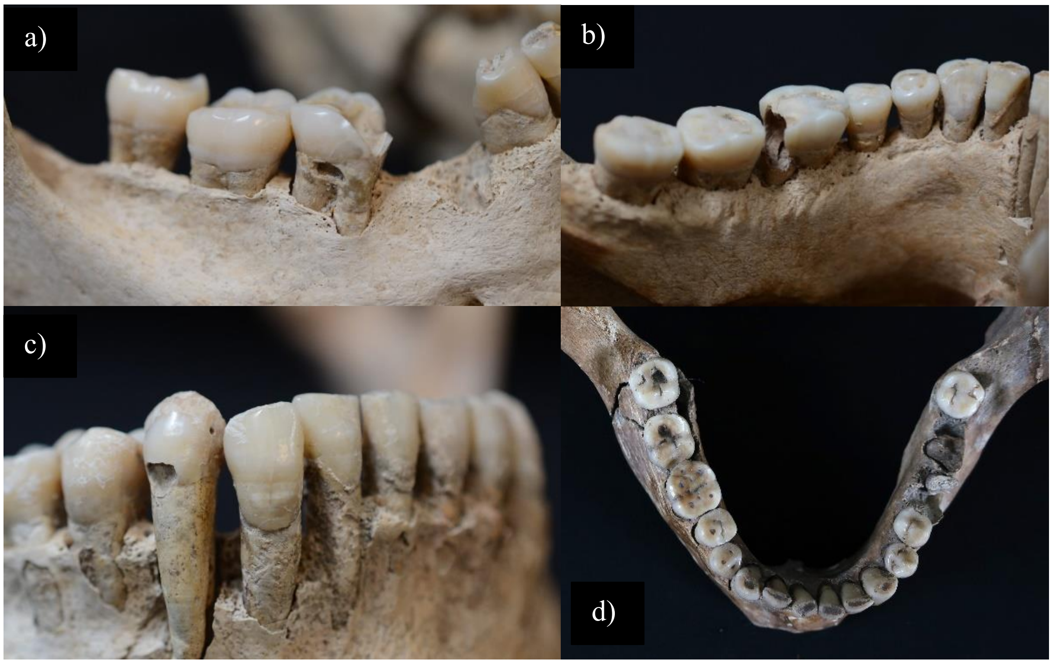

Figure 3.5: Examples of various forms of carious lesions.
a) root caries (IV_782), b) large interproximal caries (IV_779), c) CEJ caries IV_399, d) occlusal caries and complete destruction of molar crowns (left M1 and M2) (IV_773).

i. Dental Caries

Dental caries is a common form of progressive dental disease and frequently reported for archaeological populations. Caries leads to the progressive destruction of enamel and dentine, and ultimately causes the formation of a cavity either on the crown or root surface (Hillson, 1996: 269) (for examples see Figure 3.5).

Acids produced by plaque bacteria (e.g., *Lactobacillus acidophilus* and *Streptococcus mutans)* can cause a progressive demineralisation of enamel, cementum, and dentine. Diet and eating habits play a role in the development of caries, and a high intake of carbohydrates such as sugar and starch leads to higher degree of caries (Arcella et al., 2002; Lingström et al., 2000; Punitha et al., 2015). The role of proteins and fats is understood to a lesser degree, but caries rates are often lower in populations whose diet was more dependent on animal-based foods. Caries became more common after the introduction of agriculture and fermentable carbohydrates (Hillson, 1996: 276-279; 2019: 307; Temple, 2015). A certain genetic component involving enamel formation, crown morphology, and saliva composition is potentially also responsible for individual risk of dental caries (Larsen, 2015:68; Wendell et al., 2010; Wright, 2010).

The site of caries initiation is to a certain degree age dependent. Lesions to the dental crown may occur at any age and mainly affects the occlusal fissures and adjacent crown sides below the contact point of neighbouring teeth (interproximal caries). In contrast, root lesions are more common in older individuals when roots are exposed due to periodontal disease or continued eruption caused by attrition (Hillson, 2005: 291-293; 2019: 308).

In most cases dental caries is a disease with a slow progress. Phases of destructive activity alternate with phases of stability. Different stages of disease progression can be encountered, from small opaque spots to large cavities destroying the tooth crown (for six stages of caries development see: Hillson, 1996: 271). Other conditions such as developmental defects or significant wear with exposure of dentine can weaken the dental structure and allow carious lesions to occur. If the pulp cavity is affected, an abscess can develop (Hillson, 2005: 291; 2019: 307; Roberts and Manchester, 2005). Even in extreme cases of caries, tooth loss is not inevitable, but deliberate extraction of the affected tooth to relieve pain is a possible cause of action.

Not all teeth are equally susceptible to dental caries, and preservation and recovery can significantly influence caries statistics. Molars are generally more affected than incisors and canines, and maxillary teeth more than mandibular teeth (Hillson, 2019: 307-310). Caries is strongly related to age due to its progressive nature, but a direct correlation between age and caries is difficult. Age-at-onset cannot be determined in archaeological populations. In terms of epidemiology, caries and poor dental health in younger individuals is more informative for population health than in older individuals (Roberts and Manchester, 2005).

ii. Periapical lesions

Periapical lesions ('dental abscesses') are caused by exposure of the pulp cavity to bacteria and other microorganisms. Several factors can predispose the development of a periapical lesion including dental caries, attrition, periodontal disease, and dental trauma (Roberts and Manchester, 2005). Inflammation of the pulp produces an increased pressure within the pulp chamber. During the course of the inflammation, pus collects within the pulp chamber. This might be contained for some time by granulation tissue but ultimately leads to pulp death. The inflammation can move down the root canal and trigger an inflammation of the periodontal tissues causing the surrounding bone to recede and a periapical granuloma to develop. Chronic periapical granulomas are usually symptomless and do not necessarily progress into an acute phase. A stable granuloma can develop into two different stages. Firstly, an apical periodontal cyst may develop by replacement of the granulation tissue by fluid. Secondly, an acute periapical abscess can form leading to the accumulation of pus. This accumulation causes excess pressure and eventually a sinus or cloaca (drainage hole) develops (see Figure 3.6). Drainage holes can be identified on the buccal/labial or lingual side of the alveolar process, the maxillary sinus, or the nasal cavity (Dias and Tayles, 1997; Hillson, 1996: 284-286; 2005: 307-310; 2019: 316-318; Kinaston et al., 2019: 767-768; Rajendran and Sivapathasundharam, 2012; Roberts and Manchester, 2005).

Identification of periapical lesions in archaeological remains poses some challenges, and unambiguous terminology such as 'periapical lesion' or 'alveolar lesions' are used to encompass different lesion types (Dias et al., 2007; Kinaston et al., 2019: 767; Ogden, 2008). It can be assumed that the prevalence of periapical lesions is generally underestimated in archaeological populations. The presence of a sinus is considered as evidence for a periapical lesion, but not all drainage holes may be visible (e.g., drainage in an intact maxillary sinus may not be observable). Some periapical lesions and cysts without a drainage canal might only be identified using radiography, which is not routinely done for the entire dentition. In addition, post-mortem damage to the maxillary alveolar bone may expose roots which can be identified as periapical lesion by mistake (Hillson, 1996: 287; Roberts and Manchester, 2005). Due to the multifactorial aetiology, it is not possible to attribute single lesions to a specific cause, which has to be taken into account in any interpretation.

Figure 3.6: Examples of periapical lesions with buccal drainage holes. Top: Periapical lesion at right maxillary M2 (IV_471); Bottom: Periapical lesion at left maxillary M1 (5_216)

iii. Periodontal disease and ante-mortem tooth loss

Ante-mortem (AM) tooth loss is related to a variety of causative factors including caries, periapical lesions, alveolar resorption (periodontal disease), trauma, and attrition (Kinaston et al., 2019:770). After a tooth is lost, the alveolar socket remodels eventually filling the socket completely (Figure 3.7).

Generally, the pattern of AM tooth loss follows the pattern of caries and periodontal disease, and molars are lost more frequently than the anterior dentition (Lukacs, 2007; Oliver and Brown, 1993; Roberts and Manchester, 2005). Congenital absence of teeth or impaction should be taken into consideration as a differential diagnosis (Hillson, 2019:312). Due to the multifactorial causes of AM tooth loss, it is generally not possible to distinguish between different causative factors. Furthermore, deliberate extraction of teeth or dental trauma (caused by accident or violence) is also a possibility that should be considered. Dental disease such as caries and periapical lesions may cause severe pain, and extraction of the affected tooth or teeth can provide pain relieve. This has been routinely done in the past, and with the AM loss of the tooth, the information regarding aetiology is also not available anymore for study purposes.

Figure 3.7: Examples of AM tooth loss of multiple mandibular teeth. Left: 5_213; Right: IV_674.

A major cause of AM tooth loss is periodontal disease, a progressive inflammatory disease affecting the gingiva and alveolar bone (Loesche and Grossman, 2001; Whiting et al., 2019) (Figure 3.8). Periodontal disease is initiated by plaque build-up and calculus, and the accumulation of calculus triggers an immune response causing an inflammatory reaction of the gingiva (Clerehugh et al., 2013; Darveau, 2010). At first, the inflammation affects the soft tissue, and it can be transmitted to the bone (for four stages of periodontal inflammation see Hillson, 1996: 262-263). Periodontal disease is an episodic disease with phases of active inflammation alternating with latent phases. The inflammation leads to gradual loss of alveolar bone and the periodontal ligaments and eventually results in the loss of teeth (Cochran, 2008; Petersen and Ogawa, 2012; Roberts and Manchester, 2005). Depending on the extent, two different forms of alveolar bone loss can occur. If several teeth are involved, bone loss will appear regular and horizontal. If only one tooth is affected, the bone loss is more irregular in appearance. Bone loss does not necessarily affect all sides of the roots equally. After the loss of the tooth, the inflammation subsides, and the tooth socket is remodelled. Predisposing factors for periodontal disease are increasing age and poor oral hygiene. Periodontal disease mainly affects adults over 30 years of age (Hidebolt, 1991; Hillson, 2019).

Figure 3.8: Examples of periodontal disease in form of alveolar resorption with signs of inflammation. Top: IV_779; Bottom: IV_783

The identification of periodontal disease in archaeological remains is problematic due to the lack of pathognomonic features (Kinaston et al., 2019: 771). Identification is often only based on resorption of the alveolar bone visible as a distance between the CEJ and the alveolar crest. However, this increase may be due to reasons other than periodontal disease (Roberts and Manchester, 2005). Alveolae continue to slowly remodel in response to pressure, continued eruption, and wear, and with increasing age, the alveolar sockets become shallower and progressively expose the roots of teeth. This process can mimic alveolar resorption in response to periodontal disease (Hillson, 2019: 314-316). A more secure diagnosis can be achieved by including changes in quality of the alveolar margins, which become more irregular and rough forming a gap between the tooth and alveolus, and signs of inflammation such as pitting and new bone formation (rim) in association with root exposure (Ogden, 2008). Periodontal disease mainly affects the molars, suggesting the pattern of tooth loss potentially can be used to identify periodontal disease (Hillson, 2019:315). However, molars are also the teeth that are most commonly affected by caries, and this cause has to be considered when interpreting ante-mortem loss of molars.

iv. Dental disease and adult health status

Different forms of dental disease are interlinked and need to be considered as different expressions of oral health influenced by various biological and cultural factors. Dental disease can give insights into population health and subsistence strategy as diet has a great influence on oral health. More generally, dental health can reflect immunological status and capabilities of host-resistance on an individual and on a population level (Goodman and Martin, 2002).

Oral health is considered as an indicator of adult health (Goodman and Martin, 2002; Steckel et al., 2002b). While this makes sense as far as dental disease is a progressive disease and, therefore, more common in older individuals, it does not take into consideration possible early-onset of dental disease. Poor dental health in younger individuals is interesting from an epidemiological standpoint, but it is not possible to determine age-of-onset for carious lesions. When considering that the first permanent molars erupt at around six years of age (AlQahtani et al., 2010), gross carious lesions affecting these teeth in early adulthood possibly originated in childhood or adolescence. In addition, poor dental health or trauma in the deciduous teeth can negatively impact dental health of the permanent dentition (Lovell and Grauer, 2018). These factors have to be taken into consideration when interpreting carious lesions in young adult individuals.

Dental disease can be used to identify temporal and geographical variation in diet and subsistence strategies. Globally a wide variation of caries prevalence can be observed within and between different subsistence strategies (Hillson, 2008; Lukacs, 2008). There is a clear trend showing an increase in dental caries with the introduction of and increasing reliance on agriculture in many parts of the world. This general tendency can be explained by the higher cariogenic potential of agricultural foods than the foods consumed by prehistoric hunter-gatherers (Larsen, 2015:69-73). Similar trends can also be observed in terms of periodontal disease and AM tooth loss, which became a significant health issue only during the Holocene. However, it is necessary to differentiate between causes of AM tooth loss. While tooth loss in farmers can mainly be attributed to dental caries and periodontal disease, in foragers, tooth loss is more likely caused by severe attrition and pulp exposure (Larsen, 2015:81-83). Differential access to certain foods can explain different prevalence rates of dental disease between males and females or different status groups. These differences might also reflect division of labour and different subsistence responsibilities (Da-Gloria and Larsen, 2014; Klaus and Tam, 2010; Larsen, 2015:73-78; Temple and Larsen, 2007; Vergidou et al., 2022). Further explanation for higher caries prevalence in females may be found in life-history factors, which are not related to behaviour including slightly earlier eruption of the permanent dentition in females and changes in the oral environment related to hormonal changes during pregnancy (Laine, 2002; Larsen, 2015:76-77; Lukacs, 2008). Prevalence studies on sex differences in periodontal disease in archaeological populations are more limited than for caries prevalence. Generally, males are at higher risk to develop periodontal disease. Since AM tooth loss is a multifactorial health issue, other behavioural factors such as cultural practices or interpersonal violence are essential to consider (Larsen, 2015: 77-78, 83-85).

The relationship between poor oral environment and overall health has been investigated in clinical and epidemiological investigations, and a clear association has been identified (Ajwani et al., 2003; Irwin et al., 2008; Koren et al., 2011; Williams et al., 2008). Possible links between poor dental health and increased risk of mortality have also been found in archaeological contexts (DeWitte and Bekvalac, 2010). The exact mechanisms of this association are not fully understood, but it can generally be assumed that individuals, who had access to better food sources contributing to better oral health, also had better systemic health putting them at a decreased risk of morbidity and mortality in comparison to those who are reliant on less nutritional food (Larsen, 2015:85-86).

3.3.3.5. Periosteal new bone formation

Infectious disease is a key force in human evolution and a main factor contributing to morbidity and mortality. Acute infections do not leave any traces on the skeleton, and acute epidemics are only visible in high death rates (e.g., black death). Chronic infectious disease is often non-lethal and more important in terms of understanding community health and overall living conditions (Goodman and Martin, 2002).

A way to investigate general exposure to infectious disease is to examine periosteal reactions. Periosteal new bone formation (PNBF) can occur on any bone in the skeleton, but often affects the tibiae, sinuses, and ribs (Roberts, 2019: 289-290; Waldron, 2008: 117) (Figure 3.9). These periosteal reactions are interpreted as evidence of non-specific infection or inflammation in bioarchaeological studies, and as such, PNBF has also become a fundamental indicator of stress (Weston, 2012: 492).

Figure 3.9: Example of healed periosteal new bone formation on the medial aspect of the tibia (IV_180).

Clinical literature provides little information on periosteal reactions. In most cases, the presence of periosteal inflammation is only mentioned as manifestation of a disease but is not discussed in detail (Edeiken et al., 1966; Ragsdale, 1993; Ragsdale et al., 1981; Resnick, 1995). In part this might be because the early stages of PNBF cannot be observed in radiographic images and are also easily overlooked during autopsy (Kelley, 1989; Roberts, 2019: 291; Weston, 2012: 495).

When periosteal reactions are included in bioarchaeological studies concerning stress, it is important to differentiate between active inflammation – layers of porous, greyish woven bone – and healed inflammatory reactions – remodelled lamellar bone, which is incorporated into the cortical bone (Pilloud and Schwitalla, 2020). The differentiation between infection and inflammation is often blurred in archaeological contexts and should not be attempted for periosteal reactions alone. Inflammation is a general response to harmful stimuli including infection but can also be caused by other agents such as trauma, metabolic disease, or neoplastic disease (Roberts, 2019: 287-288; Schultz, 2001). Chronic inflammatory processes that last longer than two weeks will leave evidence on the bone (Weston, 2012: 493-494). However, in many cases it is not possible to identify direct correlations between the lesions and specific disease processes (e.g., specific infections such as tuberculosis, treponematoses, and leprosy) and to differentiate between different causes based on PNBF appearance (Weston, 2008, 2009). The periosteum is limited in its responses and reactions are similar regardless of the aetiology. In the absence of any other evidence for specific infection periosteal reactions are, therefore, frequently attributed to non-specific inflammation or infection. Differential diagnosis including the patterns of bone formation in the entire skeleton is vital to identify a specific cause.

PNBF can also be noted on the long bones of infants. As this is a common feature of infant bones, it is generally interpreted as normal bone growth rather than evidence of inflammatory processes (Hodson, 2021; Lewis, 2000, 2007; Shopfner, 1966; Waldron, 2008: 116). Therefore, caution is necessary when interpreting periosteal reactions in the bones of infants and children.

Trauma to soft tissue close to the bone or chronic skin ulcers can lead to localised periosteal new bone formation. Periosteal reactions induced by soft tissue trauma tend to be small, localised, and unilateral. In comparison, infectious disease tends to be more generalised, destructive, and affects multiple bones, most commonly long bones. The extent of the lesion might allow some interpretation in regard to cause of the lesion(Goodman and Martin, 2002).

Non-specific periosteal reactions are useful to assess levels and patterns of population health. Many studies on population health employ periosteal new bone formation as an indicator of accumulated stress (Redfern and DeWitte, 2011b; Yaussy et al., 2016). Even though periosteal reactions provide incomplete and non-diagnostic evidence for disease experience, the documented patterns in archaeological contexts support an association with infectious disease. Therefore, PNBF is an important non-specific stress indicator that can provide information on adverse living conditions. Factors such as sedentism, mobility, and population density are known factors to promote contagious diseases (Larsen, 2015:88-91).

Despite the manifold aetiology, PNBF can be used as a general indicator of population health. Evaluation of lesion patterns within and between populations can give information on differential risk and exposure as well as ecological and cultural factors predisposing certain groups to infectious agents (Goodman and Martin, 2002). In combination with other skeletal indicators of stress, these lesions can significantly contribute to our understanding of disease experience in the past.

3.3.3.6. Trauma

Trauma is used as an indicator of risk exposure and interpersonal violence. Trauma patterns can give insights into social process and power dynamics in a society and levels of risk might differ based on gender, age, socio-economic background, or ethnicity. The term 'trauma' is used to describe any injury of accidental and violent nature to soft tissue and bones. Due to the skeletal nature of archaeological remains, not all forms of trauma can be identified, and it generally has to be assumed that the observed prevalence is likely an underestimate (Redfern and Roberts, 2019).

When examining trauma, the main distinction is between fracture and dislocation, and only fractures are discussed in more detail here. Generally four main injury mechanisms have the potential to lead to a fracture: 1) direct trauma, 2) indirect trauma, 3) stress, and 4) underlying pathological conditions (for a summary see Redfern and Roberts, 2019: table 9.2). Fractures are classified by type of force responsible for injury (see Lovell and Grauer, 2018: table 10.1).

When considering fracture mechanism, two main types are distinguished: blunt force trauma (BFT) and sharp force trauma (SFT). BFT is caused by the impact of a blunt object or the impact of the body on a blunt surface. SFT is created by an instrument with at least one sharp edge. The different mechanisms cause differing fracture expression, which is relevant for the interpretation (Redfern and Roberts, 2019).

Fractures caused by sudden impact are frequent in archaeological settings, but other fracture types associated with continued patterns of stress or underlying pathological conditions can be encountered. Persistent stress may result in stress or fatigue fractures commonly associated with intense physical activity (e.g., vertebral fractures) (Redfern and Roberts, 2019). Pathological conditions have the potential to significantly impact the quality of bone and make it more susceptible to fractures. Different disease mechanisms can cause such fractures including congenital, metabolic, infectious, and neoplastic disease, and some of these diseases are associated with specific age categories (e.g., osteoporosis) (Larsen, 2015: 125-127; Lovell and Grauer, 2018; Redfern and Roberts, 2019).

The assessment of injury timing in relation to death (antemortem vs. perimortem) is fundamental for trauma interpretation. In order to be classified as AM trauma, evidence of healing has to be observable. Distinguishing criteria for a perimortem fracture in contrast to a postmortem break are staining and colouration of the fracture margins, location, morphology of fracture patterns, and angle and margin of the fracture. Contextual information and taphonomic conditions may help distinguish perimortem from postmortem (Berryman and Haun, 1996; Ortner, 2003; Redfern and Roberts, 2019).

The healing process of fractures is dependent on several different factors including age at injury, affected bone, nature of fracture, and complications such as infection (Einhorn and Gerstenfeld, 2015; Lovell and Grauer, 2018; Mirhadi et al., 2013). Fractures can entail a number of complications with varying severity, and recognising complications which might cause subsequent health issues are important for understanding quality of life (Goodman and Martin, 2002). Potential complications involve soft tissue injuries such as punctured lungs or injuries to the gastrointestinal tract, which are potentially lethal but cannot be identified archaeologically. Damage to nerves can lead to lack of pain and reduced mobility or paralysis. Especially skull fractures have the potential for serious complications involving brain injury and nerve damage (for details see Lovell and Grauer, 2018; Redfern and Roberts, 2019). Well-healed fractures are a common occurrence in archaeological contexts, which suggests that a basic knowledge of trauma treatment must have existed in the past, even if it may not have been universal knowledge (Redfern and Roberts, 2019).

Distinction between accidental fractures and fractures caused by interpersonal violence can be difficult and should only be made when sufficient evidence is present and under consideration of the limitations of skeletal studies (Grauer and Roberts, 1996; Walker, 2001). Accidental injury is generally more common than fractures caused by interpersonal violence. Most long bone fractures, other than fractures of the distal third of the ulna ('parry fracture') (Judd, 2008), are likely the result of accidents. Accidental trauma can give information on different living conditions exposing populations to differential risk of trauma (Larsen, 2015:116). In contrast, identification of violence can be more challenging. The presence of cranial SFT or embedded projectile points can be taken as clear evidence for direct interpersonal violence, but other forms of violence including structural violence are more difficult to identify. Clinical data shows that certain bones are more likely to be affected by intentional injuries such as cranium, facial bones, forearm, hand bones, and ribs as well as the anterior dentition (Brink et al., 1998). These patterns appear to be globally and temporally universal (Lovell and Grauer, 2018; Redfern and Roberts, 2019). However, similar fractures may be caused by accidents and careful evaluation is necessary for interpretation (Betsinger, 2023; Judd, 2008). In addition to direct evidence for violence provided by skeletal data, indirect evidence based on the burial context (e.g., mass burials) can be drawn upon. Interpersonal violence can relate to social pressure due to environmental and societal changes or can indicate the presence of abuse and structural violence (Lovell and Grauer, 2018). The study of violence has to be placed within the context of living conditions, society, and economy. Interpersonal and intergroup violence is a critical aspect of social interactions. High levels of social inequality, population density, and adverse climate conditions are factors that contribute to violence. Understanding these patterns allows to understand complex circumstances causing conflict and warfare (Larsen, 2015: 172-173; Martin and Harrod, 2015).

Trauma risk and patterns are linked to demographic parameters such as gender and age. Risk for trauma changes through the life course and patterns may differ between males and females. Clinical data provides insights into age and sex or gender specific trauma patterns (Carpenter et al., 2014; Kwan et al., 2011; Steyn et al., 2010), but such patterns are not universal and temporal variation must be taken into consideration (Boldsen et al., 2015; Milner et al., 2015; Redfern, 2017). Different age cohorts display distinct injury patterns, so a life course approach is advised (see Redfern, 2017: 83-125). Temporal trends show that males are generally at a higher risk for trauma, but in more advanced age cohorts, females present a higher prevalence of fractures than males. This reversed trend can most likely be connected to age-related risk taking and changes in bone quality, which affects post-menopausal women more severely than males (Larsen, 2015:129).

Socio-economic environments also influence trauma patterns due to differences in subsistence strategies, occupation, and available technology. Individuals of lower socio-economic status may be exposed to higher risks of accidental trauma working in hazardous environments (Harrod and Crandall, 2017; Muller, 2006). Furthermore, social inequality can be a trigger for interpersonal violence and repeated injury is linked to low socio-economic status (Alghnam et al., 2016; Judd, 2017; Redfern et al., 2017; Reiner et al., 1990; Tegtmeyer and Martin, 2017).

Severe trauma and secondary changes due to complications can also give insights into population dynamics. These lesions can provide a data set to investigate aspects of care and treatment. Evidence of care of impaired individuals shows the presence of a social network capable of providing resources for care and treatment (Tilley and Cameron, 2014).

High levels of physiological stress and poor health may be associated with an increased risk of trauma, and populations experiencing high levels of stress may be more susceptible to attack and defeat (Larsen, 2015: 174-175). Overall, fractures can give insights into accident patterns and differential exposure to trauma risk, interpersonal violence, and care and is, therefore, an important factor for understanding population health.

3.3.3.7. Vertebral joint disease

Evidence of joint disease is commonly seen in archaeological human remains. Osteoarthritis (OA) and earlier stages of joint degeneration (e.g. osteophytes) are more frequently encountered than erosive arthropathies (see Roberts and Manchester, 2005: 120-126; Waldron, 2019: 729-745), and OA and activity related joint disease will form the basis for this section.

OA is the most common joint disease today and affects a large proportion of the population over 60 years (Arden and Nevitt, 2006; Corti and Rigon, 2003; Loeser, 2010; Pritzker, 2003). Clinical definitions of OA cannot be used in archaeological contexts, and the palaeopathological examination is limited to eburnation of subchondral bone, formation of marginal and surface osteophytes, and bone loss (see

Figure 3.10 a-b). All these lesions are manifestations of later stages of OA (Waldron, 2019) raising issues of comparability of data between living and dead populations.

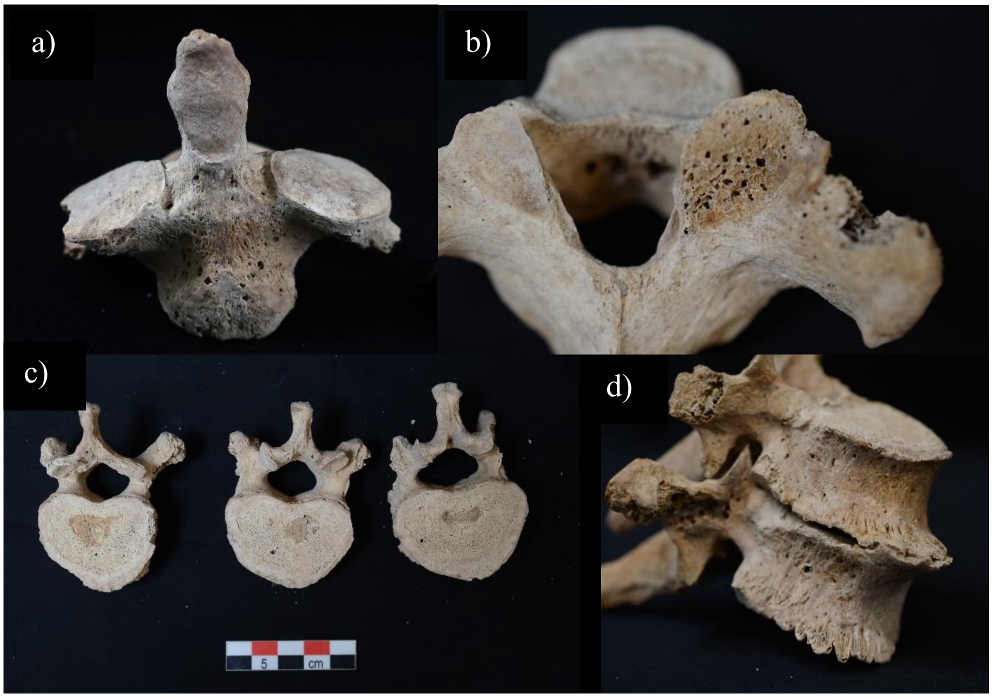

Figure 3.10: Examples of different forms of vertebral joint disease.
a) Osteophyte formation on the articulation of the dens axis (C2) (5_216); b) Porosity on the right superior articular facet (thoracic vertebra) (IV_782); c) Schmorl's nodes (lumbar vertebrae) (IV_779); d) Osteophyte formation on the vertebral bodies (lumbar vertebrae) (IV_646).

OA affects only synovial joints consisting of a cavity lined by synovial membrane that contains synovial fluid. The joint is supported by muscles, tendons, and ligaments and the articulating surfaces of the bones are covered by cartilage (Roberts and Manchester, 2005: 105). If the articular cartilage breaks down the subchondral bone gets exposed. Bone-on-bone contact may result in abnormal abrasion and sclerosis potentially accompanied by subchondral cysts and osteophyte formation on the joint surface or margins. Severe marginal osteophyte formation may result in ankylosis. Eburnation is the result of prolonged bone-on-bone contact and is considered pathognomonic for OA (Waldron, 2019). Primary OA is idiopathic and tends to occur later in life. Secondary OA is secondary to other conditions predisposing an individual such as trauma, congenital hip dislocation, or Paget's disease. Secondary OA is usually unilateral and associated with a fracture or dislocation and, therefore, it can be easily distinguished from primary OA (Waldron, 2019).

Causes of primary OA are multifactorial including age, biomechanical stress, and lifestyle among others. Genetic predisposition might be an additional factor in OA development (Corti and Rigon, 2003; Felson et al., 2000; Hart and Spector, 1993; Issa and Sharma, 2006; Pritzker, 2003; Valdes and Spector, 2008; Waldron, 2019). Not all joints have the same susceptibility to OA. Clinically, the weight-bearing joints (hip and knee) and joints of feet and hands are most affected (Felson et al., 2000). When looking at archaeological skeletal data, the joints most affected are the acromioclavicular joint, the articular facets of the vertebrae, and hand joints. In comparison, OA of hip and knee is less commonly encountered in archaeological contexts (Waldron, 2012).

The vertebral bodies can also be affected by joint disease in form of osteophyte formation, porosity, and Schmorl's nodes (see Figure 3.10 c-d). However, this is a cartilaginous joint and therefore these forms of degeneration are not referred to as OA. The term 'Schmorl's node' refers to depressed lesions affecting the superior and inferior surface of the vertebral bodies and has been linked to prolapsed intervertebral discs (Faccia and Williams, 2008). It has been argued that demanding physical activity is a causative factor of Schmorl's nodes (Angel et al., 1987; Knüsel, 2000; Owsley et al., 1987), but other possible causes that weaken the intervertebral disc such as congenital defects, age, or trauma should be taken into consideration (Resnick and Niwayama, 1978).

As with any disease, it is difficult or impossible to infer presence and severity of symptoms of joint disease from the signs on the skeleton. Clinical features associated with joint disease are pain, limited movement, joint swelling, wasting of muscles, and joint deformity but these cannot be inferred from skeletal lesions (Roberts and Manchester, 2005: 107-109). However, severe cases of joint disease would inevitably have a negative impact on an individual's life as pain and loss of movement would have physical, social, and economic consequences.

As joint disease is linked to activity, it has been suggested that repetitive strenuous movement can be visible in archaeological remains, and that joint disease can be used to deduce certain occupations based on the disease patterns in an individual. Studies of modern occupational groups have shown that groups performing strenuous activities (e.g., miners or ballet dancers) have a higher prevalence of joint disease in certain joints, but there are no forms of joint disease that are specific or unique to one occupational group (Waldron, 2012). Distribution and prevalence of joint disease in younger individuals might give more insight into activity patterns and potentially provides a more general picture of lifestyle in a population context (Larsen, 2015: 185; Roberts and Manchester, 2005: 113; Stirland and Waldron, 1997).

When looking at degenerative joint disease as an indicator of stress, it is necessary to keep in mind that osteoarthritis presents the cumulative effects of age and mechanical stress. It is therefore considered an indicator of adult health (Steckel et al., 2002b). Pattern, distribution, and severity of joint disease can be used to investigate differences in activity patters between urban and rural settings (Larsen et al., 1995; Parrington and Roberts, 1990; Rife, 2011; Saunders et al., 2002; Wilczak et al., 2009), status (Angel et al., 1987; Cohen, 1998; Klaus, 2012), and sex and gender (Bridges, 1992; Klaus et al., 2009; Novak and Šlaus, 2011; Rojas-Sepúlveda et al., 2008; Sofaer Derevenski, 2000; Woo and Sciulli, 2013). On a population scale, joint disease can give insights into overall population health and quality of life (Goodman and Martin, 2002).

Joint disease is a useful indicator of biomechanical stress and activity, but it holds several issues regarding systematic and standardised recording and identification, thus limiting comparability and identification of temporal and geographical trends. The consensus is that it is not possible to infer occupation from joint disease patterns, but they can be used as a marker of activity and may give insights into general population activity, lifestyle, and to a certain extent disability and care.

3.3.3.8. Summary

Skeletal indicators of physiological stress have been used in numerous studies investigating a wide range of geographical, temporal, and cultural contexts. Several stress indicators are considered non-specific as they cannot be linked to specific diseases. Instead, these have been frequently interpreted as the expression of exposure to adverse living conditions during different stages of live and can be used to reconstruct long-term stress on an individual and a population level. Stress indicators need to be interpreted within the historically specific contexts of cemeteries. Several limitations regarding preservation, recording standards, and interpretation need to be taken into consideration when employing skeletal indicators of physiological stress. The utilisation of multiple indicators of stress recognises that stress can be experienced over the life course and that health is a composite of stress exposure during different stages of life. A life history approach, therefore, is advised in order to gain a more comprehensive understanding of health and disease on an individual as well as on a population level. The osteological paradox needs to be taken into consideration in any interpretation of physiological stress and frailty.

3.4. Bioarchaeological research in Greece

Skeletal lesions indicative of physiological stress have also been employed in the study of living conditions in ancient Greece. Greek antiquity provides researchers with a large record of material culture and historical sources that have allowed in-depth analyses of large social, political, and economic developments. For a long time, the archaeology of the Greek world has focused on the architecture, art, and culture of the elite. In more recent decades, however, bioarchaeology has developed into a prominent and integral field in Greek archaeology covering a wide range of geographical regions, time periods, and research areas. This section provides an overview of bioarchaeological research undertaken in the Greek world with a focus on studies using indicators of physiological stress.

3.4.1. Research traditions in classical archaeology

Archaeology of the Greek world is often equated with classical archaeology, a discipline with a long-standing history. In contrast to other archaeological branches – namely American anthropological and British prehistoric archaeology – classical archaeology did not follow the development of processual archaeology ('New Archaeology') developed by Lewis Binford and which argued for a more scientific approach in archaeological studies (Binford, 1962, 1972), nor has it engaged to any large extent in the post-processualist approach associated with Ian Hodder (1982, 1986). The more recent engagement in studies of gender, ethnicity, social organisation, and inequality have helped move classical archaeology away from the traditional foci that dominated in the 20th century and earlier research (see for example Alcock and Osborne, 2012; Hall, 2007b; Morris, 1987, 1992, 2014; Whitley, 1991a, 1996).

3.4.2. Studies of physiological stress in the Greek world

Early classical funerary archaeology was focused on material culture such as grave monuments and grave goods. In contrast, human remains received a lot less attention, and if retained for research purposes, were published as lists or catalogues in appendices of excavation reports. Unlike other archaeological material, human remains were not the subject of dedicated research publications that attempted to answer clearly stated research questions. Issues such as the way in which such data was published, as well as changes in methodologies over the last decades, limits the useability and relevance of some earlier data sets (Buikstra and Lagia, 2009).

A clear exception was the research of J. Lawrence Angel, who pioneered bioarchaeological research in Greece with his seminal work on palaeodemography, migration, and population health during the 20th century (Angel, 1946, 1964, 1966, 1967, 1969, 1972, 1978). During the 1940s, J. Lawrence Angel developed a new approach to bioarchaeological research, which he termed ‘social biology’ (Angel, 1946). This methodology constituted a large step towards the life history approach focusing on context and broader research questions to investigate issues relating to demography, health, and disease. Even though this earlier work needs to be evaluated critically in the light of new research approaches, it is considered ahead of its time and set the foundation for bioarchaeological research in Greece (Buikstra and Lagia, 2009). A detailed account of Angel’s work can be found in Buikstra (2018), Buikstra and Prevedorou (2012), and Roberts et al. (2005).

In more recent decades, bioarchaeological research in Greece has become a prominent and integral field that uses a wide range of methodologies for the analysis of skeletal data, including isotope and aDNA analysis, in combination with historical sources to answer clearly defined research questions regarding the lives of the Greek population during antiquity (Buikstra and Lagia, 2009; Lagia, 2015b; Lagia et al., 2014; MacKinnon, 2007; Nikita and Triantaphyllou, 2017; Roberts et al., 2005). Despite these developments, disinterest in human skeletal remains during early excavations and poor preservation have created a lack of useable comparative data for research undertaken nowadays (Roberts et al., 2005). According to Greek law ('Protection of Antiquities and Cultural Heritage in General'), human remains are managed under the same regulations as any other archaeological findings, and projects are under no obligation to include specialists to conduct excavations of human remains (Lagia, 2015b). Complete excavation records from the 19th and earlier 20th century are often lacking, and excavations were commonly not accompanied by bioarchaeologists. Inappropriate storage of human remains has created additional issues for bioarchaeologists who research legacy collections of remains decades after excavation (e.g. Jones, 2018). While excavators have adopted better practices in more recent years, these factors put severe limits on the useability of data from earlier excavations (Lagia, 2015b).

Despite these challenges, bioarchaeological research has developed significantly during the past decades, investigating a wider range of topics covering sites on the Greek mainland as well as the islands from prehistory to the medieval period. The increasing interest in bioarchaeological research over the last years has also influenced and shaped academic and institutional developments in Greece (Lagia et al., 2014; Nikita and Triantaphyllou, 2017; Voutsaki and Valamoti, 2013b). Bioarchaeological approaches have been more readily accepted and adopted in prehistoric contexts than in historical settings (Hallager and McGeorge, 1992; Harvati, 2009; Iezzi, 2009; Michael et al., 2021; Moutafi, 2021; Papathanasiou et al., 2009; Schepartz et al., 2009; Stravopodi et al., 2009). More recently, an increasing body of research has been published on the later periods dealing with human remains from the Classical, Hellenistic, Roman as well as Byzantine periods (Bourbou, 2005, 2010, 2014; Caruso and Nikita, 2024; Fox, 1997, 2005; Ioannou and Lorentz, 2023; Karligkioti et al., 2023; Kirkpatrick Smith, 2013; Lagia, 2007, 2014, 2015a; Moles, 2020, 2023b, c; Moles et al., 2022; Rife, 2011; Sulosky Weaver, 2015; Tritsaroli, 2014; Vergidou, 2024; Vergidou et al., 2022). However, the EIA and Archaic period are still underrepresented in bioarchaeological research so far (Arrington et al., 2021; Karakostis et al., 2021; Papathanasiou et al., 2013; Prevedorou et al., 2024). Here, the burial ground at Phaleron provides us with the opportunity to gain more insight into these formative centuries.

Similar to the wide coverage of time periods, a broad range of topics have been dealt with including **palaeodemography** (Angel, 1969; Ingvarsson-Sundstrom, 2004; Lagia, 2007; Liston, 2023; Papathanasiou, 2001; Triantaphyllou, 2001), **diet** (Bourbou et al., 2013; Bourbou et al., 2011; Bourbou and Richards, 2007; Garvie-Lok, 2001; Iezzi, 2015; Lagia, 2015a; Lagia et al., 2007b; Moles, 2020, 2023a; Moles et al., 2022; Papathanasiou, 2003, 2015; Petroutsa and Manolis, 2010; Petroutsa et al., 2009; Petroutsa et al., 2007; Triantaphyllou et al., 2008; Vergidou, 2024; Voutsaki and Valamoti, 2013a), **mobility and migration** (Garvie-Lok, 2009; Keenleyside et al., 2011; Leppard et al., 2020; Nafplioti, 2008, 2011; Prowse et al., 2018), **genetic kinship** (Bouwman et al., 2009; Brown et al., 2000; Chilvers et al., 2008; Evison et al., 2000; Evison, 2001; Georgiou et al., 2009), **activity and behaviour** (Buikstra, 2023; Garvie-Lok, 2010; Karakostis et al., 2021; Mountrakis and Manolis, 2014; Papathanasiou, 2001, 2005; Triantaphyllou, 2001), and **health and disease** (Bourbou, 2009, 2014; Fox, 1997, 2005; Karligkioti et al., 2023; Kyle and Reitsema, 2020; Lagia, 2007; Lagia et al., 2007a; Lagia et al., 2007b; Liston, 2023; Liston and Day, 2009; Moles, 2020, 2023b, c; Papathanasiou et al., 2013; Schepartz et al., 2009; Tritsaroli and Karadima, 2018).

Skeletal indicators of physiological stress have been used in various studies to explore living conditions in different temporal and geographical settings. Research questions have addressed changes of living environments over time and differences between geographical locations as well as contexts. Additionally, among other methodological approaches, skeletal stress indicators have been employed to research the presence and impact of inequality (Bourbou, 2005; Fox, 2005; Karligkioti et al., 2023; Kyle and Reitsema, 2020; Lagia, 2014; Moles, 2023c; Vergidou et al., 2021). While ancient Greece is often associated with democracy and the implicit equality of such a political system, the reality differed significantly from this idea. The archaeological record of Greece provides researchers with a variety of high-quality data covering centuries to explore long-term process that created and sustained inequality and how these impacted different segments of the population (Lagia and Voutsaki, 2024). The study of inequality in ancient Greece shifted the research focus onto marginalised members of the population that have been underrepresented previously.

Indicators of physiological stress have been employed by previous studies (summarised below) to investigate the impact of different factors on living conditions including sex and gender, socio-economic status, and urbanism (Bourbou, 2005; Karligkioti et al., 2023; Lagia, 2014; Michael et al., 2017; Moles, 2020, 2023c; Triantaphyllou and Bessios, 2005; Vergidou et al., 2021).

Biological sex is one of the main identity axes commonly explored in bioarchaeological research to investigate gendered differences in disease frequency, diet, and activity. Skeletal remains estimated as biologically female have been identified from different socio-economic backgrounds allowing for a comprehensive study of female health during antiquity (Fox, 2016; Liston, 2012). Studies exploring sex differences in ancient Greek contexts have used dental disease to investigate dietary differences (Karligkioti et al., 2023; Michael et al., 2017; Moles, 2023a; Vergidou et al., 2021), as well as joint disease and entheseal changes to explore activity patterns (Karligkioti et al., 2023; Michael et al., 2017; Moles, 2023c; Vergidou et al., 2022). Clinical studies and bioarchaeological research suggest that females are more susceptible to dental caries (Laine, 2002; Lukacs, 2008). This predictable pattern was identified for rural communities in East Attica during the Roman period, which is interpreted to be the result of gendered differences in diet (Karligkioti et al., 2023). A more homogenous expression of dental disease was observed for Roman Macedonia suggesting that diet here was less dependent on biological sex and was overall characterised by carbohydrates (Vergidou et al., 2021). However, in some Greek contexts, a higher frequency of caries was found in males suggesting a more varied diet available to the male population containing more sugar and carbohydrates. The lower frequency of dental disease among females indicates a certain level of social differentiation and possibly segregation (Moles, 2023a). Furthermore, the higher social and political status of males, diverse food processing and food intake, as well as differences in dental care might explain these patterns (Michael et al., 2017).

Regardless of geographical region and time, males appear to exhibit higher frequencies of joint disease, tentatively interpreted as a gendered difference in physical hardship, with men taking on the responsibility of physically demanding labour such as agriculture, animal husbandry, and woodworking (Karligkioti et al., 2023; Vergidou et al., 2022). Joint degeneration is also observed for young adults suggesting a link to activity rather than age (Michael et al., 2017). This is especially apparent in a mass burial from Pydna in Macedonia dated to the 4th century BCE (Classical period), where arthritic changes affected young adults, and the presence of skeletal stress markers are considered consistent with heavy manual labour. Both sexes are affected to a high degree indicating that gendered division of labour was not the standard for all population sections. The high frequency in young adults might suggest that individuals were subjected to heavy manual labour at a young age, possibly even as children. The levels of physiological stress observed in the mass burial at Pydna are higher when compared to the cemetery population from Amphipolis also located in Macedonia. Individuals from Amphipolis displayed a higher average age-at-death and lower frequencies of stress indicators (Malama and Triantaphyllou, 2001). The presence of nutritional deficiencies and other physiological stressors in Pydna can be considered strong indicators of low-status individuals that were subjected to heavy manual labour during life which might be consistent with slavery (Triantaphyllou and Bessios, 2005).

Socio-economic status can have a significant impact on different aspects of health and diet, and low socio-economic status is often associated with poor health outcomes. During the Classical period, Athenian males of lower socio-economic status were significantly more affected by childhood stressors (cribra orbitalia) when compared to males of higher socio-economic status, while females displayed a high disease frequency regardless of socio-economic status (Lagia, 2014). In contrast to the Classical period, differences based on gender and socio-economic status decreased during the Roman period suggesting greater equality for males (Lagia, 2014, 2015a). High levels of dental disease (caries) were identified in elite burials from Crete dated to the Hellenistic and Roman period. The high frequency of dental disease is thought to be associated with a diet rich in carbohydrates, which might be corroborated by the presence of few cases of DISH (Bourbou, 2005). DISH is generally interpreted as an indicator of a better standard of living and nutrition with access to rich foods as it is associated with higher age-at-death and may be connected to diabetes mellitus (Stout et al., 2019). This shows that high socio-economic status did not automatically equate to better levels of health during the Hellenistic and Roman period.

In addition to biological sex and socio-economic status, living environments have the potential to influence health. Both urban and rural settlements each present their own hazards. Urban centres are characterised by high population density and diverse populations which can be tied to poor sanitation and might be conducive to the transmission of infectious diseases. Rural settlements on the other hand might be associated with higher levels of activity exposing people to an increased risk of injury as well as closer contact to animals, which might be disease carriers. Prevalence of different indicators of physiological stress suggest worse living conditions in the urban centre of Roman Knossos in comparison to the Late Antique period. The improvement in living conditions resulting in higher average age-at-death might be related to a reduction in population numbers and settlement size allowing for better sanitary conditions and reduced pressure on resources (Moles, 2020, 2023c). A comparison of rural living conditions in Eastern Attica with urban populations of Athens (Lagia, 2014), Corinth (Petry, 2020), and Akraiphia (Nikita et al., 2019) showed increased hardship in the rural population in the Classical and Roman period (Karligkioti et al., 2023). Changes in disease frequency and mortality profiles identified in these diachronic studies also suggest worse living conditions and increased hardship during the Roman period, in contrast to proceeding and succeeding time periods. Lifestyle and cultural practices during the Roman era might have exposed the population to a higher disease load (Karligkioti et al., 2023; Moles, 2020, 2023c).

Despite clear socio-political progress towards a more egalitarian society during the 1st millennium BCE, certain population groups were continuously 'othered' based on gender, ethnicity, socio-economic status, age, or a combination of these factors. Females do not display worse health than males in all contexts, but several different factors interplay in the expression of disease. A pattern of higher prevalence of joint disease and entheseal changes in males suggests more intense physical activity for males than females. A general trend towards higher prevalence of disease in those of lower socio-economic status is visible. Individuals of higher status were affected by different forms of disease that are more associated with diet and nutrition. It also appears that higher status provided less of a buffer for females than for males. Environment also plays a certain role in disease susceptibility. While it might be tempting to assume that higher levels of urbanism tend to equate to higher levels of disease and stress, individuals living in more rural settlements might be subjected to higher levels of physical labour and different disease agents.

3.5. Summary

Palaeopathological studies investigate health and disease in the past within the historical and archaeological context of specific sites. Skeletal indicators of physiological stress are commonly used to identify and reconstruct long-term stress on an individual and population level. Exposure to physiological stress during gestation, infancy, and childhood might negatively affect health status during adulthood expressed as increased risk of morbidity and mortality (DOHaD). Especially chronic stress has the potential to impact development and can result in decreased health. Indicators of physiological stress are considered non-specific and can be related to numerous causative factors.

Bioarchaeological research has become a more prominent area of research in the last decades in Greek archaeology, and skeletal indicators of physiological stress have been used to explore temporal and regional differences and the impact of biological sex or social status on health and disease exposure. The in-depth knowledge we have from Greek antiquity from archaeological, literary, and epigraphic sources provide bioarchaeology with the necessary foundation to interpret the skeletal data within a sound historical framework.

4. INEQUALITY AND STRUCTURAL VIOLENCE

4.1. Introduction

This chapter considers the theoretical foundation for the bioarchaeological study of inequality and structural violence. Prolonged physiological stress due to structural inequalities has a negative impact on a person's development, growth, and health in general. The effects of various external factors such as environment, nutrition, occupation, or sanitation on health and development have been identified in studies from different research areas, ranging from human biology to economics, across different regions, cultures, and time periods. The study of human skeletal remains can give a more direct line of evidence for the study of inequality in the past compared to other archaeological or historical analyses.

4.2. Bioarchaeology of inequality

Inequality is a constant in human history, and still nowadays, the gap between rich and poor continues to expand. Inequality permeates all aspects of life, and underlying socio-cultural and economic factors enforce the marginalisation of individuals and groups. The study of inequality in the past can give insights into the roots of structural inequalities that persist until today, and it allows researchers to identify factors such as urbanisation, political systems, or climate change, that created inequality in past societies. Understanding mechanisms that contribute to inequality is essential to address and reduce structural inequalities in modern times. Examination of mortuary contexts and skeletal remains within their historical and social context allows us to address questions about inequality in the past regarding how socio-economic status, ethnicity, and gender impacted health, social identity, and overall well-being under consideration of the intersectional effects of identity axes (Buikstra et al., 2022).

The theory of intersectionality was developed by Black feminist scholars (Crenshaw, 1989, 1991), and it outlines how multiple aspects of one's social identity such as gender, race, or socio-economic background overlap and interact, and how these intersecting aspects can shape and create systemic inequalities and oppression. Intersectionality recognises that individuals have multiple overlapping identities that can influence their lives (DeWitte and Yaussy, 2021). Intersectional approaches have also been adopted in bioarchaeological research by including multiple aspects of identity in the interpretation of lived experiences in the past (Betsinger, 2023; DeWitte and Yaussy, 2021; Mant et al., 2021; Perry and Gowland, 2022; Yaussy, 2019, 2022).

Research from the areas of social science and medical science shows that social inequality is linked to higher levels of morbidity and mortality. For example, infectious disease disproportionally impacts groups of low socio-economic status or ethnic minorities (Ansell, 2017; Dorling, 2015; Farmer, 2016; Marmot, 2015). In response to the HIV epidemic and building on observations that new epidemics disproportionately impact those who already face other health threats, Singer and colleagues developed the concept of syndemics (Singer, 1994, 1996, 2009; Singer and Clair, 2003; Singer et al., 1992). The term 'syndemics' refers to multiple interrelated social and health crises that often disproportionally affect the poor and marginalised. In syndemics, diseases do not simply co-occur, rather there is a synergistic, additive element in which each will exacerbate the impacts of the other. For example, Singer (1994, 1996) found that substance abuse, violence, and HIV/AIDS are closely interrelated ('SAVA syndemic'). Infectious disease such as HIV, tuberculosis, or sexually transmitted infections (STIs) are strongly influenced and sustained by broader socio-economic and socio-political factors such as poverty, unemployment, homelessness, or poor nutrition. Co-morbidity of infectious diseases such as HIV and tuberculosis interacted synergistically, resulting in a faster progress of both infections, and they disproportionally affected the marginalised and poor. This co-morbidity can be considered a syndemic, as disease concentration as well as disease interactions are enhanced by inadequate social conditions. Syndemics are not restricted to infectious disease, but a broad range of disorders including mental health conditions are considered (Singer et al., 2017; Tsai, 2015). Social forces such as incarceration, gender inequality, homelessness, or racial segregation are systemic risk factors that increase disease burden creating the environment for syndemics (Tsai, 2015; Tsai et al., 2017). More recently, the SARS-Cov-2 pandemic can be classified as a syndemic. Higher morbidity and mortality rates due to COVID-19 were identified in disadvantaged minorities and some low-income groups, suggesting that higher susceptibility to COVID-19 is also rooted in structural social inequalities. COVID-19 interacts with different risk factors such as chronic disease (e.g., diabetes, hypertensions) or obesity, but an infection with COVID-19 also exacerbates the risk of cardiovascular disease. In addition to such predisposing health factors that are often linked with low socio-economic status, other social factors such as living conditions, occupation, or low level of education, that are associated with income inequality, have an impact on morbidity and mortality rates. Some temporal and spatial variation in mortality rates from COVID-19 were observed, but co-morbidity and different socio-economic factors were identified as drivers of the pandemic, meaning it was experienced as a syndemic at least on a local level (Davies, 2021; Gravlee, 2020; Mendenhall et al., 2022; Perry and Gowland, 2022; Richardson et al., 2020; Roberts, 2020a, b; Singer et al., 2022; Singer et al., 2021; Sorci et al., 2020; Wade, 2020).

Recently, a syndemic approach has been adopted in bioarchaeological research (DeWitte and Wissler, 2022; Larsen and Crespo, 2022; Perry and Gowland, 2022;

Robbins Schug and Halcrow, 2022). Employing the theory of syndemics in addition to intersectionality and DOHaD allows for a deeper understanding of social and economic contexts that had an impact on health and disease frequency in the past. A systemic approach aims to incorporate all biological, social, and environmental aspects which can all lead to high disease frequency. It goes beyond the sole exploration of comorbidity and co-occurrence of disease from a cumulative perspective, but instead includes the synergy between different diseases, mental health, structural inequalities and racism, environment, and poor nutrition under consideration of the specific social and economic contexts (Perry and Gowland, 2022; Tsai, 2018).

Social inequality and syndemics are closely linked to violence. The social environment in which syndemics develop is greatly contributing to interpersonal violence (e.g., SAVA syndemic: Singer, 1996, 2006). Additionally, legacies of structural inequalities and structural violence such as slavery in the US are known contributors to intergenerational health inequalities and syndemics (Gravlee, 2020; Jasienska, 2009).

4.3. Bioarchaeology of structural violence

Societally enforced and sanctioned inequality is known as structural violence. The framework of structural violence was developed by Galtung (1969) and it is used to describe 'social structures that suppress agency and prevent individuals, groups, and societies from reaching their social, economic, and biological potential' (Klaus, 2012: 31). Structural violence is embedded in political and social structures and can result in injury and death. It is – to an extent – normalised within a society (Farmer et al., 2016; Nystrom, 2014; Nystrom et al., 2017). Cultural violence (e.g., religion, ideology, language, art, and science) can be used to legitimise and maintain direct as well as structural violence, and all three forms of violence interact with and support each other.

Long standing cultural practice has the potential to normalise the other two forms of violence in a society (Galtung, 1990). Despite the importance of research on structural violence, the theory has also received criticism since its introduction in the 1960s. It has been argued that the theory is too broad and that the term might be used loosely labelling all forms of inequality as violence (Boulding, 1977), or that the theory involves a certain degree of ambiguity and subjectivity, and is influenced by current ideology (Derriennic, 1972). Furthermore, it has been argued that the theory of structural violence conflates social control with social disparity and fails to differentiate different forms of violence including physical, political, or economic violence (Nichter, 2008; Wacquant, 2004).

In contrast to physical violence in the form of direct, personal violence towards the body, which is readily visible in the archaeological record through skeletal fractures and other traumata, structural violence is much less tangible archaeologically as it lacks aggressors that can be easily identified (Bourgois, 2009; Bright, 2021; Rylko-Bauer and Farmer, 2016). Structural violence is linked to unequal power that can enforce unequal access to resources resulting in inequality of opportunities (Galtung, 1969). It is, therefore, often identified at the intersection of extreme poverty and social marginalisation, and it is expressed along the axes of gender, class, or race. Structural violence is experienced on an individual level, but it is created within a social system that produces different levels of inequality for different groups within the society (Bright, 2021).

The framework of structural violence can be used to identify and study vulnerable people within a society. Structural violence does not put people at immediate risk of physical harm or death, but it results in conditions that compromise their ability to maintain physiological homeostasis and meet their basic needs. Structural violence can, for example, include the denial of certain foods and enforcing a group to participate in extreme physical labour. A combination of enforced negative conditions leads to poor health and early death in the supressed and marginalised groups such as enslaved people, individuals of low socio-economic status, or women (Galtung, 1969; Larsen, 2015: 176). The effects of structural violence can have a direct intergenerational impact on health as stress during pregnancy also affect the foetal development. Long-term intergenerational hardship should be considered a possible source of hidden heterogeneity in frailty in bioarchaeological studies (Gowland and Caldwell, 2023).

In order to study causes and consequences of structural inequalities in the past, Klaus (2012) developed a theoretical model of structural violence in bioarchaeology. An intersectional approach recognising that different axes of identity can contribute to different extents to individual vulnerability is crucial (DeWitte and Yaussy, 2021; Farmer, 2004; Farmer et al., 2016; Rylko-Bauer and Farmer, 2016). The idea that structural violence promotes differences in health and disease susceptibility is fundamental. The detrimental conditions a section of society is subjected to may compromise the immune system making certain individuals more susceptible to morbidity and growth disruption and consequently puts them at higher risk of mortality. Studying the skeletal evidence has the potential to give insights into social organisation and health disparities due to structural violence. Within this framework, rates of pathological lesions cannot only be understood as evidence of poor health but additionally as a consequence of socio-political decisions and actions (Bright, 2021; Klaus, 2012; Martin and Harrod, 2015).

It is advised to use the model of structural violence with caution as it is based on modern Western societies and the applicability to other historic or prehistoric settings may be more limited. Not every case of health disparity coinciding with differing social entities can or should be attributed to structural violence. A cornerstone of structural violence is a strict hierarchical organisation of society; therefore, archaeological and historical contexts are essential in the interpretation and understanding of structural violence (Klaus, 2012). In bioarchaeological research, a framework of structural violence can often only be applied in historical contexts as it is dependent on the presence of a rigidly hierarchical society, as in such a society, unequal access to resources can have significant impact on the biological potential of individuals. Prehistoric contexts often lack the necessary contextual evidence to identify structural inequalities and violence (Bright, 2021; Buikstra, 2006; Goldstein, 2009; Klaus, 2012).

Structural violence is closely linked to 'necropolitics', a theoretical concept developed by Mbembé (2003, 2008, 2019). This concept is based on the ideas of 'biopower' and 'biopolitics' proposed by Foucault (2004 [1976]). Foucault's concept of biopower means the 'domain of life over which power has asserted its control' (Mbembe, 2019: 66). In its essence, this principle implies that an authority or sovereign power within a society has the capacity to decide whether an individual gets to live, which can be equated into a sovereign right to kill. The concept of necropolitics develops this idea further and emphasises the power of death. In its extreme form, necropower and necropolitics can create a 'social existence in which vast populations are subjected to conditions of life conferring upon them the status of *living dead*' (Mbembe, 2008: 40). Examples of necropolitics are colonisation and slavery, which are constants throughout history and played a significant role in ancient Greece. Slavery and other forms of forced labour as some of the most cruel forms of structural violence and necropower have been studied in bioarchaeological research (Buikstra et al., 2024; Corruccini et al., 1982; Fleskes et al., 2021; Harrod and Crandall, 2017; Harrod and Martin, 2014; Harrod and Martin, 2015; Harrod et al., 2012; Kelley and

Angel, 1987; Redfern, 2018; Van der Merwe et al., 2010a; Van der Merwe et al., 2010b; Van der Merwe et al., 2010c).

4.4. Summary

Indicators of chronic physiological stress can be used to explore inequality and structural violence in past societies. Understanding social forces that created and sustained inequalities in the past is important in order to address and reduce structural inequalities in today's world. Underlying socio-economic and political factors enforce marginalisation, which can create persistent health inequalities that have the potential to impact frailty and disease susceptibility. If these inequalities are societally enforced and sanctioned, one can speak of structural violence. A combination of negative conditions leads to high levels of morbidity and mortality in the supressed and marginalised groups. Detrimental living conditions can trigger an epigenetic response and profound adversity can have an intergenerational effect on frailty. The framework of structural violence can be employed to identify vulnerable groups such as the enslaved, low-status individuals, or women in archaeological contexts. Structural violence subjects marginalised groups to living conditions that severely impact their health and, in extreme forms, renders them socially dead.

5. MATERIAL AND METHODS

5.1. Introduction

This chapter's aim is to present the material and methods used in this thesis. The first part gives a brief introduction to the burial ground site at Phaleron located in Athens, including site location, excavation history, and characteristics and significance of the burial ground. It further introduces the thesis sample. The second part provides an overview of the methodology used to analyse the skeletons and construct osteobiographies, as well as statistical analysis. Data collection protocols were developed by the Phaleron Bioarchaeological Project and followed the standards developed by Buikstra and Ubelaker (1994) with some adaptions using updated methodology (described below). Additionally, the process for calculating crude and true prevalence rates and any deviations from that protocol are described. Skeletal data recording included completeness and preservation, demographic parameters, and palaeopathological analysis of indicators of physiological stress.

5.2. Material

5.2.1. The burial ground at Phaleron

A sample of individuals recovered from the Archaic burial ground at Phaleron (Παλαιό Φάληρο, Athens, Greece) constitutes the basis for this research. The Phaleron burial ground is located within the city limits of the modern-day city of Athens on the Saronic Gulf (Figure 5.1). Phaleron is considered an extra-urban burial ground situated approximately four to five kilometres southwest of the Acropolis. During the Archaic period, the area of Phaleron Bay served as the main port of the polis of Athens and was replaced by Piraeus as the major port in the early 5th century BCE (Camp, 2001;

Osborne, 2009). A large part of the Phaleron coastal zone functioned as a burial ground from the 8th until the 4th century BCE. The limits of the burial ground could not be securely identified as it was not excavated in its entirety due to the constraints associated with a rescue excavation (Alexandropoulou, 2019; Ingvarsson et al., 2019).

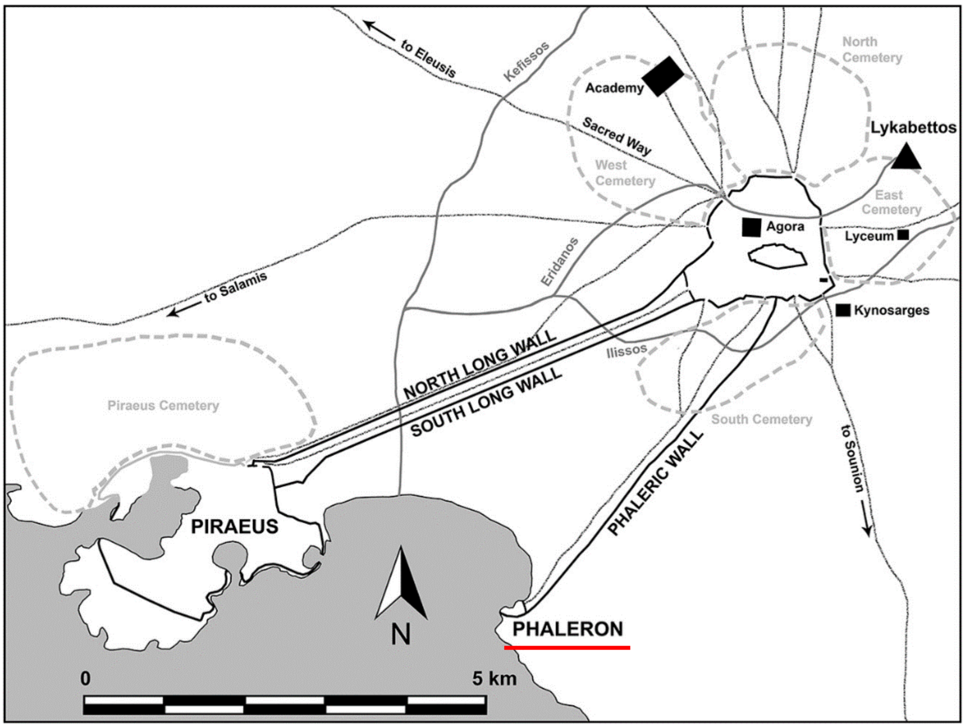

Figure 5.1: Location of Phaleron in relation to the ancient polis centre and other major burial grounds (after Costaki and Theocharaki, 2021: Map 4.2).

The burial ground at Phaleron has been known since the late 19th century. Research excavations were carried out in 1911 under the direction of Dr. Konstantinos Kourouniotis (Kourouniotis, 1911) and in 1915 by Stratis Pelekides (Pelekidis, 1916). The early excavations mostly uncovered burials of children, with jar burials (*enchytrismoi)* forming the largest burial group. Pit burials or cremations of adults as well as cist burials were underrepresented in early excavations (Alexandropoulou, 2019). Pelekidis (1916) also discovered a mass burial containing 18 shackled individuals with iron collars around their necks, who were interpreted as executed convicts and as such, they were considered *biaiothanatoi* – individuals who suffered a violent death. The presence of few adult burials, some of whom apparently suffered a violent death, next to a large number of non-adult burials led to the interpretation of Phaleron as a child cemetery of the 7th century BCE that was also used for the burial of deviant individuals such as executed men (Alexandropoulou, 2019; Morris, 1987).

These early findings demonstrated the importance and potential significance of the burial site. The burial ground area was declared public land during the 1920s and was protected from building activity until the construction of the Stavros Niarchos Foundation Cultural Centre (SNFCC) in 2012. The Ephorate of Antiquities of West Attica, Piraeus and Islands excavated the area between 2012 and 2018 under the direction of Dr. Stella Chryssoulaki. The excavation of 1,797 burials in an area spanning approximately 9,300 m^2 significantly changed our knowledge and interpretation of the burial ground (Chryssoulaki, 2020; Ingvarsson et al., 2019). Within the geographical region of Attica, the number of burials is only matched by the Kerameikos (Storoszeck, 2012).

The burial ground was located along the Phalerian Way (Φαληρική Οδός). In the southeastern part of the excavated area of the burial ground, some organisation of cist burials and primary cremations can be observed (see fig 5.2) (Chryssoulaki and Pappas, 2023). These burials are in a similar orientation and parallel to the adjacent street. This basic organisation suggests that parts of the burial ground were planned in the 7th century BCE (Alexandropoulou, 2019). In contrast, when moving further north into sectors IV, V, and IX[1], there is no uniform orientation of graves or any indication of borders or pathways. The lack of organisation and the fact that burials frequently intercut each other indicates that grave markers and a communal knowledge of grave locations was absent (see also Figure 5.3). The dating of individual burials has proven

[1] Extension of sector IV towards sector V.

challenging as the majority of burials constitutes simple pit graves lacking grave goods (Chryssoulaki, 2020).

Figure 5.2: Map of the excavation area with sectors IV and V marked. Sector IX is located between sector IV and V (after Chryssoulaki, 2020: fig.2).

Simple pit graves were the most common burial type encountered at Phaleron constituting more than 50% of burials, followed by jar burials which were almost exclusively used for the burial of infants and young children (Alexandropoulou, 2019; Vlanti, 2020), pyres, cist or stone slab graves, larnakes, secondary cremations, tile graves, and one non-adult burial in a wooden coffin (IV_732). In addition to human burials, a small number of animal burials (e.g., horse burials) was also present. The distribution of burial types for the entire burial ground has been published by Ingvarsson et al. (2019) (see table 5.1).

Identification of the pit cuts was hindered by that fact that most burials were dug into the coastal sand. Chronology is difficult to grasp in the burial ground at Phaleron. The lack of grave goods, which are usually a good indicator for temporal sequence especially in the ancient Greek world due to a well-established pottery typology and chronology, is an extremely limiting factor. The presence of pottery vessels in graves provided only a general time frame for use of the burial ground area between the 8th to the 4th century BCE, with the main activity during the Archaic period (700-480 BCE) (Ingvarsson et al., 2019).

Number and percentage of grave types in the entire burial ground		
Type	***Number of individuals/type***	***Percentage***
Pit graves	778	43.8%
Mass burials (pit graves)	183	10.2%
Pot burials	612	34.0%
Cist graves	63	3.5%
Funeral pyres	119	6.6%
Larnakes	17	0.9%
Animal burials	18	1.0%
Tile graves	3	0.2%
Secondary cremations	3	0.2%
Wooden coffin (boat)	1	0.1%
Total	**1797**	**100.0%**

Table 5.1: Number and percentage of burial types of all excavated graves in the entire burial ground (Ingvarsson et al., 2019: table 1)

While most burials were unfurnished, there are a small number of graves with pottery vessels that allow the dating of some graves. For example, it was possible to date the largest mass burial ('Esplanada mass burial') containing 79 individuals in three rows to the second half of the 7th century BCE (Ingvarsson et al., 2019). The dating of the smaller mass burials could not be achieved by using pottery dates so far. Unfortunately, it is not possible to use radiocarbon dating due to the issues around the documented ^{14}C anomaly at 500 BCE (Becker and Kromer, 1993; van der Plicht, 2005). The few grave goods present in the burial ground will allow the dating of some pit burials, and the intercutting and truncating of earlier burials by later graves (see Figure 5.3) can be used to establish an internal relative chronology in the absence of absolute dates. This has been achieved for a small area of the burial ground so far

(‘MOB36/37 area’) and will be expanded further from this area (Buikstra et al., n.d.). Establishing the chronology of the burial ground is an ongoing effort and it will be possible to consider this in future publications.

Several burials were categorised as ‘non-normative’ burials (‘Δ-burials’) during excavation based on potential evidence for violent treatment (Chryssoulaki, 2020; Ingvarsson et al., 2019). Instances of non-normative burials are mass burials, prone burials, or single burials of individuals interred in abnormal positions indicating shackled or bound limbs either by iron bonds or ties of perishable material such as ropes (Figure 5.4). In some instances, the metal shackles were preserved in-situ, but for others the positioning of arms were used as an indicator of shackling. Mass burials were defined as a burial of three or more individuals by the excavators, and the Phaleron Bioarchaeological Project adhered to this definition for the moment. The definition of all non-normative groups (‘Δ’ burials) is part of an ongoing project, and individuals included in this group might be subject to change. Here, I use this group as defined in September 2023. The burying of bound individuals in single and mass graves can be considered indirect evidence for violent death and possible torture.

Figure 5.3: Examples of non-normative burials. Left: Mass burial 2 (IV_409, IV_619, IV_620, IV_637); Right: Non-normative single burial in prone position and partially cremated (5_149).

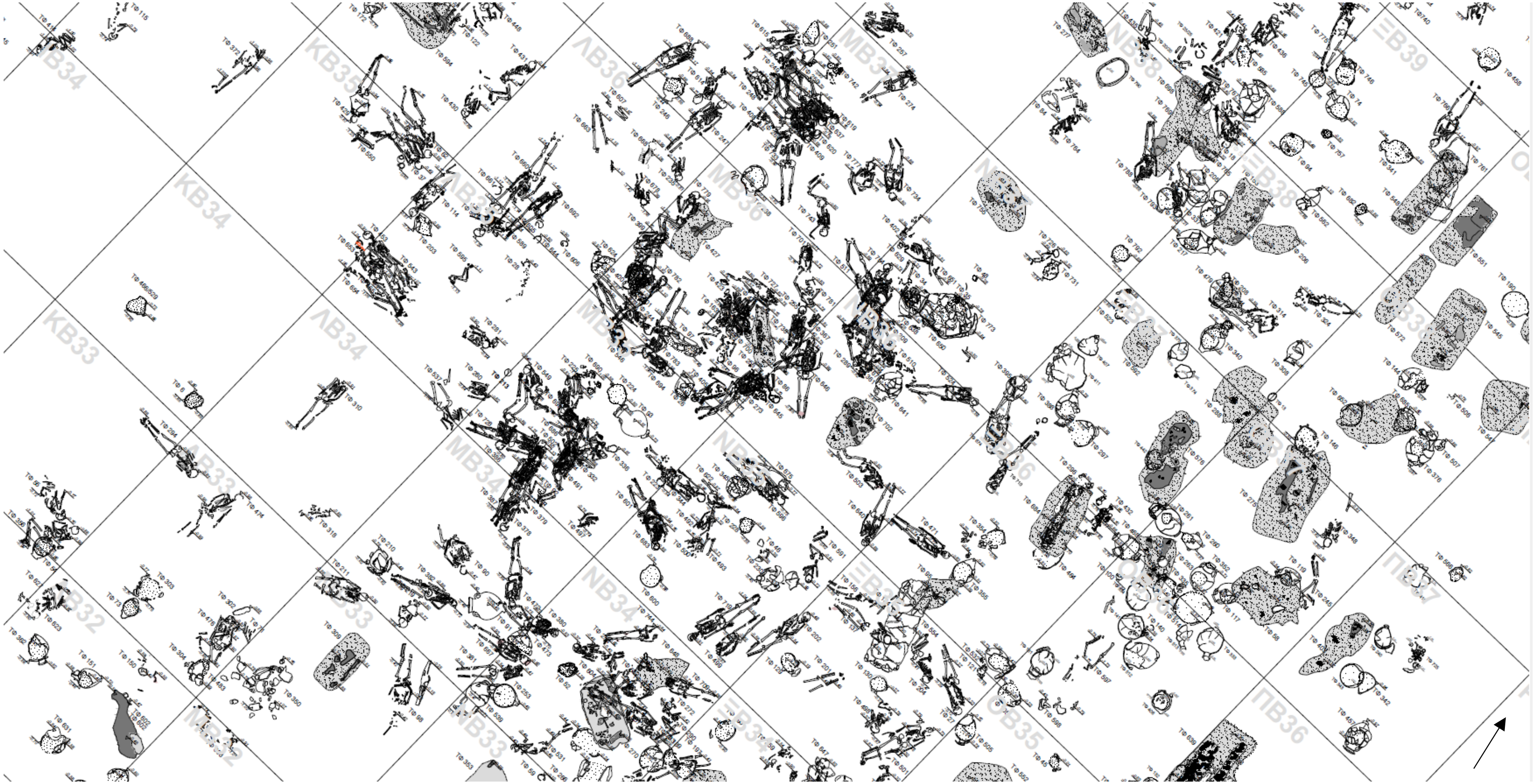

Figure 5.4: Partial plan of sector IV showing a lack of burial organisation of pit burials and intercutting of graves (after Chryssoulaki et al., 2023: fig. 1)

Few instances of pit burials contained two individuals that were interred at the same time (double burial). These double burials were considered as normative burials for the purpose of this thesis.

Simple pit burials lacking burial goods are commonly interpreted as inhumations of non-elite individuals 'near the bottom of the economic scale' (Coldstream, 2004: 113-114). Other Archaic cemeteries contained pit burials that where furnished with grave goods, showing that the simple burial type was not necessarily connected to a specific social class (Alexandropoulou, 2019). However, the lack of offering trenches, as found in the Kerameikos, that are connected to elite burial rites (Alexandridou, 2015; Kistler, 1998), suggests that a different, probably lower socio-economic class was buried at Phaleron. Some characteristics of the burial ground such as the presence of two bronze kettles and horse burials appear not consistent with the theory that this is a purely low-status burial ground (Alexandropoulou, 2019). However, changes in burial organisation from the 7th century BCE into the later Archaic period are noticeable in the burial ground, suggesting that there might have been a shift in use over time towards a burial ground for people of low socio-economic status.

During the early use of this burial ground – late 8th to early 7th century BCE – cemeteries were established outside the city boundaries of Athens. No evidence of residential building activity has been identified in the Bay of Phaleron yet, which indicates that the burial ground was used by residents of Athens or Attica and likely not solely by inhabitants of the Phaleron area. The port area was easily accessible for the inhabitants of Athens, and it is plausible that they would have chosen this area as one of their burial ground (Ingvarsson et al., 2019). However, this theory has not been proven yet, and the question 'Who are the people buried at Phaleron?' still requires further investigation.

5.2.2. The Phaleron Bioarchaeological Project

1,008 human burials were made available for study to the Phaleron Bioarchaeological Project directed by Prof. Jane Buikstra at the Malcolm H. Wiener Laboratory of the American School of Classical Studies at Athens (ASCSA).[2] These 1,008 burials include adult inhumations, non-adult inhumations, and cremation burials. In addition, 11 animal burials of canines and equines were included in the remit of the project. The individuals available came from the following burial ground sectors: sector IV, sector V, sector IX, and sector XI (numbered during excavation). Most individuals available for study came from sector IV followed by sector V. Sectors IV and V are located south-east of the Stavros Niarchos National Centre (see Figure 5.2). The two sectors are in close proximity to each other but are separated by a small strip that was defined as sector IX. Only a small number of individuals from sector IX were available for study to the Phaleron Bioarchaeological Project. The individuals available from sector IX constitute a mass burial containing four individuals, one prone burial, and two very poorly preserved graves identified as normative. Sector IX is immediately adjacent to sector IV in the northwest corner and the individuals available from sector IX can be viewed as an extension of sector IV. The individuals recovered in sector XI are exclusively from the mass graves structured in three rows, the so-called 'esplanada mass burial' (Ingvarsson et al., 2019). The differentiation into different sectors is an artifact of archaeological excavation campaigns. Considering that Sectors IV, V, and IX are immediately adjacent to each other, they were combined into one study area.

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[2] Study permits:
2015: ΥΠΟΠΑΙΘ/ΓΔΑΠΚ/ΔΙΠΚΑ/ΤΕΕΑΕΙ158386/93923/8033/777/24-6-2015
2021 (EXTENTION): ΑΔΑ: 60Ο04653Π4-2ΘΖ, ΥΠΠΟΑ 23.07/2021, Α.Π.: 493045
Permit for sampling 2020: ΥΠΠΟΑ/ΓΔΑΠΚ/ΔΣΑΝΜ/ΤΕΕ/108185/73867/1160/79/23/03/2020

5.2.3. *The thesis sample*

This thesis included the remains from children older than seven years at death, adolescent, and adult inhumations. The remains of infants and younger children as well as cremation burials are the subject of different research projects. The results of the various sub-projects will be combined in future publications to gain a more comprehensive understanding of the burial ground. A total number of 206 individuals were included in this thesis. For the purpose of this thesis, the definitions of burial categories as defined during excavation were used. Most burials were simple single inhumations in pit graves, and only a few individuals were buried in slightly more elaborate burial types such as jars or cist-like burials (table 5.2). Of the 206 burials, 74 individuals came from non-normative burials ('Δ burials') including mass graves which were defined as such by the presence of three or more individuals in one pit, and single graves considered non-normative due to burial position or associated metal finds, and one partial primary cremation in prone position[3]. The thesis sample of 206 individuals constitutes approximately one fifth of all inhumations available to the Phaleron Bioarchaeological Project and approximately 38% of adult inhumations could be covered within this thesis. Individuals were selected from all sectors available to the Phaleron Bioarchaeological Project, to provide an overview of the entire burial ground rather than a detailed picture of only one sub section. Sector IV comprises the largest part of the thesis with 165 individuals (approximately 24% of sector IV) followed by sector V with 34 individuals (13% of sector V). Sector IX is represented by only seven individuals[4]. One densely populated area in sector IV ('MOB36/37 area') that covers all burial types and the entire Archaic period has been studied in its

[3] The cremation was only partial and remained in-situ. The surface is mostly affected and shows black and grey discolouration. All methods used for inhumations could be applied in this instance.
[4] It is not known to the author how many burials were uncovered in sector IX.

entirety, and all 64 individuals aged older than 12 years at death could be included here (see also Buikstra et al., n.d.). Further individuals from sectors IV, V, and IX were selected in line with the conservation progress and complete preservation was prioritised when possible.

Distribution of burial types in the thesis sample		
Burial Type	***Number of individuals***	***Percentage of sample***
Pit burial*	163	79.1%
Mass burial	35	17.0%
Pit grave lined by mud plaster	1	0.5%
Pit grave covered by slabs	4	1.9%
Jar burial (adult)	1	0.5%
Wooden coffin	1	0.5%
Cremation*	1	0.5%
Pot burials	0	0.0%
Larnakes	0	0.0%
Funeral pyres	0	0.0%
Secondary cremations	0	0.0%
Animal burials	0	0.0%
Total	**206**	**100%**

Table 5.2: Distribution of burial types in the thesis sample (N=206).
** Non-normative single burials are represented in the categories pit burial and cremation.*

The thesis sample includes all burials designated as non-normative during excavation that were available to the Phaleron Bioarchaeological Project, except for the mass grave at the Esplanada (sector XI). This mass grave is the largest one excavated in the burial ground and held 78 bound individuals in three rows. An initial assessment of these individuals has been published by Ingvarsson et al. (2019); however, these results have to be treated with caution as all recording was undertaken in the field. The nature of these recordings created some implicit limitations that need to be taken into account when interpreting and comparing these data (Buikstra et al., 2024). Ten individuals from this mass grave were made available for the Phaleron Bioarchaeological Project for analysis in the laboratory, but some were transferred only partially, and the bone surface preservation was poor. The fact that only one eighth of the mass burial could be studied under the same conditions as the rest of the sample, along with the incompleteness and poor surface preservation of these skeletons led to the decision to exclude the mass burial from sector XI from this thesis.

5.3. Methods

For all individuals, a skeletal and dental inventory was compiled including bone surface preservation. The primary estimations for defining the osteoprofile (biological sex, age-at-death, and stature) were conducted whenever possible. Approximately 75% of the data for this thesis was collected or confirmed by the author. The data set was supplemented with the recording of non-normative burials undertaken by Dr. Aviva Cormier. The recording was standardised and followed a coding system based on Buikstra and Ubelaker (1994). All photos were taken using cameras produced by Nikon (model D5100) or Canon (model PowerShot G8X).

5.3.1. Completeness and preservation

Under preservation, the completeness of skeletal elements and preservation of the bone surface were recorded as both impact the amount and type of information that can be observed. Completeness affects the recording of demographic values as well as pathological lesions, and it was scored for every bone individually in four categories: 0 (absent), 1 (>75% complete), 2 (25-75% complete), and 3 (<25% complete). For long bones, the diaphysis was scored in thirds and the joints were treated separately. For vertebrae, the body and the neural arch were scored independently. If vertebrae could not be identified to a specific position, the bodies and neural arches were counted based on vertebral type (cervical, thoracic, and lumbar). Similarly, ribs which could not be precisely identified were counted for the left and right side separately. The innominate was divided into ilium, ischium, and pubic bone, and all three parts were scored independently (following Buikstra and Ubelaker, 1994). Each skeleton was then given an overall score of completeness in four categories: 0-25%, 25-50%, 50-75%, and 75-100%.

Surface preservation was also recorded in four categories, that follows the grade system developed by Brickley and McKinley (2004) (see table 5.3).

Stages of surface preservation	
Surface preservation stage	***Surface preservation grade****
Excellent	Grade 0
Good	Grade 1-2
Fair	Grade 3
Poor	Grade 4-5+

Table 5.3: Stages of surface preservation (after Brickley and McKinley, 2004)*

Taphonomic changes were recorded for all main body sections in order to identify specific taphonomic processes or objects such as metal shackles. If taphonomic processes altered a bone to the extent that no further analysis was possible (e.g., significant surface erosion), the bone was recorded as 'unobservable' for pathological lesions affecting the bone surface. Preservation was a significant limiting factor for all analysis and must be taken into account when calculating prevalence rates.

5.3.2. Demographic data

In addition to skeletal and dental inventories, biological sex and age-at-death were recorded and measurements of long bones were taken to calculate stature by using regression formulae.

5.3.2.1. Biological sex

The estimation of biological sex was based on pelvic and cranial morphology if these features were preserved. For the evaluation of pelvic morphology, Phenice (1969), Klales et al. (2012), and Buikstra and Ubelaker (1994) were employed. For the pubic bone, the ventral arc, subpubic concavity, and ischiopubic ramus ridge were scored. The method was developed by Phenice (1969) using a scoring scale of 1 (female) to 3 (male) and revised by Klales et al. (2012) using a scoring scale of 1 (female) to 5 (male). The greater sciatic notch was also scored using a scale of 1 (female) to 5 (male) (Buikstra and Ubelaker, 1994). The greater sciatic notch is less reliable than the methods devised by Phenice and Klales and colleagues, and may be affected by several factors including advanced age and disease (Walker, 2005) as well as preservation. However, the preservation of the ilium including the greater sciatic notch was commonly better than the pubic bone in the Phaleron assemblage and could be more frequently used for estimation of biological sex.

Cranial morphology was also employed to estimate biological sex. Nuchal crest combined with the external occipital protuberance, mastoid processes, supraorbital margins, glabella, and mental eminence were evaluated and scored on a scale of 1 (female) to 5 (male) (Buikstra and Ubelaker, 1994).

The pelvis was treated preferentially when differences in the estimated sex between pelvic and cranial morphology were identified, as the degree of sexual dimorphism expressed in the skull can vary significantly between populations. For example, the recording process has shown that the nuchal crest was overall underdeveloped in the Phaleron population, and it was not a reliable indicator of biological sex in this instance. Overall robusticity of the cranium and postcranium was noted and used as support for estimation of biological sex based on pelvic and cranial morphology.

In addition to the morphological methods, metric analysis was employed to aid the estimation of biological sex. The radial maximum head diameter was measured (Berrizbeitia, 1989) using a digital sliding calliper from Mitotuyo (Absolute Digimatic, Model No. CD-6″CS).[5] This method is based on skeletons from the Terry Collection at the Smithsonian Institute and includes black and white North Americans. When using this method, it is acknowledged that it was developed on modern populations and any application to archaeological individuals must be treated with caution. Genetic differences, different environments, nutritional status, and exposure to disease, which can all have an impact on growth and development, must be taken into consideration, and estimation of biological sex was never solely based on postcranial measurements. These were used as supplementary to the evaluation of more distinct morphological traits as it was not possible to evaluate reliability of this methodology for the Phaleron assemblage within the scope of this thesis.

The following categories of biological sex were used:

- female
- possible female
- ambiguous
- possible male
- male
- indeterminate

In some instances, the individual was not preserved sufficiently to evaluate biological sex. These individuals were identified as ‘indeterminate’. If an individual exhibited mixed traits, they were scored as ‘ambiguous’. For the purpose of analysis, the categories female and possible female as well as male and possible male were combined into one female and one male category respectively. Ambiguous and indeterminate individuals were combined into one group (‘unsexed’) for stature

[5] Female: <21.5cm; Male: >23.5cm

estimation and palaeopathological analysis. Skeletal sex was only estimated for individuals aged older than 16 years at death as estimation of skeletal sex has low reliability for younger individuals (Brickley and Buckberry, 2017). Results from aDNA analysis (Skoglund et al., 2013) or peptide analysis (Stewart et al., 2017) were not available for the younger individuals in this thesis.

Gender identity cannot be inferred from skeletal remains, and methodological bases for the estimation of biological sex have also been subject to critique (Agarwal and Wesp, 2017; Geller, 2008, 2009a, b). It is acknowledged that only skeletal sex can be estimated and reported here, and this estimate might not concur with the self-ascribed gender or identity of each individual. Current ideas of sex and gender identity might differ from social concepts in Archaic Athens and should, therefore, not be transferred directly.

5.3.2.2. Age-at-death

For the estimation of age-at-death a range of methodologies was employed. If present, the pubic symphysis was used for age-at-death assessment (Brooks and Suchey, 1990; Hartnett, 2010). Estimation of age-at-death based on the morphology of the pubic symphysis was weighed highest and given preference over other methodologies. Two methods for scoring the pubic symphysis morphology were used: Brooks and Suchey (1990) and Hartnett (2010). The scoring developed by Hartnett (2010) was given preference over Brooks and Suchey (1990) due to the updated methodology and narrower age categories provided. These methods are also used for partially preserved pubic symphyses; however, enough features must be preserved in order to classify the pubic symphysis into one or two categories. If biological sex could not be determined both male and female age-at-death estimates were recorded and combined to produce the final estimate for the population analysis.

The preservation of pubic symphyses was consistently poor in the Phaleron assemblage; therefore, Transition Analysis 2 (TA2) was used as an alternative method for age-at-death estimation as this method includes a range of traits in addition to the morphology of the pubic symphysis (Boldsen et al., 2002; Milner and Boldsen, 2012). This methodology is a good alternative in cases with poor preservation or absence of the pubic symphysis, as it allows partially preserved elements to be scored. TA2 is based on established methods using pubic symphysis, auricular area (auricular surface and the post-auricular area), and cranial suture closure. This method provides a quantitative framework for a combination of traits to produce a maximum likelihood age estimation with a 95% confidence interval (Boldsen et al., 2002; Getz, 2020; Milner and Boldsen, 2012). TA2 will also calculate a point estimate with maximum likelihood. Per element, several features can be scored but it is not necessary to score all traits in order to obtain an age-at-death estimate; therefore, TA2 can also be applied to more fragmentary remains. The statistical analysis used by TA2 allows a more nuanced evaluation of traits in comparison to age-at-death estimation methods using phases (Getz, 2020). However, as stated above, the pubic symphysis will give the most reliable age-at-death estimate and if it could be included in TA2 the estimate was considered more reliable. In contrast, if only cranial suture closure could be scored, the age-at-death estimate was often provided as a very broad range and must be considered unreliable as cranial suture closure is highly variable. The estimate of TA2 can be controlled for biological sex and ancestry. However, ancestry was not used in this thesis and was always considered ‘unknown’ when estimating age-at-death. If biological sex is inconclusive or could not be scored, sex is also considered as ‘unknown’. Thus, only one age range for biological sex unknown was created instead of one for male and one for female.

In addition to the above specified methods for aging adult individuals, epiphyseal union was also employed for estimating age-at-death of adolescents and young adults (Schaefer et al., 2009). Epiphyseal union is dependent on biological sex, and as the project did not attempt to estimate biological sex for adolescent individuals under the age of 16, both the male and the female age range were obtained for age-at-death estimates of younger individuals. The age-categories are detailed in table 5.4 (adapted from Buikstra and Ubelaker, 1994). If age-at-death could not be narrowed down into a category, the individual was estimated as 'adult'.

Age-at-death categories	
Category	***Age range***
Child II	7-11 years
Adolescent	12-17 years
Young adult	18-34 year
Middle adult	35-49 years
Mature adult	50+ years
Adult	18+ years

Table 5.4: Categories of age-at-death and associated age-at-death ranges.

Dental attrition can be used to estimate age-at-death (see Brothwell, 1981: fig. 3.9). Theoretically, advanced age is connected to higher degrees of occlusal dental wear; however, the degree of wear is impacted by different factors such as diet or antemortem tooth loss. Additionally, cultural practices may influence dental wear (Brothwell, 1981: 71-72). Dental attrition was not used as a method for all skeletons, but it has been considered for individuals with wide age-at-death spans. If an individual could only be aged as 'adult' using the above stated methods but the molars showed no or only limited dental wear, the age-at-death could be narrowed down to young adult. More caution was used when individuals showed high degrees of dental wear due to the multiple causes of attrition. In addition, if an individual showed advanced dental disease or AM tooth loss, attrition was not considered in the age-at-death estimate. Both AM tooth loss and pain due to dental disease can influence mastication which will impact dental wear patterns.

It is acknowledged that only the skeletal ages can be estimated and reported, and that the stated categories might not have been meaningful for the people of ancient Athens. Social age can only be inferred from context and exploring the relationship between biological and social age may provide insight into the lived experience and social identity in Archaic Athens.

5.3.2.3. Stature

Stature is an important parameter in population studies and can be used as an indicator of early life stress resulting in decreased height. Studies commonly use maximum femur length and regression formulae to estimate stature. Stature can be highly population specific; therefore, population specific regression formulae are recommended (Gowland and Walther, 2018; Vercellotti et al., 2009). Due to the incomplete preservation of skeletal remains at Phaleron, it was not possible to develop a population specific regression formula. Instead, this thesis used a non-population specific formula developed by Albanese et al. (2016) (see Appendix I for regression formulae). This method also provides a generic formula that can be applied to individuals that could not be sexed. For the unsexed group, ambiguous and indeterminate individuals were combined. Measurements of complete long bones were taken using an osteometric board.[6] Only fully fused bones were included in this analysis. If the long bones were unfused or still showed fusion lines, the individual was excluded. Due to the poor preservation, it was not possible to use the femur as a proxy for stature as has been done in many other studies. The sample for femur length

[6] The osteometric board used was custom made for the M. Wiener Laboratory at the ASCSA and, therefore, no make or model can be reported.

would be too small to be interpreted in a meaningful way. Instead, we combined stature estimates obtained from different long bones. If both sides of one bone were present for measurement, the left bone was given preference. If in one individual stature estimates could be obtained from multiple bones, the estimate with the lowest standard error was used (see Appendix I). Mean, median, and standard deviations were calculated within the sub samples based on burial group and biological sex. Within the scope of this thesis, stature estimation was used to evaluate childhood stress represented as reduced skeletal height and, therefore, it is reported within the palaeopathology results section rather than in the demographic results section.

5.3.3. *Palaeopathological data*

The Phaleron Bioarchaeological Project developed a data collection protocol based on the standards for palaeopathological data recording by Buikstra and Ubelaker (1994), but these standards were refined and updated. A coding system as suggested by Buikstra and Ubelaker (1994) was implemented with the aim to limit intra- and interobserver error. In addition, all lesions were described in more detail individually. Pathological lesions of interest in this thesis were:

- Childhood indicators of stress in form of cribra orbitalia, dental enamel hypoplasia, and short stature
- Dental disease in form of caries, AM tooth loss, periodontal disease, and periapical lesions
- periosteal new bone formation affecting tibiae
- skeletal trauma in form of fractures
- vertebral joint disease.

Detailed recording for all pathological lesions included location, extent, degree of lesion severity, and activity, but for the purpose of the population analysis, the lesions were converted into simple present/absent scores. This allowed for a more meaningful statistical analysis as differentiation into more refined categories would have created too small sample sizes. For most pathologies, a crude prevalence rate (CPR) (individuals with lesions in relation to the total number of individuals in the thesis sample) and a true prevalence rate (TPR) (individuals with lesions per individuals observable for the lesion in the thesis sample) was recorded. The crude prevalence rate also included individuals with the affected element not preserved and was, therefore, likely an underestimation of disease prevalence. In addition, for the dentition prevalence rates of different forms of dental disease were also calculated on the level of individual teeth, meaning that prevalence rates of teeth affected per teeth observable were calculated. Any deviations from the prevalence rate calculations are discussed in the relevant sections below.

Commonly, joint disease of the main joints is included in studies of physiological stress as these can give indications of activity levels and activity related stress (Larsen, 2015). However, in the thesis sample, the preservation of joints was poor and joint disease of these main joints could not be studied meaningfully in this instance. A larger sample size is necessary to study activity related joint disease in more detail. For the purpose of this thesis, joint disease of the main synovial joints was only discussed for four individuals in the osteobiographies, while for the population-based analysis vertebral joint disease was included.

5.3.3.1. Childhood stressors

i. Cribra Orbitalia

Cribra orbitalia (CO) was recorded separately for each orbit, but for prevalence rates a combined score was employed. Pitting severity, pitting density, presence of diploic expansion, and lesion activity were recorded (follows Stuart-Macadam, 1991). The stages of the scoring system were (1) absent, (2) capillary impressions, (3) porosity, and (4) porosity with coalescence of foramina. Stage 4 can be present with or without a raised surface, and both versions were combined into one category. It is acknowledged that CO has different aetiologies (Cole and Waldron, 2019). This thesis does not attempt to differentiate between different forms and causes of CO and, therefore, the different expressions are treated together as evidence of early life stress. If both orbits were affected by a different stage, the more advanced stage was used in the analysis. For some individuals, the preserved orbits were unobservable due to poor surface preservation, and orbits were not preserved for all individuals in the thesis sample. If the orbit was less than 25% preserved and no lesions were present, the orbit was not included in the analysis but was treated as 'orbit absent' instead. If less than 25% of the orbit was preserved, it cannot be determined with certainty if the orbit was in fact not affected by lesions or if the evidence was not preserved. Capillary impressions were recorded but it is acknowledged that capillary impressions are non-specific and might not necessarily be indicative of pathology. Therefore, these were treated as 'CO absent' in the results and discussion and only the presence of porosity with its different expressions were considered true evidence of CO. Prevalence rates were calculated as true prevalence rates per side. For the crude prevalence rate, at least one orbit had to be affected by changes.

The aetiology of CO is varied and has been discussed in detail (Angel, 1966; Brickley, 2018; Lagia, 1993; McIlvaine, 2015; Stuart-Macadam, 1985; Walker et al., 2009). Multiple causes such as acquired and hereditary forms of anaemia, various nutritional deficiencies (e.g., scurvy), or inflammation are recognised. Therefore, CO was considered a general indicator of physiological stress rather than an indicator of one specific disease process.

ii. Dental Enamel Hypoplasia

Dental enamel hypoplasia (DEH) was recorded as absent, present, or unobservable for each tooth available (Hillson, 1996; 2005: 169-174). If a defect was present, the type of lesion was recorded. It could be differentiated between linear horizontal grooves, linear vertical grooves, linear horizontal pits, nonlinear array of pits, and single pits. All these defects were treated equally in the interpretation of enamel defects and were not considered as different expressions of severity. In several instances, recording of presence or absence of DEH was not possible in preserved teeth due to poor enamel surface preservation, significant dental wear, or presence of large amounts of calculus, and these teeth were considered 'unobservable'. Due to the multiple aetiologies of DEH, the lesion was only considered indicative of developmental stress if more than one tooth showed signs of a defect (Hillson, 2005: 169-171). Individual teeth with dental enamel hypoplasia were also not reported in the true prevalence rates in the population analysis. These were not considered evidence of physiological stress and by including them in the TPR it would inflate the prevalence of stress indicators. These teeth were only included in the analysis by tooth type.

5.3.3.2. Dental disease

The recording of dental disease also followed primarily the standards created by Buikstra and Ubelaker (1994). Any changes to the recording format are detailed below. Dental disease included caries, periapical lesion, alveolar resorption, and antemortem tooth loss. As with skeletal lesions, the recording of dental disease followed a standardised coding system for each lesion. Calculus and dental wear were recorded for every tooth individually as these might impact the observability of other disease processes; however, calculus and dental wear were not pursued further within this thesis.

i. Caries

Presence and absence of caries was recorded for each tooth individually. If caries was identified, the location of the carious lesion was recorded. Descriptions of the locations of carious lesions are provided in table 5.5. Severity of caries was not recorded separately. If the tooth was not present, it was recorded as 'unobservable' for carious lesions. If more than one caries was present in one tooth, both locations were recorded. For the purpose of calculating prevalence rates, multiple lesions in one tooth were considered in prevalence rates of lesion location and in the demographic analysis. In contrast, prevalence rates by tooth types do not reflect multiple lesions in one tooth.

Location of carious lesions	
Location	***Description***
occlusal surface	all grooves, pits, cusps, and the buccal and lingual grooves of molars
interproximal surface	includes the mesial and distal surface and cervical regions
smooth surfaces	buccal/labial and lingual surfaces other than grooves
cervical caries	originates at the cementoenamel junction (except for the interproximal regions)
root caries	originates below the cementoenamel junction
large caries	extensive cavities that destroyed the tooth to an extent that location of origin could not be determined

Table 5.5: Descriptions of locations of carious lesions.

Recording of interproximal caries was limited by in-situ preservation of teeth and rates of interproximal caries are likely under reported. Additionally, some teeth were only represented by small root fragments that could not be further identified. Caries is a possible cause for the complete destruction of these teeth, but as the teeth could not be identified securely, they could not be included in the pathology recording.

Most individuals with such advanced dental disease would have displayed caries in multiple teeth, and therefore, are reflected in the crude prevalence rate.

ii. Antemortem tooth loss

Antemortem (AM) tooth loss was recorded with the dental inventory for each tooth position as absent or present. It was only identified as present if the alveolar socket was completely remodelled. If remnants of an alveolar socket were present, the tooth was recorded as lost postmortem as it was not possible to say with certainty that it was not held in place by soft tissue and lost after death. Extensive AM tooth loss was defined as six or more teeth lost during life. Congenital absence and impaction of teeth must be taken into consideration (Hillson, 2019: 312). This differentiation was particularly difficult for the third molars, and therefore, if only the third molars were missing and the alveolar bone was completely smooth, third molars were recorded as congenitally absent/impacted rather than lost AM. This approach was chosen to avoid accidentally inflating this form of dental disease.

iii. Periodontal disease

Periodontal disease was recorded as degree of alveolar resorption for every instance where tooth and alveolar bone were preserved (after Lukacs, 1989). However, if the alveolar bone was damaged postmortem, alveolar resorption could not be recorded. Alveolar resorption was measured as the distance between the CEJ and the alveolar bone, and the different stages are detailed in table 5.6.

Alveolar resorption can also be non-pathological and, for example, be related to continuous eruption (Hillson, 1996: 263-264). Therefore, only the more advanced stages (moderate and severe) were considered pathological in this thesis. At least one tooth position had to show alveolar resorption at a pathological level that periodontal disease was identified for an individual. These advanced stages were often accompanied by signs of inflammation such as pitting and bone formation (Ogden, 2008), but for recording only the distance between the CEJ and alveolar bone were considered. Complete evulsion of the tooth with obliteration of the alveolar bone was recorded as AM tooth loss, and in case of AM tooth loss, degree of alveolar resorption was recorded as unobservable. Alveolar resorption was only recorded for permanent dentition.

Stages of alveolar resorption	
Category	***Measurement***
No resorption	Less than 2 mm resorption
Slight resorption	2-3 mm resorption
Moderate resorption	3-5 mm resorption
Severe resorption	Majority of root is exposed

Table 5.6: Stages of alveolar resorption (after Lukacs, 1989)

iv. Periapical lesions

Periapical lesions were identified by drainage holes in the alveolar process. The affected tooth and location of the perforation (cloaca) were recorded (buccal/labial or lingual). While drainage holes can also occur in the maxillary sinuses or nasal cavities (Hillson, 1996: 284-285), these were not observed in the thesis sample. In one instance, two drainage holes were identified in one tooth position, and both are counted in the true prevalence rate. In well-preserved alveolar bone, only periapical lesions with a drainage hole could be identified macroscopically; however, in early stages, a drainage hole might not have formed yet. Ideally, radiographs would be taken of each mandible and maxilla to identify early stages of periapical lesions (Hillson, 1996: 287), but this was beyond the scope of this thesis.

It is acknowledged that the above-described dental disease processes are related to each other and interlinked. Preservation was a significantly limiting factor for recording and interpreting dental disease. Advanced dental wear, presence of calculus, and poor enamel surface preservation negatively affected the recording of caries and DEH. For this reason, dental wear, presence of calculus, and taphonomic changes to the enamel surface and alveolar bone were recorded to control for any obscuring factors. Only teeth and alveolar bone that were considered as observable were included in the prevalence rates. When interpreting dental disease, these factors must be taken into consideration, and one is advised to work under the assumption that dental disease is generally underestimated.

5.3.3.3. Periosteal new bone formation

Periosteal new bone formation (PNBF) was recorded for each bone; however, for the purpose of this thesis, only PNBF on the tibiae was included as a stress indicator. Studies used for comparison in this thesis mostly focused on tibial PNBF, so in order to ensure comparability, PNBF affecting the tibia has also been used here. It is, however, aimed to include further bones in future analysis and publications. For PBNF, exact location of the lesion, extent, bone characteristics, and activity were recorded. In addition – if possible – the involvement of the endosteal surface and – if present – the location of cloacae were recorded. While PNBF can have several causes, the presence of a cloaca or drainage hole is always indicative of infection of bone (osteomyelitis) rather than general inflammation as expressed by PNBF.

For the purpose of investigating inflammation, the tibia was not sectioned into thirds. More than 1/3 of the diaphysis had to be preserved and more than 1/3 of one diaphyseal surface had to be affected to be counted as indicator of non-specific stress in order to ensure that not only localised inflammation was included. If only muscle insertion areas showed some reactive bone, this was not interpreted as an indicator of stress. The lesions did not have to be present bilaterally, and if only one preserved tibia displayed PNBF that was consistent with the above outlined criteria, it was included in the data set. If the surface preservation did not allow for evaluation of surface changes (e.g., surface erosion or sediment adhesion), the tibia surface was recorded as 'unobservable' and not considered in the true prevalence rates.

5.3.3.4. Trauma

Trauma can be distinguished into two categories – fracture and dislocation –, but for the purpose of this thesis, only fractures were included. For fractures, the section of the bone affected by trauma, type of trauma force, type of fracture, fracture sequelae, and timing of injury were recorded. Especially with well-healed fractures, identifying type of fracture or sequelae can prove difficult. If the callus was extremely well remodelled, fracture type potentially had to be recorded as 'unobservable'. Radiographic imaging of bones affected by fractures can be helpful to achieve a more comprehensive understanding of the trauma process, but the presence of sand in the medullary cavity was a limiting factor as this would impact visibility in the radiograph image. In addition, it was not possible to radiograph all bones affected by trauma within the scope of this thesis.

True prevalence rates were calculated for individual bones of the cranium, long bones by diaphysis thirds, and other large bones (e.g., scapula) (after Gilmour et al., 2015; Judd, 2002). Based on the inventory recording method, a bone or bone section had to be more than 25% complete to be included in the analysis, unless the element or section was affected by trauma. By considering the bones of the cranium separately and sectioning the long bones in thirds, a more comprehensive and detailed analysis was possible. For crude prevalence rates, however, the cranium and the individual long bones were considered as one entity. Calculating true prevalence rates was not possible for ribs, vertebrae, and bones of hands and feet. The varied preservation of these elements did not allow for this level of detail in the analysis. Instead, in addition to crude prevalence rates, prevalence rates of fractures per individuals with preserved hand and foot bones, ribs and vertebrae were calculated. In order to be classified as 'element present', more than four ribs needed to be preserved and scored as >25% preserved for one side. Left and right ribs were scored independently. The vertebrae were divided into cervical (except for C1 and C2), thoracic and lumbar vertebrae, and the body and arch were treated separately. The preservation of these elements was treated as an average and more than one quarter of the relevant section had to be present to be included in the study. The separate treatment of body and arch allowed the inclusion of arches even if the bodies were too fragmented to be considered and vice versa. If a fracture was identified in individuals with poorer preservation, these were included regardless of preservation. While this is not a true prevalence rate, it is a more accurate reflection of trauma prevalence than CPR can give us. If multiple fractures affected one area (e.g., left ribs, lumbar vertebral bodies) these were treated as one fracture in the population analysis. However, if left and right ribs, or lumbar bodies and arches were affected, this was reflected in the analysis. As only individuals with elements present rather than number of bones present could be considered, the true number of fractures could not be discussed in the thorax trauma section. Instead, multiple fractures of ribs and vertebrae are discussed in the section on multiple traumata. For hand and feet, more than two metacarpals/metatarsals had to be preserved more than 25% in one hand/foot to be included. Proximal, interproximal, and distal phalanges were combined, and more than four phalanges needed to be present in one hand/foot.

5.3.3.5. Vertebral joint disease

Joint disease was considered for the vertebral column in this thesis on a population level. The vertebral column was divided into cervical, thoracic, and lumbar vertebrae, and the articulation of the dens between atlas (C1) and axis (C2) was treated separately. Changes were recorded for the vertebral bodies as well as the articulation facets. In case of the vertebral bodies, porosity to the surface as well as marginal osteophyte formation were recorded. For the superior and inferior articulation facets and the dens articulation, porosity, marginal osteophyte formation, and eburnation were recorded. In both cases, porosity was distinguished between pinpoint porosity and larger coalescing porosity. Marginal osteophyte formation was recorded in four stages: barely discernible, sharp edges and/or slight spicules extending vertically, extensive specular formation, and ankylosis. In addition, the presence of Schmorl's nodes was recorded for the superior and inferior surface of thoracic and lumbar vertebrae. In accordance with Waldron (2019: 725), the presence of eburnation – a pathognomonic feature of osteoarthritis – or a combination of porosity and marginal osteophyte formation had to be present in order to diagnose osteoarthritis in the superior and inferior articular facets. However, these were considered manifestations of later stages of osteoarthritis, and proliferative and erosive changes to the joint surface were also considered as evidence of joint degeneration, even if the changes were not severe enough to diagnose osteoarthritis. The same recording protocol that was used for the superior and inferior articular surfaces was used for the main synovial joints reported in the osteobiographies.

Joint disease was analysed by vertebra type following the same standards used for vertebral fractures, but if one section was affected by joint disease, the individual was counted as 'joint disease present' regardless of how many elements were affected.

5.3.4. Statistical analysis

Basic statistical analysis was carried out to test the validity and significance of results. The nature of statistical testing was decided based on the data type used for the enquiry (Robb, 2000; Shennan, 2014; Stodder, 2012). The palaeopathological data used in this study can mostly be categorised as nominal data. Results were accepted as statistically significant if the p-value was equal or lower than 0.05. A p-value below 0.05 indicates that the observed differences have a 95% confidence (Shennan, 2014: 52).

To test the association between single pathological lesions (nominal data) and biological sex or burial type χ^2 tests were used. The t-test assuming normal distribution was used to test for statistical significance of differences in stature estimates between different demographic and burial groups. All statistical testing was undertaken in Microsoft 365 Excel.

5.3.5. Osteobiographical approach

Osteobiographies are a useful theoretical framework to explore the life history of single individuals by creating a narrative of the individual's life based on multiple lines of evidence. This concept was pioneered by Saul (1972) and has become more popular in recent years (see for example Robb, 2002; Stodder and Palkovich, 2012). An osteobiographical approach can enhance our understanding of the past by expanding upon more traditional analyses on a population-level and adding depth on an individual level (Hosek and Robb, 2019). The focus on one individual allows for a more nuanced analysis following an intersectional and life history approach. Intersectionality recognises that different facets of social identity such as gender, race, or socio-economic background overlap, interact, and shape the individual lived experience within a specific socio-cultural context (DeWitte and Yaussy, 2021; Iyer et al., 2008). Life history theory as a research framework is used in different research fields within the social sciences. Agarwal (2016: 131) considers 'all approaches that view the individual at any point in time as the sum of previous life experiences' as life history approach including both social and biological experiences. In health studies, the role of exposure to different social and physical factors over the life span from gestation to old age is emphasised. The impact of disease and stress during early life stages on risk of morbidity and mortality in later life is recognised in the DOHaD paradigm (Barker, 2007), and a life course approach acknowledges the importance of intergenerational effects on health (Gowland, 2015, 2018).

Osteobiographies of four individuals as representatives of the burial ground population were included. In addition to the demographic and palaeopathological information that was collected for the entire study sample, these osteobiographies provided a more detailed palaeopathological analysis including all lesions that could be observed macroscopically. The aim of these osteobiographies was to gain a more comprehensive understanding of individual lived experiences based on contextual, demographic, and palaeopathological data by using a life history and intersectional approach.

5.4. Summary

The site of Phaleron has been known since the early 20th century, but large-scale systematic excavations were only undertaken during the 2010s. These excavations unearthed approximately 1,800 burials including single inhumations, cremations, and mass burials. The characteristics of the burial ground such as lack of grave goods and organisation of burials in addition to the presence of mass burials and burial of visibly shackled individuals gave rise to the idea that the burial ground was used for the burial of the low-status and potentially marginalised population of Athens and the surrounding area during the Archaic period.

The thesis includes a sample of 206 individuals that were aged older than seven years at death. The individuals were chosen from different sectors of the burial ground to gain an overview of the entire burial ground rather than a detailed picture of a small section of the cemetery. Individuals from different burial types (normative, non-normative single, and mass burials) were included in the thesis sample.

This thesis followed the data collection protocols developed by the Phaleron Bioarchaeological Project. In addition to demographic data, palaeopathological lesions indicative of physiological stress were considered here. Lesions included indicators of early life stress as well as indicators of accumulated stress over the life course. Osteobiographies were used to gain a more nuanced picture of the lived experience of a selected number of individuals. Basic statistical analysis was used to test validity and significance of results based on demographic factors and burial types.

6. RESULTS

6.1. Introduction

This chapter provides the results of the analysis of 206 individuals from three different sectors (IV, V, and IX) of the burial ground. Preservation, burial types, and demographic data, including information on biological sex and age-at-death are presented first. The results for palaeopathological analysis of the skeletal and dental lesions are then provided. The section on trauma includes information on cranial and postcranial trauma, as well as individuals with multiple fractures and fracture recidivism.

6.2. Preservation

Preservation was highly variable in the thesis sample ranging from almost completely preserved individuals to partially and extremely poorly preserved burials. This variability was partly due to the fact that earlier burials were disturbed and truncated by later burials. This inter-cutting of graves, however, will allow the future development of an internal chronology for some of the graves, in the absence of the ability to date them via grave goods (table 6.1).

Completeness of individuals		
Completeness	***Number of individuals***	***Percentage of sample***
0-25%	34	16.5%
25-50%	37	18.0%
50-75%	41	19.9%
75-100%	94	45.6%

Table 6.1: Number of individuals and percentage of the thesis sample per completeness category (N=206).

Of the 34 individuals (16.5%) with less than 25% of their skeleton preserved, five were represented only by crania. The preserved crania allowed some inference about biological sex and age-at-death; however, for most burials in the 0-25% category, the poor preservation was a limiting factor in terms of demographic and palaeopathological evaluation.

In addition to completeness, bone surface preservation is an important factor for the observability of pathological lesions, and this also varied throughout the sample (table 6.2).

Surface preservation		
Preservation stage	***Number of individuals***	***Percentage of sample***
Excellent	4	1.9%
Good	95	46.1%
Fair	69	33.5%
Poor	38	18.4%

Table 6.2: Number of individuals and percentage of the thesis sample per surface preservation category.

The main limiting factors for surface preservation were mostly surface erosion and sediment adhesion in the form of hardened sand that could not be removed during cleaning without damaging the surface further. There was some overlap between poor surface preservation and incomplete preservation. Out of the 38 individuals with poor surface preservation, 12 were also in the category of 0-25% completeness, which constitutes 17% of the entire sample. Only eight individuals with poor surface preservation were 75-100% complete. This shows that severely limiting preservation factors were mostly confined to a smaller proportion of the sample. Poor preservation was not restricted to certain areas of the cemetery or burial types.

6.3. Burial types

Simple pit burials were the most common burial type in this thesis including both normative and non-normative single burials (table 6.3). One non-normative single burial was partially cremated in situ in a prone position; however, all methods used for inhumation could also be applied to this burial. No jar burials of infants and young children or secondary cremation burials were included in this study as they formed the basis of separate research projects (see Rothwell, 2024).

Distribution of burial types in the study sample		
Burial Type	***Number of individuals***	***Percentage of sample***
Pit burial[+]	163	79.1%
Mass burial	35	17.0%
Pit grave lined by mud plaster*	1	0.5%
Pit grave covered by slabs*	4	1.9%
Jar burial (adult)	1	0.5%
Wooden coffin	1	0.5%
Cremation	1	0.5%
Total	**206**	**100%**

Table 6.3: Number and percentage of burials per burial type included in the current study sample.
[+] *Includes single non-normative pit burials*
** combined into cist-like burials in the discussion*

In the burial sample analysed in this thesis, three instances of pit burials containing two inhumations (double burials) were identified. In all three instances, both individuals were clearly interred at the same time, but otherwise the body position varied. In double burial 1 (Figure 6.1), the two individuals IV_256 and IV_273 were buried on top of each other with both heads oriented towards north. Both individuals were in a supine position with their arms located on their torso, facing towards the left and their legs were slightly bent. A third individual (IV_645) was located below the double burial, but this was established to be an earlier single inhumation.

Figure 6.1: Double burial 1 containing individuals IV_256 and IV_273 in excavation.
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In double burial 2 (Figure 6.2), the two individuals IV_400 and IV_401 were buried next to each other with their heads position towards the south. IV_401 was in a supine extended position with the left arm stretched along the torso and the right arm across the thorax. IV_400 was buried on their right side with flexed legs with arms and legs on top of IV_401.

Figure 6.2: Double burial 2 containing individuals IV_400 and IV_401 in excavation.
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In double burial 3 (Figure 6.3), the two individuals IV_378 and IV_387 were buried on top of each other in supine extended positions with arms crossed over their torsos. IV_378 was located on top of IV_387[7]. However, they were positioned with their heads in opposite directions: IV_378 was oriented with the skull towards south, while IV_387 was oriented towards north. Additionally, a third burial of a non-adult individual (IV_502) was located directly underneath the double burial, and this individual was potentially buried at a similar time. However, it was not clear whether all three individuals were buried together intentionally.

Figure 6.3: Double burial 3 containing individuals IV_378 and IV_387 in excavation.
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These three double burials were considered normative for the purpose of this thesis; however, clear differences between burial mode in all three double burials might suggest different purposes or intentions led to the interment of two individuals in the same grave, which will be further explored in the Chapter 8.

[7] This burial was only identified as double burial after recording for this thesis finished, and IV_387 is not included in the analysis of this thesis.

The 164 pit burials also contained 39 non-normative single burials. The non-normative single burials are a varied group, and burials were identified as 'deviant' based on burial position and presence of metal bonds (Figure 6.4). These burials were identified as non-normative during excavation, and a more detailed analysis can give insights regarding whether these burials should be treated as a third burial category or not.

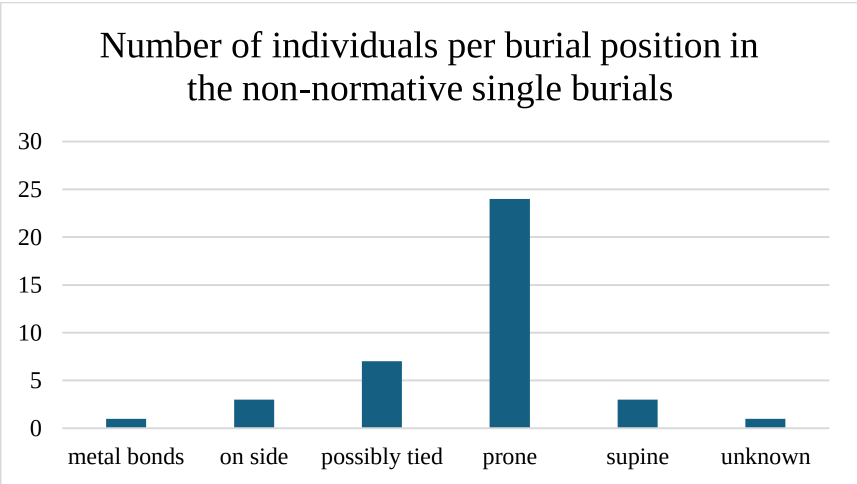

Figure 6.4: Number of individuals per burial position defined as non-normative single burials.

Eight mass burials were identified containing a total of 35 individuals. Mass burial 1 was the largest with 12 individuals, and the other mass burials ranged between three and four individuals. While the appropriate categorisation of burial groups is still ongoing, both mass burials and non-normative single burials were considered as discrete burial types in the Phaleron Bioarchaeological Project, and any demographic and palaeopathological differences between the normative burials, non-normative single burials, and mass burials are investigated.

In comparison with the overall burial distribution for the Phaleron cemetery (Chapter 5, table 5.1), pit graves and mass burials are overrepresented in this thesis sample, while cist-like burials (pit burials covered with stone slabs or lined with mud) are slightly underrepresented.

6.4. Demographic results

Approximately one third of burials across the entire Phaleron cemetery were identified as infants and young children (see table 5.1 with a percentage of pot burials of 34.02%). This suggests a normal attritional burial ground, but more detailed anthropological analysis will be necessary in order to gain a more comprehensive demographic profile of the entire excavated cemetery sample. The study sample for this thesis constituted only a sub-section of the cemetery, and this sample is not representative of the entire cemetery population as no non-adults under the age of six years were included.

6.4.1. Biological Sex

Analysis of biological sex was undertaken using the methods described in Chapter 5. This information was supplemented with ancient DNA analysis for some adult individuals, provided by the Max Planck Institute for Evolutionary Anthropology[8]. The genetic sex data correlated well with the skeletal estimates of biological sex, thus confirming the presence of clear sexual dimorphism in skeletal traits.

Table 6.4 and Figure 6.5 detail the distribution of biological sex in the study sample regardless of burial type. For 52 individuals (25.2%) it was not possible to estimate biological sex due to incomplete preservation (38 individuals) or young age-at-death (indeterminate) (14 individuals). Additionally, 14 individuals (6.8%) did not

[8] This data is unpublished.

display clear male or female skeletal characteristics, therefore, biological sex was categorised as 'ambiguous'. For the analysis, the categories 'possible female' and 'female' were combined into one female category, and the categories 'possible male' and 'male' were merged into one male category.

Demographic profile of the study sample					
	female	*male*	*ambiguous*	*indeterminate*	*total*
Normative burials					
7-11y	0	0	0	1	1
12-17y	1	1	0	6	8
18-34y	17	27	3	1	48
35-49y	1	2	0	0	3
50+y	0	5	0	0	5
18+y	12	23	2	30	67
Total	**31**	**58**	**5**	**38**	**132**
Non-normative single burials					
7-11y	0	0	0	2	2
12-17y	0	0	0	2	2
18-34y	4	8	0	0	12
35-49y	0	0	2	1	3
50+y	1	3	0	0	4
18+y	3	8	2	3	16
Total	**8**	**19**	**4**	**8**	**39**
Mass burials					
7-11y	0	0	0	0	0
12-17y	0	0	0	3	3
18-34y	0	14	1	2	17
35-49y	0	2	0	0	2
50+y	0	0	0	0	0
18+y	0	8	4	1	13
Total	**0**	**24**	**5**	**6**	**35**
Combined					
7-11y	0	0	0	3	3
12-17y	1	1	0	11	13
18-34y	21	49	4	3	77
35-49y	1	4	2	1	8
50+y	1	8	0	0	9
18+y	15	39	8	34	96
Total	**39**	**101**	**14**	**52**	**206**

Table 6.4: Demographic profile of the study sample by burial types and combined.

Ambiguous and indeterminate individuals were treated combined as 'unsexed' individuals in the palaeopathological analysis. Males form the majority in this thesis sample, while females are comparatively underrepresented.

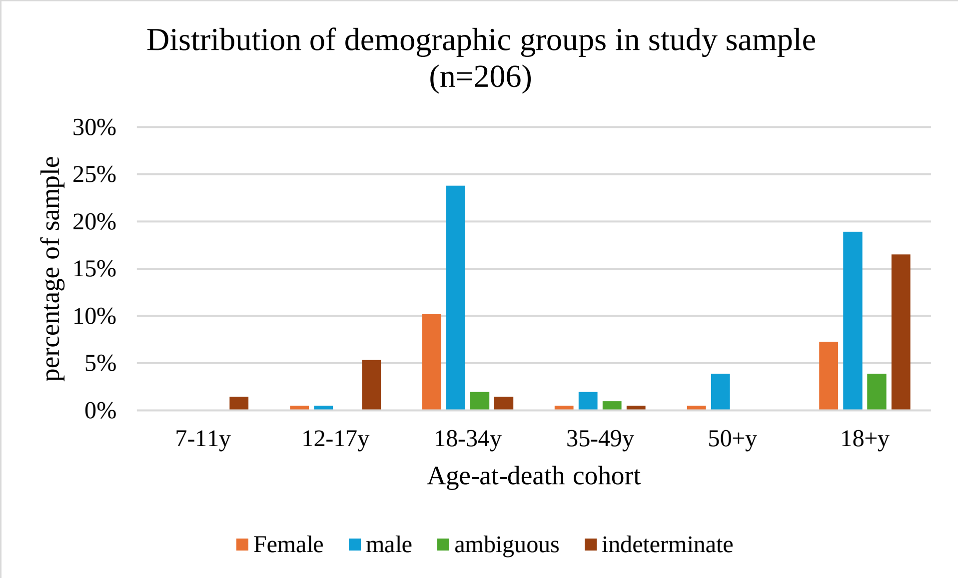

Figure 6.5: Distribution of demographic groups in percentage of the overall the study sample (n=206)

When evaluating the sex distribution amongst the normative burials compared to the overall thesis sample, the male bias is slightly reduced (Figure 6.6), while in the non-normative burials, the male bias is more pronounced than in the entire thesis sample (Figure 6.7 and 6.8). This bias is especially pronounced in the mass burials, where no (possible) females were identified.

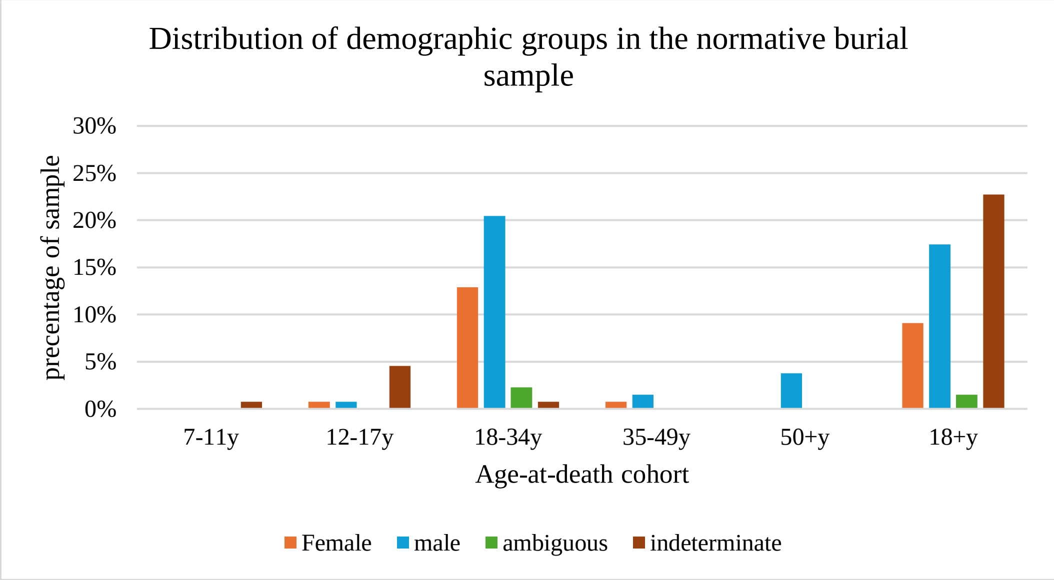

Figure 6.6: Distribution of demographic groups in percentage of the normative burial sample (n=132)

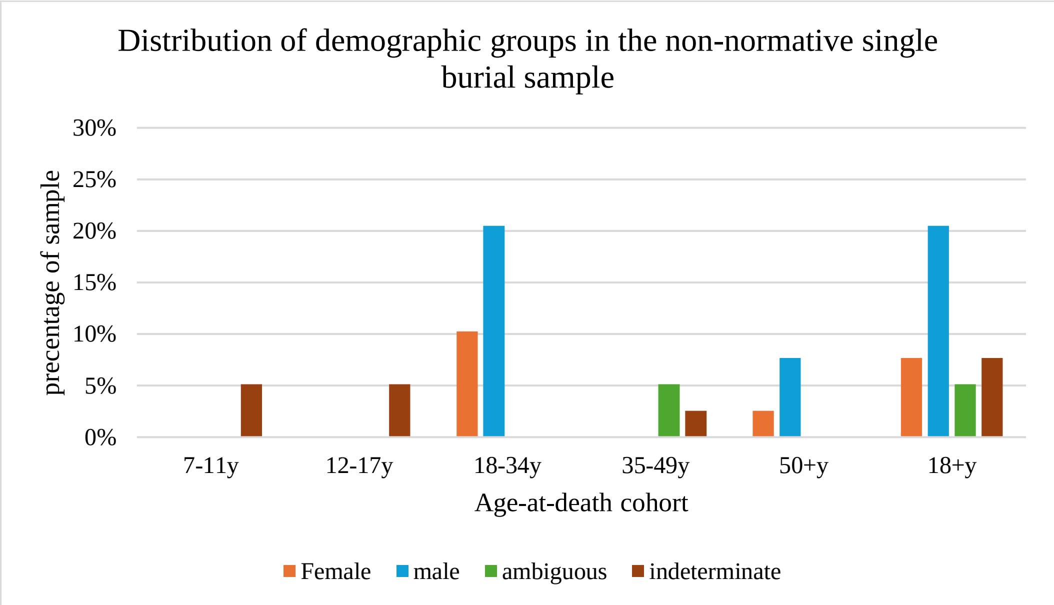

Figure 6.7: Distribution of demographic groups in percentage of the non-normative single burial sample (n=39).

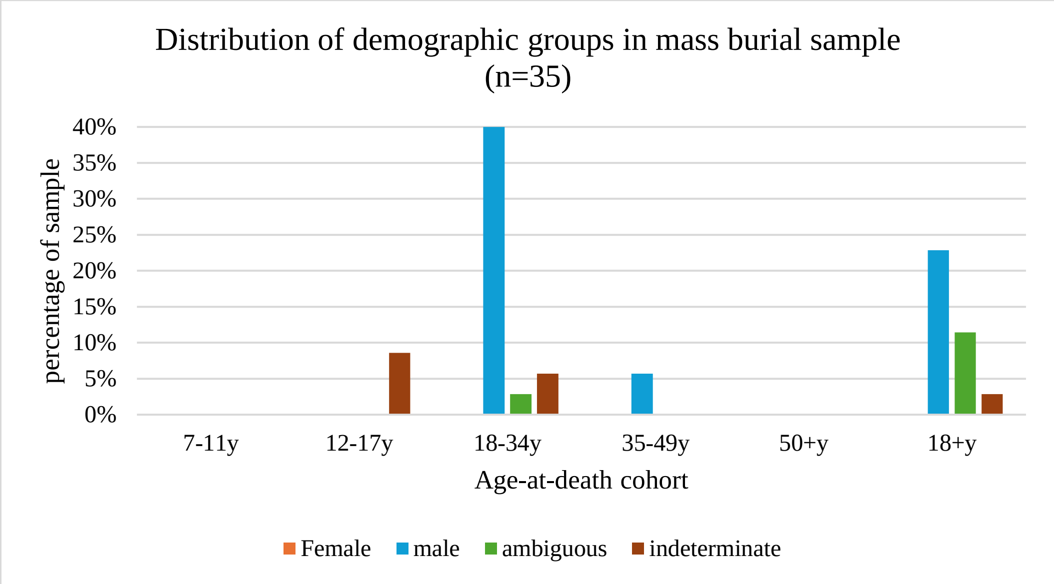

Figure 6.8: Distribution of demographic groups in percentage of the mass burial sample (n=35).

While it can be argued that – overall – approximately half of the sample estimated as (possible) males is in line with a normal attritional cemetery population, it is unlikely that all individuals estimated as ambiguous or indeterminate were females. This would be an exceptional preservation bias and cannot be confirmed. Instead, there appears to be a cultural bias in the sample, especially in the non-normative burials and more specifically in the mass burials.

6.4.2. Age-at-death

In this thesis sample, older children (7-11 years), adolescents (12-17 years), and adults (older than 18 years) of different cohorts were included. Figure 6.5 and table 6.4 detail individuals by biological sex category per age-at-death category. In addition to the male bias, there also appears to be a bias towards young adults aged 18 to 34 years. However, the estimation of age-at-death becomes gradually more difficult with increasing age, and it is possible that the 'adult' category (18+ years) includes individuals from older adult age-at-death cohorts.

In the normative burial sample, the individuals estimated as 18+ years comprised the largest group followed by individuals aged 18-34 years. All other age-at-death cohorts were represented by less than 10 individuals each (table 6.4 and Figure 6.6). Similarly, individuals estimated as 18+ years represented the largest group in the non-normative single burials also followed by the 18-34 years cohorts (table 6.4 and Figure 6.7). All other age-at-death categories were represented by four or less individuals. Within the mass burials, young adults (18-34 years) comprised the largest group followed by adults (18+ years). Other age-at-death cohorts were represented by two and three individuals respectively, and no individual aged older than 50 years was identified in the mass burials (table 6.4 and Figure 6.8).

The age-at-death curve was similar for all three sub-samples with young adults and adults forming the largest age-at-death cohort (Figure 6.9). The high number of individuals that could not be aged more accurately than adult is problematic when we try to look at disease load based on age-at-death; however, due to preservation (poor surface preservation, fragmentation, and truncation of burials) more precise age-at-death estimations were not possible. For young adults, it was possible to use epiphyseal union in some instances, which might have resulted in a higher percentage of young adults being identified in comparison to the two more mature age-at-death cohorts.

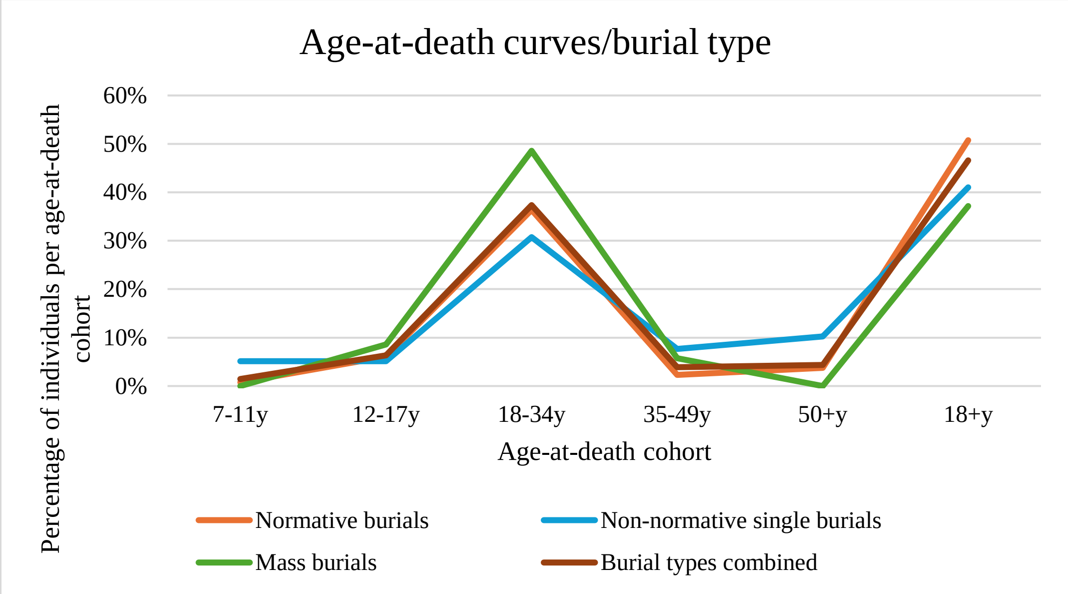

Figure 6.9: Age-at-death curves by burial category as percentage of respective burial category regardless of biological sex.

6.5. Palaeopathological results

Analysis of palaeopathological lesions showed an overall high prevalence of indicators of childhood stress, dental disease, inflammation, and an exceptionally high prevalence of skeletal trauma. In the following section, the prevalence of lesions is examined by burial group and with consideration of demographic parameters.

6.5.1. Childhood stressors

Under the umbrella of indicators of stress during infancy and childhood, cribra orbitalia (CO), dental enamel hypoplasia (DEH), and short stature are considered.

6.5.1.1. Cribra orbitalia

For the entire sample, 109 individuals (52.9%) had orbits with observable surfaces preserved, and 31 of these (28.4%) showed porotic changes to at least one orbit. An additional 29 individuals (26.6%) were affected by capillary impressions only; however, these changes were not considered to be indicators of physiological stress. For the calculations of prevalence rate, only one orbit had to be preserved to be counted in the 'orbit present' sample. If both orbits were affected by CO, and the lesions were asymmetric in severity, the more advanced stage of disease expression was used.

Prevalence of Cribra orbitalia – Normative burials				
	female	***male***	***unsexed***	***total***
7-11y				
orbits present	0/0	0/0	1/1 (100)	1/1 (100)
CO present	0/0	0/0	1/1 (100)	1/1 (100)
12-17y				
orbits present	1/1 (100)	0/1	4/6 (66.7)	5/8 (62.5)
CO present	1/1 (100)	0/0	2/4 (50)	3/5 (60)
18-34y				
orbits present	12/17 (70.6)	17/27 (63.0)	1/4 (25.0)	30/48 (62.5)
CO present	5/12 (41.7)	5/17 (29.4)	1/1 (100)	11/30 (36.7)
35-49y				
orbits present	1/1 (100)	2/2 (100)	0/0	3/3 (100)
CO present	0/1	1/2 (50)	0/0	1/3 (33.3)
50+y				
orbits present	0/0	4/5 (80)	0/0	4/5 (80)
CO present	0/0	0/4	0/0	0/4
18+y				
orbits present	10/12 (83.3)	15/23 (65.2)	3/32 (9.4)	28/67 (41.8)
CO present	3/10 (33.3)	5/15 (33.3)	1/3 (33.3)	9/28 (32.1)
total				
orbits present	24/31 (77.4)	38/58 (65.5)	9/43 (20.1)	71/132 (53.8)
CO present	9/24 (37.5)	11/38 (28.9)	5/9 (55.5)	25/71 (35.2)

Table 6.5: Presence of orbits and prevalence of cribra orbitalia in the normative burial sample. Percentage of orbits preserved in the study sample and orbits with observable CO present in parentheses.

In the normative burial sample, 25 out of 71 individuals with observable orbits displayed porotic lesions (35.2%) (table 6.5). Females showed a higher frequency than males, but lesion expression was more severe in males ('porosity' vs. 'porosity with coalescence'). The non adult age-at-death categories showed the highest prevalence of CO, but the sample was comparatively small. The adult cohorts showed lower prevalence rates of CO with increasing age-at-death. Individuals whose age was estimated to be older than 50 years were either affected by capillary impressions only or showed no lesions.

Prevalence of Cribra orbitalia – Non-normative single burials				
	female	***male***	***unsexed***	***total***
7-11y				
orbits present	0/0	0/0	1/2 (50.0)	1/2 (50.0)
CO present	0/0	0/0	0/1	0/1
12-17y				
orbits present	0/0	0/0	2/2 (100)	2/2 (100)
CO present	0/0	0/0	1/2 (50.0)	1/2 (50.0)
18-34y				
orbits present	2/4 (50)	6/8 (75.0)	0/0	8/12 (66.7)
CO present	0/2	1/6 (16.7)	0/0	1/8 (12.5)
35-49y				
orbits present	0/0	0/0	1/3 (33.3)	1/3 (33.3)
CO present	0/0	0/0	0/1	0/1
50+y				
orbits present	0/1	3/3 (100)	0/0	3/4 (75.0)
CO present	0/0	0/3	0/0	0/3
18+y				
orbits present	3/3 (100)	6/8 (75.0)	0/5	9/16 (56.3)
CO present	0/3	0/6	0/0	0/9
total				
orbits present	5/8 (62.5)	15/19 (78.9)	4/12 (33.3)	24/39 (61.5)
CO present	0/5	1/15 (6.7)	1/4 (25.0)	2/24 (8.3)

Table 6.6: Presence of orbits and prevalence of cribra orbitalia in the non-normative single burial sample. Percentage of orbits preserved in the study sample and orbits with observable CO present in parentheses.

In the non-normative single burials, 24 individuals (61.5%) had at least one observable orbit preserved. The prevalence of CO in this subsection of the study sample was lower than for the entire sample with only two individuals affected by CO (8.3%) (table 6.6). The highest prevalence was observed for non-adults; however, few non-adults were present rendering these results unrepresentative. In the adult sample, only males were affected by CO, and the prevalence rate was lower than in the normative burials. As observed in the normative sample, higher prevalence of CO was present in the younger adult age-at-death cohorts.

Prevalence of Cribra orbitalia – Mass burials				
	female	*male*	*unsexed*	*total*
7-11y				
orbits present	0/0	0/0	0/0	0/0
*CO present**	0/0	0/0	0/0	0/0
12-17y				
orbits present	0/0	0/0	1/3 (33.3)	1/3 (33.3)
*CO present**	0/0	0/0	0/1	0/1
18-34y				
orbits present	0/0	8/14 (57.1)	0/3	8/17 (47.1)
*CO present**	0/0	2/8 (25.9)	0/0	2/8 (25.9)
35-49y				
orbits present	0/0	2/2 (100)	0/0	2/2 (100)
*CO present**	0/0	1/2 (50.0)	0/0	1/2 (50.0)
50+y				
orbits present	0/0	0/0	0/0	0/0
*CO present**	0/0	0/0	0/0	0/0
18+y				
orbits present	0/0	2/8 (25.0)	1/5 (20.0)	3/13 (23.1)
*CO present**	0/0	1/2 (50.0)	0/1	1/3 (33.3)
total				
orbits present	0/0	12/24 (50.0)	2/11 (18.2)	14/35 (40.0)
*CO present**	0/0	4/12 (33.3)	0/2	4/14 (28.6)

Table 6.7: Presence of orbits and prevalence of cribra orbitalia in the mass burial sample. Percentage of orbits preserved in the study sample and orbits with observable CO present in parentheses.

For the individuals from the mass burials, preservation was a severely limiting factor for the analysis of CO. Out of 35 individuals, only 14 individuals (40.0%) had at least one observable orbit preserved. Porotic changes consistent with CO were observed in four individuals interred in mass burials (28.6%) (table 6.7). Only males showed evidence of CO in form of porosity and porosity with coalescence. CO was identified in all present age-at-death cohorts. The only adolescent individual with orbits preserved showed capillary impressions, but these were not considered clear evidence of physiological stress. The individuals in the mass burials differed from the other two burial types with older individuals showing higher prevalence rates than the younger age-at-death cohorts. However, the mass burial sample was small with only 14 individuals.

In summary, the highest prevalence of CO was identified in the normative sample, while the individuals buried in non-normative single burials displayed the lowest frequency. Generally, individuals from younger age-at-death cohorts showed higher prevalence rates than individuals aged older than 35 years, but the association of disease prevalence and age-at-death cohorts was not statistically significant (χ^2 test: p-value: 0.298). A comparison between males and females was problematic due to the relatively low number of females with orbits preserved in the non-normative sample. In the normative burials, females displayed a higher prevalence than males, but this difference was not statistically significant (χ^2 test: p-value: 0.483). The difference in prevalence between normative and non-normative burials (mass burials and single burials combined) regardless of biological sex and age-at-death was statistically significant (χ^2 test: p-value: 0.032), but this might be driven more by the low prevalence in the non-normative single burials than prevalence in the mass burials.

6.5.1.2. Dental Enamel Hypoplasia

Dental enamel hypoplasia (DEH) was present in all burial types and affected all demographic groups. The majority of data was obtained from permanent dentition. The TPR for DEH in the entire sample was 40.1%. Canines were most affected followed by incisors and first premolars (table 6.8). The lowest prevalence of DEH was present in the third molars. Most defects were linear grooves, but a few instances of non-linear pits or single pits were observed.

Presence of DEH per tooth type			
	Teeth observable	***Teeth with DEH present***	***% of teeth with DEH present***
M3	273	34	12.5%
M2	339	61	18.0%
M1	309	48	15.5%
PM2	352	129	36.6%
PM1	348	155	44.5%
C	374	281	75.1%
I2	293	174	59.4%
I1	285	150	52.6%
Total	**2573**	**1032***	**40.1%**

*Table 6.8: True prevalence rates for DEH per tooth type (mandible/maxilla and left/right combined). * This number also includes 11 teeth that were the only affected teeth in the individuals' dentition.*

The normative burials showed a higher TPR for DEH of 48.2% (table 6.9). Females displayed the highest true prevalence, while the highest CPR was detected for males. Non-adults had a higher TPR of DEH than the adult age-at-death cohorts. In addition to the permanent dentition, 21 deciduous teeth were available for the normative burials. Most deciduous teeth were present in non-adults with mixed dentition, but a few adults had retained deciduous teeth. Only one deciduous tooth of an individual aged 7-11 years showed evidence of DEH (TPR 7.1%). This individual also had permanent dentition affected by DEH; thus, the evidence for deciduous teeth did not impact the CPR.

The TPR for DEH in the non-normative single burials was substantially lower than in the normative burial sample with 19.5% (table 6.9). In the adult population, TPR for DEH was comparable for males and females. None of the adult unsexed individuals showed any enamel defects in the permanent dentition. Similar to the normative burials, individuals aged under 18 years at death showed a higher TPR than the adult age-at-death cohorts. However, the evidence for DEH in the age-at-death category 7-11 years was extremely limited. One tooth showed evidence of linear defects, however, as only one tooth was affected, this did not count as an indicator of stress as defined in the methodology and was, therefore, not included. The highest CPR was identified in males and individuals aged 12-17 years. In the single non-normative burials, 18 deciduous teeth were present, but none of these teeth showed any signs of developmental defects.

The TPR for DEH in the mass burials was between the normative and non-normative single burials with 28.6% (table 6.9). Most instances of DEH and the highest TPR were observed for males. There was no evidence in the non-adult individuals for DEH, but the representation of this group was limited in the mass burials. Young adults (18-34 years) had the highest TPR followed by middle adults (35-49 years). No deciduous teeth were identified, so all evidence for DEH was observed in the permanent dentition. CPR for the mass burials was 22.9% overall with the highest rates for males and middle adults.

In summary, normative burials displayed the highest prevalence of developmental enamel defects followed by mass burials. Males consistently displayed higher CPRs, but females showed a higher TPR of DEH than males in the normative burials. The difference between males and females in the normative burial sample was not statistically significant (χ^2 test: p-value: 0.282). In contrast, the prevalence differences between males buried in normative burials and non-normative burials was statistically significant (p-value for combined non-normative burials: 0.000403; p-value for mass burials only: 0.00028). There was no significant association between presence of DEH and age-at-death regardless of biological sex and burial type (χ^2 test: p-value: 0.407).

Prevalence of DEH in the permanent dentition								
	TPR				***CPR***			
	F	***M***	***?***	***Total***	***F***	***M***	***?***	***Total***
Normative burials								
7-11	0/0	0/0	6/14 (42.9)	6/14 (42.9)	0/0 (0)	0/0	1/1 (100)	1/1 (100)
12-17	20/28 (71.4)	0/0	82/99 (82.8)	102/127 (80.3)	1/1 (100)	0/1	5/6 (83.3)	6/8 (75.0)
18-34	188/300 (62.7)	238/544 (43.8)	16/33 (48.5)	442/877 (49.8)	13/17 (76.4)	22/27 (81.5)	0/4	35/48 (72.9)
35-49	0/13 (0)	6/13 (46.2)	0/0	6/26 (23.1)	0/1 (0)	1/2 (50.0)	0/0	1/3 (33.3)
50+	0/0 (0)	22/75 (29.3)	0/0	22/75 (29.3)	0/0	2/5 (40.0)	0/0	2/5 (40.0)
18+	35/83 (42.2)	175/360 (48.6)	44/165 (26.7)	254/608 (41.8)	5/12 (41.7)	17/23 (73.9)	10/32 (31.3)	32/67 (47.8)
Total	**243/424 (57.3)**	**441/992 (44.5)**	**148/311 (47.6)**	**832/1727 (48.2)**	**19/31 (61.3)**	**42/58 (72.4)**	**16/43 (37.2)**	**77/132 (58.3)**
Non-normative single burials								
7-11	0/0	0/0	0/17	0/17	0/0	0/0	0/2	0/2
12-17	0/0	0/0	12/30 (40.0)	12/30 (40.0)	0/0	0/0	2/2 (100)	2/2 (100)
18-34	14/43 (32.6)	37/136 (27.2)	0/0	51/179 (28.5)	2/4 (50.0)	4/8 (50.0)	0/0	6/12 (50.0)
35-49	0/0	0/0	0/33	0/33	0/0	0/0	0/3	0/3
50+	0/20	2/54 (3.7)	0/0	2/74 (2.7)	0/1	1/3 (33.3)	0/0	1/4 (25.0)
18+	10/48 (20.8)	32/123 (26.0)	0/44	42/215 (19.5)	1/3 (33.3)	4/8 (50.0)	0/5	5/16 (31.3)
Total	**24/111 (21.6)**	**71/313 (22.6)**	**12/124 (9.7)**	**107/548 (19.5)**	**3/8 (37.5)**	**9/19 (47.4)**	**2/12 (16.7)**	**14/39 (35.9)**
Mass burials								
7-11	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17	0/0	0/0	0/18	0/18	0/0	0/0	0/3	0/3
18-34	0/0	70/189 (37.0)	0/0	70/189 (37.0)	0/0	5/14 (35.7)	0/3	5/17 (29.4)
35-49	0/0	10/37 (27.0)	0/0	10/37 (27.0)	0/0	2/2 (100)	0/0	2/2 (100)
50+	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18+	0/0	0/30	2/13 (15.4)	2/33 (6.1)	0/0	0/8	1/5 (20.0)	1/13 (7.7)
Total	**0/0**	**80/256 (31.3)**	**2/31 (6.5)**	**82/287 (28.6)**	**0/0**	**7/24 (29.2)**	**1/11 (9.1)**	**8/35 (22.9)**

Table 6.9: TPR and CPR for DEH of the permanent dentition. Percentage frequency in parentheses. If only one tooth was affected per individual, this was not included.

6.5.1.3. *Stature*

Stature could be estimated for 91 out of 199 individuals (45.7%) whose long bones had completely fused. This included 61 individuals from normative burials (48.0%), 13 from non-normative single burials (35.1%), and 17 from mass burials (48.6%). Males and females were similarly represented with 59 male individuals (58.4%) and 22 female individuals (56.4%) respectively. Stature estimation was only possible for ten unsexed individuals (17.2%).

Combining all individuals regardless of burial type (Figure 6.10), females showed a median stature of 152.14 cm with a standard deviation (SD) of 5.72 cm. Two individuals fell outside two standard deviations; these were taller than the expected stature estimates. For males, the median stature was calculated as 165.66 cm with an SD of 7.17 cm. Five individuals were outside two standard deviations; two individuals fell below and three above the expected stature estimates. For unsexed individuals, the median height was 166.05 cm with an SD of 8.44 cm. All individuals fell within two standard deviations. As expected, females showed a lower median height than males.

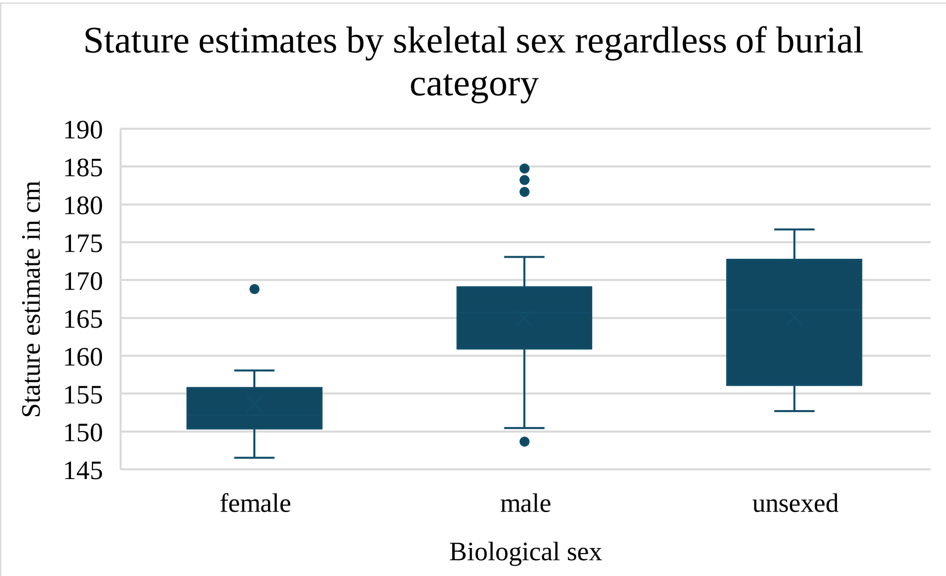

Figure 6.10: Stature estimation using the sex specific formulae for females and males and the generic formula for unsexed individuals regardless of burial category (N=91). Stature estimates are in cm.

A comparison of estimated stature in the normative burials by biological sex showed a similar picture to the overall stature estimates with a higher mean stature for males (164.73 cm) than females (154.87 cm) with a higher SD of 8.40 cm in males versus 7.07 cm for females (Figure 6.11). The difference in estimated stature between males and females in the normative burials was statistically significant (t-test; p-value: <0.001).

Due to the lower number of female and unsexed individuals, it was not possible to report any meaningful results based on burial type for females and unsexed adults. The two females with statures outside of two standard deviations were buried in normative burials. Stature estimation for individuals from non-normative single burials was only possible for two females and both were estimated close to the median height.

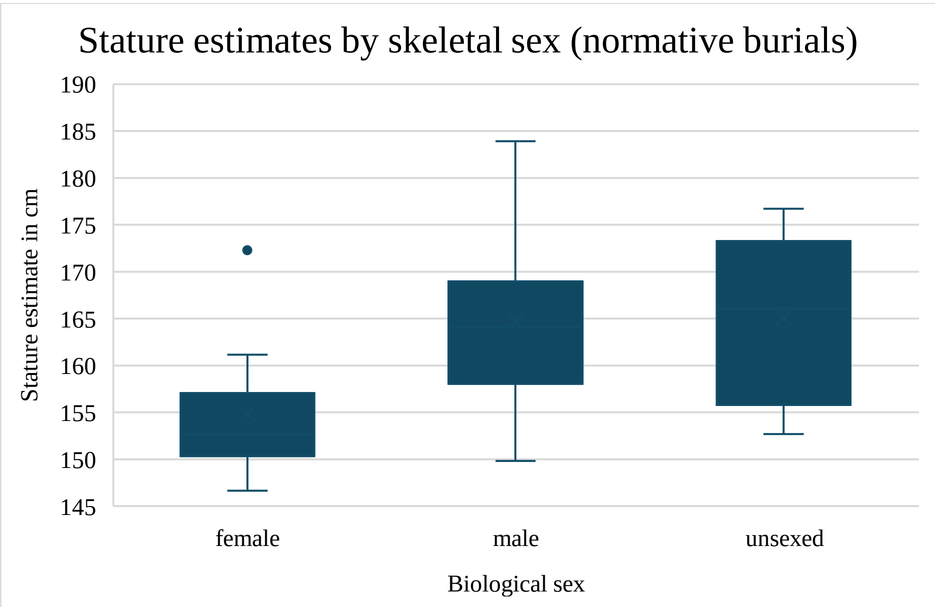

Figure 6.11: Stature estimation using the sex specific formulae for females and males and the generic for unsexed individuals in the normative burial sample (N=61). Stature estimates in cm.

For males, 35 individuals from normative burials, nine from non-normative single burials, and 15 from mass burials were available for stature estimation (Figure

6.12). Non-normative single burials showed the tallest median height with 167.43 cm, while the median height was lowest in mass burials with 163.53 cm. Non-normative single burials also showed the highest SD of 8.17 cm; however, the difference in height from minimum and maximum height was the largest in the normative burials with 34.55 cm in comparison to non-normative single burials (30.21 cm) and mass burials (19.25 cm). The individuals buried in mass burials displayed the least variation in stature and all were within two standard deviations from the overall and mass burial mean height. The difference in male stature was not significant between burial types (t-test; p-value: 0.91).

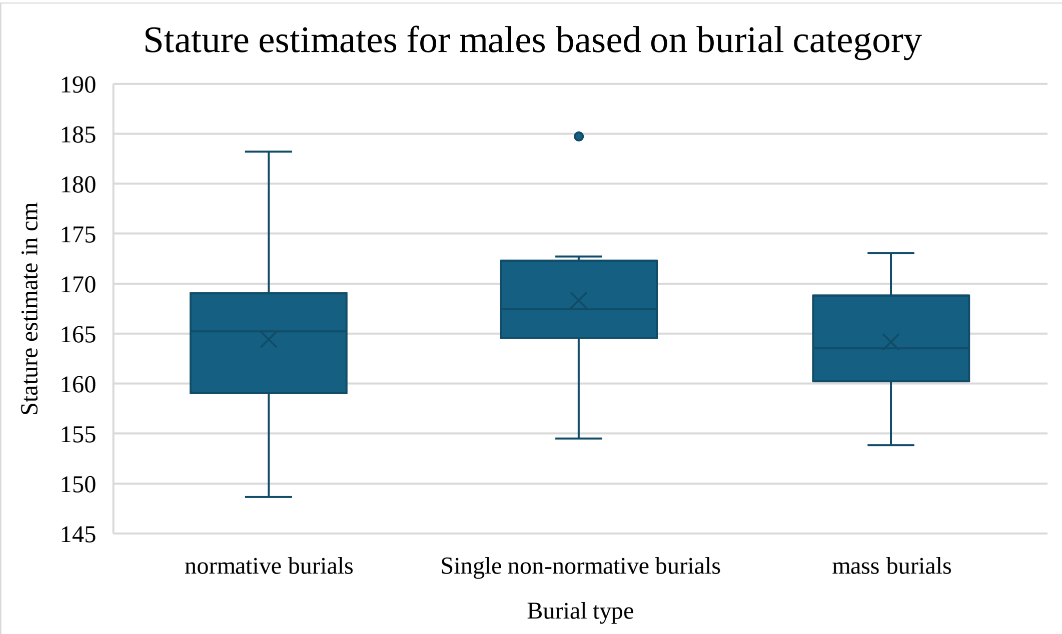

Figure 6.12: Stature estimates using the sex specific formulae for male individuals grouped by burial type. Stature estimates in cm.

For statistical purposes, the age-at-death categories 35-49 years and 50+ years were combined to test for an association between short adult statue and higher risk of mortality. Regardless of burial category, it was not possible to identify a statistically significant association between younger age-at-death and shorter stature for male and female combined (p-value: 0.92) and male alone (χ^2 test: p-value: 0.34).

The stature estimations and analysis of stature were limited by several factors. Ideally, femur lengths would have been used as a proxy for stature rather than calculated stature using regression formulae. However, the preservation of long bones did not allow use of femora alone, and instead stature obtained from different long bone measurements had to be used. The demographic structure of the sample in combination with high levels of fragmentation did not allow for comparisons between different burial groups other than for males, but for the normative burials a statistically significant difference of stature estimates between males and females could be identified.

6.5.1.4. Childhood stressors: Summary

Preservation was an overall limiting factor for recording of childhood stressors, but some clear trends were visible. Normative burials showed the highest prevalence rates for CO and DEH. Females were more affected by these early life stressors than males based on TPR, and younger age-at-death cohorts displayed higher frequencies of early life stressors than older individuals. The median stature of male normative burials fell between single non-normative and mass burials.

Individuals buried in non-normative single burials showed the lowest prevalence rates for early life stressors and the median stature for males was estimated higher than for males in the normative and mass burial samples. Males were slightly more affected by CO and DEH than females, and similar to the normative burials, younger individuals showed higher prevalence rates for childhood stressors than middle and mature adults.

Prevalence rates for early life stressors in the mass burials were between normative and non-normative single burials. Comparisons between demographic groups proved difficult for the mass burial sample due to the biased demographic structure. The median stature for males was the lowest of all three burial groups, but the standard deviation was the lowest for the mass burials meaning there was less variation in stature for the mass burials than in the other two burial groups.

Regardless of biological sex, age-at-death, and burial type, the co-occurrence of DEH and CO was not statistically significant (χ^2 test: p-value: 0.637).

6.5.2. Dental disease

This section presents data for the different forms of dental disease considered in the thesis. All diseases reported here are cumulative in nature and considered indicators of stress and disease over the life course.

6.5.2.1. Caries

The overall TPR for caries in this thesis sample based on 206 individuals was 6.3% with 228 of 3598 teeth affected by at least one instance of caries (table 6.10). If one tooth was affected by more than one carious lesion, this is not reflected here. Molars showed the highest frequency of caries – third molars were mostly affected – followed by second premolars. The lowest frequency was observed in the incisors. This pattern is consistent with what is expected based on tooth position and morphology.

Interproximal caries was by far the most common location in the sample (51.0%). Occlusal caries, caries at the cementoenamel junction (CEJ), and lesions that destroyed the crown to an extent that origin location could not be determined were present approximately equally. Lesions of the smooth buccal and lingual surface and root caries had the lowest frequency (table 6.11).

Prevalence of caries per tooth type			
	# teeth present	***# teeth affected by caries***	***Percentage***
M3	351	45	12.8%
M2	434	49	11.3%
M1	423	41	9.7%
PM2	468	28	6.0%
PM1	490	19	3.9%
C	494	23	4.7%
I2	470	13	2.8%
I1	468	10	2.1%
sum	3598	228*	6.3%

Table 6.10: True prevalence rates of caries affecting the permanent dentition in the entire study sample by type of tooth regardless of demographic profile and burial category.
** This number reflects the number of teeth affected and does not consider multiple instances of caries affecting one tooth.*

Caries location		
Location	***Number of lesions***	***Percentage***
occlusal	32	12.5%
interproximal	130	51.0%
CEJ	37	14.5%
smooth surfaces	11	4.3%
roots	11	4.3%
large caries with unknown origin site	34	13.3%
sum	255*	100.0%

Table 6.11: Location of caries affecting the permanent dentition in the entire study sample by type of tooth regardless of demographic profile and burial category.
** This number reflects number of caries and does not reflect how many teeth were affected.*

In the normative burials, the TPR for caries was 8.7%, which was slightly higher than the overall frequency of 6.3% in the entire thesis sample (table 6.12). Females showed a higher TPR (13.3%) and CPR (64.5%) of caries than males. Non-adults displayed the lowest TPR in the permanent dentition. The highest TPR for permanent teeth was present in the two more advanced adult age-at-death cohorts. A higher prevalence of caries in these age-at-death cohorts is consistent with what is expected in a cumulative disease process such as caries. In addition, 21 deciduous teeth were present of which three were affected by interproximal caries (14.3%). One affected individual was aged 7-11 years, one 12-18 years, and one 18-34 years. For the adult and adolescent individual, the caries affected a retained deciduous tooth, while the child showed mixed dentition. All three individuals also had carious lesions affecting the permanent dentition, meaning this did not affect the CPR, which was 46.4% in the normative burials considering all individuals. The highest frequency was recorded for females and the lowest for unsexed individuals. Mirroring the TPR, an increase in caries prevalence with increasing age was visible. However, all cohorts with a CPR of 100% included only a low number of individuals. The difference in caries prevalence between males and females was not statistically significant (p-value: 0.314551).

Caries prevalence rates in the non-normative single burials was similar to the normative burials (TPR: 9.3%) (table 6.12). Here, females showed a lower TPR but higher CPR of caries than males. Prevalence by age-at-death also increased with increasing age-at-death in the single non-normative burials with the more advanced age cohorts displaying the highest prevalence of caries. In contrast, none of the permanent teeth in the 7-11 years cohort were affected by caries, and the prevalence was also low in the 18+ years category. A small number of deciduous teeth were present; one was a retained deciduous tooth in a male individual aged 18-34 years and 17 deciduous teeth were preserved for the 7-11 years cohort. Five teeth associated with one individual aged 7-11 years were affected by interproximal caries, while none of the permanent teeth in this individual showed evidence of caries. The CPR for caries was 46.2% and, therefore, comparable to the CPR of the normative sample.

Prevalence rates of caries								
	TPR				***CPR***			
	F	***M***	***?***	***Total***	***F***	***M***	***?***	***Total***
Normative burials								
7-11y	0/0	0/0	2/32 (6.3)	2/32 (6.3)	0/0	0/0	1/1 (100)	1/1 (100)
12-17y	2/28 (7.1)	0/0	2/112 (1.8)	4/140 (2.9)	1/1 (100)	0/1	2/6 (33.3)	3/8 (37.5)
18-34y	39/338 (11.5)	40/623 (6.4)	0/46	79/1007 (7.8)	11/17 (64.7)	12/27 (44.4)	0/4	23/48 (47.9)
35-49y	6/21 (28.6)	5/16 (31.1)	0/0	11/37 (29.7)	1/1 (100)	2/2 (100)	0/0	3/3 (100)
50+y	0/0	14/90 (15.6)	0/0	16/115 (13.9)	0/0	5/5 (100)	0/0	5/5 (100)
18+y	19/111 (17.1)	29/415 (7.0)	18/201 (9.0)	64/702 (9.1)	7/12 (58.3)	12/23 (52.2)	8/32 (25.0)	27/67 (40.3)
Total	**66/498 (13.3)**	**88/1144 (7.7)**	**22/391 (5.6)**	**176/2033 (8.7)**	**20/31 (64.5)**	**31/58 (53.4)**	**11/43 (25.6)**	**62/132 (47.0)**
Non-normative single burials								
7-11y	0/0	0/0	0/42	0/42	0/0	0/0	0/2	0/2
12-17y	0/0	0/0	3/50 (6.0)	3/50 (6.0)	0/0	0/0	1/2 (50)	1/2 (50)
18-34y	6/57 (10.5)	5/166 (3.0)	0/0	11/223 (4.9)	2/4 (50)	3/8 (37.5)	0/0	5/12 (41.7)
35-49y	0/0	0/0	18/56 (32.1)	18/56 (32.1)	0/0	0/0	3/3 (100)	3/3 (100)
50+y	1/24 (4.2)	21/75 (28.0)	0/0	22/99 (22.2)	1/1 (100)	2/3 (66.7)	0/0	3/4 (75)
18+y	2/30 (6.7)	14/205 (6.8)	0/49	16/284 (5.6)	2/3 (66.7)	4/8 (50)	0/5	6/16 (37.5)
Total	**9/111 (8.1)**	**40/446 (9.0)**	**21/197 (10.7)**	**70/754 (9.3)**	**5/8 (62.5)**	**9/19 (47.4)**	**4/12 (33.3)**	**18/39 (46.2)**
Mass burials								
7-11y	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17y	0/0	0/0	0/25	0/25	0/0	0/0	0/3	0/3
18-34y	0/0	6/326 (1.8)	0/28	6/354 (1.7)	0/0	2/14 (14.3)	0/3	2/17 (11.8)
35-49y	0/0	0/62	0/0	0/62	0/0	0/2	0/0	0/2
50+y	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18+y	0/0	0/183	3/36 (8.3)	3/219 (1.4)	0/0	0/8	1/5 (20)	1/13 (7.7)
Total	**0/0**	**6/571 (1.1)**	**3/89 (3.4)**	**9/660 (1.4)**	**0/0**	**2/24 (8.3)**	**1/11 (9.1)**	**3/35 (8.6)**

Table 6.12: TPR and CPR for caries in the permanent dentition by biological sex and age-at-death cohort for the three burial categories. Percentage frequencies in parentheses.

The prevalence of caries was considerably lower in the mass burials with a TPR of 1.4% (table 6.12); however, the demographic profile and the preservation were limiting factors. The highest TPR was observed in the 18-34 years age-at-death cohort. None of the individuals aged under 18 years at death showed any evidence of caries. Interestingly, there was also no caries present in the 35-49 years age-at-death cohort that was represented by 62 teeth. In contrast to the other two groups, there were no deciduous teeth present in the mass burials. CPR was also low with 8.6% of individuals affected by at least one carious lesion. The CPR by biological sex and age-at-death reflected the true prevalence rates in the mass burials.

In summary, the normative and non-normative single burials were equally affected by caries, but the mass burials showed a very low prevalence of caries. Females where slightly more affected than males especially when considering the CPR. The normative and non-normative single burials displayed an increase of caries prevalence with increasing age-at-death. The higher caries prevalence observed for males from normative burials in comparison to the mass burials was statistically significant (χ^2 test: p-value: <0.001). Including all burial types, a significant association of caries with advanced age-at-death regardless of biological sex could be observed (χ^2 test: p-value: 0.009).

6.5.2.2. Antemortem tooth loss

Antemortem (AM) tooth loss of the permanent dentition had a true prevalence rate of 6.9% and a CPR of 31.6% in the thesis sample of 206 individuals. First and second molars were most commonly affected by AM tooth loss with a TPR of 16.5% and 13.6% respectively. The prevalence of AM tooth loss was slightly higher in the mandible than in the maxilla.

Prevalence rates of AM tooth loss								
	TPR				***CPR***			
	F	***M***	***?***	***Total***	***F***	***M***	***?***	***Total***
Normative burials								
7-11	0/0 (0)	0/0 (0)	0/14 (0)	0/14 (0)	0/0 (0)	0/0 (0)	0/1 (0)	0/1 (0)
12-17	0/28 (0)	0/0 (0)	1/104 (1.0)	1/132 (0.8)	0/1 (0)	0/1 (0)	1/6 (16.7)	1/8 (12.5)
18-34	18/344 (5.2)	11/622 (1.8)	5/55 (9.0)	34/1021 (3.3)	7/17 (41.2)	4/27 (14.8)	1/4 (25)	12/48 (25)
35-49	8/26 (30.8)	9/37 (24.3)	0/0 (0)	17/63 (27)	1/1 (100)	1/2 (50)	0/0 (0)	2/3 (66.7)
50+	0/0 (0)	9/111 (8.1)	0/0 (0)	9/111 (8.1)	0/0 (0)	3/5 (60)	0/0 (0)	3/5 (60)
18+	26/125 (20.8)	38/433 (8.8)	20/172 (11.6)	84/730 (11.5)	6/12 (50)	13/23 (56.5)	6/32 (18.8)	25/67 (37.3)
Total	**52/523 (9.9)**	**67/1203 (5.6)**	**26/345 (7.5)**	**145/2071 (7.0)**	**14/31 (45.2)**	**21/58 (36.2)**	**8/43 (18.6)**	**43/132 (32.3)**
Non-normative single burials								
7-11	0/0 (0)	0/0 (0)	0/38 (0)	0/38 (0)	0/0 (0)	0/0 (0)	0/2 (0)	0/2 (0)
12-17	0/0 (0)	0/0 (0)	0/40 (0)	0/40 (0)	0/0 (0)	0/0 (0)	0/2 (0)	0/2 (0)
18-34	6/45 (13.3)	4/139 (2.9)	0/0	10/184 (5.4)	1/4 (25)	3/8 (37.5)	0/0 (0)	4/12 (33.3)
35-49	0/0 (0)	0/0 (0)	10/30 (33.3)	10/30 (33.3)	0/0 (0)	0/0 (0)	2/3 (66.6)	2/3 (66.7)
50+	2/29 (6.9)	18/87 (20.7)	0/0	20/116 (17.2)	1/1 (100)	2/3 (66.7)	0/0 (0)	3/4 (75)
18+	4/79 (5.1)	16/180 (8.9)	6/14 (42.9)	26/273 (9.5)	1/3 (33.3)	4/8 (50)	2/5 (40)	7/16 (43.8)
Total	**12/153 (7.8)**	**38/406 (9.4)**	**16/122 (13.1)**	**66/681 (9.7)**	**3/8 (37.5)**	**9/19 (47.4)**	**4/12 (33.3)**	**16/39 (41.0)**
Mass burials								
7-11	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)
12-17	0/0 (0)	0/0 (0)	0/19 (0)	0/19 (0)	0/0 (0)	0/0 (0)	0/3 (0)	0/3 (0)
18-34	0/0 (0)	1/308 (0.3)	1/31 (3.2)	2/339 (0.6)	0/0 (0)	1/14 (7.1)	1/3 (33.3)	2/17 (11.8)
35-49	0/0 (0)	0/48 (0)	0/0 (0)	0/48 (0)	0/0 (0)	0/2 (0)	0/0 (0)	0/2 (0)
50+	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)
18+	0/0 (0)	2/147 (1.4)	17/68 (25)	19/215 (8.8)	0/0 (0)	1/8 (12.5)	3/5 (60)	4/13 (30.8)
Total	**0/0 (0)**	**3/503 (0.6)**	**18/118 (15.3)**	**21/621 (3.4)**	**0/0 (0)**	**2/24 (8.3)**	**4/11 (36.4)**	**6/35 (17.1)**

Table 6.13: TPR and CPR for AM tooth loss of the permanent dentition by biological sex and age-at-death cohort for the three burial categories. Percentage frequencies in parentheses.

The TPR of AM tooth loss was 7.0% in the normative sample and, therefore, similar to the overall prevalence in the study sample (table 6.13). Females were affected slightly more than males and unsexed individuals. The higher prevalence of AM tooth loss in females was consistent with the higher frequency of caries in the female population. The lowest frequency was present in the non-adult cohort with only one instance of AM tooth loss in the individuals aged younger than 18 years at death. An increase of AM tooth loss could be observed with increasing age, but the highest prevalence was present in the middle adult cohort (35-49 years). The CPR of AM tooth loss reflected the TPR with highest frequency of AM tooth loss in female individuals and the two advanced adult age-at-death cohorts. There were several instances of extensive AM tooth loss with six or more teeth lost during life. Four females (CPR 12.9%), three males (CPR 5.2%), and one unsexed individual displayed evidence of extensive AM tooth loss.

The highest TPR of AM tooth loss was identified in the non-normative single burials with 9.7% (table 6.13). Unsexed individuals were mostly affected, and males displayed a slightly higher prevalence than females. As with the normative burials, middle adults showed the highest frequency of AM tooth loss followed by mature adults. There was no evidence of AM tooth loss of permanent teeth in the individuals aged under 18 years at death. The CPR largely mirrored the TPR; however, individuals aged older than 50 years at death displayed a slightly higher crude prevalence than the 35-49 years cohort. Extensive AM tooth loss affecting six or more teeth was also observed in the single non-normative burials in five adult individuals.

Individuals buried in mass burials displayed the lowest frequency of AM tooth loss with a TPR of 3.4% (table 6.13). This difference in prevalence is potentially connected to the different demographic profile with a higher percentage of younger individuals. Most occurrences were identified in unsexed individuals and only a minority of recorded instances in males. Considering age-at-death, the 18+ years age-at-death cohort showed the highest prevalence of AM tooth loss followed by individuals aged 18-34 years. The crude prevalence rates reflected the true prevalence rates. One adult unsexed individual displayed extensive AM tooth loss with ten tooth positions affected.

The difference in prevalence between males and females was not statistically significant in the normative burial sample (χ^2 test: p-value: 0.41) and in the entire study sample (χ^2 test: p-value: 0.185). In contrast, the difference in disease frequency was statistically significant between males buried in normative burials and mass burials (χ^2 test: p-value: 0.011) as well as between non-normative single burials and mass burials (χ^2 test: p-value: 0.004). The association of AM tooth loss and age-at-death was statistically significant when considering the entire thesis sample of 206 individuals (χ^2 test: p-value: 0.018).

6.5.2.3. Periodontal disease

The recording of periodontal disease was restricted by preservation. For some groups within the study sample, the data available was very limited and, therefore, any interpretation concerning these groups will be flawed. Incomplete preservation and severe taphonomic damage of the alveolar bone were the main limiting factors. The TPR of alveolar resorption in the entire sample was 30.5%.

TPR for alveolar resorption in the normative burials was 25.9% and, therefore, lower than in the other two burial groups (table 6.14). Females were more affected than males based on TPR, thus mirroring the higher prevalence of AM tooth loss in females. As previously discussed, more advanced age-at-death cohorts were also more affected by alveolar resorption and periodontal disease than younger cohorts. There was no evidence of pathological alveolar resorption in individuals aged younger than 18 years at death, while the age-at-death cohort 35-49 years displayed the highest frequency. CPR for the normative sample combined was 49.2% and highest in males.

Prevalence rates of periodontal disease								
	TPR				***CPR***			
	F	***M***	***?***	***Total***	***F***	***M***	***?***	***Total***
Normative burials								
7-11	0/0 (0)	0/0 (0)	0/32 (0)	0/32 (0)	0/0 (0)	0/0 (0)	0/1 (0)	0/1 (0)
12-17	0/27 (0)	0/0 (0)	0/83 (0)	0/110 (0)	0/1 (0)	0/1 (0)	0/6 (0)	0/8 (12.5)
18-34	29/238 (12.2)	95/531 (17.9)	3/43 (7)	127/812 (15.6)	9/17 (52.9)	15/27 (55.6)	1/4 (25)	25/48 (52.1)
35-49	16/17 (94.1)	9/15 (60)	0/0 (0)	25/32 (78.1)	1/1 (100)	2/2 (100)	0/0 (0)	3/3 (100)
50+	0/0 (0)	19/72 (26.4)	0/0 (0)	19/72 (26.4)	0/0 (0)	4/5 (80)	0/0 (0)	4/5 (80)
18+	76/89 (85.4)	112/324 (34.6)	51/111 (45.9)	239/524 (45.6)	7/12 (58.3)	17/23 (73.9)	9/32 (28.1)	33/67 (49.3)
Total	**121/371 (32.6)**	**235/942 (24.9)**	**54/269 (20.1)**	**410/1582 (25.9)**	**17/31 (54.8)**	**38/58 (65.5)**	**10/43 (23.3)**	**65/132 (49.2)**
Non-normative single burials								
7-11	0/0 (0)	0/0 (0)	0/2 (0)	0/2 (0)	0/0 (0)	0/0 (0)	0/2 (0)	0/2 (0)
12-17	0/0 (0)	0/0 (0)	0/24 (0)	0/24 (0)	0/0 (0)	0/0 (0)	0/2 (0)	0/2 (0)
18-34	1/38 (2.6)	47/133 (35.3)	0/0 (0)	48/171 (28.1)	1/4 (25)	5/8 (62.5)	0/0 (0)	6/12 (50)
35-49	0/0 (0)	0/0 (0)	6/7 (85.7)	6/7 (85.7)	0/0 (0)	0/0 (0)	2/3 (66.6)	2/3 (66.7)
50+	8/16 (50)	66/84 (78.6)	0/0 (0)	74/100 (74)	1/1 (100)	3/3 (100)	0/0 (0)	4/4 (100)
18+	35/60 (58.3)	31/90 (34.4)	3/12 (25)	69/162 (42.6)	3/3 (100)	6/8 (75)	1/5 (20)	8/16 (50)
Total	**44/114 (38.9)**	**144/307 (46.9)**	**9/45 (20)**	**197/466 (42.3)**	**5/8 (62.5)**	**12/19 (63.2)**	**3/12 (25)**	**20/39 (51.3)**
Mass burials								
7-11	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)
12-17	0/0 (0)	0/0 (0)	0/8 (0)	0/8 (0)	0/0 (0)	0/0 (0)	0/3 (0)	0/3 (0)
18-34	0/0 (0)	48/166 (28.9)	0/6 (0)	48/172 (27.9)	0/0 (0)	7/14 (50)	0/3 (33.3)	7/17 (41.2)
35-49	0/0 (0)	25/48 (52.1)	0/0 (0)	25/48 (52.1)	0/0 (0)	2/2 (100)	0/0 (0)	2/2 (100)
50+	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)
18+	0/0 (0)	32/63 (50.9)	10/27 (37)	42/90 (46.7)	0/0 (0)	6/8 (75)	4/5 (80)	10/13 (76.9)
Total	**0/0 (0)**	**105/277 (37.9)**	**10/41 (24.4)**	**115/318 (36.2)**	**0/0 (0)**	**15/24 (62.5)**	**4/11 (36.4)**	**19/35 (54.3)**

Table 6.14: TPR and CPR for periodontal disease (alveolar resorption) of the permanent dentition by biological sex and age-at-death cohort for the three burial types. Percentage frequencies in parentheses.

Individuals buried in non-normative single burials exhibited the highest TPR of 42.3% for periodontal disease (table 6.14). In contrast to the normative burials, males showed a higher TPR than females, while the CPR was comparable. The preservation of unsexed individuals was especially poor in the non-normative single burials, and the results might not be meaningful due to the limited evidence. The highest TPR was present in individuals aged 35-49 years; however, only few alveolar sockets were available in this age-at-death cohort. The second highest prevalence was observed in adults aged 50+ years. There was no evidence of periodontal disease in the non-adults. CPR for the single distinct burials combined is 51.3%.

Periodontal disease had a TPR of 36.2% and a CPR of 54.3% in the mass burials, meaning the CPR was highest in mass burials (table 6.14). Males showed a higher TPR and CPR than unsexed individuals; however, the limited preservation of unsexed individuals was a highly limiting factor in the mass burials, thus possibly rendering this result not meaningful. A similar pattern for higher disease prevalence in the older age-at-death cohorts as in the normative and non-normative single burials could also be identified in the mass burials.

The differences in disease prevalence between males and females and between males from different burial types were not statistically significant. However, there was a statistically significant association of periodontal disease with age-at-death (χ^2 test: p-value: <0.001).

6.5.2.4. Periapical lesions

Periapical lesions were also only recorded for the permanent dentition. The TPR for periapical lesions was 1.5% and CPR 15.5% in the entire study sample. The maxilla was affected more often than the mandible (2.6% vs. 0.7%). In both dental arches, the first molar showed the highest prevalence of periapical lesions. Buccal drainage holes were considerably more common than lingual.

In the normative burials, 32 periapical lesions were identified meaning a TPR of 1.6% (table 6.15). Males were more commonly affected than females and unsexed individuals. The highest TPR was recorded for individuals aged older than 35 years, but the 18-34 years cohort displayed a higher CPR than the 50+ years cohort. Only one instance of a periapical lesion was present in the non-adults (12-17 years).

The non-normative single burials showed the highest TPR for periapical lesions (table 6.15). Unsexed individuals were most affected by periapical lesions based on TPR followed by males; however, the CPR was higher for males than unsexed individuals. Females showed the lowest frequency for periapical lesions. Considering age-at-death, the highest TPR was observed in the 35-49 years cohort, but this age-at-death cohort exhibited a similar CPR as the 18-34 years group, while the 50+ years cohort showed the highest CPR. In contrast to the other burial groups, one periapical lesion was also identified in an individual aged 7-11 years. Overall CPR for periapical lesions was 25.6% and as such higher than the other two burial groups.

Individuals buried in mass burials showed by far the lowest prevalence of periapical lesions with two lesions in the entire sample equating to a TPR of 0.9% (table 6.15).

Prevalence of periapical lesions								
	TPR				***CPR***			
	F	***M***	***?***	***Total***	***F***	***M***	***?***	***Total***
Normative burials								
7-11	0/0 (0)	0/0 (0)	0/32 (0)	0/32 (0)	0/0 (0)	0/0 (0)	0/1 (0)	0/1 (0)
12-17	0/32 (0)	0/0 (0)	1/105 (1)	1/137 (0.7)	0/1 (0)	0/1 (0)	1/6 (16.7)	1/8 (12.5)
18-34	4/343 (1.2)	9/612 (1.5)	0/58 (0)	13/1013 (1.3)	4/17 (23.5)	6/27 (22.2)	0/4 (0)	10/48 (20.8)
35-49	0/18 (0)	3/37 (8.1)	0/0 (0)	3/55 (5.5)	0/1 (0)	1/2 (50)	0/0 (0)	1/3 (33.3)
50+	0/0 (0)	5/105 (4.8)	0/0 (0)	5/105 (4.8)	0/0 (0)	1/5 (20)	0/0 (0)	1/5 (20)
18+	3/121 (2.5)	6/406 (1.5)	1/153 (0.7)	10/680 (1.5)	2/12 (16.7)	5/23 (21.7)	1/32 (3.1)	8/67 (11.9)
Total	**7/507 (1.4)**	**23/1160 (2)**	**2/348 (0.6)**	**32/2022 (1.6)**	**6/31 (19.4)**	**13/58 (22.4)**	**2/43 (4.7)**	**21/132 (15.9)**
Non-normative single burials								
7-11	0/0 (0)	0/0 (0)	1/23 (4.3)	1/23 (4.3)	0/0 (0)	0/0 (0)	1/2 (50)	1/2 (50)
12-17	0/0 (0)	0/0 (0)	0/35 (0)	0/35 (0)	0/0 (0)	0/0 (0)	0/2 (0)	0/2 (0)
18-34	2/60 (3.3)	5/166 (3)	0/0 (0)	7/226 (3.1)	1/4 (25)	3/8 (37.5)	0/0 (0)	4/12 (33.3)
35-49	0/0 (0)	0/0 (0)	3/27 (11.1)	3/27 (11.1)	0/0 (0)	0/0 (0)	1/3 (33.3)	1/3 (33.3)
50+	0/25 (0)	3/83 (3.6)	0/0 (0)	3/108 (2.8)	0/1 (0)	2/3 (66.7)	0/0 (0)	2/4 (50)
18+	0/80 (0)	1/182 (0.5)	1/19 (5.3)	2/281 (0.7)	0/3 (0)	1/8 (12.5)	1/5 (20)	2/16 (12.5)
Total	**2/165 (1.2)**	**9/431 (2.1)**	**5/104 (4.8)**	**16/700 (2.3)**	**1/8 (12.5)**	**6/19 (31.6)**	**3/12 (25)**	**10/39 (25.6)**
Mass burials								
7-11	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)
12-17	0/0 (0)	0/0 (0)	0/23 (0)	0/23 (0)	0/0 (0)	0/0 (0)	0/3 (0)	0/3 (0)
18-34	0/0 (0)	2/322 (0.6)	0/28 (0)	2/350 (0.6)	0/0 (0)	1/14 (7.1)	0/3 (0)	1/17 (5.9)
35-49	0/0 (0)	0/64 (0)	0/0 (0)	0/64 (0)	0/0 (0)	0/2 (0)	0/0 (0)	0/2 (0)
50+	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)	0/0 (0)
18+	0/0 (0)	0/129 (0)	0/58 (0)	0/187 (0)	0/0 (0)	0/8 (0)	0/5 (0)	0/13 (0)
Total	**0/0 (0)**	**2/515 (0.4)**	**0/109 (0)**	**2/624 (0.9)**	**0/0 (0)**	**1/24 (4.2)**	**0/11 (0)**	**1/35 (2.9)**

Table 6.15: TPR and CPR for periapical lesions in the permanent dentition by biological sex and age-at-death cohort for the three burial categories. Percentage frequencies in parentheses.

The difference in prevalence between females and males was not statistically significant when considering the entire study sample (χ^2 test: p-value: 0.803) as well as just the normative burial sample (χ^2 test: p-value: 0.737). When considering males from different burial types, a statistically significant difference could be observed between males buried in normative burials and in mass burials (χ^2 test: p-value: 0.046) as well as between males buried in non-normative single burials and mass burials (χ^2 test: p-value: 0.016). In contrast, the difference in lesion frequency was not statistically significant between males from normative and non-normative single burials (χ^2 test: p-value: 0.421). There was a statistically significant link between periapical lesions and advanced age-at-death when considering the entire thesis sample of 206 individuals (χ^2 test: p-value: 0.035).

6.5.2.5. Dental disease: Summary

Dental disease was present in all burial types affecting all demographic groups. There was a general trend of higher prevalence of dental disease in advanced age-at-death categories with highest true prevalence rates mostly identified in the age-at-death category 35-49 years. Normative burials and non-normative single burials were more affected by dental disease than the individuals buried in mass burials. The lower prevalence of dental disease in mass burials might in part be connected to differences in demographic profile lacking older adults and females, but these trends were also visible in the younger age-at-death categories and for males only. Only periodontal disease showed a higher crude prevalence in the mass burials than in the two other burial groups. In the normative burials, females appear to have a higher prevalence of dental disease than males, while in the non-normative single burials, males were more affected than females. This comparison was not possible for the mass burials as no females were present in this group.

6.5.3. Periosteal new bone formation

Periosteal new bone formation (PNBF) was recorded for tibiae as an indicator of physiological stress. The overall CPR was 54.8% with 113 out of 206 individuals displaying evidence of PNBF on the tibia. This number includes all burial types and lesions in all healing stages.

Prevalence of periosteal new bone formation (normative burials)				
	female	***male***	***unsexed***	***total***
7-11yr				
Tibia present	0/0	0/0	1/1 (100)	1/1 (100)
PNBF present	0/0	0/0	0/1 (0)	0/1 (0)
12-17yr				
Tibia present	1/1 (100)	0/1	5/6 (83.3)	6/8 (75)
PNBF present	1/1 (100)	0/0	4/5 (80)	5/6 (80)
18-34yr				
Tibia present	15/17 (88.2)	23/27 (85.2)	3/4 (75)	41/48 (85.4)
PNBF present	12/15 (80)	21/23 (91.3)	3/4 (75)	36/41 (87.8)
35-49yr				
Tibia present	1/1 (100)	2/2 (100)	0/0	3/3 (100)
PNBF present	1/1 (100)	2/2 (100)	0/0	3/3 (100)
50+yr				
Tibia present	0/0	5/5 (100)	0/0	5/5 (100)
PNBF present	0/0	4/5 (80)	0/0	4/5 (80)
18+yr				
Tibia present	6/12 (50)	17/23 (73.9)	17/32 (53.1)	40/67 (59.7)
PNBF present	6/6 (100)	11/17 (64.7)	14/17 (82.3)	31/40 (77.5)
Total				
Tibia present	23/31 (74.2)	47/58 (81)	26/43 (60.5)	96/132 (72.7)
PNBF present	20/23 (87)	38/47 (80.9)	21/26 (80.1)	79/96 (82.3)

Table 6.16: Presence of tibiae and prevalence for periosteal new bone formation on the tibia in the normative burials. Results for left and right tibia are combined, and prevalence rates are irrespective of healing state. Percentage frequencies in parentheses.

For the normative burials, 79 out 96 individuals (82.3%) with at least one tibia with observable surface preserved was affected by PNBF (table 6.16). The lesions were fully healed and remodelled in almost 85% of instances. None of the lesions were solely active at the time of death, and in twelve instances healing or mixed lesions were observed. Males and females buried in normative burials were equally affected with prevalence rates of slightly over 80%.

The individuals buried in non-normative single burials displayed a lower prevalence of periosteal new bone formation than the normative burials (71.4%) (table 6.17). In 14 cases, the lesions were completely healed, while six individuals displayed mixed lesions. In this burial group, males were more affected than females; however, these differences were not statistically significant (χ^2 test: p-value: 0.201).

Prevalence of periosteal new bone formation (non-normative single burials)				
	female	***male***	***unsexed***	***total***
7-11yr				
Tibia present	0/0	0/0	1/2 (50.0)	1/2 (50.0)
PNBF present	0/0	0/0	1/1 (50)	1/1 (100)
12-17yr				
Tibia present	0/0	0/0	0/2	0/2
PNBF present	0/0	0/0	0/0	0/0
18-34yr				
Tibia present	3/4 (75)	6/8 (75)	0/0	9/12 (75)
PNBF present	2/3 (66.7)	6/6 (100)	0/0	8/9 (88.9)
35-49yr				
Tibia present	0/0	0/0	3/3 (100)	3/3 (100)
PNBF present	0/0	0/0	2/3 (66.6)	2/3 (66.7)
50+yr				
Tibia present	1/1 (100)	2/3 (66.7)	0/0	3/4 (75.0)
PNBF present	1/1 (100)	2/2 (100)	0/0	3/3 (100)
18+yr				
Tibia present	2/3 (66.7)	6/8 (75)	4/5 (80)	12/16 (75)
PNBF present	0/2 (0)	3/6 (50)	3/4 (75)	6/12 (50)
Total				
Tibia present	6/8 (75)	14/19 (73.7)	8/12 (66.7)	28/39 (71.8)
PNBF present	3/6 (50)	11/14 (78.6)	6/8 (75)	20/28 (71.4)

Table 6.17: Presence of tibiae and prevalence for periosteal new bone formation on the tibia in the non-normative single burials. Results for left and right tibia are combined, and prevalence rates are irrespective of healing state. Percentage frequencies in parentheses.

The lowest frequency of periosteal new bone formation was observed in the mass burials with 50% of individuals with preserved tibiae affected by periosteal new bone formation (table 6.18). While most lesions were completely or partially remodelled, two male individuals (one aged 18-34 and one aged 18+ years) displayed lesions that were active at the time of death.

Prevalence of periosteal new bone formation (mass burials)				
	female	***male***	***unsexed***	***total***
7-11yr				
Tibia present	0/0	0/0	0/0	0/0
PNBF present	0/0	0/0	0/0	0/0
12-17yr				
Tibia present	0/0	0/0	1/3 (33.3)	1/3 (33.3)
PNBF present	0/0	0/0	0/1	0/1
18-34yr				
Tibia present	0/0	11/14 (78.6)	2/3 (66.7)	12/17 (70.6)
PNBF present	0/0	4/11 (36.4)	0/2	4/12 (33.3)
35-49yr				
Tibia present	0/0	1/2 (50)	0/0	1/2 (50)
PNBF present	0/0	1/1 (100)	0/0	1/1 (100)
50+yr				
Tibia present	0/0	0/0	0/0	0/0
PNBF present	0/0	0/0	0/0	0/0
18+yr				
Tibia present	0/0	6/8 (75)	1/5 (10)	7/13 (53.8)
PNBF present	0/0	4/6 (66.7)	1/1 (100)	5/7 (71.4)
Total				
Tibia present	0/0	18/24 (75)	2/11 (18.2)	20/35 (57.1)
PNBF present	0/0	9/18 (50)	1/2 (50)	10/20 (50)

Table 6.18: Presence of tibiae and prevalence for periosteal new bone formation on the tibia in the mass burials. Results for left and right tibia are combined, and prevalence rates are irrespective of healing state. Percentage frequencies in parentheses.

The highest prevalence of periosteal new bone formation was present in the normative burials followed by non-normative single burials. Overall, males were slightly more affected than females, but the differences were not statistically significant (χ^2 test: p-value: 0.531). There was no statistically significant association between age-at-death and prevalence rates of periosteal new bone formation in the entire thesis sample. The difference in prevalence rates between males buried in normative burials and mass burials was, however, statistically significant (χ^2 test: p-value: 0.013), while comparisons between males from normative and non-normative single burials (χ^2 test: p-value: 0.851) and males from non-normative single burials and mass burials (χ^2 test: p-value: 0.098) were not statistically significant.

6.5.4. Trauma

Skeletal trauma in the form of antemortem fractures was prevalent to an exceptionally high degree in this thesis sample affecting all burial types and most demographic groups. For 91 out of 206 individuals in the thesis sample (44.2%), at least one instance of AM fracture was observed (table 6.19). Males were most commonly affected, but prevalence rates for females were only slightly lower. No evidence of trauma was present in the three individuals aged younger than 11 years, and an increase of trauma frequency could be observed with increasing age-at-death. There was no statistically significant difference in trauma frequency between males and females in the overall thesis sample, and, additionally, it was not possible to identify a statistically significant relationship with age-at-death.

Summary of AM trauma prevalence				
	F	***M***	***?***	***Total***
7-11yr	0/0	0/0	0/3	0/3
12-17yr	1/1 (100)	0/1	3/11 (27.3)	4/13 (30.8)
18-34yr	10/21 (47.6)	28/49 (57.1)	4/7 (57.1)	42/77 (54.5)
35-49yr	1/1 (100)	3/4 (75)	1/3 (33.3)	5/8 (62.5)
50+yr	0/1	7/8 (87.5)	0/0	7/9 (77.8)
18+yr	7/15 (46.7)	16/39 (41.0)	10/42 (23.8)	33/96 (34.4)
Total	**19/39 (48.7)**	**54/101 (53.5)**	**18/66 (27.2)**	**91/206 (44.2)**

Table 6.19: CPR of AM trauma in the study sample (N=206). This table includes all types of AM trauma regardless of skeletal region affected and number of trauma instances per individual. Percentage frequencies in parentheses.

Individuals buried in normative burials displayed the highest frequency of trauma with 64 out of 132 individuals affected by trauma (48.5%) (table 6.20 and Figure 6.13 a,b). The highest frequency was observed for males; however, the difference in prevalence between males and females was not statistically significant (χ^2 test: p-value: 0.340). The two older age-at-death cohorts (35-49 years and 50+ years) displayed the highest prevalence of AM trauma, but the frequency rates were also very high for young adult (18-34 years) for both males and unsexed individuals.

Prevalence of AM Trauma (CPR)				
	F	***M***	***?***	***Total***
Normative burials				
7-11yr	0/0	0/0	0/1	0/1
12-17yr	1/1 (100)	0/1	1/6 (16.7)	2/8 (25)
18-34yr	7/17 (41.2)	17/27 (63)	4/4 (100)	28/48 (58.3)
35-49yr	1/1 (100)	2/2 (100)	0/0	3/3 (100)
50+yr	0/0	5/5 (100)	0/0	5/5 (100)
18+yr	7/12 (58.3)	12/23 (52.2)	7/32 (21.9)	26/67 (38.8)
Total	**16/31 (51.6)**	**36/58 (62.1)**	**12/43 (27.9)**	**64/132 (48.5)**
Non-normative single burials				
7-11yr	0/0	0/0	0/2	0/2
12-17yr	0/0	0/0	0/2	0/2
18-34yr	3/4 (75)	4/8 (50)	0/0	7/12 (58.3)
35-49yr	0/0	0/0	1/3 (33.3)	1/3 (33.3)
50+yr	0/1	2/3 (66.7)	0/0	2/4 (50)
18+yr	0/3	2/8 (25)	**1/5 (20)**	3/16 (18.8)
Total	**3/8 (37.5)**	**8/19 (42.1)**	**2/12 (16.7)**	**13/39 (33.3)**
Mass burials				
7-11yr	0/0	0/0	0/0	0/0
12-17yr	0/0	0/0	2/3 (66.6)	2/3 (66.6)
18-34yr	0/0	7/14 (50)	0/3	7/17 (41.2)
35-49yr	0/0	1/2 (50)	0/0	1/2 (50)
50+yr	0/0	0/0	0/0	0/0
18+yr	0/0	2/8 (25)	2/5 (40)	4/13 (30.8)
Total	**0/0**	**10/24 (41.7)**	**4/11 (36.4)**	**14/35 (40)**

Table 6.20: CPR for trauma for each burial category by biological sex and age-at-death category. This table includes all types of AM trauma regardless of skeletal region affected, and instances of multiple traumata affecting one individual are not reflected here. Percentage frequencies in parentheses.

The second highest prevalence of trauma was recorded for individuals buried in mass burials with 14 out of 35 individuals showing evidence of trauma (40.0%) (table 6.20 and Figure 6.13 c). Males were affected more than unsexed individuals, but this general pattern might be connected to preservation rather than risk. Adolescents (12-18 years) displayed the highest frequency, while individuals aged between 18-34 years appeared least affected by trauma.

The lowest fracture frequency was observed for the non-normative single burials with 13 out of 39 individuals (33.3%) affected by AM trauma (table 6.20). As with normative burials, males were more commonly affected than females. Highest prevalence rates were observed for individuals aged 18-34 years, and females in this age-at-death cohort displayed the highest frequency of AM trauma.

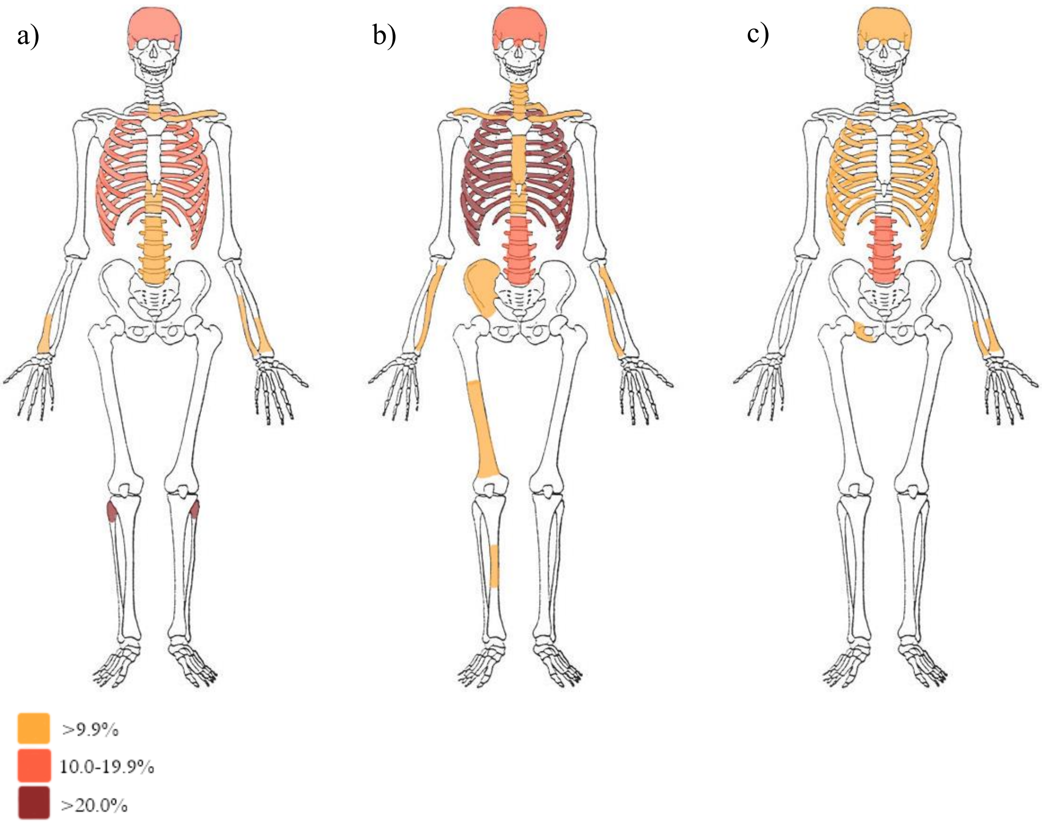

Figure 6.13: Distribution and frequency of fractures by skeletal regions.
a) Females from normative burials; b) Males from normative burials; c) Males from mass burials. © Skeletal diagrams from Department of Archaeology at Durham University

The difference in trauma prevalence between males buried in normative burials and those buried in non-normative burials (single and mass burials combined) was statistically significant (χ^2 test: p-value: 0.044). For all three burial types, instances of multiple traumata could be identified; however, evidence of fracture recidivism was only observed in the normative burial sample (see 6.5.4.3. Multiple traumata and fracture recidivism).

6.5.4.1. Cranial trauma

In the entire study sample, 27 individuals displayed evidence of AM cranial trauma. Cranial trauma was present in all burial types and affected most demographic groups. Instances of blunt force trauma (BFT) as well as sharp force trauma (SFT) were identified (Figure 6.14). The combined CPR of AM cranial trauma was calculated as 13.1% (table 6.21). Males displayed a higher CPR of cranial trauma than females in all burial types. A small number of individuals displayed multiple instances of cranial trauma, but this is reported in more detail in section 6.5.4.3.

Cranial Trauma – CPR				
	F	***M***	***?***	***Total***
Normative burials	4/31 (12.9)	13/58 (22.4)	4/43 (9.3)	21/132 (15.9)
NN single burials	0/8	2/19 (10.5)	0/12	2/39 (5.1)
Mass burials	0/0	4/24 (16.7)	0/11	4/35 (11.4)
Total	4/39 (10.3)	19/101 (17.4)	4/66 (6.0)	27/206 (13.1)

Table 6.21: CPR for cranial trauma (BFT and SFT combined) for each burial type and for the combined study sample by biological sex. Percentage frequencies in parentheses. NN=non-normative

Figure 6.14: Instances of cranial trauma in the normative burial sample. Left: SFT to the left frontal and parietal bones (IV_554); Right: BFT to the right frontal bone (IV_269).

The CPR of AM cranial trauma (BFT and SFT combined) in the normative sample was 15.9% with 21 individuals displaying evidence of AM BFT or SFT (table 6.21). The highest CPR was recorded for males. Five individuals in the normative burial group were affected by SFT. AM trauma most often affected the parietal bones and frontal bones (table 6.22). The left side displayed a higher number of trauma instances than the right; however, for females, all fractures were identified on the right side both for the frontal bone and the parietal bones. All instances of SFT were identified in males.

TPR Cranial trauma - Normative burials (BFT and SFT)								
	L FB	***R FB***	***L PB***	***R PB***	***L TB***	***R TB***	***OB***	***NB***
Female	0/20	1/22 (4.5)	0/23	3/26 (11.5)	0/18	0/21	0/24	0/13
Male	**2/40 (5)**	0/42	**7/46 (15.2)**	**3/48 (6.25)**	**1/41 (2.4)**	1/45 (2.2)	**2/48 (4.2)**	1/25 (4)
Unsexed	1/11 (9.1)	0/10	1/17 (5.9)	1/17 (5.9)	0/12	0/11	1/21 (4.8)	0/5
Total	**3/71 (4.2)**	1/74 (1.4)	**8/86 (9.3)**	**6/91 (6.6)**	**1/71 (1.4)**	1/77 (1.3)	**3/93 (3.2)**	1/43 (2.3)

Table 6.22: TPR for cranial trauma (BFT and SFT combined) for the normative burial sample by biological sex. Instances of SFT or combined numbers of BFT and SFT are marked in bold. Percentage frequencies in parentheses. For more detail on age-at-death see Appendix I. FB: frontal bone; PB: parietal bone; TB: temporal bone; OB: occipital bone; NB: nasal bone.

Non-normative single burials and mass burials displayed lower prevalence rates than the normative burial samples, and in both groups, only males were affected. Interestingly, there was no evidence of cranial SFT present in the entire non-normative burial sample. In the non-normative single burials, only two individuals displayed cranial fractures (table 6.23). Both individuals were estimated as male. One of the only two nasal fractures present in the sample was identified in a young adult male buried in a non-normative single burial. The second fracture affected the left parietal bone of an adult male. While the number of females was smaller in this group than in the normative burial sample, it is noticeable that none of them were affected by any cranial trauma.

TPR Cranial trauma - Non-normative single burials								
	L FB	***R FB***	***L PB***	***R PB***	***L TB***	***R TB***	***OB***	***NB***
Male	0/15	0/16	1/15 (6.7)	0/16	0/14	0/13	0/15	1/15 (6.7)
Total	0/29	0/28	1/30 (3.3)	0/29	0/23	0/19	0/32	1/25 (4)

Table 6.23: TPR for cranial trauma (BFT) for the non-normative single burial sample for males and the entire sample. Percentage frequencies in parentheses. For more detail on females and unsexed individuals as well as age-at-death see Appendix I. FB: frontal bone; PB: parietal bone; TB: temporal bone; OB: occipital bone; NB: nasal bone.

As in the non-normative single burials, only males showed evidence of cranial trauma in the mass burial sample and only BFT was identified; however, the prevalence was higher than in the single non-normative burials (table 6.24). Parietal bones and frontal bones were affected, which is comparable to the higher prevalences in the normative burials for these bones. Similarly, the left side was slightly more affected (3 vs 1 fracture), but with only four instances of cranial trauma, trends are difficult to identify.

TPR Cranial trauma - Mass burials								
	L FB	***R FB***	***L PB***	***R PB***	***L TB***	***R TB***	***OB***	***NB***
Male	1/17 (5.9)	0/17	2/17 (11.8)	1/19 (5.23)	0/16	0/16	0/19	0/12
Total	1/23 (4.3)	0/22	2/23 (8.7)	1/25 (4)	0/20	0/20	0/26	0/17

Table 6.24: TPR for cranial trauma (BFT) for the mass burial sample for males and the entire sample. Percentage frequencies in parentheses. For more detail on unsexed individuals and age-at-death see Appendix I. FB: frontal bone; PB: parietal bone; TB: temporal bone; OB: occipital bone; NB: nasal bone.

In addition to the AM cranial traumata, one instance of possible perimortem blunt force cranial trauma was identified in a young adult female (IV_399) buried in a normative setting. The right temporal bone was poorly preserved with significant taphonomic damage, but it appeared to be the site of impact (Figure 6.15a). Six radiating fractures could be traced from the right temporal bone across the cranial vault on the frontal bone, parietal bones, and occipital bone. The radiating fractures were characterised by sharp fracture margins and for the fractures on the frontal bone similar colouration as the surface could be observed (Figure 6.16b). The fractures began in a very linear manner, then became more irregular and serrated before they tapered out (see arrows in Figure 6.16c). The fractures affecting the right parietal bone crossed over the sagittal suture and extended onto the left parietal bone. For the frontal bone and the parietal bones, it could be observed that the bone anterior to the fracture was slightly raised in comparison to posterior bone and slight overlap could be noticed. Overall, these fractures appear consistent with perimortem trauma, but it could not be identified with absolute certainty. The above-described radiating fractures could be the result of a significant blow to the right side of the cranium causing loss of structural integrity of the cranial vault. The head was tilted towards left in the burial thus exposing the right side to taphonomic damage. No other evidence of trauma – both AM and perimortem – were identified in this individual. The left femur displayed a postmortem cut inferior to the greater trochanter. The inferior appendicular skeleton is otherwise not preserved, and this appears most likely due to truncation of the burial at a later stage.

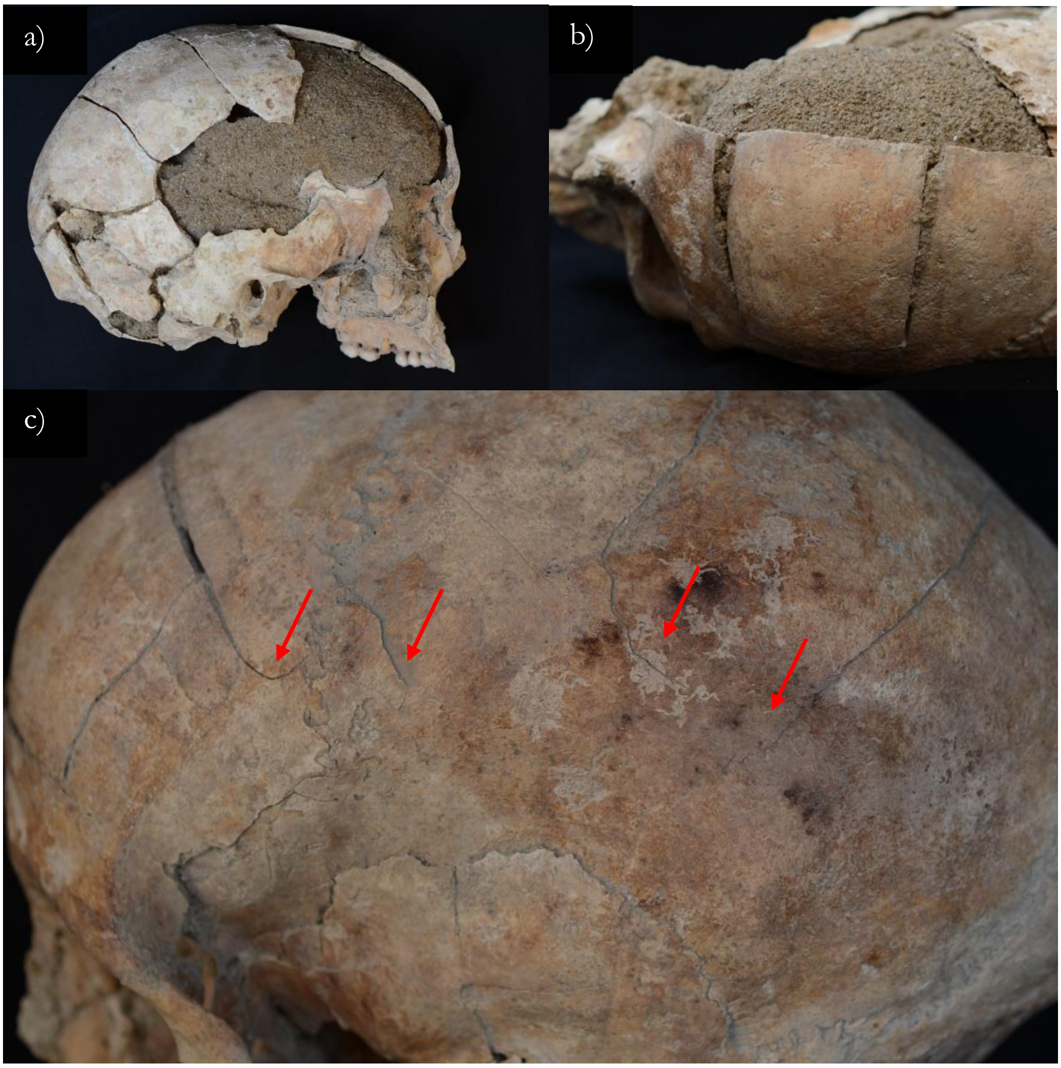

Figure 6.15: Cranium of IV_399 with possible perimortem trauma. a) Possible site of impact; b) Anterior view with fracture lines; c) Left view of cranium (IV_399) with possible perimortem fracture. Fracture lines taper out (see arrows).

In summary, the highest prevalence of cranial trauma was identified in the normative burials. Interestingly, all instances of SFT were observed in the normative burials, while none of the individuals buried in mass burials or shackled individuals displayed evidence of cranial SFT. Overall, males showed a greater prevalence of cranial trauma, but the difference between males and females was not statistically significant both for the normative burials alone (χ^2 test: p-value: 0.214) and the entire thesis sample (χ^2 test: p-value: 0.438). Similarly, the males buried in normative burials displayed a higher frequency than in the other two burial types, but the difference in cranial trauma prevalence was not statistically significant between males buried in normative and non-normative single burials (χ^2 test: p-value: 0.256) and normative burials and mass burials (χ^2 test: p-value: 0.559).

6.5.4.2. Postcranial trauma

Postcranial trauma was observed in all burial groups and recorded for all demographic groups except for the 7-11 years age-at-death cohort. In total, 79 individuals were affected by at least one instance of postcranial trauma, which is a CPR of 38.3% for postcranial trauma (table 6.25). This rate includes all postcranial elements and all types of fracture. The presence of multiple fractures or fracture recidivism is reported in section 6.5.4.3.

Almost all fractures in the postcranial skeleton were identified as AM evidenced by any stage of healing ranging from woven bone formation around the fracture site to a fully remodelled stable callus. The highest prevalence was observed in the normative burials followed by individuals buried in mass burials (table 6.25). Overall, males were more commonly affected, but in the single non-normative burials, females displayed a slightly higher frequency than males. There was a general trend towards higher prevalence of fractures with increasing age-at-death, but in the non-normative burials younger individuals appeared to be more frequently affected by trauma than in the normative burial population. The differences between males and females in the normative burial sample (χ^2 test: p-value: 0.178) and between males from normative and non-normative single burials (χ^2 test: p-value: 0.129) as well as mass burials (χ^2 test: p-value: 0.052) were not statistically significant.

Postcranial AM trauma summary				
	F	***M***	***?***	***Total***
Normative burials				
12-17yr	1/1 (100)	0/1	1/6 (16.7)	2/8 (25)
18-34yr	6/17 (35.3)	16/27 (59.3)	4/4 (100)	25/48 (52.1)
35-49yr	1/1 (100)	2/2 (100)	0/0	3/3 (100)
50+yr	0/0	5/5 (100)	0/0	5/5 (100)
18+yr	5/12 (41.7)	10/23 (43.5)	4/32 (12.5)	20/67 (29.9)
Total	**13/31 (41.9)**	**33/58 (56.9)**	**9/43 (20.9)**	**55/132 (41.7)**
Non-normative single burials				
12-17yr	0/0	0/0	0/2	0/2
18-34yr	3/4 (75)	3/8 (37.5)	0/0	6/12 (50)
35-49yr	0/0	0/0	1/3 (33.3)	1/3 (33.3)
50+yr	0/1	2/3 (66.7)	0/0	2/4 (50)
18+yr	0/3	2/8 (25)	**1/5 (20)**	3/16 (18.8)
Total	**3/8 (37.5)**	**7/19 (36.8)**	**2/12 (16.7)**	**12/39 (30.8)**
Mass burials				
12-17yr	0/0	0/0	2/3 (66.6)	2/3 (66.6)
18-34yr	0/0	5/14 (35.7)	0/3	5/17 (29.4)
35-49yr	0/0	1/2 (50)	0/0	1/2 (50)
50+yr	0/0	0/0	0/0	0/0
18+yr	0/0	2/8 (25)	2/5 (40)	4/13 (30.8)
Total	**0/0**	**8/24 (33.3)**	**4/11 (36.4)**	**12/35 (34.3)**
Total				
12-17yr	1/1 (100)	0/1	3/11 (27.3)	4/13 (30.8)
18-34yr	9/21 (42.9)	24/49 (49)	4/7 (57.1)	36/77 (46.8)
35-49yr	1/1 (100)	3/4 (75)	1/3 (33.3)	5/8 (62.5)
50+yr	0/1	7/8 (87.5)	0/0	8/9 (88.9)
18+yr	5/15 (33.3)	14/39 (35.9)	7/42 (16.7)	26/96 (27.1)
Total	**16/39 (41)**	**48/101 (47.5)**	**15/66 (22.7)**	**79/206 (38.3)**

Table 6.25: CPR for postcranial AM trauma for each burial group based on biological sex and age-at-death and overall. Percentage frequencies in parentheses. The 7-11 years cohort was not affected by fractures and has been excluded here. Three instances of tibial perimortem trauma are not reflected here.

6.5.4.2.1. *Upper limb trauma*

For the entire study sample, 21 instances of AM trauma to the upper limb long bones could be observed (CPR: 10.2%). All fractures were identified in the ulna or radius, while none of the preserved humeri were affected. In addition, ten instances of trauma to hand bones including metacarpals and phalanges were recorded.

Upper limb trauma - normative burials			
	Female	*Male*	*Unsexed*
L ulna			
nf [%]	**2 [7.1]**	**3 [5.9]**	**1 [4.0]**
Ne	28	51	25
P1/3	28	50	23
M1/3	**1/25 (4.0)**	**1/51 (2.0)**	**1/23 (4.3)**
D1/3	**1/24 (4.2)**	**2/47 (4.3)**	17
R ulna			
nf [%]	0	**4 [7.8]**	0
Ne	29	51	25
P1/3	28	**1/51 (2.0)**	22
M1/3	25	**1/50 (2.0)**	22
D1/3	13	**2/45 (4.4)**	17
L radius			
nf [%]	**1 [3.7]**	**1 [2.0]**	0
Ne	27	51	25
P1/3	25	**1/51 (2.0)**	22
M1/3	28	51	23
D1/3	**1/26 (3.8)**	46	21
D epiph	17	31	10
R radius			
nf [%]	**3 [11.1]**	0	0
Ne	27	51	23
P1/3	25	49	20
M1/3	26	49	21
D1/3	**2/24 (8.3)**	46	20
D epiph	**1/14 (7.1)**	36	8

Table 6.26: TPR of AM upper limb trauma for normative burials. Percentage frequencies in parentheses. Ne: number of elements present; nf: number of fractures present.
This table only shows the bones that displayed at least one instance of trauma. For more details on presence of bones and fracture patterns by age-at-death see Appendix I.

For the normative burials, 15 instances of upper limb long bone trauma and six instances of trauma to hand bones were identified with a CPR of arm bone trauma of 10.6% and a CPR of upper limb trauma combined of 15.9% (for examples of ulna and radius fractures see figs. 6.16 and 6.17). When considering TPR (for details see table 6.26), the ulnae were generally more affected than radii (10 vs. 5 fractures). The distal third of the ulna was most commonly affected on both sides (for example see Figure 6.16 bottom), and this pattern was most pronounced for males. Fracture patterns revealed gendered differences in upper limb fractures. Males displayed a higher prevalence of ulna fractures than radial fractures, but the opposite could be observed for females. One female individual showed fractures of the distal third of the radius (Colles fracture) on both sides (example see Figure 6.17b).

Figure 6.16: Examples of ulna fractures.
Top: healing/non-union fracture of the mid third of the diaphysis of the R ulna (IV_378);
Bottom: healed 'parry-fracture' (distal third of the diaphysis) of the L ulna (IV_102)

Figure 6.17: Examples of radius fractures.
a) Healed fracture to the proximal-mid third of the L radius with complications in form of angulation, overlap, and partial apposition (IV_34); b) Healed fracture of the distal third of the R radius ('Colles fracture') (IV_169); c) Impacted fracture of the distal articulation surface of the R radius with secondary joint disease (porosity and eburnation) (IV_777)

For hand bones, only crude prevalence rates were calculated for individuals that had metacarpals and hand phalanges present. In total, trauma to the hand bones could be recorded for six males from normative burials (10.3%). Four individuals displayed trauma to the left hand and two to the right hand. In one case, the traumatic injury was identified as AM amputation of a left finger (phalanx).

Upper limb trauma - non-normative single burials		
	Male	***Unsexed***
L ulna		
nf [%]	**1 [5.6]**	0
Ne	18	9
P1/3	18	9
M1/3	18	9
D1/3	**1/17 (5.9)**	9
L radius		
nf [%]	0	**1 [11.1]**
Ne	17	9
P1/3	17	7
M1/3	17	8
D1/3	17	**1/8 (12.5)**
R radius		
nf [%]	0	**1 [11.1]**
Ne	17	9
P1/3	16	7
M1/3	17	9
D1/3	17	**1/8 (12.5)**

Table 6.27: TPR of AM upper limb trauma for the non-normative single burials. Percentage frequencies in parentheses. Ne: number of elements present; nf: number of fractures present. This table only shows the bones that displayed at least one instance of trauma. For more details on presence of bones and fracture patterns by age-at-death see Appendix I.

Only a small number of fractures was observed in the non-normative single burials. In this subsample, three instances of long bone trauma for the upper limbs and two instances of fractures of hand bones were present (CPR 12.8%). While one of the fractures to the hand bones was identified in a female, the arm bone fractures affected male and unsexed individuals only (see table 6.27). As in the normative burials, no humerus fractures were present. Two fractures affected the left side, but from only three fractures it was not possible to identify patterns. Two individuals from non-normative single burials also displayed evidence of fractures of hand bones. In both cases, the right hand was affected (CPR 5.1%), with one instance affecting a metacarpal (female, 18-34 years) and one a phalanx (male, 18+ years).

Within the mass burials, two instances of upper limb long bone trauma and two instances of trauma to hand bones were observed (CPR: 11.4%, 4/35 individuals). Both long bone fractures were identified in males (table 6.28), and the two hand fractures affected metacarpals, with one observed in a male (18-34 years) and the second one in an unsexed individual (18+ years). For long bones, one fracture was observed affecting an ulna and the other one a radius. Both long bone fractures were identified on the left side and affecting the distal third of the diaphysis for each bone.

Upper limb trauma – male (mass burials)			
	nf [%]	***Ne***	***D1/3***
L Ulna	**1 [4.5]**	22	**1/20 (5.0)**
L Radius	**1 [4.5]**	22	**1/21 (4.8)**

Table 6.28: TPR of AM upper limb trauma for the mass burials. Percentage frequencies in parentheses. Ne: number of elements present; nf: number of fractures present. This table only shows the bones that displayed at least one instance of trauma. For more details on presence of bones see Appendix I.

Overall, the left ulna was the upper limb bone most affected by trauma with eight out of 170 preserved ulnae displaying evidence of an AM fracture (4.7%). The distal third of the left ulna showed the highest TPR of 4.1% (6/146). All other affected upper limb long bones showed lower prevalence rates of trauma (see table 6.29).

	Elements Present	Elements fractured	Prevalence rate
Left ulna combined	**170**	**8**	**4.7%**
L Ulna mid 1/3	*160*	*2*	*1.3%*
L ulna distal 1/3	*146*	*6*	*4.1%*
R ulna combined	**166**	**4**	**2.4%**
R ulna prox 1/3	*159*	*1*	*0.6%*
R ulna mid 1/3	*155*	*1*	*0.6%*
R ulna distal 1/3	*139*	*2*	*1.4%*
L radius combined	**168**	**4**	**2.4%**
L radius prox 1/3	*156*	*1*	*0.6%*
L radius distal 1/3	*153*	*3*	*2.0%*
R radius combined	**167**	**4**	**2.3%**
R radius distal 1/3	*150*	*3*	*2.0%*
R radius distal art	*84*	*1*	*1.2%*

Table 6.29: TPR for AM fractures of upper limb long bones. All burial types, and demographic groups (biological sex and age-at-death) are included. Elements without fractures are excluded from this table.

6.5.4.2.2. Lower limb trauma

For the investigation of lower limb trauma, leg and foot bones were considered. Fifteen instances of AM lower limb trauma were present in the entire sample; however, two individuals were affected by multiple fractures to lower limbs. Considering these multiple fractures, twelve individuals were affected by lower limb trauma equating to a CPR of 5.8% (N=206).

The normative burial sample displayed the highest number of lower limb fractures with seven fractures to long bones, one fracture to a patella, and four fractures to foot bones (table 6.30). Males displayed fractures affecting two femora (Figure 6.18) and one tibia, while for females and unsexed individuals, fractures of the fibula were recorded. The two femora were affected by three fractures with two fractures observed in one femur (IV_511) affecting the mid and the distal third of the diaphysis (Figure 6.18a). In addition to the femoral fracture, IV_511 also displayed the only evidence of trauma to the tibia in the normative burials. Individual 5_100 also showed two fractures to the leg bones in form of a combination of fibula and patella fracture.

Figure 6.18: Examples of femur fractures. a) Fractures of the mid and distal third of the R femur with complications in form of overlap, angulation, and secondary joint disease in the knee joint (IV_511); b) Fracture of the R femur with large callus and soft tissue ossification (IV_503).

An avulsion fracture to the right patella was the only evidence of a fractured patella in the sample with a TPR of 2.0% (1/49). For females and unsexed individuals two metatarsal fractures were identified, while for males two phalanx fractures can be observed.

In addition to these fractures, individual IV_401 exhibited a clearly defined depression on the medial condyle affecting the left femur distal articulation (Figure 6.19). The lesion measured 1.5x1 cm in maximum diameter and approximately 0.5 cm in depth. The margins were well defined and smooth. On the floor of the depression some porosity and traces of eburnation suggested contact with other bone tissue, and the appearance indicated a long-standing issue. Possible causes might be congenital defects, osteochondritis dissecans, or a chondroblastoma. Osteochondritis dissecans is considered the most likely cause of this lesion as the distal femur articulation is one of the most common places for osteochondritis dissecans.

Lower limb trauma - normative burials		
	Female	***Male***
L femur		
nf [%]	0	0
Ne	28	53
P1/3	28	53
M1/3	27	52
D1/3	22	50
R femur		
nf [%]	0	**2 [3.8]***
Ne	26	52
P1/3	24	48
M1/3	25	**2/49 (4.1)**
D1/3	24	48
L tibia		
nf [%]	0	0
Ne	23	43
P1/3	22	41
M1/3	21	40
D1/3	21	36
R tibia		
nf [%]	0	**1 [2.2]**
Ne	24	45
P1/3	16	43
M1/3	21	**1/43 (2.3)**
D1/3	22	37
L fibula		
nf [%]	**1 [4.3]**	0
Ne	23	43
P epiph	**1/4 (25)**	5
P1/3	23	41
M1/3	22	42
D1/3	21	38
R fibula		
nf [%]	**1 [4.3]**	0
Ne	23	41
P epiph	**1/2 (50)**	8
P1/3	23	41
M1/3	22	40
D1/3	22	38

Table 6.30: TPR of AM lower limb trauma in the normative burials. Percentage frequencies in parentheses. Ne: number of elements present; nf: number of fractures present.
This table only shows the bones that displayed at least one instance of trauma. For more details on presence of bones and fracture patterns by age-at-death see Appendix I.
** One femur is affected by two instances of trauma, but only one fracture is reflected here (IV_511: Figure 6.18a).*

Figure 6.19: Osteochondritis dissecans affecting the distal articulation surface of the left femur (IV_401).

Figure 6.20: Green stick fracture of the left femur causing slight deformation of the proximal-mid diaphysis (IV_675). Posterior view of the left and right femur for comparison.

The non-normative single burials and mass burials were considerably less affected by lower limb trauma. For individuals buried in non-normative single burials, one fracture was identified in the lower limbs (CPR: 2.6%). The fracture affected the left femur of a male individual (18-34 years) (Figure 6.20) (see Appendix 1 for more details on presence of bones by demographic groups). The femur fracture was identified through unilateral changes in shape that were considered most likely indicative of a well-healed greenstick fracture. The diaphysis was unusually flattened and broader in comparison to the right femur. Additionally, the proximal third was angled medially, and changes to the linea aspera at the mid third of the shaft were observed. The linea aspera was less pronounced but broader extending medially suggesting changes in muscle attachment. The left femur was 2 cm shorter than the right.

Within the mass burials, only two instances of foot fractures were identified (CPR 5.7%), while none of the leg bones were affected. One individual was an adolescent of indeterminate biological sex, the second one was estimated as young adult male.

Overall, twelve individuals displayed 15 instances of AM trauma in the bones of the lower limbs including foot bones (table 6.31). Two instances of multiple fractures to lower limbs are reported in more detail in section 6.5.4.3. The highest prevalence of lower limb fractures was present in the normative burials with twelve fractures in 132 individuals (CPR 9.1%). In contrast, only one individual was affected in the 39 single distinct burials (CPR 2.6%) and two out of 35 individuals buried in mass graves (CPR 5.7%).

	Elements Present	Elements fractured	Prevalence rate
L femur combined	**178**	**1**	**0.6%**
L femur mid 1/3	*167*	*1*	*0.6%*
R femur combined	**189**	**4**	**2.1%**
R femur mid 1/3	*165*	*3*	*1.8%*
R femur distal 1/3	*156*	*1*	*0.6%*
R tibia combined	**156**	**1**	**0.6%**
R tibia mid 1/3	*144*	*1*	*0.7%*
L fibula combined	**149**	**1**	**0.7%**
L fibula prox art	*16*	*1*	*6.3%*
R fibula combined	**142**	**2**	**1.4%**
R fibula prox 1/3	*133*	*1*	*0.8%*
R fibula distal art	*69*	*1*	*1.4%*
R Patella	**88**	**1**	**1.1%**

Table 6.31: TPR for AM fractures of the leg bones (foot bones excluded). All burial types, and demographic groups (biological sex and age-at-death) are included. Elements without fractures are excluded from this table.

The proximal fibula displayed the highest true prevalence of trauma in the lower limbs followed by the femur midshaft and the distal fibula. The right side was slightly more affected than the left side. Overall, males appeared at greater risk for lower limb trauma than females, but the difference in leg trauma prevalence was not statistically significant (χ^2 test: p-value: 0.964).

In addition to AM trauma, three males buried in normative burials showed evidence of perimortem sharp force trauma to the tibia in form of cuts to the anterior crest. In one case, the right tibia was affected (IV_499) and in the other two instances the left side (IV_241, IV_733). In all three examples, the straight cut margins were smooth, and the surface was similar in colouration to the rest of the bone surface. The tibia of IV_241 also displayed slight striations on the cut surface (Figure 6.21). In all three instances, no evidence of healing or infection was identified. Considering that these wounds would have been open and bone on the anterior tibia exposed, infection of the trauma site would be expected.

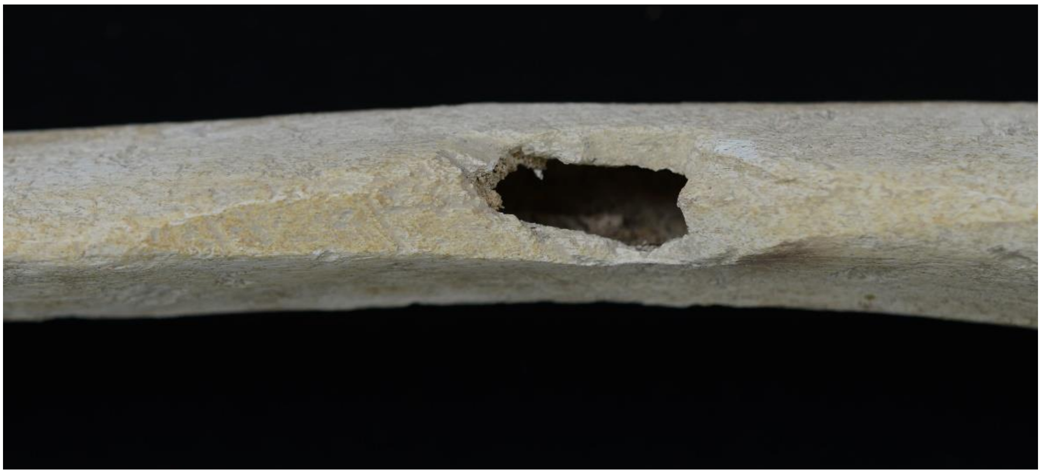

Figure 6.21: Perimortem cut to the anterior crest of the left tibia (IV_241) with striations on the cut surface and some PM damage.

IV_499 did not show evidence of other fractures, but IV_241 was also affected by multiple rib fractures, and IV_733 by a single cranial fracture and trauma to a right hand bone. Therefore, fracture recidivism could be identified for IV_241 and IV_733 (see section 6.5.4.3.2.).

6.5.4.2.3. Thorax trauma

The investigation of thorax trauma included the shoulder (clavicles and scapulae), sternum, vertebral column, and ribs (Morgan et al., 2022). The bones of the thorax were most commonly affected by trauma in the Phaleron burial ground.

i. Shoulder trauma

For shoulder trauma, the scapula (excluding os acromiale) and clavicle were considered. Overall, a small number of shoulder fractures were identified in the sample and only affected normative and non-normative single burials.

In the normative burials, fractures to both clavicles and the right scapula were present, while the left scapula appeared unaffected by fractures (table 6.32). Overall, six fractures were identified (CPR: 4.5%, N=132), and clavicles were more affected than scapulae (five vs. one fracture) (examples see Figure 6.22 and Figure 6.23). The TPR for right clavicles was higher than for the left side. The crude prevalence for clavicle fractures was higher for males (6.9%) than females (3.2%). The only scapula fracture present affected an unsexed adult individual.

Shoulder trauma – normative burials												
	Female			***Male***			***Unsexed***			***Total***		
	Ne	nf	nf (%)	Ne	nf	nf (%)	Ne	nf	nf (%)	Ne	nf	nf (%)
L Clavicle	24	**1**	**4.2%**	52	**1**	**1.9%**	21	0	0	97	**2**	**2.1%**
R Clavicle	24	0	0	51	**3**	**5.9%**	14	0	0	89	**3**	**3.4%**
L Scapula	14	0	0	43	0	0	8	0	0	65	0	0
R Scapula	18	0	0	39	0	0	9	**1**	**11.1%**	66	**1**	**1.5%**

Table 6.32: Prevalence of AM shoulder trauma in the normative burial sample. For fracture patterns by age-at-death see Appendix I. Ne: number of elements present; nf: number of individuals with fractures present.

Figure 6.22: Examples of clavicle fractures. Top: fracture of the acromial end (IV_554); Bottom: fracture of the acromial end with soft tissue ossification (IV_782).

Figure 6.23: Example of scapula fracture: healed fracture of the lateral border (IV_700)

Shoulder trauma in the non-normative single burials only affected the clavicles (table 6.33). In this burial group, four instances of clavicle fractures were identified in three individuals. One individual (5_135) displayed bilateral clavicle fractures. No difference in prevalence between the left and the right side could be observed. Overall CPR for clavicular trauma was with 9.7% visibly higher than in the normative burial sample. The CPR for clavicle fractures was slightly higher for females (12.5%) than males (10.5%).

In contrast to normative and non-normative single burials, no fractures to the shoulder bones were identified in the mass burials.

Shoulder trauma – non-normative single burials									
	Female			***Male***			***Total***		
	Ne	nf	nf (%)	Ne	nf	nf (%)	Ne	nf	nf (%)
L Clavicle	8	0	0	17	**2**	**11.8%**	32	**2**	**6.3%**
R Clavicle	7	**1**	**14.3%**	15	**1**	**6.7%**	30	**2**	**6.7%**

Table 6.33: Prevalence of AM shoulder trauma in the non-normative single burial sample. This table only shows the shoulder bones that displayed at least one instance of trauma. For more details on presence of shoulder bones and fracture patterns by age-at-death see Appendix I. Ne: number of elements present; nf: number of individuals with fractures present.

ii. Sternal trauma

Sternal fractures were infrequent with only two fractures in the entire study sample. Poor preservation of sternal bodies had an impact on prevalence rates so these fractures may be underrepresented. In the normative burial sample, one individual displayed evidence of a fracture to the sternal body (TPR 3.3%, CPR 0.8%) (Figure 6.24). The second instance of a fracture to the sternal body was identified in the non-normative single burials. Due to the low number of sterna preserved and sternal fractures, it was difficult to identify any trends. However, it is noteworthy, that both fractures affected male individuals.

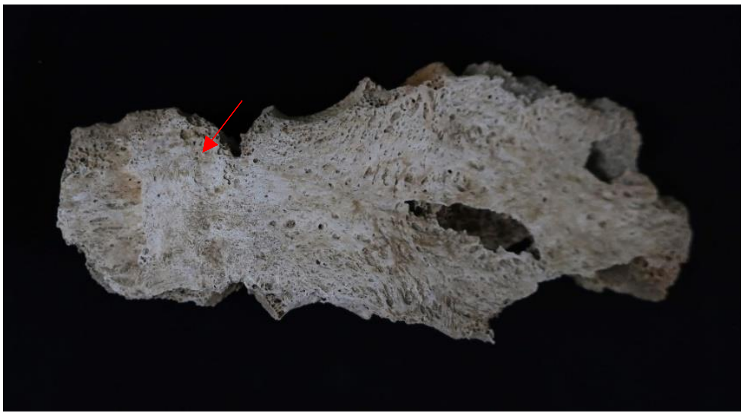

Figure 6.24: Example of fracture of the sternal body indicated by arrow (IV_758)

iii. Vertebral trauma

For the vertebral column, it was not possible to calculate true prevalence rates per vertebral position due to varied preservation. Instead, prevalence rates were calculated by vertebral type (cervical, thoracic, and lumbar vertebra), and vertebral bodies and the vertebral arches were treated separately. The body or arches of one vertebral type was considered as present in one individual if more than 25% of the bodies or arches were present. However, if a fracture could be identified in a poorly preserved vertebral column, the individual was still included in the analysis due to the fracture. Prevalence rates reported here reflect instances of trauma per individuals with preserved vertebral elements. If multiple fractures affecting the bodies or the arches were identified in one vertebral type, this is not reflected in the tables here, but will be reported further in section 6.5.4.3.

In the normative burial sample, fifteen individuals were affected by vertebral fractures with some displaying multiple fractures (CPR: 11.4%) (table 6.34). The highest true prevalence rates of trauma could be identified for the lumbar vertebrae both for males and unsexed individuals. Lumbar vertebrae displayed higher prevalence of fractures to the arch (spondylolysis) (Figure 6.25), while cervical and thoracic vertebrae exclusively presented trauma to the bodies (compression fractures) (Figure 6.26). For females, only one instance of trauma to one thoracic vertebral body and one instance of unilateral spondylolysis in an L5 (Figure 6.25) were observed (CPR: 6.5%). Two unsexed individuals displayed fractures (CPR: 4.7%), and in this group only the lumbar vertebrae were affected. In contrast, males were overall more affected by vertebral trauma and displayed a higher variance than females and unsexed individuals. Most individuals affected by vertebral trauma were considered adult except for one individual aged between 12 and 17 years, who was affected by spondylolysis to the fifth lumbar vertebra. It is noteworthy that the prevalence of lumbar vertebral arch fractures was over 20% for males and unsexed individuals aged between 18-34 years.

Figure 6.25: Examples of spondylolysis. Left: bilateral spondylolysis (IV_255); Right: unilateral spondylolysis (left neural arch) (5_245)

Figure 6.26: Examples of vertebral body fractures. Top: Compression fracture of T11 (IV_511); Bottom: Compression fracture of L vertebra (IV_692)

Vertebral trauma – Normative burials						
	Body			***Arch***		
	NI	nf	nf (%)	NI	nf	nf (%)
Female						
T vert	21	1	4.8%	26	0	0
L vert	22	0	0	26	1	3.8%
Male						
C vert	45	1	2.2%	46	0	0
T vert	43	4	9.3%	53	0	0
L vert	36	1	2.8%	48	7	14.6%
Unsexed						
L vert	4	0	0	17	2	11.8%
Total						
C vert	78	1	1.3%	83	0	0
T vert	70	5	7.1%	90	0	0
L vert	62	1	1.6%	91	10	11.0%

Table 6.34: Prevalence of AM vertebral trauma in the normative burials. NI: number of individuals with elements present; nf: number of individuals with fractures present. This table only shows the vertebral types that displayed at least one instance of trauma. For more details on presence of vertebrae and fracture patterns by age-at-death see Appendix I.

Vertebral trauma – Non-normative single burials						
	Body			***Arch***		
	NI	nf	nf (%)	NI	nf	nf (%)
Female						
L vert	4	1	25.0%	5	1	20.0%
Male						
T vert	10	0	0	12	1	8.3%
Total						
T vert	16	0	0	19	1	5.3%
L vert	17	1	5.9%	21	1	4.8%

Table 6.35: Prevalence of vertebral trauma in the non-normative single burial sample by biological sex and combined. NI: number of individuals with elements present; nf: number of individuals with fractures present. This table only shows the vertebral types that displayed at least one instance of trauma. For more details on presence of vertebrae and fracture patterns by age-at-death see Appendix I.

In contrast to the normative burial sample, individuals buried in non-normative single burials displayed a lower frequency of vertebral fractures (table 6.35). Three instances of vertebral trauma were present, but the two lumbar fractures were identified in the same individual (see Chapter 7: IV_734) meaning that only two individuals were affected by vertebral fractures (CPR: 5.1%). Additionally, the affected vertebral types differed from the normative burial sample with lumbar vertebral fractures in the female group and thoracic vertebra fracture only in the male group.

In the mass burials, only two males displayed evidence of lumbar fractures (spondylolysis) (table 6.36). In addition, one unsexed adolescent individual was affected by a healed fracture to the second cervical vertebra. The CPR for all vertebral fractures was 8.6% in the mass burials. Fractures to C1 and C2 were not observed in any other individuals.

Vertebral trauma – Mass burials						
	Body			***Arch***		
	NI	nf	nf (%)	NI	nf	nf (%)
Male						
L vert	13	0	0	19	2	10.5%
Unsexed						
C vert	3	1	33.3%	5	0	0
Total						
C vert	14	1	7.1%	21	0	0
L vert	16	0	0	28	2	7.1%

Table 6.36: Prevalence of vertebral trauma in the mass burial sample by biological sex and combined. NI: number of individuals with elements present; nf: number of individuals with fractures present. This table only shows the vertebral types that displayed at least one instance of trauma. For more details on presence of vertebrae and fracture patterns by age-at-death see Appendix I.

Overall CPR for vertebral trauma in the study sample was 11.2%. The highest prevalence and most variation of vertebral trauma was observed in the normative burial sample and within this burial group males displayed the highest prevalence. The differences between males and females buried in normative burials (χ^2 test: p-value: 0.056), as well as the differences between males buried in normative and non-normative single burials (χ^2 test: p-value: 0.176) and males buried in normative and mass burials (χ^2 test: p-value: 0.243) were not statistically significant. For cervical and thoracic vertebrae, fractures to the body were more common, while for lumbar vertebrae fractures of the neural arch (spondylolysis) were more often recorded. Overall, most fractures to the vertebral column can be considered stress fractures likely caused by excessive strain on the vertebral column.

iv. Rib trauma

As with vertebral trauma, it was not possible to calculate true prevalence rates per rib position due to differential preservation. Instead, prevalence rates were calculated for the left and right side for individuals with ribs present. The first rib was treated separately from ribs 2-12. At least one third of the ribs had to be present to be included in the analysis, and the left and right side were treated independently from each other. If rib fractures were identified in an individual with poorly preserved ribs that did not meet the requirements to be included based on preservation, that individual was nevertheless included to reflect the fracture in prevalence rates.

Fractures of first ribs were only observed for males, and two instances were identified in the entire study sample. One instance was present in the normative burials and one in the mass burials (table 6.37). Both fractures were observed for the left side, while none of the right first ribs displayed any evidence of fractures. Due to the low number of fractures to first ribs, no clear trends could be identified; however, it is noteworthy that both fractures were identified in males.

Fractures rib 1 – male individuals only						
	Left			***Right***		
	NI	nf	nf (%)	NI	nf	nf (%)
Normative burials	73	1	1.4%	77	0	0
Non-normative single burials	25	0	0	28	0	0
Mass burials	13	1	7.7%	16	0	0

Table 6.37: Prevalence of fractures to first ribs by burial category (males only). NI: number of individuals with elements present; nf: number of individuals with fractures present.

For ribs 2-12, the highest number of fractures was recorded for normative burials (table 6.38). Both sides were affected equally (22.8% and 22.9%), and males displayed a slightly higher prevalence than females. Several individuals showed multiple rib fractures (see also Figure 6.27), and this is reported further in section 6.5.4.3.

Fractures to ribs 2-12 – normative burials						
	Left			***Right***		
	NI	nf	nf (%)	NI	nf	nf (%)
Female	23	4	17.4%	25	4	16.0%
Male	45	10	22.2%	46	10	21.7%
Unsexed	11	4	36.4%	12	5	41.7%
Total	79	18	22.8%	83	19	22.9%

Table 6.38: Prevalence of fractures to ribs 2-12 in the normative burial sample. NI: number of individuals with elements present; nf: number of individuals with fractures present. For more details on fracture patterns based on age-at-death see Appendix I.

Figure 6.27: Example of multiple healed fractures affecting left ribs (IV_169)

The lower prevalence of rib fractures was statistically significant in the non-normative single burials (p-value: 0.024346) when compared to normative burials. Only two individuals displayed evidence of rib fractures (table 6.39). The prevalence rate was higher in females than in males, but both groups only showed one fracture instance each.

Fractures to ribs 2-12 – non-normative single burials						
	Left			***Right***		
	NI	nf	nf (%)	NI	nf	nf (%)
Female	4	1	25.0%	4	0	0
Male	9	0	0	9	1	11.1%
Unsexed	3	0	0	5	0	0
Total	16	1	6.3%	18	1	5.6%

Table 6.39: Prevalence of fractures to ribs 2-12 in the non-normative single burial sample. NI: number of individuals with elements present; nf: number of individuals with fractures present. For more details on fracture patterns based on age-at-death see Appendix I.

As non-normative single burials, individuals buried in mass burials also displayed a significantly lower prevalence of rib fractures than individuals buried in normative burials (χ^2 test: p-value: 0.044) (table 6.40). The difference between non-normative single burials and mass burials, on the other hand, was not statistically significant (χ^2 test: p-value: 0.714). Males and unsexed individuals were both affected in the mass burials.

Fractures to ribs 2-12 – mass burials						
	Left			***Right***		
	NI	nf	nf (%)	NI	nf	nf (%)
Male	14	1	7.1%	13	1	7.7%
Unsexed	5	0	0	5	1	20.0%
Total	19	1	5.3%	18	2	11.1%

Table 6.40: Prevalence of fractures to ribs 2-12 in the mass burial sample. NI: number of individuals with elements present; nf: number of individuals with fractures present. For more details on fracture patterns based on age-at-death see Appendix I.

Overall, rib fractures were prevalent to an unusually high degree, but the highest frequency was identified in the normative burials, and this difference was statistically significant when compared to non-normative burials. In the normative burials, males and females were equally affected, but the highest prevalence was identified for the unsexed individuals. There was a general trend towards higher prevalence of rib fractures in the two older age-at-death categories (35-49 years, 50+ years), but all age cohorts older than 12 years were affected. Additionally, several individuals displayed multiple rib fractures both unilaterally and bilaterally. While all rib fractures were identified as AM, a small number of individuals displayed fractures in early healing stages (woven callus only).

v. Thorax trauma: Summary

Overall, 79 instances of trauma to the thorax were observed equating to a CPR of 38.3%. This number does not include multiple fractures of the same element or area. For example, if one individual was affected by multiple fractures of the left ribs, this was only counted once in the above stated prevalence. The highest frequency of trauma was identified in the ribs with 20.8%. Lumbar vertebrae showed the second highest fracture prevalence with 7.3% followed by left and right clavicles combined with a prevalence of 4.3%. Scapulae, cervical and thoracic vertebrae, and sternal bodies all displayed a CPR of less than 3%. Fractures were identified in all demographic groups except for the 7-11 years cohort and all burial types were affected.

In the normative burial sample, the CPR of thoracic trauma was 47.0% with 62 instances of thoracic trauma. Excluding fractures of the midline bones (vertebral column and sternum), the right side was slightly more affected than the left. Rib fractures were most common (CPR 27.8%) followed by lumbar vertebra fractures (8.3%). Fractures to the shoulder girdle were more limited with six instances combined in both scapulae and clavicles. Males were more affected than females and there was a higher prevalence of fractures in older age-at-death cohorts.

In the non-normative single burials ten instances of trauma to the thorax were identified. The CPR for thorax trauma was 25.6%, and both sides were affected at a similar rate. Clavicles showed the highest prevalence of trauma followed by ribs (both sides combined) and lumbar vertebrae. In this burial group, females were more affected than males.

With seven instances of trauma in the mass burial sample, the CPR for thoracic trauma was 20.0% and, as such the lowest rate of all three burial groups. The highest frequency here was also encountered for the ribs followed by lumbar and cervical vertebrae.

6.5.4.2.4. Trauma to the innominate and sacrum

The bones of the pelvic gridle (innominate and sacrum) were affected by only a small number of fractures. In the entire sample, only four instances of pelvic and sacral trauma were recorded equating to a CPR of 1.9% (N=206). Due to the low number of fractures to the pelvis and sacrum, it was not possible to identify any meaningful trends.

In the normative burials, one case of trauma to the right innominate was identified. In this instance, the right ilium displayed evidence of a healed fracture (1/132; CPR: 0.8%). The affected individual was estimated as male and older than 50 years at death.

In the non-normative single burials, one fracture to a sacrum was observed (1/39, CPR: 2.6%). The TPR for sacral fractures in the non-normative single burials was 5.3% (1/19). The individual affected was estimated as female and aged between 18-34 years (see Chapter 7: IV_734, Figure 7.11). No further sacral fractures could be identified in the entire thesis sample.

In the mass burials, two fractures of the pelvic girdle were present affecting two different individuals (2/35; CPR 5.7%). The two fractures were observed in the ischium, and one instances affected the left side (Figure 6.28) and the second the right side. The TPR for specific demographic groups are high (100%) due to the low number of elements preserved in the respective groups; therefore, these high prevalence rates are not considered meaningful. A combined prevalence shows a TPR of 4.5% and 5.0% for ischium fractures of the left and right side.


Figure 6.28: Example of AM fracture of the left ischium (IV_361)

Overall, fractures of the bones of the pelvic girdle were rare in the thesis sample, but evidence for pelvis fractures could be identified in all three burial groups with the highest prevalence observed in the mass burials. The fractures affected different demographic groups, and no individuals aged younger than 18 years displayed evidence of trauma to this area. The only fracture in the normative sample was identified in an ilium, while in the non-normative single burials a sacrum displayed evidence of trauma. The fractures in the mass burials affected only ischia.

6.5.4.3. Multiple traumata and fracture recidivism

In the study sample, 45 individuals were affected by more than one instance of trauma meaning 21.7% of all individuals or 49.5% of individuals with evidence of trauma (N=91) were affected by more than one fracture. Multiple traumata either affected one area of the body only (e.g., multiple traumata to the cranium, multiple rib fractures) or different skeletal areas. In addition to distinguishing between single and multiple traumata, it is also important to differentiate between multiple traumata and fracture recidivism. Fracture recidivism was identified by the presence of multiple fractures in different healing stages. The different healing stages allow the identification of multiple injury events. In contrast, the number of trauma events cannot be identified in multiple traumata that were all completely healed (Biehler-Gomez et al., 2023; Redfern et al., 2017).

6.5.4.3.1. Multiple traumata

Overall, 37 individuals affected by multiple traumata could be identified (18.0%). All fractures were fully healed; therefore, it was not possible to identify whether the multiple fractures were the result of one traumatic event or multiple events. Multiple traumata affected individuals from all burial types (table 6.41), but the normative burials displayed the highest prevalence of multiple traumata (21.2%) followed by mass burials (17.1%), while non-normative single burials were least affected by multiple traumata (12.8%).

Males displayed the highest prevalence in the normative burials and in the mass burials, while females were more affected than males in the non-normative single burials. There was a trend towards higher prevalence of multiple traumata with increasing age; however, in the non-normative single burials, adults aged 18-34 years and 50+ years displayed the same prevalence.

Most individuals with multiple fractures buried in normative burial settings displayed evidence of thoracic trauma either in combination with fractures to other body areas or multiple fractures within the thorax region (for a detailed list see table 6.42). Fractures of ribs and vertebrae could be observed in 22 of the 26 individuals (84.6%). For nine individuals, trauma to the cranium was observed and in two cases multiple instances of trauma to the head were present. Furthermore, seven instances of arm fractures, two leg fractures, and three fractures of hand bones and foot bones respectively were observed. Spondylolysis was generally prevalent, but two instances of multiple spondylolysis were observed in the normative sample. In IV_255 (male, 18-34 years) the fourth and fifth lumbar vertebrae were affected, and individual IV_5 displayed spondylolysis affecting three lumbar vertebrae (L3-L5). Fractures of ribs were also highly prevalent with 17 out of 26 individuals with multiple traumata being affected by rib fractures. In eleven cases, multiple ribs were affected and five of these individuals did not display evidence of other fractures in addition to the rib fractures. The individual showing the only pelvic fracture in the normative burial sample also displayed a femur fracture (IV_503). One case of a male individual aged older than 50 years at death (IV_554) was especially striking. This individual displayed multiple instances of blunt force and sharp force trauma to the cranium. In addition, the left ulna, the right clavicle, multiple left ribs and one right rib, and one left foot phalanx were fractured AM, and the fifth lumbar vertebra displayed evidence of spondylolysis.

In the single non-normative burials, five individuals with multiple fractures were identified (table 6.41 and for detailed list see table 6.42). All individuals affected here could be estimated as male or female. Analogous to the normative burials, most individuals with multiple instances of trauma in the single distinct burials (4/5) also showed fractures of the thorax. There was only one instance of cranial trauma present in combination with a fracture of a right hand bone in a male individual aged older than 18 years (5_173). One male individual (18-34 years) showed bilateral clavicle fractures (5_135). One female individual (18-34 years) was affected by two fractures in the lumbar vertebrae, one compression fracture of a vertebral body and spondylolysis in L5, in addition to a fracture of the sacrum and of the right MC3

(Chapter 7: IV_734). The two remaining individuals displayed exclusively fractures of the thorax.

In the mass burials, six individuals showed evidence of multiple fractures (table 6.41 and for detailed list see table 6.42). Individuals from three mass burials were affected (mass burial 2, 6, and 7). Like in the normative and the non-normative single burials, thorax trauma was common in the mass burials, but fewer multiple fractures within the thorax area were observed. One individual was also affected by multiple instances of spondylolysis (L4-5). Cranial fractures had the second highest frequency. Both individuals with pelvic trauma displayed additional fractures.

Multiple traumata					
	female	***male***	***unsexed***	***total***	***% of N***
Normative burials					
7-11 yr	0	0	0	0	-
12-17yr	1	0	1	2	25.0
18-34yr	1	5	1	7	14.6
35-49yr	0	1	0	1	33.3
50+ yr	0	5	0	5	100.0
18+ yr	3	6	2	11	16.7
total	5 (16.1)	17 (29.3)	4 (9.3)	26 (19.8)	
Non-normative single burials					
7-11 yr	0	0	0	0	-
12-17yr	0	0	0	0	-
18-34yr	2	1	0	3	25.0
35-49yr	0	0	0	0	-
50+ yr	0	1	0	1	25.0
18+ yr	0	1	0	1	6.3
total	2 (25.0)	3 (15.8)	0 (0.0)	5 (12.8)	
Mass burials					
7-11 yr	0	0	0	0	-
12-17yr	0	0	0	0	-
18-34yr	0	3	0	3	17.6
35-49yr	0	1	0	1	50.0
50+ yr	0	0	0	0	-
18+ yr	0	1	1	2	15.4
total	0 (0.0)	5 (20.8)	1 (9.1)	6 (17.1)	

Table 6.41: Number of individuals affected by multiple traumata by burial type and demographic group. Percentage frequencies in parentheses.

Multiple traumata				
ID	***burial type***	***skeletal sex***	***age-at-death***	***AM fractures***
5_100	normative	female	12-17y	single rib, R fibula and patella
IV_169	normative	female	18+y	L radius, R radius, multiple ribs
IV_295	normative	female	18+y	multiple ribs
IV_777	normative	female	18+y	R radius, unidentified T vertebra
IV_782	normative	female	18-34y	L clavicle, single rib
5_125	normative	male	18+y	cranium, left metacarpal
5_164	normative	male	18+y	R ulna, multiple ribs
5_167	normative	male	18-34y	cranium, single hand phalanx
IV_5	normative	male	18-34y	cranium, L3-L5
IV_34	normative	male	18+y	L radius, single rib
IV_102	normative	male	49+y	cranium, L ulna, multiple ribs
IV_180	normative	male	18-34y	cranium, single rib, T12, L5
IV_202	normative	male	50+y	single rib, R metacarpal
IV_255	normative	male	18-34y	L4 and L5
IV_274	normative	male	18+y	multiple ribs
IV_400	normative	male	18+y	multiple cranium fractures
IV_401	normative	male	50+y	T12, single rib
IV_503	normative	male	50+y	R femur, R ilium
IV_554	normative	male	50+y	multiple cranium fractures, R clavicle, multiple ribs, L5, single foot phalanx
IV_692	normative	male	18-34y	R ulna, single T body, multiple L bodies
IV_703	normative	male	35-49y	cranium, multiple ribs
IV_779	normative	male	18+y	cranium, multiple ribs, L5, multiple hand phalanges
IV_114	normative	unsexed	18+y	multiple ribs
IV_244	normative	unsexed	18-34y	multiple ribs
IV_348	normative	unsexed	18+y	multiple ribs
IV_701	normative	unsexed	12-17y	L5, single metatarsal
IV_647	NN single	female	18-34y	multiple ribs
IV_734	NN single	female	18-34y	multiple lumbar vertebrae, sacrum, R metacarpal
5_135	NN single	male	18-34y	L and R clavicle
5_173	NN single	male	18+y	cranium, single hand phalanx
IV_62	NN single	male	50+y	L clavicle, multiple ribs
IV_289	mass burial	male	18+y	multiple ribs
IV_619	mass burial	male	18-34y	cranium, L5
IV_620	mass burial	male	18-34y	multiple cranium fractures
IV_637	mass burial	male	35-49y	L radius, R ischium, L4-5
IX_826	mass burial	male	18-34y	cranium, single rib
IV_361	mass burial	unsexed	18+y	single rib, L ischium

Table 6.42: Individuals affected by multiple instances of trauma. NN=non-normative

Overall, multiple traumata had a high frequency in the thesis sample (18.0%). This means that 40.7% of individuals with evidence of trauma experienced multiple fractures (37/91). The high frequency of thoracic trauma is also reflected in the individuals with multiple fractures. Interestingly, all individuals with pelvic fractures – an uncommon fracture type in this sample – were affected by multiple traumata.

6.5.4.3.2. Fracture recidivism

In addition to the evidence of multiple traumata, seven individuals displayed clear evidence for fracture recidivism and one individual for possible fracture recidivism (table 6.43). All eight individuals with evidence of (possible) fracture recidivism came from normative burials. For all eight individuals rib fractures were recorded in addition to at least one other fracture, and in most cases, the rib fracture was in early stages of healing (see Figure 6.29). The trauma observed is reported individually.

Fracture recidivism				
ID	***skeletal sex***	***age-at-death category***	***healed fractures***	***healing fractures***
IV_241	male	18+	Multiple ribs	L tibia (SFT)
IV_472	male	18+	R clavicle, R ribs	L and R ribs
IV_511	male	18+	R femur, R tibia, T11, L and R ribs	L ribs
IV_546	female	18-34	Cranium	L ribs
IV_674	male	18+	Cranium	L rib
IV_700	unsexed	18+	Cranium, R scapula, R and L ribs	R rib
IV_733	male	18-34	Cranium, R foot phalanx	L tibia (SFT)
IV_378	male	18-34	R rib	R ulna (?)

Table 6.43: Instances of fracture recidivism. All individuals were buried in normative burial settings.

Figure 6.29: Example of healing rib fracture with woven callus only (IV_700)

Burial IV_241

IV_241 (male, 18+ years) was affected by multiple AM rib fractures (Figure 6.30). One was identified for the left side (unnumbered) and two ribs were fractured on the right side (ribs 9-10). The right rib 10 was affected by two fractures, one on the middle third and one on the sternal third of the rib shaft. All rib fractures are well-healed and identified by a stable remodelled callus. In addition, the left tibia was affected by SFT to the anterior crest. The trauma site showed no evidence of healing or infection secondary to an open wound and was, therefore, identified as perimortem.

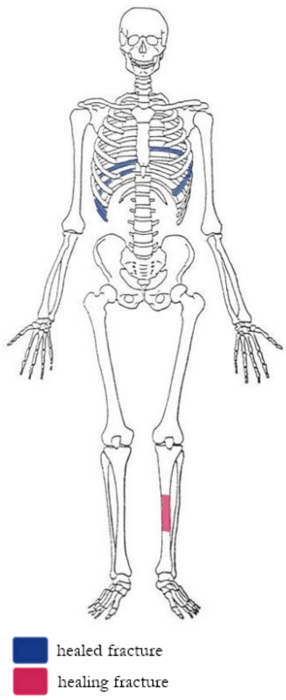

Figure 6.30: IV_241 Fracture recidivism.

Burial IV_472

IV_472 (male, 18+ years) displayed a fracture of the right clavicle at the medial third of the diaphysis (Figure 6.31). The fracture site showed malunion in form of slight overlap and angulation. The inferior aspect of the fracture site was irregular suggesting ossification of soft tissue. A minimum of seven ribs were fractured. Three ribs on the left side and one right rib displayed complete fractures that were in the process of healing at the time of death as evidenced by the presence of woven calluses making one fracture event for all four fractures plausible. Additionally, three ribs on the right side were fractured, but these fractures were completely healed at death (remodelled calluses). The left parietal bone was possibly also affected by a depression fracture (BFT). A small and shallow indentation was observed ectocranially, but due to the small size of the indentation this could not be identified as clear evidence of AM cranial trauma; therefore, this possible fracture was not included in the trauma analysis.

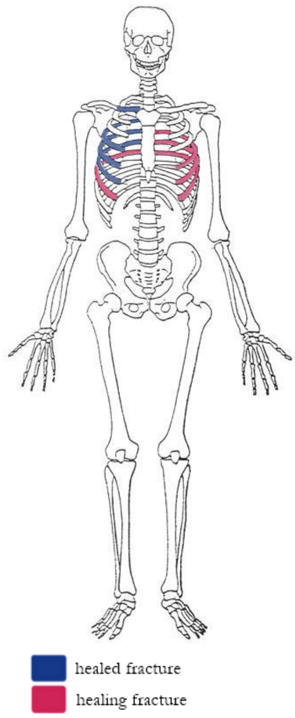

Figure 6.31: IV_472 Fracture recidivism.

Burial IV_511

IV_511 (male, 18+ years) was affected by severe trauma to the right femur and tibia (Figure 6.32). The femur displayed two fractures of the diaphysis affecting the mid and distal third suggesting very strong force (Figure 6.18a). The fracture to the distal third was fully healed but malunion in the form of overlap of approximately 4 cm and angulation was observed, while the healed fracture affecting the mid third displayed only slight angulation and no overlap. The fractures resulted in a considerably shorter right femur than the left. Degenerative changes in the knee joint provided evidence that the individual lived for considerable time after the traumatic incident and continued to use their leg.

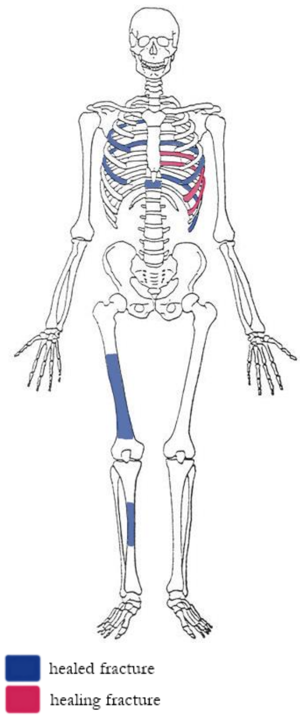

Figure 6.32: IV_511 Fracture recidivism.

Furthermore, the right tibia was fractured midshaft, which might have been caused by the same event. The tibia fracture was incomplete and visible by an oblique callus on the lateral aspect. Additionally, T11 exhibited a healed compression fracture of the vertebral body resulting in a wedge-shaped body. At least six instances of trauma were present in the ribs. The left ribs 6 and 7 exhibited fractures to the vertebral third. The fracture sites showed some evidence of healing activity in form of mixed woven and remodelled bone formation, but the fractured ribs were not united. The appearance of these two fractures suggests that they were in the process of healing at the time of death. In addition, four more ribs (two left and two right ribs) were affected by fractures that were completely healed when the individual died.

Burial IV_546

IV_546 (female, 18-34 years) showed a depression fracture of the right parietal bone (11.6x8.2mm) attributed to blunt force trauma (Figure 6.33). The fracture was well healed and can be considered superficial, as the endocranial surface appeared unaffected. Two left ribs (ribs 5 and 7) were fractured at the sternal third of the body. The fracture sites showed extensive woven new bone formation and could be identified as fractures in early stages of healing. Additionally, the left fourth rib showed some active new bone formation on the visceral surface. A break was present at the exact site, but reconstruction of the rib limited the possibility to evaluate whether this was an AM fracture or a postmortem break in an area that was affected by an active inflammation. A connection between the three rib lesions is possible.

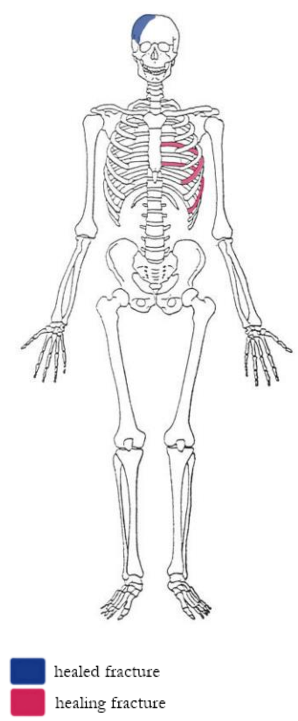

Figure 6.33: IV_546 Fracture recidivism.

Burial IV_674

IV_674 (male, 18+ years) was affected by a depression fracture to the right parietal bone (12x6mm) (Figure 6.34). Furthermore, the left seventh rib was fractured at the sternal end of the body. The fracture was stabilised but not fully healed as evidenced by a partially remodelled callus. Especially on the visceral surface, the extensive new bone formation was still active at the time of death.

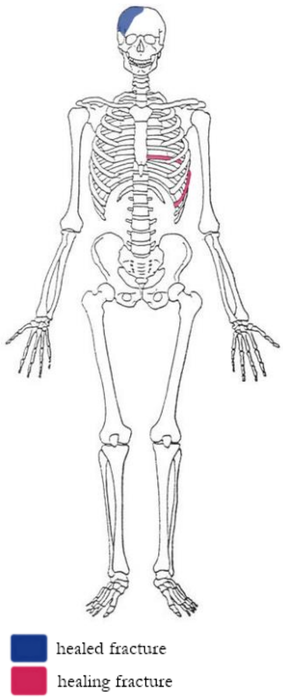

Figure 6.34: IV_674 Fracture recidivism.

Burial IV_700

IV_700 (unsexed, 18+ years) displayed an oval depression fracture on the occipital bone (10.5x8.5mm) located on lambda (not visible in the diagram Figure 6.35). The fracture was completely healed, and no changes were observed on the endocranial surface. In addition, several fractures affected the thorax (Figure 6.35). The right scapula displayed a fracture on the lateral border approximately 2.5 cm inferior to the glenoid fossa (see also Figure 6.23). The fracture was visible as a line with some lamellar new bone formation; however, postmortem damage limited observability. Four left ribs (5-8) showed evidence of fully healed fractures, and for the right side, three ribs affected by

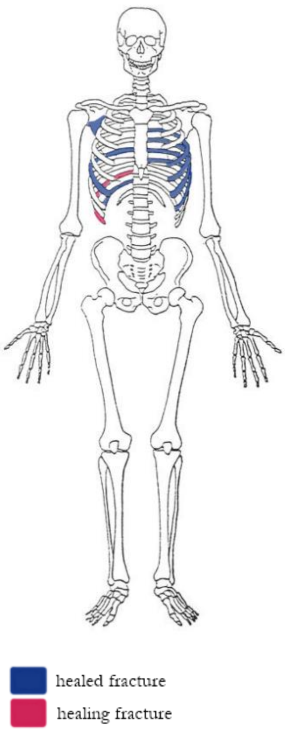

Figure 6.35: IV_700 Fracture recidivism.

trauma were identified. Ribs 7 and 11 showed evidence of healed stable fractures on the mid-third of the body (rib 7) and sternal third (rib 11). The right rib 10 also displayed a complete fracture; however, this fracture was only in the process of healing. Callus formation on the visceral and lateral aspect of the shaft can be observed, but the new bone was only partially remodelled indicating that the fracture was not fully healed when this individual died.

Burial IV_733

IV_733 (male, 18-34 years) was affected by multiple instances of SFT (Figure 6.36). The left parietal bone showed a small instance of AM SFT (1.3cm) parallel to the coronal suture. The deepest part of the fracture was superior, and it tapered out towards inferior. The trauma margins were smooth and well remodelled. The right first proximal foot phalanx was affected by an AM fracture (BFT) that could be identified by a well-healed callus. As IV_241, IV_733 also showed evidence of a perimortem SFT to the anterior crest of the left tibia. The smooth margins, similar colouration, and lack of any indication of healing or infection are suggestive of perimortem trauma.

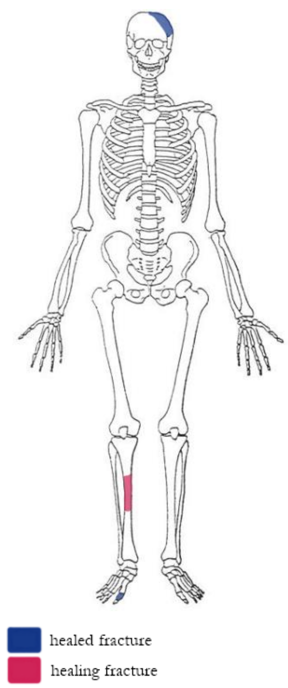

Figure 6.36: IV_733 Fracture recidivism.

Burial IV_378

IV_378 (male, 18-34 years) was affected by multiple fractures, and possible fracture recidivism was identified (Figure 6.37). The right rib 11 was affected by a completely remodelled fracture at the vertebral third of the body. In addition, the right ulna displayed a fracture at the mid third of the diaphysis. The fracture was complete, and some remodelling was present, but the fracture was not united and woven bone formation could be observed along the fracture lines. Bone formation was also present in the medullary cavity. The woven bone indicates active processes at death; however, the possibility that this was a longer standing fracture with a non-union complication could not be excluded. Therefore, this was not considered clear evidence of fracture recidivism. The possibility that this presents another case of multiple traumata rather than fracture recidivism should be taken into consideration.

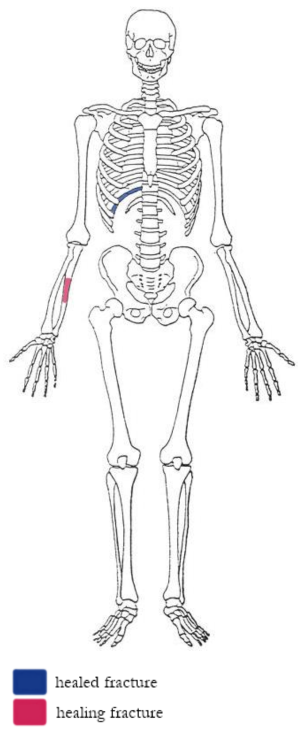

Figure 6.37: IV_378 possible fracture recidivism.

6.5.4.4. Summary

AM trauma was prevalent to an exceptionally high degree in the thesis sample, while evidence for perimortem trauma was more limited. The highest frequency of fractures was identified in the thorax mostly affecting ribs and vertebrae. Instances of multiple fractures in the thorax were common in all burial types. Additionally, cranial trauma was frequently identified affecting all burial types and adult demographic groups. Most cases of cranial trauma were attributed to blunt force trauma, but several male individuals buried in normative burial settings were also affected by sharp force trauma. The upper limbs displayed more instances of trauma than the lower limbs, but a small number of cases of high impact fractures affecting femur and tibia were identified. The lowest trauma prevalence was identified in the pelvic bones and sternum. Interestingly, all cases of pelvic trauma were found in individuals with multiple traumata.

An important differentiation for trauma is between accidental trauma and interpersonal violence; however, this differentiation is not always clear cut. Generally, cranial fractures and fractures of the distal third of the ulna ('parry fracture') (Judd, 2008) are considered as evidence of interpersonal violence. Using this definition, the highest prevalence of interpersonal violence was identified in the normative burials. Here, males were more affected than females, but the difference was not statistically significant (χ^2 test: p-value: 0.225). Difference in trauma frequency attributed to interpersonal violence between males from normative burials and non-normative burials was also statistically not significant (χ^2 test: p-value: 0.294). In contrast to interpersonal violence, the higher prevalence of accidental injury in males buried in normative burials than in males buried in non-normative burials was statistically significant (χ^2 test: p-value: 0.02), while the difference in accidental injury prevalence between males and females from normative burials was also not statistically significant (χ^2 test: p-value: 0.185).

6.5.5. Vertebral joint disease

Vertebral joint disease was also highly prevalent in the study sample. As with the trauma analysis, it was not possible to calculate true prevalence rates per vertebral position for joint disease due to differential preservation. Instead, prevalence rates were calculated by vertebral type (cervical, thoracic, and lumbar vertebra). The vertebral body and vertebral arch were treated separately. Body or arch of one vertebral type was considered as present in an individual if more than 25% of the bodies or arches were preserved. If joint disease could be identified in a vertebral column section that did not qualify as 'present' by those standards, the individual was still included to reflect the disease presence. Prevalence rates reflect instances of vertebral joint disease per individuals with preserved vertebral elements.

Overall, females displayed a slightly higher prevalence than males for vertebral joint disease (tables 6.44 and 6.47); however, prevalence varied for different sections of the vertebral column. For females, higher prevalence of joint disease was observed for the vertebral arches, while males exhibited a higher frequency of joint degeneration to the vertebral bodies except for Schmorl's nodes (table 6.44). The differences between males and females overall were only slight and not statistically significant (χ^2 test: p-value: 0.319). Cervical vertebrae displayed a higher prevalence of arch degeneration, while lumbar vertebrae were more affected by degeneration of the body. For both males and females, the dens articulation showed osteoarthritic changes in approximately 25% of individuals (see also table 6.45).

Vertebral joint disease							
Observation	***Vertebrae***	***Number of individuals with vertebral elements***		***Number of Individuals affected***		***Percentage affected***	
		F	*M*	*F*	*M*	*F*	*M*
OP/P/EB	C1/C2 (dens art)	30	85	7	22	23.3	25.9
	C arch	29	74	9	19	31.0	25.7
	T arch	29	82	10	24	34.5	29.3
	L arch	30	80	5	8	16.7	10.0
OP/P	C body	28	67	4	21	14.3	31.3
	T body	21	63	6	22	28.6	34.9
	L body	25	59	11	27	44.0	45.8
SN	T body	21	63	6	17	28.6	27.0
	L body	25	59	5	11	20.0	18.6
All JD	all	37	94	27	60	73.0	63.8

Table 6.44: Prevalence of vertebral joint disease in the entire study sample regardless of burial type by biological sex. Unsexed individuals are excluded. OP: Osteophyte formation, P: porosity, EB: eburnation, SN: Schmorl's nodes, JD: joint disease.

Regardless of biological sex, evidence of vertebral joint disease was present in all adult age-at-death cohorts, but none of the individuals aged younger than 18 years at death were affected by joint degeneration of the vertebral column. An overall tendency towards higher prevalence with increasing age could be observed, which is in line with what can be expected as joint disease is correlated with increased age. However, a high prevalence of degeneration of vertebral bodies could also be observed for younger adults (18-34 years at death) (tables 6.45 and 6.47).

Vertebral Joint disease (percentage) – Overall									
	OP/P/EB				***OP/P***			***SN***	
	C1/C2 (dens)	*C arch*	*T arch*	*L arch*	*C body*	*T body*	*L body*	*T body*	*L body*
18-34y	12.9	13.8	21.7	7.5	10.9	25.5	25.9	29.1	7.5
35-49y	14.3	14.3	14.3	0.0	42.9	42.9	60.0	14.3	0.0
50+y	44.4	55.6	66.7	12.5	77.8	42.9	100.0	14.3	12.5
18+y	32.8	36.4	36.6	20.4	33.3	33.3	46.2	15.8	20.4
Total	23.5	25.4	29.4	11.5	25.2	30.2	40.0	25.0	11.5

Table 6.45: Prevalence of vertebral joint disease in percentage in the entire study sample regardless of burial type by age-at-death (female, male, and unsexed individuals included). OP: Osteophyte formation, P: porosity, EB: eburnation, SN: Schmorl's nodes, JD: joint disease

Vertebral Joint disease – Male only										
Obs.	***Vertebrae***	***Number of individuals with vertebral elements***			***Number of Individuals affected***			***Percentage affected***		
		N	*NN*	*MB*	*N*	*NN*	*MB*	*N*	*NN*	*MB*
OP/P/EB	C1/C2 (dens art)	50	16	19	12	8	2	24.0	50.0	10.5
	C arch	45	13	16	12	6	1	26.7	46.2	6.3
	T arch	52	12	18	16	7	1	30.8	58.3	5.6
	L arch	47	14	19	5	3	0	10.6	21.4	0.0
OP/P	C body	44	12	11	14	6	1	31.8	50.0	9.1
	T body	42	10	11	15	5	2	35.7	50.0	18.2
	L body	35	11	13	17	8	2	48.6	72.7	15.4
SN	T body	42	10	11	14	1	2	33.3	10.0	18.2
	L body	35	11	13	10	1	0	28.6	9.1	0.0
All DJD	all	55	17	22	42	12	6	76.4	70.6	27.3

Table 6.46: Prevalence of vertebral joint disease for male individuals only by burial type. OP: Osteophyte formation, P: porosity, EB: eburnation, SN: Schmorl's nodes, JD: joint disease. N: Normative burial, NN: non-normative single burial, MB: mass burial

Comparison between burial types was only possible for males, and some clear differences between males buried in normative and non-normative single burials when compared to individuals buried in mass burials could be observed (table 6.46). Males from normative burials displayed statistically significant higher frequencies of vertebral joint disease than males from mass burials (χ^2 test: p-value: <0.001). The lower frequency in the mass burials might be partially related to the lack of advanced age-at-death cohorts in the mass burial sample, but the results were still significant after excluding adults aged older than 50 years from the normative and non-normative single burials.

In addition, two unsexed adult individuals (5_103 and IV_192) exhibited evidence of diffuse idiopathic skeletal hyperostosis (DISH) or ankylosing spondylitis (AS) (Figure 6.38). In both cases, a minimum of four thoracic vertebrae were fused, but the preservation limited identification of certain vertebrae and a definite diagnosis as DISH or AS. Based on the appearance and location of lesions, an interpretation as DISH appears more plausible than AS. Both DISH and AS are inflammatory reactions and not considered activity related joint degeneration; therefore, both examples are not reflected in the tables regarding degenerative vertebral joint disease and will not be discussed as indicator of activity. One female individual (IV_684) displayed ankylosis of L4, L5, and the sacrum, and the appearance of these lesions is more consistent with AS (see section 7.5.).

Figure 6.38: Example of possible DISH or ankylosing spondylitis in the thoracic vertebrae (5_103).

Overall, the study sample displayed a high prevalence of vertebral joint disease. The normative and non-normative single burials were statistically significantly more affected than the individuals buried in mass burials. Overall, females showed a slightly higher prevalence than males. An increase in prevalence could be observed in older age-at-death cohorts, but individuals aged younger than 35 years at death also showed relatively high prevalence of vertebral joint disease (table 6.47).

Vertebral Joint disease												
	Number of individuals with vertebral elements				***Number of Individuals affected***				***Percentage affected***			
	F	*M*	*?*	*T*	*F*	*M*	*?*	*T*	*F*	*M*	*?*	*T*
18-34	21	48	7	76	15	28	2	45	71.4	58.3	28.6	59.2
35-49	1	4	3	8	1	2	1	4	100	50.0	33.3	50.0
50+	1	8	0	9	1	8	0	9	100	100	0.0	100
18+	14	34	28	76	10	22	12	44	71.4	64.7	42.9	57.9
Total	37	94	38	169	27	60	15	102	73.0	63.8	39.5	60.4

Table 6.47: Prevalence of vertebral joint disease in the study sample by biological sex and age-at-death cohort regardless of burial type.

6.5.6. Co-occurrence of lesions

Co-occurrence of lesions was tested for statistical significance for all discussed pathology categories (summary see table 6.48). Incomplete preservation impacted the recording of different pathological lesions; therefore, statistical analysis for co-occurrence of pathological lesions was undertaken regardless of demographic groups and burial type to ensure sufficient data for statistical testing.

The co-occurrence of two indicators of childhood stress, DEH and CO, was not statistically significant (χ^2 test: p-value: 0.637). The statistically analysis suggested that individuals presenting with DEH were at significantly higher risk for inflammatory reactions such as tibial periosteal new bone formation (χ^2 test: p-value:

0.043) and periodontal disease (χ^2 test: p-value: 0.039). DEH also significantly correlated with trauma (χ^2 test: p-value: 0.035). In contrast, DEH was not significantly linked with other categories of dental disease. However, different forms of dental disease were interconnected, and statistical significance was observed for the co-occurrence of AM tooth loss and periodontal disease (χ^2 test: p-value: <0.001), periapical lesions and caries (χ^2 test: p-value: 0.014), as well as periapical lesions and AM tooth loss (χ^2 test: p-value: 0.027) and the co-occurrence of caries and AM tooth loss (χ^2 test: p-value: <0.001). In contrast to DEH, CO did not strongly correlate with other pathological lesions and does not appear to be linked to increased frailty in this instance. Additionally, caries and trauma were significantly linked (χ^2 test: p-value: 0.011), and co-occurrence of trauma and periodontal disease was also statistically significant (χ^2 test: p-value: 0.010). Co-occurrence of vertebral joint disease and different forms of dental disease was statistically significant. All forms of destructive and degenerative dental disease including caries (χ^2 test: p-value: 0.002), AM tooth loss (χ^2 test: p-value: 0.002), periodontal disease (χ^2 test: p-value: 0.028), and periapical lesions (χ^2 test: p-value: 0.019) appear significantly associated with vertebral joint disease. Additionally, a statistically significant co-occurrence with trauma could also be observed (χ^2 test: p-value: <0.001). None of the other investigated indicators of early life stress or periosteal new bone formation was statistically significantly linked with vertebral joint disease.

Statistical significance for co-occurrence of lesions								
	CO	***C***	***AMTL***	***PD***	***PAL***	***PNBF***	***VJD***	***Trauma***
DEH	0.091	0.078	0.077	***0.039***	0.351	***0.043***	0.875	***0.035***
CO	-	0.893	0.428	0.652	0.217	0.149	0.789	0.525
C	-	-	***<0.001***	0.208	***0.014***	0.206	***0.002***	***0.011***
AMTL	-	-	-	***0.001***	***0.027***	0.387	***0.002***	0.305
PD	-	-	-	-	0.068	0.377	***0.028***	***0.010***
PAL	-	-	-	-	-	0.323	***0.019***	0.101
PNBF	-	-	-	-	-	-	0.177	0.222
VJD	-	-	-	-	-	-	-	***0.001***

Table 6.48: Summary of statistical significance of co-occurrence of pathological lesions using χ^2 testing.
Statistically significant results *(alpha: 0.05).*
DEH: Dental enamel hypoplasia; CO: cribra orbitalia; C: Caries; AMTL: AM tooth loss; PD: periodontal disease; PAL: periapical lesions; PNBF: tibial periosteal new bone formation; VJD: Vertebral joint disease.

6.6. Summary

In summary, the above presented results show some differences in demographic composition of the three burial groups and significant differences in diseases frequency in addition to some more general trends that are not statistically significant.

Overall, males dominated the thesis sample, while females were underrepresented. For approximately 25% of individuals, it was not possible to estimate biological sex due to preservation or young age-at-death, but it is unlikely that preservation bias would disproportionally affect females in such a way that the indeterminate category would balance the apparent sex bias. In all three burial types, the age-at-death category 18-34 years constituted the largest age-at-death cohort except for the category 18+ years. The large proportion of individuals that could not be aged more accurately than 18+ years was a limiting factor. Males and adults aged under 34 years were overall identified as the largest demographic groups, but they were most dominant in the mass burials potentially suggesting a cultural selection bias for the mass burials.

Considering differences in pathological lesions based on biological sex, females displayed higher rates of early life stressors and dental disease than males in the normative burials, while this trend was reversed in the non-normative single burials, where males appear to be more affected. Generally, dental disease was correlated with advanced age. Males were slightly more affected by PNBF than females regardless of burial type, and males also showed a higher prevalence of skeletal trauma than females; however, the difference was not statistically significant in the normative burial sample. In contrast, females displayed a slightly higher prevalence rate of vertebral joint disease. Differences in disease frequency between males and females interred in normative burials were generally not statistically significant, but instead more general trends can be identified.

When considering burial types, individuals buried in normative burials showed generally higher disease frequencies, and lowest prevalence of lesions was consistently identified in the mass burials. In contrast to the gendered differences within the normative burial sample, variations in disease frequency between males from different burial groups were often statistically significant. The prevalence of early life stressors was highest in normative burials, while non-normative single burials displayed the lowest frequency in combination with the highest median stature. The higher frequency of DEH in males buried in normative burials than in mass burials was statistically significant. Normative burials and non-normative single burials were generally more affected by dental disease than the individuals buried in mass burials and the higher prevalence of caries, AM tooth loss, and periapical lesions in males buried in normative burials than in mass burials was statistically significant. Similarly, the higher prevalence of PNBF of males buried in normative burials than those buried in mass burials was statistically significant. Interestingly, the highest prevalence of fractures that are associated with interpersonal violence was identified in the normative burials, but only the higher prevalence in accidental trauma in the normative burial sample was statistically significant when compared to the mass burials. Furthermore, the prevalence of vertebral joint disease was significantly higher in normative and non-normative single burials than in the mass burials.

Trauma was generally highly prevalent in the thesis sample, and a large number of individuals with multiple AM traumata could be identified in all burial groups. All eight instances of (possible) fracture recidivism were found in the normative burial sample and affected males more than females.

The results present us with a picture of generally and often significantly higher disease prevalence in the normative burials than in the mass burials with the non-normative single burials often sitting between the two other burial categories. Females interred in normative burials tended to show slightly higher disease prevalence than males except for trauma, but these differences were general trends and not statistically significant.

Co-occurrence of some lesions was statistically significant. Different expressions of dental disease were interlinked, and association was often statistically significant. Individuals affected by DEH appear at higher risk for inflammatory reactions based on statistically significant co-occurrence of these stress indicators. Both trauma and vertebral joint disease were significantly linked with each other and some forms of dental disease.

7. An Osteobiographical Approach

7.1. Introduction

The following chapter presents four osteobiographies of individuals buried at Phaleron. These include two individuals interred in simple pit burials, one burial lined with mud bricks (‘cist-like burial’), and one non-normative single burial (prone burial). Individuals of both skeletal sexes (male and female) and adults of different age-at-death groups were selected. Individuals from mass graves were excluded in this section as these present a distinctly different group and potentially are not representative of the broader population. It is recognised that osteobiographies do not speak for the entire population and that experience of life and disease is a highly individual and personal matter (Hosek and Robb, 2019). The four individuals were selected with the intention of including multiple different identity intersections into the osteobiographies. In addition to the stress indicators that were employed on a population basis, all macroscopically identified pathological lesions were incorporated in the osteobiographical analysis. The data was interpreted within the historical and individual burial context in reference to clinical and bioarchaeological research. In combination with the population-based analysis, this allows to gain a more comprehensive and multifaceted picture of the lives of the people buried at Phaleron.

7.2. Osteobiography of 5_253

7.2.1. Burial context

Individual 5_253 was buried in sector V in a simple pit burial dug into the coastal sand. The burial could not be excavated in its entire extent as it was cut by the excavation boundaries (Figure 7.1). The body was buried in a north-south orientation with the head positioned towards south, and the skeleton was found in a stretched supine position. The neck was overextended with the skull tilted backwards and the face oriented towards the cranial end of the grave. The left arm was extended along the body, while the right arm was slightly bent with the right hand resting in the pelvic area. The burial type, positioning of the body, and lack of grave goods are all representative of the simple pit burials in the cemetery. The archaeological analysis is still underway, and the burial has not yet been dated.

Figure 7.1: Burial 5_253 in excavation. © The Ephorate of Antiquities of West Attica, Piraeus and Islands.

7.2.2. Skeletal analysis

The individual was between 50-75% complete (Figure 7.2) with the bones of the lower legs and feet not excavated due to the location outside excavation boundaries. Fragmentation was limited and surface preservation was moderate to severe with some surface erosion and root markings obscuring the surface observability. Biological sex was estimated as male, and age-at-death between 24-40 years (young-middle adult). Stature was estimated as 169.30 +/- 5.108 cm based on the length of humerus and ulna.

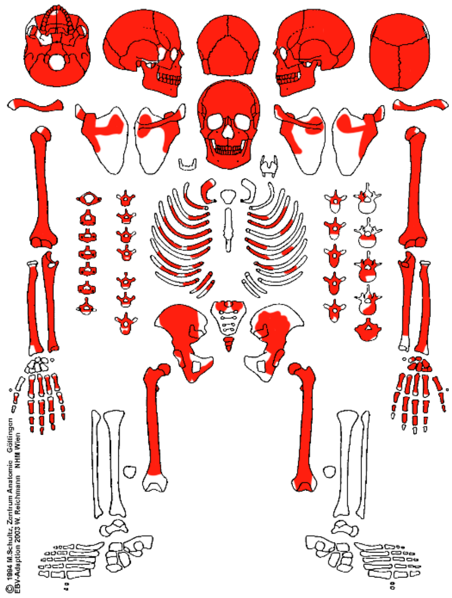

Figure 7.2: Skeletal diagram of completeness of individual 5_253

Evidence of childhood stress was observed in form of porosity in the orbits and DEH on the maxillary and mandibular canines and maxillary second incisors. Recording of dental pathology was limited by the poor surface preservation that masked the more subtle changes. Dental wear was moderate in most of the dentition, and most severe wear affected all four first molars. Evidence of calculus could only be observed in the maxillary right canine and first and second molars. Alveolar resorption was slight throughout the dentition and not considered pathological.

The right ulna, radius, and metacarpals were affected by a severe infection that was active at time of death (Figure 7.3). The carpals were not present for the right hand. The distal third of the diaphyses of the ulna and radius showed several layers of woven bone formation. There was limited evidence of healing, but transitional bone could be observed in small areas, and the joint surfaces had a health appearance. In contrast, the entire diaphyses of the preserved metacarpals were affected by new bone formation. The identification of the metacarpals is tentative as the proximal ends were not preserved and the shaft morphology has been altered by new bone formation.

Figure 7.3: Localised infection of the right arm and hand bones (5_253).
a) Overview of radius ulna and hand bones; b) Detail of new bone formation affecting the metacarpals; c) Detail of new bone formation affecting the radius.

The metacarpals, tentatively identified as MC2, MC3 and MC4, presented thick layers of irregular new bone formation with some porosity on all surfaces. Some remodelling was observed, but the appearance of the new bone suggests a severe active infection. The metacarpal that was identified as likely MC5 was affected to a lesser degree. Woven bone formation was also observed on the diaphysis of this bone, but here it presented as a thinner layer of periosteal new bone. Slight woven bone formation was also observed on the palmar aspects of the proximal phalanges. Overall, the bone formation on the distal radius and ulna and all preserved metacarpals suggests an active, potentially longer standing, and severe but localised infection. A possible cause would be an open wound on the right hand.

The fifth lumbar vertebra presented evidence of bilateral spondylolysis. The fracture site was remodelled. Whether this led to spondylolisthesis of L5 cannot be determined due to poor preservation of the sacrum. The bodies of vertebrae L3 to L5 appeared slightly compressed. However, this was not expressed enough to identify compression fractures of the bodies with certainty. Slight osteophyte formation was observed in the superior articulation facets of L5 and the vertebral body of L4. These changes are potentially connected to the spondylolysis and a reaction to stabilise the vertebral column.

7.2.3. Synthesis

The burial context of individual 5_253 was typical for the burial ground and thesis sample population. The individual was buried in the most common burial type encountered in the cemetery: a simple unfurnished pit burial. The burial position suggests a careful placement of the body in the grave. While the lower leg bones could not be recovered due to the excavation constraints, the burial position was supine and likely completely extended. The individual was estimated as a 'young to mid adult' male and as such is in the majority demographic for the sample population.

The presence of cribra obritalia and dental enamel hypoplasia is indicative of physiological stress during childhood. The crowns of the affected teeth (permanent incisors and canines) form between the ages of 1 and 5 years (AlQahtani et al., 2010). However, skeletal growth did not appear impacted, suggesting that skeletal catch-up growth was possible. The estimated stature of 169.30 cm was slightly higher than the median height for males buried in normative burials (165.22 cm).

Dental health was comparatively good with no significant pathological lesions such as caries or periapical lesions present. While periapical lesions were limited in the sample in general, caries was more prevalent. All teeth were present in-situ except for maxillary third molars, which might have been impacted, congenitally absent, or lost AM. The in-situ preservation of the dentition was a limiting factor as interproximal surfaces were not always observable. However, any lesions affecting the interproximal surfaces would have been small and likely would not have impacted the individual in any significant way. One factor for comparatively good dental health could be a diet with limited carbohydrate intake (Hillson, 2008).

The fifth lumbar vertebra was affected by bilateral spondylolysis. This defect of the pars interarticularis is considered a stress fracture that is secondary to chronic trauma to the lower back. Spondylolysis can be asymptomatic in some cases, but clinical research shows that it has the potential to cause spinal instability or back pain (Leone et al., 2011). It is possible that asymptomatic spondylolysis stays undetected in clinical cases thus creating an underestimation of prevalence in the clinical literature. Nowadays, spondylolysis is more prevalent in males than in females, and disproportionately affects athletes such as rugby and football players or ballet dancers. Repetitive movements such as extension and rotation of the lower back appear to be connected to lumbar spondylolysis (Sakai et al., 2010). Spondylolysis in this context was likely connected to undertaking repetitive activity in an occupational context, which would have been demanding on the individual physically in general. Individual

5_253 might have experienced either none or only minor symptoms caused by the lumbar fracture.

The most significant and debilitating pathological lesion observed in individual 5_253 was the infection affecting the right hand and forearm. Metacarpals and the inferior third of ulna and radius displayed active and extensive periosteal new bone formation (Figure 7.3). The carpals were not recovered, but it can be assumed that these bones were also affected, which might have impacted preservation. No other source of infection was identified in the preserved remains and the infection appears to have been localised. The affected area is not associated with any specific infectious diseases. Instead, it can be suggested that the localised infection was the result of serious complication from a soft tissue injury. The bones of the right hand did not display any evidence of fractures, so the lesion was most likely caused by an infection secondary to soft tissue trauma. These injuries, that typically do not affect the bones, are often difficult to identify in archaeological contexts leading to an underrepresentation in bioarchaeological research. If the soft tissue barrier is injured, pathogens such as bacteria can enter the organism and cause infection. These infections have the potential to enter the bloodstream and affect the entire body resulting in sepsis and ultimately in death (Larsen, 2015: 115; Redfern and Roberts, 2019). Sepsis and septic shock have the potential to lead to organ failure and, if detected late, have a high mortality rate (25-30% for sepsis and 40-60% for septic shock) even in modern contexts with the availability of antibiotics and targeted surgical intervention (Cecconi et al., 2018; Matot and Sprung, 2001), and in premodern societies, sepsis was highly fatal. The analysis of the population data has shown high risk for injury especially for males buried in normative burials. For 5_253, an injury such as a cut to the hand might have led to infection of the injury site as suggested by extensive woven bone formation. Lack of medical intervention and proper sanitation in living quarters as well as the need to continue working in potentially polluted environments might have resulted in spread of the infection, sepsis, and death. Whether the infection was indeed the cause of death could not be determined with certainty; however, the pathological processes affecting the right hand were evidently active at time of death.

The case study of 5_253 showed the life of an individual who survived early life stressors and potentially even caught up some of the physiological development deficits acquired during childhood in later stages of development. The presence of spondylolysis affecting the fifth lumbar vertebra suggests that the individual was undertaking repeated activities that were strenuous on the back consistent with heavy manual labour such as working on building sites, in mines, manufacturing, or agriculture (Forsdyke, 2021). While no further skeletal injuries in form of fractures were observed, the working conditions in any of these labour contexts would involve high risk for accidental injury. The pathological changes to the hand bones most likely were caused by a secondary infection after soft tissue injury that might have eventually caused death during young adulthood.

7.3. Osteobiography of IV_779

7.3.1. Burial context

Individual IV_779 was buried in sector IV and is part of the ‘MOB36/37 area’ sample (see also Buikstra et al., n.d.). The remains were buried in a simple pit burial dug in the coastal sand, and no associated grave goods except for a few pottery sherds were found during excavation. The burial was oriented north-south with the cranium located towards north. The individual was buried on the right side with the legs flexed. The left arm was mostly extended along the thorax and the hand rested in the pelvic area. The right hand was flexed with the hand located next to the right shoulder (Figure 7.4).

Figure 7.4: Burial IV_779 in excavation. © The Ephorate of Antiquities of West Attica, Piraeus and Islands.

Several additional human bones were identified during the analysis belonging to another adult individual. Approximately ten small fragments of cremated bone were also identified; these likely belonged to the cremation IV_427 located directly next to burial IV_779.

7.3.2. Skeletal analysis

Individual IV_779 was more than 75% complete with most elements present (Figure 7.5). Only the preservation of the left arm and specifically the left humerus was poor. This is likely due to the burial position with the left humerus presenting one of the highest points within the burial. Bones that were commonly not preserved in the Phaleron cemetery such as the sternum, hyoid, and bones of hands and feet were recovered for this individual. Surface preservation was good, and fragmentation mainly affected the ribs, long bones, and pelvis. The cranium displayed some excavation damage.

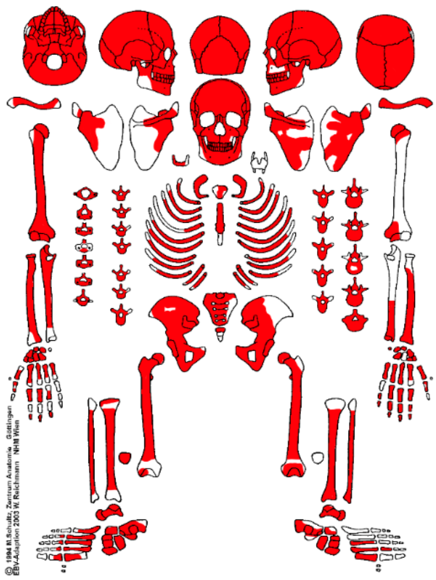

Figure 7.5: Skeletal diagram of completeness of individual IV_779

Biological sex was estimated as male based on pelvic and cranial morphology. For estimation of age-at-death, the pubic symphysis was scored as phase 3 (21-57 years) after Brooks and Suchey (1990) and phase 4 (27-61 years) after Hartnett (2010). Dental wear was slight to moderate in the molars which is more consistent with an age-at-death estimate of young to middle adult with an age-at-death range of 21 to 49 years. It was not possible to estimate stature due to incomplete preservation of the long bones. Skeleton IV_779 was very robust with strongly expressed entheses. In addition, this individual displayed some unusual pathological lesions that can be used to gain a more detailed picture of living conditions in Archaic Athens.

Evidence of early life stress in form of linear dental enamel hypoplasia was observed on incisors, canines, and premolars. In the mandibular dentition interproximal caries affected three teeth. The right first premolar and the left second molar displayed small interproximal lesions while the first left molar was partially destroyed by caries exposing the pulp cavity. Calculus was present in the mandibular and maxillary dentition. Alveolar resorption was slight to moderate, but porosity around the alveolar sockets and a bony ridge forming on the buccal aspect were considered indicative of periodontal disease (Ogden, 2008). In addition, the mandible was affected by active periosteal new bone formation on the labial aspect extending from the alveolar bone to the mentum consistent with inflammation of the gums.

Degenerative joint disease was present in the vertebral column in form of marginal osteophyte formation on the vertebral bodies as well as the superior and inferior articular facets. In addition, Schmorl's nodes were identified. The inferior thoracic and the lumbar vertebrae were mostly affected (T7-T12, and L1, L2, L4, and L5 vertebrae), but slight degenerative changes were also observed in the C6 and C7 vertebrae. Furthermore, both shoulder joints were affected by joint degeneration in form of marginal osteophyte formation on the glenoid fossae.

In addition, the left scapula was affected by active inflammatory processes on the posterior aspect along the lateral margin, in the location where the infraspinatus muscle, a member of the rotator cuff muscle group, attaches. Several long bones also showed pronounced muscle attachment sites including the right humerus (pectoralis major and deltoid) (Figure 7.6), both femora (adductor magnus), and both tibiae (popliteus muscle), and the anterior crest of both tibiae was very sharp. The lesser tubercle of the right humerus, the insertion point of the subscapularis muscle, also displayed some bone loss which might be connected to muscle activity.

Figure 7.6: Right humerus with pronounced deltoid tuberosity (IV_779)

Individual IV_779 was affected by multiple instances of trauma, and both cranial and postcranial traumata were identified. The right nasal bone showed a healed fracture (Figure 7.7). The left nasal bone exhibited PM damage, so it was difficult to assess, but it is likely that the left nasal bone was also affected by the traumatic incident. A horizontal fracture line was visible, which was remodelled and extended approximately halfway along the nasal bone. The bone segment inferior to the fracture line was displaced and angled inferior-posteriorly. The fracture was well remodelled and stable.

Figure 7.7: Nasal fracture (IV_779)

The fourth thoracic vertebra potentially was affected by a partial fracture of the spinous process. Some irregularity on the right aspect of the spinous process was observed, and a fracture is the most likely explanation. The fifth lumbar vertebra was affected by spondylolysis. Two right ribs – ribs 6 and 12 – were fractured AM, and the fractures were identifiable by a remodelled callus. One left proximal hand phalanx displayed new bone formation on the palmar surface of the proximal half of the diaphysis. The new bone was fully remodelled and well-integrated, and the shape of the bone itself had not been altered significantly. These changes were potentially caused by soft tissue trauma or by a fracture that was well-healed. On the right side, two proximal hand phalanges showed evidence of trauma. One phalanx was affected by a fracture approximately mid-shaft, while the other phalanx showed a fracture at the distal third. Both fractures were visible as a remodelled callus, which was more pronounced on the palmar surface. The appearance suggests that the fractures were completely healed. None of the phalanges could be associated with a specific ray.

Non-specific inflammatory new lamellar bone formation was present on the right tibia, and a more localised area of healed lamellar bone on the anterior crest on the mid third of the diaphysis was likely caused by soft tissue trauma.

A further instance of possible soft tissue trauma was identified on the sternum which displayed new bone formation on the anterior surface of the manubrium and the superior third of the body (Figure 7.8). The surface of the posterior aspect was not preserved, so it could not be determined whether similar bone formation was present; however, the exposed trabecular bone did not exhibit any indication that this new bone formation was in response to a fracture. The lesion on the sternal body was slightly raised, and it appeared as a horizontal band (10-11mm broad) across the sternal body. The surface was smooth, and the plaque-like bone was remodelled resulting in a clearly raised lesion with very distinct margins. Similar to the sternal body, the lesion on the manubrium consisted of a horizontal band (approx. 10mm broad). In addition, there were two squared off extensions on the superior border of the band of new bone. These were symmetrical and approximately 1 cm apart from each other. The left extension measured approximately 7.5x6.5 mm and the right 7.8x4.5mm. Due to PM damage, it was difficult to assess, whether the lesions were confined to the sternum or extended laterally.

Figure 7.8: Bone formation likely associated with soft tissue lesions on the anterior surface of the sternum (IV_779).

7.3.3. Synthesis

The burial situation of IV_779 was a simple pit burial without grave goods. The body was positioned on its side with flexed legs, which is considered a normative burial position at Phaleron. As a 'young to mid adult' male, IV_779 is in the majority demographic for the thesis sample. Several pathological lesions described above might be related to each other, and these can be considered evidence of repetitive activity and are consistent with heavy manual labour.

Evidence of early life stressors was identified in form of dental enamel hypoplasia on maxillary and mandibular incisors, canines, and premolars suggesting prolonged physiological stress between the ages of 2 and 8 years (AlQahtani et al., 2010). Porotic changes were absent in the orbits, but extensive porosity was observed affecting the ectocranial surface of the parietal bones and the occipital bone. The porosity was not associated with an increased thickness of the cranial vault bones; therefore, this was not clearly identified as porotic hyperostosis associated with different forms of anaemia (Brickley, 2018; Stuart-Macadam, 1992); instead, other causes such as scalp inflammation should be taken into consideration for the interpretation of these lesions rather than identifying them as clear indicator of anaemic conditions during childhood (Walker et al., 2009).

Dental health of individual IV_779 could be considered moderate. Three instances of caries were identified in the mandibular dentition, and only the lesion on the left first molar was extensive, exposing the pulp chamber. While small carious lesions might not impact someone's wellbeing significantly, more extensive lesions as the one presented here would have likely resulted in substantial pain. The appearance of alveolar resorption with porosity and a rim forming is consistent with periodontal disease. Inflammatory processes of the gums were further evidenced by active bone formation in the buccal and lingual aspect of the mandibular body. While none of these conditions had progressed far enough to cause AM tooth loss, there was considerable destructive dental pathology present that would have impacted the quality of life of IV_779.

Multiple AM fractures affected individual IV_779. All fractures were fully healed at death, so it was not possible to identify fracture recidivism. The fracture of the nasal bones appeared to have altered the shape of the nose creating something resembling a 'hook nose'. Clinical data suggests that fractures of the facial bones are often the result of interpersonal violence (Walker, 2014). Fractures of hand bones and ribs as observed in this individual can also be caused by physical altercations. These patterns of trauma caused by interpersonal violence appear globally and temporally universal (Lovell and Grauer, 2018; Redfern and Roberts, 2019). Fractures of hand bones and ribs might also have occurred accidentally and would not be considered as clear evidence of interpersonal violence if encountered as singular trauma instances in one individual. However, the co-occurrence of three fractures potentially associated with interpersonal violence are a strong indicator for violent behaviour. Other causes of rib fractures include stress fractures attributed to habitual activity, coughing, falls, or direct blows to the thorax (Lovell and Grauer, 2018). One of the rib fractures affected rib 6, which is one of the most commonly fractured ribs (Galloway and Wedel, 2014), while fractures of the inferior ribs 9 to 12 (see second rib fracture) are often associated with intra-abdominal injury (Park, 2012). Rib fractures can entail serious and potentially fatal complications, but all fractures in this case were well healed before death. Similarly, fractures to phalanges can also be of accidental nature (e.g., falls, crushing) (Galloway, 2014b). The T4 vertebra was likely affected by a fracture of the spinous process that resembled a clay-shoveler's fracture; however, this specific fracture type affects C7 and T1. As spondylolysis, these fractures are considered stress fractures associated with strenuous activity involving the back (Lovell and Grauer, 2018). IV_779 also displayed bilateral spondylolysis indicative of repetitive activity (see individual 5_253). Considering hazards associated with the previously described working environments in Archaic Greece, crush fractures of finger bones and ribs could also be attributed to accidental risk. While all fractures are associated with considerable pain, none of the observed fractures would have necessarily impacted the individual significantly over a longer period of time.

In addition to these fractures, lesions consistent with soft tissue trauma were also observed. The lesion on the tibia was located on the anterior crest. This location is only covered by a thin layer of skin and soft tissue and is, therefore, especially prone to bone reactions in response to soft tissue trauma. The lesions on the sternum are not consistent with fracture or activity markers, but rather seem connected to soft tissue inflammation or irritation (Figure 7.8). Similar to the tibia, the sternum is only covered by a thin layer of soft tissue and, therefore, easily damaged. However, it is rare to see lesions in this location. The clear margins of the lesion are also striking and suggest a localised inflammatory reaction. One example of extreme, localised damage to the skin and soft tissue that could have impacted the underlying bone is branding. Branding of humans is difficult to identify historically for ancient Greece but is mentioned by Xenophon (Ways and Means 4.21). Slaves belonging to the public were branded thus ensuring that public slaves could not be stolen and sold (Forsdyke, 2021: 83-84). The passage from Xenophon provides no further information regarding what body part was branded or what symbols were used. Jones (1987) argues that social outcasts such as enslaved people, criminals, or war prisoners were marked with tattoos on the forehead or on the limbs rather than being branded with hot iron. Branding is a known practice to mark enslaved people in later periods and caused extreme physical as well as physiological pain (Forsdyke, 2021: 83-84; Keefer, 2019). Evidence of branding in bioarchaeological research could not be found and it is also unclear, whether the chest would be the most likely place for such branding as it is not immediately visible and can be hidden with clothing. Perhaps a more likely possibility is that the lesion was related to an inflammatory reaction to skin trauma caused by repetitive stress on the sternum such as carrying or pulling something heavy with a metal buckle on the chest for prolonged periods of time (e.g., harness with metal ring). Wearing a harness as part of a construction to carry heavy loads (see for example Merbs, 1983) would not destroy the soft tissue as permanently as using a brand iron, but repetitive stress caused by continuous use of such equipment would cause damage and inflammation to the soft tissue and underlying bone. Contemporaneous depiction of slaves outside the household setting are scarce, so reconstruction of work attire and equipment is difficult. The use of a harness does, however, seem plausible in working contexts such as construction, mining, or farming. However, an inflammatory reaction due to repetitive stress might have resulted in a less clearly defined lesion with a more irregular surface appearance. The clear definition and smooth surface of the lesion do not fully support this theory. A differential diagnosis could be myositis ossificans of the pectoralis major muscle caused by trauma (Lovell and Grauer, 2018; Ortner, 2003).

However, the lesion spans across the entire manubrium while the attachment sites for the pectoralis major run along the lateral margins of the sternum, so the soft tissue anatomy is not fully consistent with the appearance of the lesion. On the other hand, in combination with other evidence for interpersonal violence, soft tissue trauma causing myositis ossificans could be explained by a punch to the sternum. The interpretation of this specific lesion is complicated as no comparable evidence could be found so far. This was further hindered by limited research for sternal pathology.

Additionally, markers of activity in form of joint disease, pronounced entheses, and new bone formation affecting muscle insertion sites were present (Figure 7.6). Joint disease of the spine is a common occurrence in archaeological and modern populations, and the normal ageing process plays a role in development of spinal joint disease (Roberts and Manchester, 2005: 108). The presence of Schmorl's nodes in multiple thoracic and lumbar vertebrae was also likely connected to repeated stress on the vertebral column leading to a higher degree of degeneration than what would be expected based on age-at-death (Stirland and Waldron, 1997). The degenerative changes in the shoulder joints in combination with marked muscle attachment sites for the muscles forming the rotator cuff is notable. Biomechanical stress is a strong factor contributing to the development of primary osteoarthritis. Therefore, joint degeneration in the main synovial joints can be used to identify repetitive strenuous movement in archaeological remains. Studies of modern occupational groups have shown that groups performing strenuous activities (e.g., miners or ballet dancers) have a higher prevalence of osteoarthritis in certain joints (Waldron, 2012). While it is not possible to connect patterns of joint degeneration to specific occupational groups, in combination with contextual data we can draw some conclusions about activity and lifestyle (Larsen, 2015: 185). In theory, muscles that are used more often produce larger entheses. However, these changes have to be interpreted with extreme caution since activity is only one predisposing factor among other such as age, hormones, genetic predisposition, diet, or disease (Roberts and Manchester, 2005: 113-115). In the context of individual IV_779, the changes to the shoulder area in combination with several stress fractures can be interpreted as indicator of strenuous activity involving shoulders, upper limbs, and back. Of the larger joints, the shoulder joint tends to be affected by osteoarthritis less commonly than other joints, but is connected to pain and limitation of movement (Waldron, 2019). Inferring severity of symptoms from archaeological evidence for joint disease is difficult, but it is possible that osteoarthritic changes would impact an individual's lived experience and that IV_779 suffered from painful movements of their arms.

The lesions identified in individual IV_779, while not necessarily debilitating individually, show combined a hard and likely painful life. If we consider the pattern of nasal fracture, rib fractures, and fractures to hand bones to be a probable indicator of interpersonal violence, this suggests beating or pugilism rather than military combat. Stress fractures, degeneration of joints in the vertebral column, and osteoarthritic changes in the shoulder joints are indicative of repetitive manual labour. The interpretation of the lesions on the sternum proved difficult, but if caused by soft tissue irritation related to gear such as a harness, it would fit the overall picture of a strenuous work environment such as mining or quarrying. Myositis ossificans caused by trauma to the sternum would be consistent with the evidence of beating.

Physical hardship leading to the above-described disease patterns could be caused by multiple lines of manual labour including construction, agricultural work, or mining. Such activities would also explain the stress fractures and entheseal changes affecting IV_779; however, it is not possible to identify one occupation with certainty.

7.4. Osteobiography of IV_734

7.4.1. Burial context

Individual IV_734 was excavated from a simple pit grave and is considered a non-normative single burial based on body position, which was prone (Figure 7.9). The individual is part of the 'MOB36/37 area' sample (see also Buikstra et al., n.d.). The arms were stretched along the torso and the legs extended. The orientation of the burial was north-west to south-east with the head towards south-east. The feet were not preserved, and the burial appears truncated, but no other burial was identified in that location. No grave goods were found during excavation. The burial position did not suggest that the individual was shackled or bound as observed in some of the other single non-normative burials. The burial situation differed from burial 5_253 only by the fact that the individual was buried prone rather than in a supine position.

A few intrusive bone fragments were found with the remains of IV_734. These might belong to individual IV_777 buried under the stone seen in Figure 7.9. This individual was preserved in a very fragmentary state.

Figure 7.9: Burial IV_734 during excavation. © The Ephorate of Antiquities of West Attica, Piraeus and Islands.

7.4.2. Skeletal analysis

Individual IV_734 was more than 75% complete (Figure 7.10). The inferior half to third of the lower leg bones as well as foot bones were not present. The thorax, upper limbs and pelvic girdle were well preserved, and several postmortem breaks could be reconstructed. The cranium was fragmented and only partially preserved. Overall, surface preservation was good with limited cortical surface erosion.

The individual showed a combination of female and ambiguous traits in the cranium and pelvis, and skeletal sex was estimated as possible female. Molecular analysis confirmed the sex as female. Age-at-death was estimated as 21-29 years (young adult) based on the auricular area and partially fused epiphyses of the medial clavicle. This was also supported by unfused first and second segments of the sacrum. Stature was estimated as 152.48 cm +/- 3.89 cm which is close to the median height for females in the population.

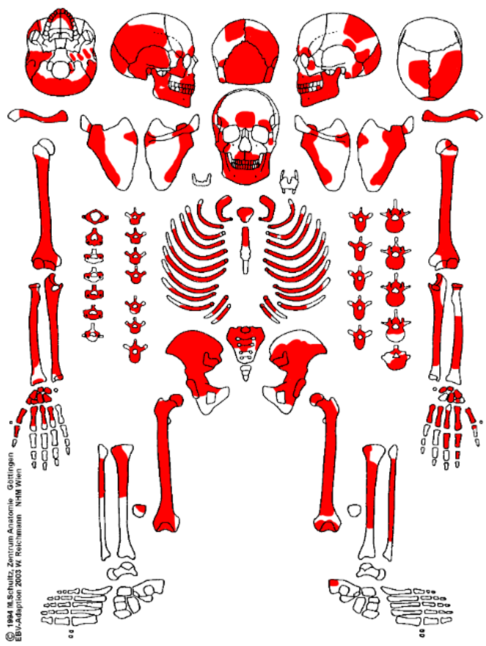

Figure 7.10: Skeletal diagram of completeness of individual IV_734

Indicators of early life stress were present in the form of dental enamel hypoplasia on the maxillary and mandibular incisors and canines. The left orbit showed slight capillary impressions, but this was not considered a clear indicator of physiological stress. The left tibia showed slight periosteal new bone formation on the medial surface, consistent with well remodelled striated lamellar bone.

The right parietal bone was slightly thickened (8.6mm). The external and internal table showed a decreased thickness, while the diploe was increased, and the trabeculae were enlarged. No porosity was observed on the ectocranial surface, so the appearance was not considered consistent with porotic hyperostosis. The endocranial surface showed deep and sharp meningeal grooves. These changes might not be severe enough to be considered pathological, but some process appears to have affected the cranial vault, and the thickening of the parietal bone affected the endocranial surface more than the ectocranial surface.

Considering the young age-at-death, dental health was extremely poor including six teeth lost AM (Figure 7.11). The mandible was more severely affected than the maxilla with four molars and one premolar lost AM. The sockets are completely remodelled indicating that the individual lived a considerable amount of time after partially losing their dentition. The extensive AM tooth loss resulted in irregular dental wear in the maxillary dentition with the anterior dentition showing a higher degree of wear than the molars. Additionally, the left mandibular third molar exhibited caries affecting the CEJ on the buccal and lingual aspect. In the maxillary dentition, the right canine, the left canine, and the left first premolar were affected by interproximal caries. In addition, two periapical lesions with buccal drainage holes were identified in the maxilla at the right first premolar and the left second premolar. While alveolar resorption was slight in the in-situ preserved dentition, porosity indicates inflammation of the gums. Calculus presence was limited, but considering the extent of overall dental disease, the individual would have been in considerable pain.

Figure 7.11: AM tooth loss of mandibular molars (IV_734)

The left maxillary sinus showed slight healed spicule type bone formation and porosity on the floor of the sinus indicative of chronic sinusitis (Roberts, 2007). Additionally, several ribs on both sides exhibited nodules of remodelled bone on the visceral surface of the rib shaft creating an irregular surface. While the appearance might be indicative of subtle inflammatory changes caused by pulmonary stress (Nicklisch et al., 2012), there is a possibility that this represents normal variation caused by attachment of intercostal muscles (Davies-Barrett et al., 2019).

Multiple traumata affected individual IV_734, but no fracture recidivism could be identified. The styloid process of the right third metacarpal was underdeveloped. There was no evidence of remodelling, so this might be congenitally absent rather than related to trauma. However, this metacarpal also showed a clear, diagonal ridge on the lateral aspect of the proximal half of the diaphysis. The new bone was completely remodelled and integrated into the cortical bone. The cause is not entirely clear, but trauma is the most likely explanation for the observed changes. Trauma mechanism could not be determined due to the advanced remodelling. The second lumbar vertebra was affected by an AM crush fracture to the anterior left section of the body. A sharp ridge of osteophyte formation on the superior margin of the body was most likely secondary to the fracture as no other indicators of joint disease were present in the vertebral column. The fifth lumbar vertebra exhibited bilateral spondylolysis. Additionally, the right ala of the sacrum showed evidence of a stress fracture (Figure 7.12). This partial fracture affected the anterior superior aspect, and the fracture was observed on the anterior surface of the ala and the sacroiliac joint surface. The margins were remodelled and smooth, but the fracture line was not fused. The remodelling, however, suggests an AM fracture. A faint line was also visible on the auricular surface of the right ilium that lined up with the fracture, but there was no further evidence for trauma to the ilium.

Figure 7.12: Stress fracture affecting the right ala of the sacrum (IV_734)

The humeri showed pronounced deltoid tuberosities, and both femora were unusually straight only showing a slight anterior curvature. The lateral and posterior surfaces displayed periosteal new bone formation in form of striated lamellar bone.

7.4.3. Synthesis

The burial position differed from what is considered a normative burial as individual IV_734 was buried prone. However, no evidence of shackles or bound limbs was identified, thus also differing from some of the other single non-normative burials. While shackled or bound individuals were clearly treated differently in death, prone burials in an extended position might not necessarily be a deviation from the norm but rather a variation (Aspöck, 2008). Other than the prone position, IV_734 received similar treatment and funerary care as most normative burials at Phaleron. Additionally, one prone extended burial at Phaleron was interred with one grave good in form of a pottery vessel (IV_373) suggesting that the prone burial position alone might not necessarily equate to a 'deviant' burial with all the negative implications that term brings.

As discussed in the two previous osteobiographies, dental enamel hypoplasia suggests physiological stress during childhood that was survived into adulthood. Based on stature that was estimated as close to the median height for females in the sample, it is possible that some catch-up growth happened during adolescence. However, a stature of approximately 152 cm is not considered tall, and it is possible that the entire sample experienced stress that impacted skeletal development and growth.

The extent of dental pathology is especially striking given the young age-at-death. Commonly, females present with a higher prevalence of caries irrespective of temporal and geographical setting (Larsen, 2015: 73-77). Risk factors for higher caries prevalence in women are multifactorial. Often differences in diet and subsistence strategies and responsibilities between males and females are suspected to cause the differences in caries prevalence (Da-Gloria and Larsen, 2014; Klaus and Tam, 2010; Temple and Larsen, 2007; Vergidou et al., 2022). However, other aspects such as reproductive function and related hormonal changes can have an impact on dental health (Laine, 2002; Lukacs, 2008). While diet likely can account for some of the dental disease encountered in IV_734, the extent of AM tooth loss is unusual for a young adult. AM tooth loss has several aetiologies, and a specific cause cannot be determined. Periodontal disease can cause AM tooth loss but has a slow disease progress (Hillson, 2019) and alveolar resorption was not very advanced in this instance. Therefore, it is more likely that caries caused the AM tooth loss in this case as it is a faster acting disease. Additionally, the possibility that some teeth were extracted for medical purposes (e.g., pain management) cannot be excluded; however, an underlying cause such as caries or periapical lesions likely would have made the extraction necessary. Extensive dental disease resulting in loss of teeth would likely have caused considerable pain over extended periods of time. The loss of most molars might also have impacted mastication and might have required different subsistence or food preparation than other young adults in the population. As this individual was estimated as a young adult female, the possibility of hormonal changes due to puberty, menses, and pregnancy should be taken into consideration when interpreting the high levels of dental disease.

Maxillary sinusitis can be caused by multiple factors including poor air quality (e.g., smoke), particles such as pollen or dust, as well as bacteria. Occupations such as pottery manufacturing, mining, textile manufacture, and metalworking are especially exposed to irritants causing disease of the upper respiratory tract. In addition, poor health of the maxillary dentition can result in maxillary sinusitis (Roberts, 2007). Due to the multifactorial aetiology no clear cause can be proposed for the presence of these lesions in IV_734. Dental disease as a causative agent should be considered as well as external factors such as high levels of pollution.

The presence of spondylolysis and a compression fracture of a lumbar vertebra are likely indicative of repeated stress straining the vertebral column (see also individuals 5_253 and IV_779). Fractures of the sacrum are more infrequent and commonly caused by indirect force. In rare cases, sacral fractures can be attributed to falls or direct blows to the sacroiliac region (Galloway and Wedel, 2014; Lovell and Grauer, 2018). The sacral trauma affected the attachment site of the anterior sacroiliac ligament, so the fracture might have been connected to excessive stress on the ligaments. This is further supported by the presence of clear osteophytes on the postauricular area, which were more developed than usually expected in a young individual. In combination with the fractures in the lumbar vertebrae, the sacral fracture is indicative of repetitive stress as observed in athletes in modern clinical literature (Kendall and Eckner, 2013; Micheli and Curtis, 2006). As this individual was a female, a connection with pregnancy and softening of the ligaments in the pelvis might also be taken into consideration, but this interpretation should be approached with caution. Few clinical cases of sacral fractures in the last trimester of pregnancy have been reported; however, back pain, which is the main symptom of sacral stress fractures, is common in pregnant women and these fractures might remain undiagnosed clinically (Giannoulis et al., 2015; Schmid et al., 1999; Thienpont et al., 1999). While both poor dental health and stress fractures to the lower back and sacrum have a possible connection to pregnancy, there was no clear connection to pregnancy in this archaeological case (e.g., presence of a foetus in situ). While the cause cannot be determined, the fractures of the vertebral column and sacrum would most likely have presented with pain and would have impacted quality of life, especially if the individual did not get time to rest and recover.

The stress fractures observed in the spine and sacrum can also be considered consistent with repetitive activity causing stress on the lower back and manual labour. These lesions might indicate similar physiological hardship as identified for individuals 5_253 and IV_779; however, in Archaic Athens, labour division was largely gendered and heavy manual labour such as mining usually was undertaken by men. Women were working in different settings such as domestic areas, manufacturing, or ore processing, and these occupations also had the potential to put continuous stress on their bodies. Additionally, enslaved women were also forced into prostitution, which would put women at risk for repeated pregnancies from an early age onwards (Forsdyke, 2021: chapter 3). The fracture of the sacrum in combination with poor dental health might be an indicator for pregnancies, but other causes as discussed above are equally possible. Pregnancy is extremely difficult to identify in bioarchaeological studies and the present pathologies can only be considered potentially secondary to pregnancy.

7.5. Osteobiography of IV_684

7.5.1. Burial context

Individual IV_684 was buried in a rectangular pit grave lined by mud brick walls that measured 1.60x0.95m (fig 6.13). This grave form was uncommon at the burial ground of Phaleron and is considered under the umbrella term 'cist-like burial'. The individual is part of the 'MOB36/37 area' sample (see also Buikstra et al., n.d.).

The grave was relatively modest but still slightly elevated from a simple pit burial. The orientation of the burial was south to north with the head oriented towards south. The individual was buried in a supine stretched position with the arms extended and close to the body. The head was slightly tilted and facing towards the right. The thorax appeared compressed, and not all vertebrae were recovered in anatomical position. The right arm bones, the right femur, and the right innominate were slightly twisted, too. It is likely that the burial was disturbed, but most elements were present.

A few additional skeletal elements were identified but could be excluded from the main burial based on duplicate presence of bones.

Figure 7.13: Burial of IV_684 in excavation. © The Ephorate of Antiquities of West Attica, Piraeus and Islands.

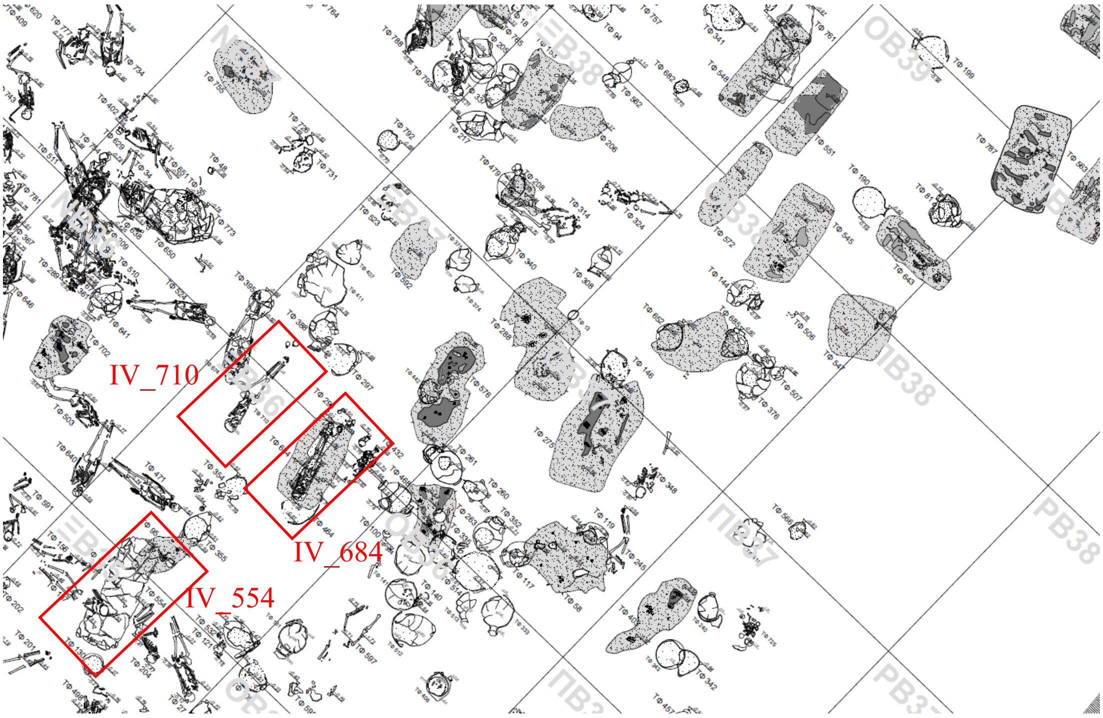

Figure 7.14: Map showing location of burials IV_684, IV_554, IV_710, and a cluster of jar burials dated to ca. 700 BCE. © The Ephorate of Antiquities of West Attica, Piraeus and Islands.

Individual IV_684 was buried with three simple grave offerings in form of pottery jars, which had been placed at the feet. These were identified as trefoil oenchoe, potyle, and olpe and were dated around 700 BCE[9]. Burial IV_684 is one of the earliest burials identified in Sector IV, together with the stone covered pit burials IV_710 and IV_554 (marked in Figure 7.14). These three burials are in close proximity to each other at a similar level and in similar orientation. A concentration of jar burials (*enchytrismos*) dated in the 7th century[10] were located in the vicinity of these burials and further burials in similar orientation were found north of the cluster.

7.5.2. Skeletal analysis

Individual IV_684 was more than 75% complete with almost all elements preserved (Figure 7.15). The dentition was mostly loose, and four small root fragments could not be identified. The surface preservation was good with limited erosion, but the surface showed brown staining. Fragmentation affected the facial bones, lumbar vertebrae, the pelvic girdle, and the lower limb bones, especially the joints.

Biological sex was estimated as female and age-at-death as older than 33 years (middle-mature adult). The right humerus was preserved well enough for measurement for stature estimation, which was estimated as 153.91 +/- 4.41 cm, close to the median female stature in the sample.

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[9] Communication from the archaeologist.
[10] Communication from the archaeologist.

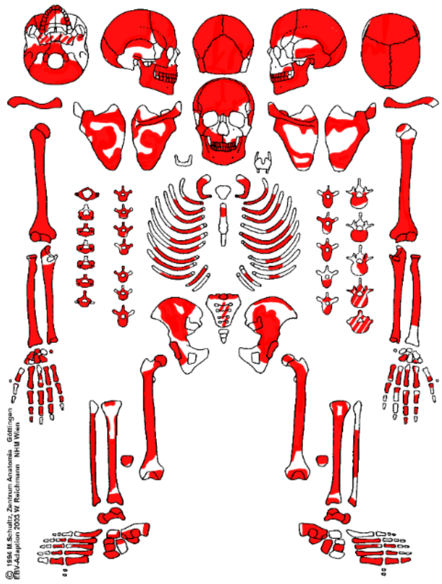

Figure 7.15: Skeletal diagram of completeness of individual IV_684.

Individual IV_684 was affected by several pathological lesions. Some evidence of early life stress present in form dental enamel hypoplasia was observed. Additionally, early stages of cribra orbitalia (capillary impressions) were present, although these are not considered clear indicators of stress.

Dental wear was irregular and ranged from moderate to severe. The mandibular right first incisor was lost AM as evidenced by a remodelled tooth socket. The mandibular right first molar and the maxillary right second premolar were affected by carious lesions. Small amounts of calculus were present throughout the upper and lower dentition. Alveolar resorption was moderate to severe and a slight rim along the buccal aspect of the mandibular alveolar bone as well as some porosity can be considered indicative of periodontal disease (Figure 7.16) (Ogden, 2008). The maxillary alveolar bone showed a periapical lesion with a small buccal perforation at the site of the right first molar.

Figure 7.16: Periodontal disease and dental enamel hypoplasia affecting multiple tooth positions and teeth in the mandible (IV_684).

Inflammatory reactions were observed throughout the skeleton affecting cranial and postcranial elements in different ways. Evidence of inflammation was present in form of healed bone addition on the endocranial surface. The inflammation was not active at the time of death as evidenced by substantial remodelling. The frontal sinus showed evidence of healed chronic sinusitis. Several ribs on both sides displayed an irregular surface that might have been caused by healed pulmonary stress expressed as periosteal new bone formation on the visceral surface of the rib shafts. Both tibiae were affected by non-specific inflammatory processes consistent with a general inflammatory reaction. Additionally, a small area of partially remodelled new bone was observed on the left tibia affecting the posterior aspect medial to the nutrient foramen, which was in the process of healing, suggesting a localised inflammation/infection. Both fibulae were affected by more severe infectious or inflammatory processes.

On the left fibula, a mix of woven and lamellar bone indicates a chronic inflammation. An area of more extensive bone formation could be identified approximately mid-shaft where the diaphysis almost doubles in diameter due to this new bone formation (Figure 7.17). The infection of the left fibula had started to penetrate the cortical bone; however, the medullary cavity was not narrowed, and no drainage channels could be observed.

Figure 7.17: Periosteal new bone formation associated with shaft expansion affecting the left fibula (IV_684).

The right fibula was also affected by healed new bone formation, but these changes were less severe than the changes observed in the left fibula and only affect the surface. Periosteal new bone formation was also identified on one left metatarsal (MT1) and four right metatarsals (MT1-4) covering the shafts. All showed compact remodelled bone consistent with healed lesions. The MT1s only exhibited small nodules on the medial aspect, while the MT2-4 displayed more extensive layers of new bone (1/3-2/3) mostly affecting the lateral aspect of the diaphyses.

The vertebral column showed evidence of degeneration of joints in all sections, in form of marginal osteophyte formation and porosity in cervical and thoracic vertebrae. Additionally, L4, L5, and the sacrum displayed syndesmophyte formation leading to ankylosis of all three elements, but the spacing between the vertebral bodies was preserved (Figure 7.18a). Further evidence of joint degeneration was present in the left hip joint, both shoulder joints (Figure 7.18b), and both elbow joints. Only the left shoulder showed enough evidence to diagnose osteoarthritis (after Waldron, 2019).

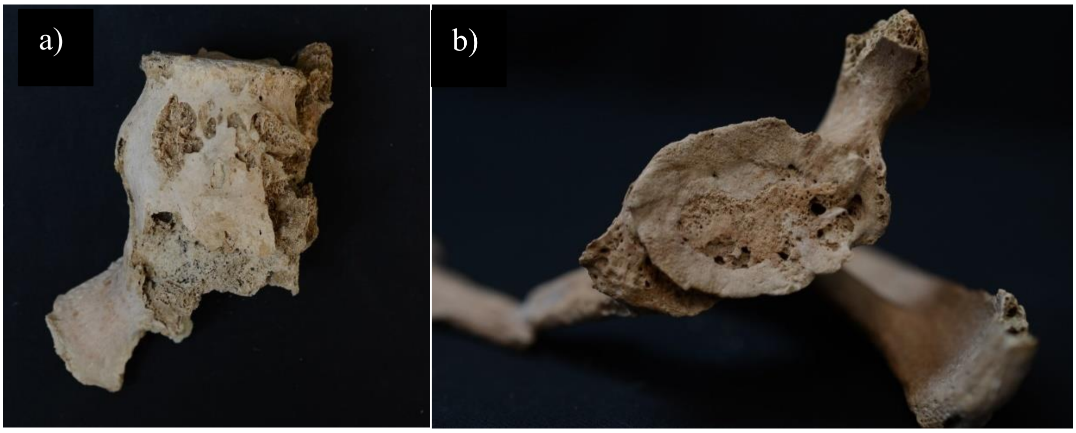

Figure 7.18: Instances of joint disease affecting individual IV_684. a) Ankylosis of L4, L5, and sacrum; b) Osteoarthritis of the left glenohumeral joint.

The right fourth rib was affected by a fracture on the vertebral third of the shaft just anterior to the angle. The fracture was well healed and almost obliterated and can be identified as AM.

The right scapula displayed a localized focal destruction in the form of two lesions on the scapular neck. A smaller lesion (7.5x6mm) was observed on the anterior surface inferior to the coracoid process (Figure 7.19). The second lesion (10x6mm) was found on the posterior aspect of the scapula neck. Both lytic lesions exhibited well defined smooth margins indicating that these were healed at the time of death.

Figure 7.19: Lytic lesion on the visceral aspect of the right scapula close to the glenoid fossa (IV_684).

Both humeri exhibited pronounced muscle attachments for the pectoralis major in form of sharp ridges. A septal aperture was present on the left humerus.

7.5.3. Synthesis

Individual IV_684 was likely more advanced in age than the previously discussed individuals. Together with several other furnished cist-like burials, IV_684 was dated to the earlier phases of the cemetery (late 8th to early 7th century). The differential burial treatment might, therefore, be attributed to temporal changes in the use of the burial ground (see also Chapter 8). The similar orientation and slightly elaborate format in the earlier burials suggested a more organised burial plot around 700 BCE; however, in the following centuries, the burial organisation appears to have been abandoned (Alexandropoulou, 2019). IV_684 provided an opportunity for comparison with pit burials dated to the following centuries.

The presence of dental enamel hypoplasia showed that the individual was also exposed to physiological stress during childhood. The estimated stature of IV_684 was close to median height for the female sample potentially indicating that some catch-up growth was possible during adolescence either due to better living conditions or improved buffering capabilities.

Dental health was moderate, which is consistent with the age-at-death estimate. The periapical lesion and caries might have been associated with pain. One carious lesion was only small and might not have impacted the individual significantly, while the second lesion affected the root. It was possible for caries to affect the tooth below the CEJ due to advancing alveolar resorption exposing the dental roots. The appearance of the alveolar bone suggests that periodontal disease was the causative factor for alveolar resorption. Periodontal disease is associated with other indicators of physiological stress during adulthood and increased mortality in the past (DeWitte and Bekvalac, 2011).

Sinusitis of the frontal bone suggests that – like individual IV_734 – individual IV_684 was affected by chronic sinus inflammation. The irregular surface of the ribs might have been caused by chronic pulmonary disease (but see Davies-Barrett et al., 2019). While for maxillary sinusitis, dental disease can be strong causative factor due to proximity, this association cannot be found for frontal sinusitis. Generally, studies on sinusitis involving frontal sinuses are scarce (Liebe-Harkort, 2012; Roumelis, 2007). As with maxillary sinusitis, environmental factors such as air pollution, poor indoor air quality, population density, as well as climate are suspected causes for frontal sinusitis. Occupational hazards as well as spending long periods of time indoors (e.g., crowding, poor air quality due to smoke from cooking) should be taken into consideration (Roberts, 2007). No evidence for specific disease affecting the pulmonary tract such as tuberculosis were identified (Roberts and Buikstra, 2019).

The periosteal lesions on the left fibula were more extensive than on the tibiae and right fibula. These changes were potentially linked to a more severe inflammation rather than a generalised inflammatory stress response, but the lesions were still treated as non-specific. However, the metatarsals also displayed some inflammatory changes, and a possible connection between the lesions in the foot bones and bones of the lower legs should be considered.

Individual IV_684 was affected by extensive joint disease. Osteoarthritis is strongly linked with advanced age and biomechanical stress (Loeser, 2010; Waldron, 2019; Weiss and Jurmain, 2007). For IV_684, both factors likely contributed to the expression of joint disease. Archaeologically, the glenohumeral joint tends to be the least affected of the main joints (Waldron, 2019). In contrast to this evidence, in this instance, the joint with most severe changes was the left glenohumeral joint.

Degeneration of the shoulder joint likely caused pain and limited mobility (Kerr et al., 1985). Eburnation was not identified, but porosity and marginal osteophyte formation causing slight changes to the joint contour were present. The degeneration of the shoulder joint was likely linked to activity and exacerbated by advanced age. The lytic lesions close to the glenoid fossa might be connected to joint disease. In addition, evidence for joint degeneration was also observed in the vertebral column. All three sections of the vertebral column showed some degeneration, mostly of the articular facets. The lower vertebrae were more affected than the cervical vertebrae consistent with higher weight support. L4, L5, and the sacrum showed evidence of ankylosis. This location is affected in early stages of ankylosing spondylitis (AS); however, based on the age-at-death, further advancement with involvement of more elements would be expected, and the appearance might not fully support a diagnosis of ankylosing spondylitis. In advanced cases, AS can cause pain and stiffness of the spine (Waldron, 2019). However, in this instance, only the two most inferior vertebrae and the sacrum were involved, thus the impact of the ankylosis on lived experience likely was limited. AS is associated with increased mortality; however, comorbidities such as diabetes, infection, or cardiovascular diseases as well as socio-economic status, and lower levels of education are confounding factors (Exarchou et al., 2016).

In contrast to the previously discussed individuals IV_779 and IV_734, IV_684 was only affected by one rib fracture. As no other fractures were present, it appears that the individual was exposed to one singular traumatic event most likely of accidental nature (Galloway and Wedel, 2014).

Individual IV_684 represents the earlier burials at Phaleron, who were afforded slightly more elaborate graves. Orientation of burials was more uniform, and it is possible that some type of grave marker showed the location of individual graves. IV_684 was also exposed to stressors during childhood. The individual suffered from healed chronic pulmonary disease, and joint disease affecting the vertebral column and major joints of the appendicular skeleton indicates high levels of activity that might have been exacerbated by a longer life. Nevertheless, the disease patterns observed in individual IV_684 are consistent with overall degeneration as expected over the life course.

7.6. Summary

The four osteobiographies were chosen to represent a cross section of the burial ground population discussed in this study. Individuals from different burial types and demographic groups were employed to gain a more in-depth picture of health and living conditions and how different sub-sections of the population were affected. Several skeletal lesions were commonly identified, and these are considered as more general indicators of stress and poor health. Regardless of skeletal sex and age-at-death, individuals were affected by dental enamel hypoplasia, which indicates that early life stressors affected both biological sexes. Dental health was varied throughout the study sample, but it is significant that younger individuals such as IV_734 had very poor dental health including extensive AM tooth loss affecting multiple teeth. All four individuals displayed evidence of fractures that are for the most part either considered stress fractures consistent with strenuous activities such as manual labour or indirect force fractures. However, individual IV_779 displayed fracture patterns that are consistent with interpersonal violence. The localised infection of the hand and arm bones of individual 5_253 was most likely caused by injury to the soft tissue and subsequent infection of the wound supported the overall picture of a hazardous environment exposing individuals to risk of injury. The sternal lesions of IV_779 are unprecedented, and the interpretation of the new bone formation is tentative. However, the appearance might be consistent with repeated stress on the sternal region such as the prolonged use of a harness to carry heavy loads. Overall, all four individuals showed skeletal markers and pathological lesions that are consistent with poor living conditions during childhood such as poor nutrition and exposure to infectious disease agents and a physically demanding life during adulthood.

8. DISCUSSION

8.1. Introduction

This chapter interprets and contextualises the results presented in Chapters 6 and 7 with a particular focus on social and health inequalities in Athens during the Archaic period. It aims to investigate the social implications of health differences observed between the burial groups and to explore the lived experience of the population of Archaic Athens. To evaluate this, the discussion draws on the theoretical framework of inequality research outlined in Chapter 4 as the archaeological evidence suggests that these were burials of those of lower socio-economic status. To place the individuals excavated from the Phaleron cemetery into a broader regional and thematic context, the results will be compared to other historical sites of a similar period in the Mediterranean, with a focus on Greece. There is, however, a lack of comparative published skeletal material from the Archaic period. Therefore, in addition to data from Athens and Attica, data from the broader Greek world from the Classical, Hellenistic, and Roman period are considered. The geographical and temporal distances do limit the interpretive value of such comparisons, but some conclusions can still be drawn.

8.2. Burial type, health, and social status

One aim of this thesis was to investigate the social implications of the demographic and health differences between burial groups. Variation in demographic makeup as well as health status can provide insights regarding whether different social groups were interred in the burial ground, thus allowing a deeper understanding of the population of Phaleron.

8.2.1. Differential burial practice and demographic variation

Burial practices and differences in deposition do not only provide information about the deceased but also about those who buried them (Pearson, 1993). It has been argued that the position of an individual in society and different aspects of identity influence burial practice (Binford, 1971), and that deviation from what is considered 'normal' burial practice is related to an individual's status in life. A person, who was considered 'deviant' in life for any reason such as sex/gender, age, or social status would also receive 'deviant' treatment in death, often characterised by visibly less care in the deposition of the body (Saxe, 1970). However, this idea has been challenged, and it has been argued that the interpretation of atypical burials requires more consideration and care (Betsinger et al., 2020; Chapman, 2010; Murphy, 2008). The distinct differences in burial practice encountered at Phaleron raise the question whether the differential treatment in death can give information regarding the identity and social status of the individuals during life. The separation of normative burials and mass burials into two distinctly different burial categories appears straight forward based on the differential treatment in death, while the non-normative single burials are more complicated to identify as a separate burial group. Within the normative and non-normative single burials some variation in burial practice was observed regarding grave type (e.g., pit burial, cist burial) and burial position (e.g., supine, on the side, prone), and there is considerable variability in the mass burials in terms of number of individuals per grave, which ranges from three to close to 80 individuals (see Ingvarsson et al., 2019).

Inhumations in supine extended position or with flexed legs in simple pit burials were the normative burial practice at Phaleron; however, some deviation in burial position such as burial on their side with flexed legs (e.g., individual IV_779: Figure 7.4) was identified as simple variation of normative burial practice. The variation in burial position and burial practice including different grave types for inhumations and cremations is reflective of different burial practices during the EIA and Archaic period (Alexandridou, 2016, 2020; Papathanasiou et al., 2013; Rönnberg, 2021a: 180-185).

Normative graves almost exclusively contained the inhumation of a single individual. However, a small number of pit burials within the thesis sample contained two individuals that were evidently interred at the same time (figs. 6.1, 6.2, and 6.3). Burial position and relationship between the individuals in each double pit grave varied significantly. Only double burial 2 (Figure 6.2) potentially contained the intentional deposition of two individuals next to each other, while double burial 1 and 3 (figs. 6.1 and 6.3) contained two individuals on top of each other, which raises the question whether the collective interment was the initial intention, or if other factors such as convenience played a role. We can never be certain about the intentions behind the burial position, but the burial of two individuals next to each other, with the arm of individual IV_401 on the torso of IV_400, might be interpreted as showing more care during deposition than the other two double burials. The position is reminiscent of the 'Lovers of Valdaro', but such interpretations are problematic and often guided by modern expectations of intimate relationships (Geller, 2017: 90-94). The possibility of convenience should be considered as a distinct option for all three double burials.

When considering the graves classified as non-normative single burials, the largest category was those buried prone (see Figure 6.4). Most of these were interred in an extended position with arms close to the torso (e.g., individual IV_734, Figure 7.9) and were thus very similar to the normative burials, suggesting that the prone burial position alone might not be sufficient evidence to speak of a non-normative burial practice, but rather is simply a normal variation (Aspöck, 2008). This is supported by the fact that at least one prone burial was furnished with a pottery jar while a large proportion of normative burials was unfurnished. By contrast, individual 5_149 (Figure 6.3) was partially cremated and buried with extremely flexed legs and spread arms, which was a clear deviation from the norm. This position might be the result of binding of limbs with perishable materials. However, muscle contraction during the cremation process (Thompson, 2015) might have also created the distinct burial position. The limited colour changes of the bones indicate low intensity and incomplete burning, while the blackening of the surrounding surface implies that the cremation took place in situ. The observed variation within this burial group suggests that the non-normative single burials might have contained normative burials that showed a variation in burial position as well as true non-normative burials that potentially can be considered together with the mass burials. The burial situation of the mass burials is distinctly different and is, therefore, considered non-normative. Further detailed analysis will be necessary for a more conclusive interpretation of the non-normative single burials.[11]

The demographic profiles of the normative and non-normative single burials are slightly biased towards young adult males, but they also include females and individuals of more advanced age (see figs. 6.6 and 6.7). Based on the presence of specific grave goods such as drinking vessels usually associated with the burial of men, it has been argued previously that females are archaeologically less visible in the burial record than males in the earlier Archaic period (7th century BCE) in comparison to earlier cemeteries with more balanced sex ratios (Liston, 2017; Liston, 2023). The relative lack of women has been interpreted as a sign of socio-political change as the disappearance of female burials is suggested to reflect the restriction of formal burial to the male elite (e.g., Houby-Nielsen, 1992). The general trend of male bias is visible

[11] The detailed analysis of the non-normative single burials is subject of an ongoing research project by Dr. Aviva Cormier.

here as well, but considering the slightly more elaborate cist-like burials, more females than males were identified (Prevedorou et al., 2024). While pit burials were found throughout all phases of use of the burial ground, most cist-like burials present in the current study could be dated into the early 7th century. The study sample of the cist-like burials is small, but the higher percentage of females and adults aged older than 35 years at death could be indicative of selective mortuary behaviour for the burial of (mature) women in cist-like burials, or it might show a temporal shift in cemetery use indicated by changes in burial practice towards fewer cist burials in favour of simple pit burials. Cist-like burials are clustered in the eastern section of the excavated area and, in contrast to the pit burials, the orientation was more standardised (see also Chapter 6 and section 7.5). The potential shift in cemetery use might also be supported by changes in the demographic profile towards a bias for males and younger adults in the later Archaic period. The presence of females in the more elaborate cist-like burials at Phaleron might suggest a higher visibility of women during the 7th century than previously thought (discussed also in Prevedorou et al., 2024), but the cist-like burials only represent a small section of the population, and the higher percentage of males in the Phaleron burial record is evident and requires further investigation on a larger scale (see also Buikstra et al., n.d.).

In contrast to the single inhumations, the demographic profile of the mass burials is much more homogenous (table 6.8). The bias towards males and young adult individuals (18-34 years at death) is much more pronounced in this burial group, which lacked female individuals entirely. The difference in demographic data supports the idea that two separate groups were interred in the burial ground at Phaleron. The demographic bias towards young adult males is also clearly visible in the 'Esplanada mass burial' (Ingvarsson et al., 2019) supporting that this is not merely a sample bias in this thesis sample. Mass burials have been identified in several other contexts in

Greek antiquity and can be associated with warfare (e.g., Himera on Sicily or Paros), massacres and executions as has been suggested for Phaleron, epidemics (e.g., Kerameikos in Athens), or slavery (e.g., Pydna in Macedonia) (Bérard and Castex, 2021). While the rationale for the mass burials at Phaleron requires further investigation, this burial group can certainly be identified as 'atypical', 'distinct', or 'deviant'. The skeletal data can be used to investigate the lived experience of the individuals interred in the mass burials to identify potential reasons for the deviant burial treatment. Regardless of some temporal variation in burial practice, the observed differences in the demographic profile between the different burial types suggests that at least two contrasting social groups were interred in the burial ground.

8.2.2. Early life stressors and heterogeneity of frailty

The average age-at-death of under 34 years for adults in the sample population is indicative of high risk of mortality that might be linked to poor health throughout the life course (Barker, 2007; Gowland, 2015). For both males and females, adults aged 18-34 years at death constitute approximately half of the sample obtained from normative and non-normative single burials suggesting a high risk of mortality regardless of sex. The percentage of individuals aged younger than 34 years at death is considerably higher at Phaleron in comparison to EIA populations that showed a higher average age-at-death especially for males (Liston, 2017; Liston, 2023). Risk for death is potentially linked to different causes for each sex. Pregnancy and associated dangers of childbirth are high risk factors for adolescent and young adult females, while males would have been subjected to different hazards associated with different living or working environments.

	Phaleron - Norm. Burials	**Phaleron - Mass burials**	**Agios Dimitrios[1]**	**Athens Kerameikos[2]**	**Athens Plateia Kotzia[2]**	**Attica[3]**	**Pydna[4 x]**	**Knossos[5]**	**Pontokomi-Vrsyi[6]**
Period	*Archaic*	*Archaic*	*EIA*	*Classical*	*Classical*	*Classical*	*Classical*	*Hellenistic*	*Roman*
CO	25/71 (35.2)	4/14 (28.6)	5/18 (27.8)	2/11 (18.2) °	9/18 (50) °	20/22 (90.9)	55%	-	19/54 (35.2)
DEH*	832/1727 (48.2)	82/287 (28.6)	7/352 (2.0)	-	-	47/184 (25.5)	33%	-	461/969 (47.6)
Caries*	176/2033 (8.7)	9/660 (1.4)	33/352 (9.4)	-	-	67/277 (24.1)	-	40/476 (8.4)	136/1052 (12.9)
AMTL*	145/2071 (7.0)	21/621 (3.4)	91/200 (46.5)	-	-	16/497 (3.2)	-	16/517 (3.1)	264/1930 (13.7)
PNBF	79/96 (82.3)	10/20 (50)	-	-	-	12/19 (63.1)$^{+}$	52% $^{+}$	-	L: 43/47 (91.5)***** R: 45/49 (91.8)*****
Trauma	64/132 (48.5)	14/35 (40)	4/51 (7.8)	-	-	-	7%	-	14/60 (23.3)
VJD									
VBD	44/98 (44.9)	5/23 (21.7)	-	-	-	8/10 (80)	-	30/60 (50)$^{+}$	37/50 (74)
SN	23/89 (25.8)	2/21 (9.5)	-	-	-	4/8 (50)	-	0/60 (0)$^{+}$	-
VOA	42/109 (38.5)	3/32 (9.4)	-	-	-	7/12 (58.3)	-	18/51 (35)$^{+}$	22/53 (41.5)

Table 8.1: Comparative data of pathological lesions from sites in the Greek world. Data per individual unless otherwise specified. Percentage frequencies in parentheses.
VJD: Vertebral Joint Disease; VBD: Vertebral Body Degeneration; SN: Schmorl's nodes; VOA: Vertebral Osteoarthritis
** prevalence based on teeth/tooth positions and bones affected (TPR)*
° This study only provides pooled frequency for CO and porotic hyperostosis.
$^{+}$ Per preserved vertebrae
1 Papathanasiou et al. (2013)
2 Lagia (2014)
3 Karligkioti et al. (2023): $^{+}$ PNBF is scored for the lower limbs and not only for the tibia.
4 Triantaphyllou and Bessios (2005): ^{x} Publication only details frequency for 58 individuals and it is unclear whether prevalence rates are CPR or TPR. $^{+}$ PNBF is scored for the lower limbs and not only for the tibia.
5 Moles (2023c)
6 Vergidou et al. (2021, 2022)

In contrast, the young age-at-death for adults in the mass burials should be treated separately from morbidity driven mortality. While it is not possible to identify perimortem trauma or any skeletal lesions suggestive of a violent death, the burial situation is unusual especially given the evidence of shackling. Mass burials encountered in archaeological contexts have been associated with different circumstances, and for example, mass burials in settlement cemeteries have been connected to epidemics (Bérard and Castex, 2021). However, in contrast to what can be observed at Phaleron, epidemics kill more indiscriminately, and the demographic profile of a such a mass burial would be more reflective of a living population including older individuals and females (DeWitte, 2009, 2018; DeWitte and Hughes-Morey, 2012; Wissler and DeWitte, 2023). In combination with the evidence of shackled or otherwise bound individuals, the demographic profile indicates that these individuals died violent deaths and were potentially executed. While individuals from normative burials show consistently higher prevalence of indicators of physiological stress during childhood as well as during later stages of life than those buried in the mass burials, it can be assumed that the young age-at-death in the mass burials is not indicative of higher frailty as it would be in a normal attritional assemblage (Wood et al., 1992), but it is more likely that the burial of executed men in mass burials created a bias in the demographic profile. Different forms of executions were performed in ancient Greece. Some political opponents were given the opportunity of a death sentence outside of the public eye by drinking poison (hemlock) (e.g., Socrates) (Riess, 2016). In contrast to this stood the public execution by *apotympanismos*, a specific form of crucifixion. The sentenced person was fixed with clamps and a collar onto a poll or wooden board, that was set up vertically, and left until death. There are some similarities to crucifixion, but the consequential blood loss of nailing the limbs in the process of crucifixions would have resulted in a quicker death than the bloodless *apotympanismos*. This form of execution was practiced in Athens between the 7th and 4th century BCE (Gernet, 2004). Death by poison as well as *apotympanismos* would have left no visible signs on the skeletal remains in form of perimortem trauma. During the early excavations at Phaleron in 1915, one mass burial was uncovered that contained several individuals that were shackled at their limbs and still wore iron collars around their necks who were interpreted as prisoners executed by *apotympanismos* (Arrington, 2021: 115-118; Pelekidis, 1916; Rönnberg, 2023). The more recently discovered mass burials did not show any evidence of iron collars, but the presence of shackles still would be consistent with a similar mode of execution.

Presence and prevalence of the early life stressors CO and DEH vary between the different burial types (see table 8.2 for a summary of prevalence rates). The higher prevalence rates of early life stressors in the normative burials – especially DEH – are consistent with the notion that the younger age-at-death is more informative in terms of frailty for this burial group as adolescents (12-17 years) and young adults (18-34 years) are considerably more affected by the CO and DEH than the two more advanced age-at-death cohorts. While younger age-at-death cohorts survived adverse conditions during development and early childhood, they were seemingly at higher risk of mortality during adulthood. In contrast, the mass burial individuals appear to have been exposed to stressors to a lesser degree during development. A higher prevalence of early life stressors in females has been identified in comparative studies using CO (Lagia, 2014, 2015b), suggesting that females might have been exposed to more adverse conditions during childhood. Considering the osteological paradox (Wood et al., 1992), it is also possible that females had a better buffer capacity and, therefore, survived early life insults better than male infants and children who consequently would have died before they reached adulthood.

Short stature is also considered an indicator of physiological stress during development and is associated with a compromised immune system and an increased risk of morbidity and mortality (Vercellotti et al., 2014). Mean stature of males and females is comparable to what has been observed for EIA Athens (Liston, 2017), and there appears to be no significant association between shorter stature and increased risk of mortality at Phaleron. Males from normative burials show more variation in stature than those in the mass burials. Environmental influences are a strong factor determining adult stature, but genetics are also a key factor. The smaller standard deviation and limited variation in stature in the mass burials might be owed to a genetically more homogenous group of people in this burial category than in the normative burials, or due to a shared childhood environment including nutrition and disease exposure.

Like higher frailty during early life and development, the normative burials were exposed to a higher degree of physiological stress during adulthood as expressed in dental disease, tibial PNBF, vertebral joint disease, and trauma (see table 8.2 for a summary of prevalence rates).

Dental disease has a higher prevalence in the normative burials in contrast to mass burials, suggesting differential access to certain foods creating different disease patterns. While the rates for normative burials are comparable to EIA, Classical, Hellenistic, and Roman sites in the Greek world (see table 8.1), the observed frequency in the mass burials is considerably lower. However, in contrast to caries and periapical lesions, the mass burials were more affected by periodontal disease than the normative burials. Periodontal disease is a major factor contributing to AM tooth loss, but the pattern of higher frequency of AM tooth loss in the normative burials suggests that other risk factors such as caries or periapical lesions contributed more to AM tooth loss than periodontal disease especially at a younger age. Extensive AM tooth loss of multiple teeth in young adult individuals is especially noteworthy, and this was also more often identified in normative burials than in mass burials.

Differences in demographic profiles between the burial categories might have had influence on the observed differences in dental disease. The lack of older adults and females in the mass burials created a bias, but for statistical testing only males from normative and non-normative single burials were used. Presence of more advanced age-at-death cohorts might provide a partial explanation for the higher prevalence of dental disease in the normative and non-normative single burials, but the general trends are also visible when only considering the younger age-at-death cohorts. The higher prevalence of dental disease in normative burials is highly suggestive that the differences are connected to burial type and likely culture driven. It appears that those buried in normative burials were more reliant on a more cariogenic diet rich in carbohydrates such as cereal, while those buried in mass burials might have had preferential access to an animal-based diet. Poor oral health has been associated with overall poor well-being (Ajwani et al., 2003; Koren et al., 2011) and an increased risk of mortality (DeWitte and Bekvalac, 2010) as an adequate diet does not only contribute to better oral health but also to better systemic health and immune response.

Tibial PNBF as a proxy for exposure to infectious agents is common in the study sample, suggesting poor living conditions such as poor sanitation and crowded living conditions (Larsen, 2015: 88-91). Like dental disease, males from normative burials are statistically significantly more affected by tibial PNBF than those interred in mass burials. This pattern reflects the picture of generally better health in the mass burials as observed for dental disease. The majority of lesions observed in the sample were healed at death indicating that these individuals survived the health insults. The higher frequency of PNBF in the normative burials might be interpreted as preferential exposure to infectious agents putting this burial group at higher risk for infectious disease than those buried in the mass burials. The statistically significant association between PNBF and DEH also suggests that the higher levels of stress during development experienced by the normative burials has impacted the immune response considerably thus resulting in a higher susceptibility to infections and other stressors during later life.

Summary table for disease prevalence					
	Normative burials		*Non-normative single burials*		*Mass burials*
	M	*F*	*M*	*F*	*M*
CO	11/38 (28.9)	9/24 (37.5)	1/15 (6.7)	0/5 (0.0)	4/12 (33.3)
DEH	42/58 (72.4)	19/31 (61.3)	9/19 (47.4)	3/8 (37.5)	7/24 (29.2)
Caries	31/58 (53.4)	20/31 (64.5)	9/19 (47.4)	5/8 (62.5)	2/24 (8.3)
AMTL	21/58 (36.2)	14/31 (45.2)	9/19 (47.4)	3/8 (37.5)	2/24 (8.3)
PAL	13/58 (22.4)	6/31 (19.4)	6/19 (31.6)	6/19 (31.6)	1/24 (4.2)
PD	38/58 (65.5)	17/31 (54.8)	12/19 (63.2)	5/8 (62.5)	15/24 (62.5)
PNBF	38/47 (80.9)	20/23 (87)	11/14 (78.6)	3/6 (50)	9/18 (50)

Table 8.2: Summary table for disease prevalence (TPR except for dental disease [CPR]) by burial type and biological sex.

8.2.3. Risk and activity

The overall frequency of antemortem trauma (43.7%) observed in the Phaleron sample is exceptionally high, which becomes especially apparent when compared to published studies from other Greek sites ranging from the EIA to the Roman period (table 8.1). The trauma prevalence suggests a highly elevated risk for bodily harm in Archaic Athens including interpersonal violence and accidental injury that has not been observed in other Greek cemeteries.

A slightly higher prevalence of fractures observed in males than in females interred in normative burials is consistent with expected gendered risk patterns (Kwan et al., 2011). Considering the burial context of the mass burials, higher levels of fractures indicative of interpersonal violence might have been expected in this burial group, but the prevalence of interpersonal injury is slightly higher in the normative burial settings than in the mass burials (see summary table 8.3) Multiple head wounds and facial fractures are associated with interpersonal violence as seen in battlefield or massacre mass burials, and both perimortem as well as healed cranial trauma sustained in previous armed conflict or battles can be expected in such burial contexts (Novak, 2007; Redfern, 2017; Steyn et al., 2010). Evidence for healed cranial trauma is present in all three burial groups, but the overall trauma patterns are not consistent with armed conflict or battles. Limited evidence of SFT and the only instance of possible perimortem cranial trauma (individual IV_399: see Figure 6.15) were identified in normative burial settings. When considering evidence of interpersonal violence, individual IV_554, who was buried in a cist-like grave, constitutes a special case that warrants a more detailed discussion (see also Buikstra et al., n.d.). Among numerous postcranial fractures, this mature adult male had two instances of healed SFT inflicted likely by a long knife or sword to the left side of the cranium (see Figure 6.14). The injuries penetrated the cranium completely and likely would have exposed the brain tissue. These lesions showed evidence of remodelling indicating survival of severe cranial trauma, and the smooth and rounded margins potentially suggest treatment in form of scraping with a rasp as detailed by Hippocrates on the treatment of head injuries (Corpus Medicorum Graecorum I 4,1). It is a distinct possibility that both traumata were the result of one event, but fracture recidivism should be considered. The location on the anterior left aspect of the cranium suggested that the blows were directed from the front (e.g., face-to-face combat) (Novak, 2007; Wenham, 1989), and the severity of the injury implies that the individual was not wearing protective head gear. Skull fractures have the potential for serious complications including brain damage (Redfern and Roberts, 2019), and the injury would also significantly damage the overlying soft tissue leading to scaring and muscle damage (Powers, 2005). In this instance, the left temporalis muscle was affected possibly impacting the masticatory capabilities. The trauma to the left parietal bone might have penetrated deep enough to injure the dura mater. Subsequent damage such as chronic headaches, motor and visual impairment, or memory loss can be caused by severe cranial trauma (Powers, 2005; Wenham, 1989). The extent of long-term care requirements cannot be determined based on the skeletal remains; however, it is to be expected that individual IV_554 received medical treatment and care immediately after suffering these injuries as evidenced by long-term survival (Tilley and Cameron, 2014).

The limited evidence of severe trauma potentially attributed to combat or armed conflict on a population level suggests that the injuries presented here for individual IV_554 are not the result of large-scale warfare but perhaps a more isolated incident. The fractures that affected individual IV_779, as discussed in the osteobiography, were potentially also the result of interpersonal violence. The pattern of nasal fracture, rib fractures, fractures to hand bones, and possible myositis ossificans caused by trauma to the chest, however, is more suggestive of beating or pugilism rather than military combat (Lovell and Grauer, 2018; Redfern and Roberts, 2019).

Evidence of fractures attributed to violence					
	Normative burials		***Non-normative single burials***		***Mass burials***
	M	*F*	*M*	*F*	*M*
Cranial SFT	6/52 (11.5)	0/26 (0.0)	0/18 (0.0)	0/8 (0.0)	0/19 (0.0)
Cranial BFT	8/52 (15.4)	4/26 (15.4)	2/18 (11.1)	0/8 (0.0)	4/19 (21.1)
Facial bones	1/52 (1.9)	0/26 (0.0)	1/18 (5.6)	0/8 (0.0)	0/19 (0.0)
Parry fractures	4/58 (6.39)	1/24 (4.2)	1/17 (5.9)	0/8 (0.0)	1/20 (5.0)
CPR violence	16/58 (27.6)	5/31 (16.1)	3/19 (15.8)	0/8 (0.0)	5/24 (20.8)

Table 8.3: Summary of fracture prevalence attributed to violence by burial group and biological sex.

Evidence for interpersonal violence was observed in all burial types affecting males and females, suggesting that both normative and mass burials were exposed to similar risk of interpersonal violence over the life course (see summary table 8.3).

Continuous change in leadership, struggle for political power, and intra-elite rivalry during the early Archaic period resulted in high levels of interpersonal violence between aristocratic families and their supporters (Anderson, 2005), but the evidence from Phaleron suggests that violence was present in all socio-economic levels.

In contrast, the individuals in the normative burial feature suffered a significantly higher risk of accidental trauma during their lifetime than the non-normative single and mass burials, including multiple cases of fracture recidivism. Similarly to interpersonal violence, males are slightly but not statistically significantly more affected by accidental trauma than females indicating a high-risk environment for the population section buried in the normative burials regardless of biological sex. Hazards might have been encountered in domestic settings, but a more likely explanation is exposure to risk of accidental injury in different lines of work such as construction, agricultural work, or mining. High velocity fractures (e.g., femoral fractures) as well as stress fractures (e.g., spondylolysis) are associated with high-risk environments and elevated levels of physical activity.

The evidence for vertebral joint disease showed a higher frequency in the normative and non-normative single burials than in mass burials, lending support to the idea that these individuals experienced physical hardship consistent with heavy manual labour. The presence of vertebral joint disease is positively associated with advanced age-at-death (table 6.45) as expected in a progressive degenerative disease (Arden and Nevitt, 2006; Corti and Rigon, 2003; Loeser, 2010). However, age-at-death does not appear to be the only risk factor as those younger than 34 years at death also exhibited clear evidence of vertebral joint degeneration. A higher prevalence of joint disease in the thoracic and lumbar vertebrae than in the cervical vertebrae is expected due to the greater demands of weightbearing on the lower sections of the vertebral column (Bridges, 1994; Sofaer Derevenski, 2000). This pattern was observed for the normative and non-normative burials, while the distribution for the mass burials is opposite with higher levels of degeneration in the cervical vertebral arches, specifically the atlantoaxial joint. A higher prevalence of joint disease in the cervical vertebrae has been associated with carrying heavy loads on the head (Merbs, 1983; Sofaer Derevenski, 2000), while carrying weight on the back also increases risk for fractures in the lower vertebrae affecting both the vertebral arch as well as the bodies. These patterns were observed on a population level and were also discussed in the osteobiographies for individuals 5_253, IV_779, and IV_734. It is not possible to identify type of activity conclusively, but the contrasting patterns between burial categories indicate that they may have been subjected to different forms of mechanical stress on the vertebral column.

8.2.4. Summary

The demographic and palaeopathological evidence suggests that at least two contrasting social groups were buried at Phaleron. The significant differences observed between the burial categories indicate that cultural factors impacted disease susceptibility and risk, while other factors such as biological sex appear to have played a lesser role within the normative and non-normative single burial groups. Living conditions were characterised by increased levels of hardship for the individuals buried in the normative burials when compared to those interred in mass burials.

The differences observed in the demographic profile as well as prevalence of physiological stressors between the normative and mass burials indicates a diversity in the burial ground population that appears to be connected to the different burial categories. The data suggests that the burial ground was used for the interment of two groups with contrasting lived experience during development and later stages of life. While the normative burials received a more careful burial treatment in individual graves than the mass burials, the lived experience of the mass burials is characterised by seemingly better living conditions over the life course. It can be argued that the differences in the demographic profile between the normative and mass burials are likely caused by cultural selection that potentially was related to the social status of the individuals. This cultural bias is supported by statistically significant differences with higher exposure to physiological stress and disease burden observed for males buried in normative burials when compared to mass burials while prevalence of stressors is more homogenous within the normative burials regardless of biological sex. Social status is a strong determinant of health status, but it is not necessarily static and can change over the life course and is dependent on other axes of identity such as gender or age. Individual changes in social status cannot be traced in the burial record of Phaleron; therefore, social status is considered as cumulative over the life course. Based on this, the palaeopathological data suggests a higher social status for those interred in mass burials that gave a certain protection from health insults over the life course. However, sudden changes in social status as suggested by the violent death and possible execution of the individuals buried in mass burials would only be reflected in the burial situation and not as indicators of long-term physiological stress in the skeletal record. It has been suggested before that the mass burials contained executed political prisoners who followed elite groups that were unsuccessful in the struggle for power during the Archaic period (Buikstra et al., 2024; Ingvarsson et al., 2019; Papadopoulou, 2017; Rönnberg, 2023). Evidence from Pydna in Macedonia showed that mass burials were likely also used for the disposal of slaves (Triantaphyllou and Bessios, 2005), but the skeletal evidence does not indicate that the mass burials at Phaleron were used for the burial of enslaved people. The biased demographic profile towards young adult males is inconsistent with the possibility that the mass burials were used during epidemics, as this would result in a more diverse demographic profile, and no shackles would be expected in this scenario either. The centuries in question were marked by major socio-political changes characterised by instability, and they are associated with outbursts of violence such as the Kylonian coup, that reportedly resulted in the exile of Kylon and the killing of his followers (Anderson, 2005; Wallace, 2007). While it is impossible to conclusively link historical events with the burials at Phaleron (Rönnberg, 2023), the archaeological context and bioarchaeological evidence from these mass burials is suggestive of interpersonal conflict that is consistent with the hostile environment that intra-elite rivalry and competition would have created. It is a distinctly plausible explanation that the young men interred in the mass burials represent groups of high-status citizens who supported unsuccessful elite leaders in their attempt to seize power, and who were captured and killed or executed in the struggle for political power. If Phaleron indeed served as a burial ground for those of low socio-economic status as suggested before, the informal interment of executed high-status young men in mass burials here could then be interpreted as a punishment of the elite families of political prisoners as well as an insult to the men themselves. They were not only denied formal burial in one of the elite cemeteries but also the visibility that such a burial afforded.

The interpretation of non-normative single burials is more difficult, as these often fall between mass burials and normative burials, but statistically significant results put the non-normative single burials by trend closer to the normative burials. The position between the two other burial categories underlines the need for further analysis of these individuals in order to identify those that might have been treated differently in death and those whose burial was simply a variation of the normative custom.

8.3. Structural violence in Archaic Athens

Section 8.2. showed that there are clear differences in demographic makeup and disease exposure between the normative burials and mass burials indicating that people from different social backgrounds were buried at Phaleron with those interred in the normative burials experiencing worse living conditions. The population results and osteobiographies have shown evidence of a high level of physical hardship amongst the normative burials, including early life stressors, dental disease, fractures associated with accidental injury as well as direct violence, and stress on the musculoskeletal system in form of stress fractures, joint disease, and marked entheseal changes. This section will discuss whether the skeletal evidence provides an indicator of structural forms of oppression and violence at Phaleron (see also Buikstra et al., 2024).

Social status can be one of the strongest determinants of health as it affects almost all aspects of life, including living conditions, working conditions, diet, and exposure to risk (Gowland and Thompson, 2013; Sofaer, 2006). Inequitable social structures are known to have a profound impact on the very poorest and marginalised in society. Bioarchaeological analyses of populations subjected to structural violence have repeatedly found evidence for poor development and growth, exposure to infectious and metabolic disease, poor dental health, skeletal injuries, musculoskeletal changes associated with high levels of activity, as well as high mortality rates in younger adult age cohorts (Harrod and Martin, 2014; Martin and Harrod, 2015; Redfern, 2018).

Several enslaved populations have been studied in New World contexts showing some diversity in disease expression, thus reflecting the heterogenous experience of enslavement (Blakey, 2001). A large proportion of those enslaved in the New World were born into slavery, but this might not have been the case in other cultural contexts resulting in different disease exposure during early life. The absence of clear historical documentation for Archaic Athens makes it more challenging to categorically identify the bodies of the enslaved. Despite the cultural, temporal, and geographical divide, it has been argued that approaches to archaeological material from contexts of enslavement from the New World can also be applied to the study of enslavement in the Roman World (Webster, 2005, 2008a, b), and this is also applicable to ancient Greece. While the material record differs, exposure to social control and structural violence can leave similar traces on the human body. However, patterns of stress and disease are not unique or specific to enslavement, and other forms of inequality might result in similar evidence. Therefore, it might not be possible to conclusively differentiate between enslaved individuals and other poor or bonded labourers, due to the similarity of their lived experience (Redfern, 2018).

8.3.1. Manual labour and physical hardship over the life course

Systemic inequality and structural violence are found embedded in the political, economic, and cultural systems of social hierarchies (Farmer et al., 2016). Ancient Athens was a stratified hierarchical social system, consisting of a ruling elite, a middle class of varying wealth, a low status working class, and enslaved people that existed outside of society. While slavery is always a form of structural violence (Mbembe, 2008), other marginalised sections of society such as unskilled labourers, migrants, or women might also have been subjected to structural inequalities that promoted and enforced detrimental living and working conditions and poor health. The practice of enslavement is documented for Greek antiquity, and enslaved individuals are represented in literature and art; however, exploration of the lived experience of enslaved people or the perspective of enslaved people are the exception in these sources. More often we encounter the views of the polis and slave owners thus providing us with a one-sided narrative (Forsdyke, 2021: 7-12, 52-53; Hunt, 2011).

The normative burial sample is biased towards males and young adults under the age of 34 years. Preservation has proven to be an issue with a large proportion of adults that cannot be aged more accurately than 'adult'. Nevertheless, few individuals reached middle adulthood (35-49 years) and mature adulthood (50+ years). Cemeteries that have been used for the burial of a low status work force are often dominated by young adult male individuals (Angel et al., 1987; Harrod and Crandall, 2015; Owsley et al., 1987; Rankin-Hill et al., 2009; Rathbun, 1987; Van der Merwe et al., 2010a; Van der Merwe et al., 2010b), but a more balanced biological sex divide and presence of older adults have also been observed (Fleskes et al., 2021; Triantaphyllou and Bessios, 2005), and young age-at-death is not exclusive to these contexts.

The palaeopathological evidence from the normative burials displayed evidence of physiological hardship over the life course. High levels of early life stressors such as CO and DEH are frequent at Phaleron with females displaying slightly higher levels than males (DEH: table 6.9 and CO: table 6.5). The high prevalence of early life stressors is suggestive of poor living conditions during infancy and early childhood including poor nutrition and exposure to infectious disease. In comparison with EIA Greek populations, prevalence of DEH and CO were considerably higher at Phaleron. When considering prevalence rates observed for the low status population in Athens and rural Attica during the Classical period, frequency of CO was lower at Phaleron, but DEH was more prevalent (see table 8.1).

Overall, a higher average stature could be estimated for males than for females in the thesis sample. This pattern is universal and can be observed regardless of time period and geographical region. The higher variability in stature estimate in the male sample might be indicative of a more diverse genetic make-up or more variation in living conditions during earlier stages of life than for the female sample. Regardless, males and females both exhibit high levels of CO and DEH suggesting adverse living conditions during early childhood.

Increased demands on the female body's resources such as pregnancy during adolescence might have had a harmful impact on the later development, which could also be a causative factor for the high levels of nutritional deficiency seen in the infants at Phaleron. Approximately one third of the burials are those of non-adults, and the palaeopathological data showed high levels of nutritional stress during infancy suggesting a diet lacking in essential nutrition during infancy (Rothwell, 2024). Infants who died under the age of one year that showed signs of active nutritional deficiencies such as scurvy and possibly rickets, are also highly informative about mothers' and women's health (Gowland, 2015, 2018; Gowland and Halcrow, 2020). A foetus or young infant usually receives all vital nutrition from their mother, either in-utero or via breastfeeding. The early onset of nutritional deficiencies is either indicative of lack of breastfeeding, poor maternal health, or both. It is possible that women were required to feed their infants supplemental food with lower nutritional qualities early in life, but it should be considered that women's health was also generally poor with high levels of nutritional deficiencies. Inadequate diet in combination with higher demands due to pregnancy and breast feeding would have led to an inability of women to provide sufficient nutrition for their newborn children.

The high prevalence of physiological markers of early life stress suggests nutritional deficiencies and other factors such as infectious disease or unsanitary and crowded living conditions played a key role during early life, and the poor health status during infancy and childhood appears to have significantly impacted the immune system. The higher prevalence of CO and DEH in those under 34 years (tables 6.5 and 6.9) is consistent with higher frailty, and risk for morbidity and mortality (Barker, 2007; Gowland, 2015). High levels of early life stress have been identified archaeologically in populations subjected to structural inequalities such as enslaved populations and forced labourers; however, not all populations that are associated with structural violence or enslavement display high levels of CO and DEH (see table 8.4) and these factors are not exclusive to populations experiencing structural violence.

Exposure to considerable infectious disease load on a population level is also reflected in the high prevalence of PNBF affecting all demographic groups regardless of biological sex and age-at-death. Most lesions were fully healed at death suggesting exposure to stressors during earlier times in life rather than a continuous exposure which would be consistent with the high levels of indicators of stress during development. It is also plausible that the individuals who survived these stressors during childhood developed a certain resilience. A statistically significant association between DEH and PNBF suggests that hardship during development compromised the population's immune system putting them at higher risk for inflammatory reactions and infectious disease at a younger age (table 6.48). The higher prevalence of both DEH and PNBF in females is suggestive that females experienced a higher stress load than males and developed less resilience over the life course. Generally, Greek populations experienced moderate to high levels of PNBF (see table 8.1), but these lesions are not universally seen (Bourbou, 2005). All lesions are considered non-specific, and generalised infectious disease in combination with other stressors such as nutritional deficiencies would have put considerable stress on the population as a whole (Null et al., 2009).

		Phaleron - Norm. Burials	Kelley and Angel (1987)	Rathbun (1987)	Blakey and Rankin-Hill (2009)	Fleskes et al. (2021)	Owsley et al. (1987)	Van der Merwe et al. (2010a)	Harrod and Martin (2015); Harrod et al. (2012)
CO	CPR	25/71 (35.2)	-	43%	23.7%		12.5%	9/82 (11.0)	-
DEH	CPR	77/132 (58.3)	18th c.: 56% Catoctin: 46%	50%(F) 92% (M)	70.8%	14%	-	-	2/10 (20)
	TPR	832/1727 (48.2)	-	-	-	-		-	-
Caries	CPR	62/132 (47.0)	-	-	72.9% (M) 84.3% (F)	49%	22.3%	-	7/10 (70%)
	TPR	176/2033 (8.7)	-	-	-			-	40/212 (18.9)
	L/ind	1.76	9.6	3.20-5.17	-			-	3.1
AMTL	CPR	43/132 (32.3)	-	-	-	36%	-	-	9/13 (69.2)
	TPR	145/2071 (7.0)	-	-	-			-	-
	L/ind	1.1	-	6.5-11.57	3.7-4.3			-	-
PNBF	CPR	79/96 (82.3)	-	70%	55.9%	-	-	-	3/13 (23.1)
Trauma	CPR	59/132 (44.7)**	-	-	23.1%	3/36 (8.3)	10.3%	28/101 (26.2)	13/13 (100)
SPL	CPR	10/91 (11.0)			4/187 (0.5)		-	7/82 (8.5)	-
VJD			-	-	-				
VBD	CPR	44/98 (44.9)	-	30-48%	33.3% (M) 31.9% (F)	-	-	13/87 (14.9)	-
SN	CPR	23/89 (25.8)	-	39%	20.9% (M) 20.9% (F)	-	13.8%	13/87 (31)	-
VOA	CPR	42/109 (38.5)	-	20-38%	41.3% (M) 57.8% (F)	-	-	-	-

Table 8.4: Comparative data of pathological lesions from burial grounds associated with enslavement and forced labour (see also table 8.1. for Pydna, Greece). Percentage frequencies in parenthesis. Data per individual or per element as specified (CPR/TPR).
SPL: Spondylolysis; VJD: Vertebral Joint Disease; VBD: Vertebral Body Degeneration; SN: Schmorl's nodes; VOA: Vertebral Osteoarthritis
L/ind: lesion per individual
*** 4 individuals with no trauma instances except for spondylolysis excluded here.*

Diet and poor nutrition are factors that have the potential to impact both early life development as well as susceptibility to infectious disease. Dental disease can provide a proxy for diet, and it is prevalent in form of caries, periapical lesions, and AM tooth loss in the normative burial sample. The population was affected by moderate amounts of dental disease comparable to what has been observed in other Greek population studies (table 8.1), and the observed patterns are consistent with sex differences in subsistence strategy. Higher levels of dental disease in females might be indicative of higher intake of cariogenic food, but other physiological and hormonal factors associated with hormonal levels and pregnancy might be able to provide some explanation for the higher caries prevalence and AM tooth loss in females (Lukacs, 2017). The introduction of a cariogenic diet rich in carbohydrates including cereals or bread at an early age would have had the potential to start initiation of dental disease early in life resulting in high levels of caries and AM tooth loss in younger adults (see for example IV_734) (Kelley and Angel, 1987; Mack et al., 2009).

In addition to the clear evidence of poor living conditions during childhood, the skeletal remains also reflect high levels of physical hardship and an exceptionally high risk of bodily harm during adolescence and adulthood expressed in considerable amount of skeletal trauma, musculoskeletal stress, and joint disease. Trauma as the result of violence or accidents has been identified frequently for archaeological populations, and reported levels are often high in populations that were subjected structural violence (see table 8.4); however, the frequency of skeletal injury is exceptionally high at Phaleron with 51.6% of females (16/31) and 62.1% of males (36/58) in the normative burials showing at least one instance of AM fractures (table 6.20). In comparison, studies of EIA, Archaic, Classical, and Roman populations in the Greek world have identified notably lower prevalences of skeletal trauma (see table 8.1., as well as Liston (2017): less than 10%; Liston (2023): 15%). The high number of individuals affected by trauma in this sample is striking especially considering the poor preservation in some cases which will inevitably lead to an underestimation of fractures.

Skeletal traumata likely caused by interpersonal violence were identified in 27.6% of males and 16.1% of females in the normative burial sample (see table 8.3). Cranial fractures are often considered as a clear signifier of interpersonal violence, but while this can be relatively securely inferred for instances of SFT, the differentiation between direct violence and accidental causes is more difficult for cranial BFT. Although cranial depression fractures can be indicative of beatings (Harrod and Martin, 2014), the possibility of non-violent causes such as an accidental fall or falling objects in unsafe environments should be taken into consideration (Betsinger, 2023; Van der Merwe et al., 2010b). Repeated beatings and corporal punishment can serve as means to control and dominate individuals (Harrod et al., 2012), and in the context of Archaic Athens, it is plausible that the low-status working class or enslaved people were subjected to repeated violence as a form of control and abuse of the subordinate. The constant threat of violence would not only have had a physical effect in form of injury, but also profound psychological consequences (Hunt, 2016). On the other hand, interpersonal violence may also have existed within the community. Violent behaviour is linked to social inequality and low socio-economic status (Alghnam et al., 2016; Tegtmeyer and Martin, 2017), and crowded living conditions or competition for access to subsistence could have acted as triggers for violence within the non-elite population.

The prevalence of accidental injury is higher than of interpersonal violence, and similar to the observed frequency of fractures attributed to violence, males are slightly more affected by accidental trauma suggesting males were generally exposed to higher risk of injury than females (table 6.25. and Figure 6.14). Males showed a higher prevalence of rib fractures, vertebral fractures, and fractures of lower limb bones, while a higher prevalence in radial fractures was observed in females. The high prevalence of fibula fractures in females is likely owed to the low number of proximal fibulae preserved in the sample, but the other differences might give insights into gendered activity patterns and risk. Most long bone fractures affecting females are consistent with low-energy, indirect forces such as accidental falls on an outstretched arm (e.g., distal radial fractures) (Galloway, 2014b). Distal radius fractures are clinically more commonly identified in women with associated risk factors such as osteoporosis, issues with balance, or a history of frequent falls. These risks are more common in elderly individuals (Galloway, 2014b), however, malnutrition might have altered bone chemistry in females and increased susceptibility to fractures that are commonly more associated with advanced age-at-death cohorts. While similar mechanisms can provide explanations for some instances of upper limb fractures affecting males, a higher percentage of ulna fractures is consistent with direct force ('parry fracture') and likely related to violence rather than accidental injury (Judd, 2008). The fractures of the lower limbs observed in males are more consistent with high-energy direct injuries that might be associated with physically dangerous activities and linked to manual labour including farming, construction, mining, or handling animals (Gilmour et al., 2015; Lovell, 1997b). Such an environment would also be consistent with the possible evidence for soft tissue trauma resulting in infection of the hand bones observed in individual 5_254 (Figure 7.3) and the perimortem cuts affecting three tibiae (IV_241, IV_499, IV_733) (see figure 6.21). Soft tissue injuries are difficult to identify in archaeological contexts, but the case of individual 5_253 can provide insights into trauma affecting the soft tissue only in form of secondary infection of the hand bones. Poor sanitation in living quarters and lack of medical intervention in combination with the potential need to continue working in possibly polluted environments would have put individual 5_253 at high risk for infection of an open wound on the left hand that might have caused sepsis and potentially resulted in the individual's death. Perimortem cuts to the anterior crest of the tibia have been identified in battlefield contexts and interpreted as an attempt to sever the feet (Liston, 2020). However, in contrast to these battlefield examples, the tibia cuts found at Phaleron only appear as single instead of multiple cuts and are, therefore, likely more consistent with accidental injury caused by heavy machinery such as ploughs as used in agriculture or construction. The anterior tibia is only covered by a thin layer of soft tissue, and trauma to this area would easily affect the bone. A clear cut to the anterior crest removing part of the bone can be considered a very severe injury. The fact that the affected individuals died shortly after the traumatic incident is either suggestive of lack of medical treatment or the individuals might have sustained further severe injuries that are not reflected in the skeleton. Individual IV_499 also shows evidence of a systemic generalised infection in form of active PNBF affecting several bones, which might be connected to the open wound on the tibia and subsequent infection (Lovell and Grauer, 2018; Redfern and Roberts, 2019). The sustained injuries were certainly severe and might have played a role in the individuals' death.

The majority of long bone fractures healed with limited visible complications (e.g., slight angulation), but two femoral fractures (IV_503, IV_511) displayed more severe complications resulting in overlap, angulation, and shortening of limbs that caused secondary joint disease. Complete fractures of the femur are considered serious injuries and would have been highly debilitating rendering someone immobile for a considerable amount of time (Galloway, 2014a: 264-267). Reducing a fracture of the femur is also challenging due to the powerful thigh muscle which can cause overlap of the fractured ends in the absence of traction. Although the fractures affecting individuals IV_503 and IV_511 appear to not have received medical attention in form of fracture reduction, the individuals would have received care in form of food provisions or assistance with personal hygiene. This form of care allowed them to fully recover mobility as indicated by secondary joint degeneration (Tilley and Cameron, 2014).

Ribs showed the highest prevalence of fractures identified in approximately 20% of individuals (table 6.38). Fractures of ribs can be the result of interpersonal violence such as beating especially when encountered in combination with cranial fractures (see individual IV_779). However, fractures can also be caused by falls or stress fractures attributed to habitual activity or coughing (Lovell and Grauer, 2018). Single rib fractures as observed for individual IV_684 or rib fractures in combination with other thoracic or long bone fractures are more likely the result of accidental injury (Galloway and Wedel, 2014). The high prevalence of healed rib fractures at Phaleron clearly shows that such fractures often healed without any complications, but rib fractures can also result in potentially fatal conditions such as haemothorax, pneumothorax, or pneumonia (Brickley, 2006: table 3). In five cases, the rib fractures were in the process of healing at the time of death, and it is highly possible that these deaths are connected to a complication caused by the fractured ribs. Rib fractures are associated with high levels of pain and have the potential to impact breathing, thus resulting in lower quality of life during the healing process (Kerr-Valentic et al., 2003; Kramaker and Ho, 2003). While some substances for pain relief would have been available during the Archaic period, high levels of pain can still be expected. As rib fractures are not as debilitating as long bone fractures for example, affected individuals would have resumed their normal activities comparatively soon after the injury occurred before the fracture had time to fully heal. This would have had an impact on the healing time and success of the fractures, and might have increased the risk of secondary complications causing death days or even weeks after the fracture occurred (Brickley, 2006).

Fracture recidivism is difficult to identify in the archaeological record. In contrast to multiple traumata, it is necessary to identify different healing stages for multiple fractures in order to classify fracture recidivism (Redfern et al., 2017). However, fracture recidivism could be identified for eight individuals or 6.1% of the normative sample population (table 6.43). In addition, 26 cases of multiple traumata were identified in the normative burials (19.7%) (tables 6.41 and 6.42). In these cases, it is not possible to conclusively identify injury recidivism, and one traumatic instance may have caused multiple fractures. Both polytrauma and fracture recidivism have been clinically linked to specific socio-economic circumstances often affecting young males from marginalised social backgrounds (Alghnam et al., 2016; Reiner et al., 1990). Fracture recidivism is potentially indicative of subordination as it relates to high risk environments and physical hardship such as heavy manual labour or violence in form of beatings (Harrod and Martin, 2014). At Phaleron, higher risk of injury was identified for males, who were also more affected by multiple traumata and injury recidivism than females. Especially combined cranial and postcranial fractures are more commonly identified in males than in females (13/58 vs. 1/31 individuals), and cranial fractures often occurred in combination with rib fractures potentially indicating that males were subjected to endemic abuse.

A life course approach attempts to understand interrelated and cumulative factors contributing to individual and community health outcomes (Agarwal, 2016; Cheverko, 2021). In the thesis sample, this approach was limited by the high numbers of individuals that could only be aged as ‘adult’. While no evidence for fractures has been identified in children and only limited evidence is available for those aged between 12-17 years, the age at which trauma had occurred could not be determined for healed fractures. Nevertheless, the presence of fully healed fractures in the young adult cohort (18-34 years) demonstrates that younger individuals were exposed to a certain risk of injury. The presence of a fully healed femoral greenstick fracture identified in an individual aged 18-34 years (IV_675: Figure 6.20) supports this theory. Generally, there is an increase in fracture prevalence over the life course with all individuals aged over 35 years affected by at least one instance, which is consistent with the nature of skeletal injury as an accumulative indicator of stress (Glencross, 2011). Additionally, all individuals aged over 50 years at death displayed evidence of multiple fractures, all of which were fully healed. Age-related risk for injury was suggested by the fact that three of the eight individuals, for whom fracture recidivism could be identified, and eight of 26 individuals affected by multiple traumata, were aged between 18 and 34 years.

The overall high prevalence of accidental injury suggests a high-risk environment consistent with heavy manual labour as would be expected in low-status labour contexts in which individuals were also exposed to beatings and corporal punishment. This is supported by skeletal lesions that are associated with continuous high stress on the musculoskeletal apparatus including stress fractures, joint disease, and musculoskeletal stress markers (entheseal changes).

Vertebral fractures are commonly associated with repeated stress on the vertebral column. Only a small number of vertebral body fractures were identified, most of which were in the thoracic vertebrae while the prevalence of spondylolysis in the lumbar vertebrae is comparatively high, affecting males more often than females (table 6.34). The spondylolysis rate of 14.6% observed for males is considerably higher than the rate of 3-8% reported in clinical studies (Fibiger and Knüsel, 2005; Leone et al., 2011; Merbs, 2001; Sairyo et al., 2003; Sakai et al., 2010; Tipper et al., 2023). Spondylolysis is present in one adolescent individual (IV_701), and prevalence is over 20% for males aged between 18-34 years which is comparable to enslaved populations and forced labour contexts (table 8.4). While spondylolysis is commonly found in archaeological populations, multiple instances of spondylolysis in one individual, as observed twice in the normative burials and once in the mass burials, are rare (Więckowski, 2021). Interestingly, individual IV_734 was affected by a combination of stress fractures in the vertebral column and sacrum. This burial has been identified as a single non-normative burial based on the prone burial position, but as discussed, this is likely a variation in burial position rather than a true reflection of deviant burial practice. The combination of stress-related fractures here is consistent with repetitive activity.

Consistent stress to the back is also reflected in the high prevalence of vertebral joint disease, with more than 70% of males and females affected (table 6.44). The prevalence of vertebral joint disease is generally higher than observed in other Greek contexts (see table 8.1), but one of the comparative populations displayed a higher prevalence (Karligkioti et al., 2023). Joint disease is linked to advanced age (Arden and Nevitt, 2006; Loeser, 2010), and this pattern is also reflected in the study sample; however, high prevalence rates of vertebral joint disease were also observed for adults aged 18-34 years at death (female: 82.5%; male: 74.1%). This high frequency suggests elevated levels of stress on the vertebral column from an early age – possibly childhood – onwards, which likely has been exacerbated by advanced age in some individuals (Stirland and Waldron, 1997). Similar patterns have been observed for enslaved populations with advanced joint degeneration in younger adult individuals (table 8.4; see also Rojas-Sepúlveda et al., 2008). Thoracic vertebrae were more affected by osteoarthritic changes of the apophyseal facets, and lumbar vertebrae showed a higher prevalence of osteophyte formation on the bodies, while for cervical vertebrae the bodies and arches were affected equally. Joint disease affecting the cervical vertebrae has been associated with specific ways to carry burdens for example using a tumpline (Bridges, 1994; Merbs, 1983). In addition to proliferative changes to the vertebral bodies, a high prevalence of Schmorl's nodes affected the thoracic and lumbar vertebrae. As with other joint degeneration, age is one important factor in the development of Schmorl's nodes (Aufderheide and Rodriguez-Martin, 1998), but mechanical stress can contribute to the early development of Schmorl's nodes (Wilczak et al., 2009). Females were slightly more affected by vertebral joint disease, but the differences in prevalence were not marked. In combination with vertebral stress fractures, the evidence of vertebral joint disease suggests that activity related stress on the entire vertebral column was comparable between males and females in the normative burial sample.

Entheseal changes or musculoskeletal markers of activity were not recorded systematically but hypertrophy of muscle attachment sites was observed for numerous individuals. This was especially noted in the upper limbs, including the muscle attachment sites for the deltoid muscle, pectoralis major, and teres major, and for the lower limbs in form of a pronounced linea aspera ('pilastering'). All four individuals, for whom an osteobiography was created, displayed strongly expressed muscle attachment sites on the humerus (deltoid muscle or pectoralis major) suggesting that males and females were working in occupations involving heavy manual tasks that required them to undertake repetitive tasks such as lifting heavy objects (Kelley and Angel, 1987; Villotte et al., 2010). Age might have played an additional factor in the development of OA in the shoulder and elbow joint of individual IV_684 (Waldron, 2012), but in combination with the pronounced entheses within this context, it is likely that activity was one relevant factor in the development of OA. The most severe expression of activity related changes was identified in individual IV_779 with pronounced entheses for multiple muscles on the upper and lower extremities as well as reactive bone formation on muscle attachment sites on the left scapula. The combination of these lesions is highly suggestive of repetitive and strenuous activity of the upper limbs with high involvement of the shoulders. The unique changes to the sternum of individual IV_779 might also be related to repetitive stress on the chest such as the carrying of heavy loads on the back that is secured by a strap or buckle along the chest (Merbs, 1983). In addition to the evidence derived from the adults, the adolescent individual IV_273 buried in double burial 1 (Figure 6.1) showed well-developed entheses. Marked muscle attachments in form of reactive bone especially on the humeri were identified for this young individual suggesting physical activity such as manual labour from an early age onwards (see also Buikstra, 2023).

The interpretation of entheseal changes should be considered with caution and a direct extrapolation of specific activities is difficult as activity is not the only relevant factor (Roberts and Manchester, 2005: 113-115); nevertheless, pronounced expression of musculoskeletal markers has been identified in multiple contexts of forced labour and enslavement, where these were interpreted as reflection of high levels of physical activity and occupational stress (Angel et al., 1987; Harrod et al., 2012; Kelley and Angel, 1987; Martin, 2008; Martin et al., 2010; Owsley et al., 1987; Rathbun, 1987; Triantaphyllou and Bessios, 2005; Wilczak et al., 2009).

The presence of accidental and stress fractures in combination with high levels of joint disease and entheseal changes in younger age-at-death cohorts can give some insights into social age as cultural construct in Archaic Greece (Gowland, 2006; Halcrow and Tayles, 2008; Knudson and Stojanowski, 2008; Sofaer, 2006). The evidence suggests that especially males were subjected to heavy manual activities from a young age. Child labour was likely prevalent in several lines of occupation in ancient Greece such as agricultural settings, mining, and even prostitution. Child labour was not only a form of slavery but also a reality for free children from poor families, so this practice was not exclusive to enslaved children (Forsdyke, 2021: 156-157). Children could be born into slavery as a result of either relationships between enslaved men and women or rape (Braund, 2011; Golden, 2011). The historical sources for child labour in ancient Greece are limited, but it was also practiced in ancient Rome (Laes, 2008; 2011: 148-221).

8.3.2. Social control and exploitation in Archaic Athens

The skeletal evidence from the Phaleron burial ground illustrates that nutritional deficiencies, infectious disease, trauma, and musculoskeletal stress defined the lives of those buried in normative burials. Males and females were affected to high degrees. Some variation in disease prevalence has been observed, but the fairly homogenous distribution of indicators of stress suggests overall comparable diets, environments, and risks. While some lesions including dental disease and PNBF showed similar disease frequencies to other Greek populations, the prevalence of DEH and trauma were considerably higher. The demographic profile and patterns of physiological stress are comparable to some contexts of forced labour and enslavement (see table 8.4).

The bioarchaeological analysis is consistent with the interpretation of Phaleron as a burial ground for the low-status labourers living in Athens and the surrounding areas. The poor and socially marginalised are disproportionally affected by health insults and social crises, and these individuals most likely worked in high risk environments performing strenuous manual labour that is consistent with occupations that were known to be performed by enslaved and other low-status labourers such as agriculture, mining and quarrying, or certain steps in manufacturing processes (Forsdyke, 2021; Lewis, 2018). Their social status did not allow them to move out of these hazardous lines of work and pursue an occupation in safer environments.

Violence against enslaved individuals and labourers was used as a form of social control. This does not only include direct violence in form of beating, but also more subtle forms such as food deprivation (Hunt, 2016). This kind of abuse would have resulted in malnutrition exposing the labourers to further harm such as an increased risk of infectious disease. The living situation in crowded and likely unsanitary housing conditions would have further impacted health as these factors contribute to transmission of diseases and parasites. Malnutrition during pregnancy and breastfeeding also negatively impacted the health of infants resulting in high levels of deficiency diseases such as scurvy and high childhood morbidity and mortality (Rothwell, 2024). The infants and children who survived these adverse conditions were immunocompromised and highly susceptible to any health insults during adulthood.

Direct violence with the aim to control and subjugate the low-status workforce had the potential to disproportionally be used against those who are already weakened by malnutrition or recovering from previous injury thus putting them at higher risk of repeated injury. Different morbidity factors including risk of bodily harm, malnutrition, and infectious disease were interlinked. The negative impact of these health insults likely increased and reinforced the negative effects of co-morbidity factors, which share some of the characteristics identified for syndemics (see Singer, 1996; Singer, 2009; Singer et al., 2017). The poor low-status population was disproportionally affected by disease, and social status was one important factor in disease susceptibility as systemic inequalities based on socio-economic status created and sustained the detrimental living conditions that subjected the marginalised population to disease agents and put them at high risk for mortality. The possibility for identification of syndemics in historical context is limited as fundamental factors cannot be obtained from the archaeological record (Perry and Gowland, 2022).

Nevertheless, the data derived from the Phaleron cemetery illustrated an interaction between social status and disease susceptibility allowing a deeper understating of how social factors determined health in Archaic Athens.

The exploitation of low-status and marginalised individuals was societally sanctioned in the hierarchical society of Archaic Athens. The economy of Athens from the Archaic period onwards was highly dependent on slave labour which peaked during the Classical period. Especially the mining and processing of silver from the mines of Laurion in close proximity to Athens was essential for wealth accumulation that allowed Athens to become the most powerful polis during the Classical period (Kyrtatas, 2011; Papadopoulos, 2014; van Wees, 2013). While mining was predominantly slave labour, in other areas such as construction and quarrying citizens of low socio-economic status were also employed. The free people working in these occupations were paid for their work (Parker, 2007, 2014), but it can be imagined that these highly strenuous and dangerous lines of work were only pursued by those who had limited options. The evidence from the Phaleron burial ground does not allow an unambiguous identification of enslaved people; however, the burial ground was likely used for the burial of enslaved people as well as low-status workers that might have been citizens of the polis or poor non-citizens who were free, nevertheless. The bioarchaeological data tell a story of hardship throughout the life course and high levels of physical hardship that clearly differentiated the normative burials from the mass burials, and the systematic poor treatment and systemic oppression of the work force was likely socially accepted. A lack of grave goods alone is not necessarily indicative of a low status population in Archaic Greece (Morris, 2000; Rönnberg, 2021a: 181; Whitley, 2001: 185-188), but the lack of burial organisation and uniform orientation in combination with intercutting of graves are highly suggestive of a lack of significant care and investment in the funerary process. These characteristics correspond more with the simple disposal of bodies rather than with organised burials rituals. In light of this, the double burials can be considered as a simpler way of disposing of multiple people rather than giving it a deeper social meaning. The non-normative single burials have been largely excluded from this section except for one osteobiography, due to the ambiguity of this burial group; however, if a lack of care during interment is assumed for the burial ground, prone burials or some other deviation from a 'normative' burial position are potentially meaningless.

8.3.3. Summary

Individuals of lower socio-economic status were at a greater risk of injury, health inequality, and degeneration of the musculoskeletal system. Structural violence as an extreme form of inequality created a harmful environment that was socially sanctioned and contributed to and enforced poor health of a section of the population. The patterns of polytrauma, injury recidivism, and comorbidity factors identified in this study suggest life histories with strenuous manual labour in hazardous environments and interpersonal violence for large sections of the Phaleron burial ground population. A high frequency of fractures that can be attributed to direct violence suggest a highly aggressive environment and a pattern of endemic abuse especially towards males. Females displayed slightly higher levels of early life stressors, while males appear to have been at higher risk during adulthood, but exposure to physiological stress was elevated for the entire population over the life course. The greater risk burden on males and the expression in high levels of trauma, joint degeneration, and entheseal changes identifies them as low-status labourers and potentially enslaved people.

8.4. Conclusion

The discussion has shown that the burial ground at Phaleron has been used for at least two contrasting social groups. The larger group of normative burials showed high prevalence of nutritional stress, infectious disease, trauma, and musculoskeletal stress, that is consistent with poor living conditions and high levels of physical activity. These individuals likely belonged to the low status work force and potentially also included enslaved people, that worked in hazardous occupations. The comparatively low disease frequency in the mass burials suggests that these individuals were part of a higher social class and possibly can even be identified as elite. The young age-at-death in the mass burials is meaningless in terms of palaeoepidemiology as the contexts suggests that they were executed, but several forms of execution used in ancient Greece would not necessarily have left visible trauma on the bones (Gernet, 2004). The differences between burial groups clearly showed that social status is a stronger determinant in disease exposure and health outcome than biological sex as males and females in the normative burial samples were more equally affected by physiological stress.

The burial of shackled high-status individuals in mass burials in a burial ground that was predominantly used for the low-status work force is highly unusual. In the historical context of intra-elite rivalry for political power it can be suggested that these were executed political prisoners who were unsuccessful in their attempt to seize power and were denied formal burial in the elite cemeteries. Instead, they were disposed of informally in the burial ground of the poor and enslaved.

9. Conclusion and Future Directions

9.1. Introduction

This chapter provides a summary of the key findings of this study in reference to the research questions. It further discusses the significance of this project and some limitations that impacted the study. Finally, a brief discussion of future research will be given to enhance and further develop our understanding of the population of the Phaleron burial ground within the historical setting of the EIA and Archaic period.

9.2. Summary of key findings

This thesis aimed to investigate social and health inequalities during the Archaic period, a period that is largely considered the stepping stone for democracy. A sample of 206 adolescent and adult individuals from the Phaleron burial ground provided the basis for the thesis. The demographic and palaeopathological data were used to explore the lived experience of the population of Athens and Attica within the historical and socio-political framework of the Archaic period. The thesis is centred around three research questions in order to explore the skeletal evidence of inequality in the burial ground of Phaleron. The data suggests that individuals of contrasting social backgrounds were interred in the burial ground, and the individuals from normative burial settings were subjected to high degrees of physiological stress and hardship throughout the life course indicative of structural violence. The thesis addressed three main research questions.

(1) Are there any differences in health status between subgroups of the burial ground (as defined by funerary type), or is the health profile homogenous

throughout? Were certain subgroups at a higher risk of morbidity and mortality, and what are the social implications of such differences?

Three different burial categories were identified in the burial ground: normative burials, non-normative single burials, and mass burials. Research question 1 was formulated to investigate differences in the demographic profile as well as health and disease exposure between these subgroups of the burial ground in order to identify population sections that were at higher risk for morbidity and mortality. The bioarchaeological analysis found clear differences in the demographic profiles of these burial categories. The entire study sample was biased towards young adult and male individuals, but the higher percentage of young adult males and absence of females in the mass burials clearly differed from the more balanced demographic profiles of the normative and non-normative single burials. While the numbers of females and middle-mature adults was generally low, these burial categories appear to reflect the demographic profile more closely. The palaeopathological analysis of indicators of physiological stress supported the distinction into two different social groups based on burial category. The individuals buried in normative burials displayed significantly higher levels of early life stressors as well as physiological stress and hardship during later stages of life. Living conditions of the normative burials were characterised by heightened physical hardship in contrast to those interred in mass burials suggesting that the normative burials were used for the interment of individuals of low socio-economic status, while the mass burials held more high-status or elite members of society. The non-normative single burials, in comparison, are a more ambiguous group that often fall between the two other burial categories in terms of demographic parameters as well as disease frequency. Some statistically significant results situated the non-normative burials by trend closer to the normative burials suggesting that burial positions such as prone burials might be less informative in terms of deviations from a funerary norm. Instead, it can be argued that the general lack of care in the burial process that can be observed in the absence of burial organisation and intercutting of graves also extended to the burial position. However, the ambiguity of the non-normative single burial category underlines the need for further investigation. Nevertheless, the trends and significant differences in disease expression, that were observed between the normative and mass burial categories, indicate that cultural factors such as social status influenced disease susceptibility and risk. In contrast, biological factors such as biological sex appear to have played a lesser role as evidenced by similar levels of stress between males and females in the normative burial sample. The results of this thesis suggest that the Phaleron cemetery was mainly used for the burial of the low-status population in normative burial settings, but a comparatively small number of high-status young males, who were likely executed, were interred in the same burial ground in mass burials.

The clear differences between the normative and mass burials suggested people from different social backgrounds were interred at Phaleron, and research questions 2 and 3 were formulated to investigate the presence of structural violence.

(2) Is it possible to detect evidence for social control and oppression or structural violence through inequalities in health in those groups which the burial evidence suggests are of lower social status? Can any negative effects of multiple systemic inequality be identified that would be indicative of marginalised groups?

The palaeopathological results indicate that individuals buried in normative burials were subjected to poor living conditions and hazardous environments. Especially the patterns of polytrauma, injury recidivism, and comorbidity factors identified in this study convey a life history of physically demanding lives that is comparable to populations that have been associated with systemic inequality and structural violence such as enslaved people and forced labourers. The population was exposed to high levels of stress regardless of biological sex, and the prevalence of fractures was exceptionally high in the thesis sample; however, males appear to have been at higher risk for skeletal injury throughout the life course. The high frequency of fractures attributed to interpersonal violence suggests an aggressive environment and endemic abuse, especially towards males. The higher risk burden and high levels of joint degeneration and entheseal changes is consistent with high levels of physical activity such as manual labour performed by low-status labourers and potentially enslaved people. It has been shown in multiple studies, that poor and socially marginalised people are disproportionally affected by health insults and social crises. The different risk factors observed in the Phaleron population show a connection between low-status, poverty, malnutrition, infectious disease, and abuse, and the interaction between these factors created an unsafe environment for the low-status population of Archaic Athens.

(3) Is there evidence that individuals or certain demographic or burial groups at Phaleron were enslaved or subjected to forced labour?

The economy of Athens was built on enslavement and the exploitation of the low-status workforce. Poor treatment and systemic oppression of the work force was socially accepted as it allowed the Athenian society and especially the elite to accumulate the wealth that eventually led to Athens becoming the most powerful polis in the Aegean. While some occupations were dominated by slave labour such as silver mining, other lines of work were also performed by free low-status labourers, who were, nevertheless, subjected to highly strenuous labour in hazardous environments that would have affected their bodies in similar ways. The evidence presented here does not allow us to conclusively identify the people buried at Phaleron as enslaved people, but it should be considered that the burial ground was used for the interment of marginalised people including free people of low socio-economic status as well as the enslaved population.

Under consideration of this interpretation as a low-status cemetery, the burial of high-status and elite individuals in mass burials is unusual. The mass burials can be interpreted as the informal burial of elite men who were unsuccessful in the struggle for power during the Archaic period and were executed as political prisoners. While they were likely not marginalised in life, the denial of a formal burial in one of the elite cemeteries shows the loss of status and marginalisation in death.

9.3. Significance of the study

The polis of Athens is one of the most studied settlements in the ancient Greek world, and its history has been discussed in numerous historical and archaeological publications. Bioarchaeological studies of the Athenian population during the Classical, Hellenistic, and Roman period have been able to shed light on the living conditions during these centuries, but a focus on the preceding centuries of the Archaic period has been scarce so far. The Phaleron burial ground provides the opportunity to study the lived experience of the population of Athens and the surrounding area during the Archaic period. These centuries have been vital for the trajectory for Greek history and are now considered the stepping stone of political equality and democracy. The focus of historical and archaeological studies has long been set on the exploration of the high-status population with a special interest in the material culture of the elite. In contrast, the low-status population that made up a large proportion of the population and who contributed to the success of the polis in various ways has featured considerably less in archaeological and historical research as the population of lower socio-economic status is harder to identify in the historical traditions as well as in the material record. The Phaleron burial ground provides us with the opportunity to study the lives of those whose stories remain untold or potentially were distorted by historians, philosophers, and writers, and these bioarchaeological investigations have the potential to examine this section of the population in a much more direct way by studying the physical impacts of structural inequalities and social control.

9.4. Limitations of the study

Several limitations of this study need to be acknowledged, but future research has the potential to address some of these limitations. Due to the constraints of the PhD project, only a section of the burial ground population could be investigated within this study, and therefore, a certain sample bias occurred. This was further compounded by the exclusion of non-adults aged less than seven years (these form part of another PhD project, see Rothwell, 2024). Infant morbidity and mortality are important factors in the investigation of population health, and the integration of adult and non-adult health will be essential for a more comprehensive understanding of living conditions. Further investigation including the entire burial ground population will be necessary to address whether the observed biases partially reflect a bias in the thesis sample. Regardless, a certain bias can never be eliminated due to the implicit biases of archaeological populations. The thesis sample contained one densely populated area of the cemetery ('MOB36/37 area') as this area was considered to provide a representative cross-section of the burial ground including different burial categories and grave types spanning the entire time of use of the burial ground (see also Buikstra et al., n.d.). Approximately two thirds of the thesis sample, however, were selected more randomly in line with the progress during conservation.

The preservation of the skeletal material was extremely varied ranging from fragmented and poorly preserved individuals to complete skeletons with good or even excellent surface preservation. The variation in completeness had an impact on estimation of biological sex as well as age-at-death in a lot of instances thus especially limiting the consideration of age-at-death in the interpretation. In addition, it was not possible to record all pathological lesions used in the thesis for all 206 individuals due to the absence of the relevant skeletal elements. For statistical analysis for co-occurrence of pathological lesions it was necessary to pool data from different sub-groups (e.g., biological sex, burial category) to test a sufficiently large data set. Due to these constraints, it was only possible to investigate co-occurrence of pathological lesions for the entire population instead of gaining a more nuanced picture based on demographic and burial categories. A focus on more complete individuals might allow to limit the taphonomic bias in the sample. On the other hand, in the absence of absolute dates for individual burials, the inclusion of incomplete burials due to truncating, for example, will allow a more nuanced analysis that also considers temporal variation once an internal stratigraphic chronology is completed for the entire burial ground.

The lack of comparative published studies from the Archaic period in Greece was a further limitation factor as it proved difficult to situate the results within the bioarchaeological context of Greece. Depending on the individual pathological lesions, the availability of comparative material varied. Data on dental disease or indicators of childhood stress are comparatively accessible, while other lesions such as skeletal trauma have been published to a lesser extent so far. The lack of comparative skeletal data from the Archaic Greek world undoubtedly underlines the need for further bioarchaeological study of this period.

9.5. Outlook for future studies

This PhD project is situated within the larger Phaleron Bioarchaeological Project, and it is aimed to integrate the findings of this thesis with the results from various other research projects within the larger project.

In order to address some of the previously stated limitations, it will be necessary to broaden the scope in future studies and investigate skeletal indicators of physiological stressors on a larger scale. This will allow us to examine whether the presently observed patterns and trends can also be identified in the wider cemetery population thus supporting the findings of this research project.

Some preliminary isotope analyses have already been undertaken (see Hannigan, 2022), and a more comprehensive analysis of different isotope systems exploring diet and migration on a larger scale are the subject of another doctoral dissertation at Arizona State University. An integration of the isotopic data with the palaeopathological data discussed here will allow to enhance our understanding of the living conditions in Archaic Athens.

Initial analysis of ancient DNA undertaken at the Max Planck Institute for Evolutionary Anthropology so far confirmed the presence of a clear skeletal sexual dimorphism observed during the recording. Further analysis will give insights into genetic ancestry and presence of pathogen DNA. The combination of the genetic data for ancestry with the isotope data will give a more nuanced picture of migration into the polis of Athens. The pathogen DNA will allow the investigation of the presence of various infectious diseases that might not have left any visible signs on the bones. This analysis is going to provide further insights into the environment and lived experience.

In addition to isotope and ancient DNA analysis, the analysis of trace elements such as lead or mercury will be of great value. Elevated levels of these trace elements can give insights into pollution levels on an individual level (see for example Budd et al., 2000; Millard et al., 2014; Moore et al., 2021). Considering the results of the current study that suggest that individuals were working in occupations such as mining, ore processing, or manufacturing, it is highly plausible that these people were exposed to toxic substances. The analysis of trace elements would give further insights into the risks and dangers the Phaleron burial population was exposed to over the life course.

The current study can be considered one of the first comprehensive analyses on a population level of the Phaleron burial ground that has investigated the lives and lived experiences of the adult population with a special focus on those who were buried in normative burial samples (see also Buikstra et al., n.d.; Buikstra et al., 2024; Prevedorou et al., 2024; Rothwell, 2024). Additional analyses as detailed above will further enhance and refine our knowledge of the low-status population of Archaic Athens and Attica.

I. Appendix I: Supplementary tables

This section includes additional material for methodology and supplementary tables containing more detailed information regarding demographic parameters and prevalence rates.

I. Additional methodological materials

I.1. Estimating stature

The female, male, and generic stature equations developed by Albanese et al. (2016) were employed. Tables I.1, I.2., and I.3 provide an overview of the equations. All long bone measurements were collected in mm, and the final estimate and range are provided in cm.

Female stature equation						
Constant	**Humerus**	**Radius**	**Ulna**	**Femur**	**Tibia**	**SEE**
55.405	0.345					4.600
73.232		0.380				5.120
76.230			0.389			5.377
57.915				0.237		3.892
73.985					0.244	4.425
52.024	0.082			0.125	0.082	3.712
51.454	0.099			0.182		3.816
53.300	0.178				0.149	3.022
57.360				0.165	0.089	3.761
50.247	0.245	0.155				4.414
48.101	0.265		0.146			4.425

Table I.1: Female stature equation

Male stature equation						
Constant	**Humerus**	**Radius**	**Ulna**	**Femur**	**Tibia**	**SEE**
56.374	0.348					5.172
79.850		0.367				5.650
82.467			0.383			5.863
55.797				0.250		4.781
78.999					0.244	4.754
56.423	0.100			0.088	0.109	4.446
47.939	0.137			0.168		4.607
62.390	0.144				0.162	4.526
63.094				0.127	0.131	4.528
56.442	0.252	0.126				5.067
55.493	0.270		0.114			5.108

Table I.2: Male stature equation

Generic stature equation						
Constant	**Humerus**	**Radius**	**Ulna**	**Femur**	**Tibia**	**SEE**
47.493	0.373					4.933
63.174		0.429				5.551
61.610			0.465			5.919
41.507				0.278		4.624
59.745					0.289	5.068
40.582	0.145			0.106	0.087	4.224
38.286	0.165			0.168		4.326
45.472	0.209				0.147	4.395
43.790				0.183	0.109	4.453
47.315	0.264	0.145				4.769
44.905	0.288		0.132			4.804

Table I.3: Generic stature equation

II. Supplementary tables

This section includes supplementary tables for the trauma analysis. Age-at-death was omitted from the tables used in Chapter 5 to ensure clarity. Below, supplementary tables detailing trauma prevalence based on biological sex and age-at-death cohort are provided.

II.1. Cranial Trauma

TPR Cranial trauma - Normative burials (BFT)								
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Female								
7-11yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17yr	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
18-34yr	0/10	0/10	0/12	2/13 (15.3)	0/10	0/9	0/12	0/6
35-49yr	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
50+yr	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/0
18+yr	0/7	1/9 (11.1)	0/8	1/10 (10)	0/5	0/9	0/9	0/5
Total	0/20	1/22 (4.5)	0/23	3/26 (11.5)	0/18	0/21	0/24	0/13
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Male								
7-11yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18-34yr	**1/18 (5.6)**	0/21	**3/21 (14.2)**	**1/23 (4.3)**	0/18	0/21	0/23	0/12
35-49yr	0/2	0/2	1/2 (50)	0/2	0/2	0/2	0/2	0/1
50+yr	1/4 (25)	0/4	**1/4 (25)**	**1/4 (25)**	**1/4 (25)**	0/3	**2/4 (50)**	0/3
18+yr	0/16	0/15	**2/19 (10.5)**	1/19 (5.3)	0/17	1/19 (5.3)	0/19	1/9 (11.1)
Total	**2/40 (5)**	0/42	**7/46 (15.2)**	**3/48 (6.25)**	**1/41 (2.4)**	1/45 (2.2)	**2/48 (4.2)**	1/25 (4)
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Unsexed								
7-11yr	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/0
12-17yr	0/3	0/1	0/4	0/4	0/4	0/3	0/4	0/2
18-34yr	0/1	0/1	0/2	0/2	0/1	0/0	0/2	0/2
35-49yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
50+yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18+yr	1/6 (16.7)	0/7	1/10 (10)	1/10 (10)	0/6	0/7	1/14 (7.1)	0/2

Total	1/11 (9.1)	0/10	1/17 (5.9)	1/17 (5.9)	0/12	0/11	1/21 (4.8)	0/5
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Combined								
7-11yr	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/0
12-17yr	0/4	0/2	0/5	0/5	0/5	0/4	0/5	0/3
18-34yr	1/29 (3.4)	0/32	3/35 (8.6)	2/38 (5.2)	0/29	0/30	0/37	0/19
35-49yr	0/3	0/3	1/3 (33.3)	0/3	0/3	0/3	0/3	0/2
50+yr	1/5 (20)	0/5	1/5 (20)	1/5 (20)	1/5 (20)	0/4	2/5 (40)	0/3
18+yr	1/29 (3.4)	1/31 (3.2)	3/37 (8.1)	3/39 (7.7)	28	1/35 (2.9)	1/42 2.4	1/16 (6.25)
Total	3/71 (4.2)	1/74 (1.4)	8/86 (9.3)	6/91 (6.6)	1/71 (1.4)	1/77 (1.3)	3/93 (3.2)	1/43 (2.3)

Table I.4: Prevalence of cranial BFT by sex and age-at-death for normative burials. FB: frontal bone; PB: parietal bone; TB: temporal bone; OB: occipital bone; NB: nasal bone.

TPR Cranial trauma - Non-normative single burials								
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Female								
7-11yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18-34yr	0/2	0/2	0/3	0/3	0/2	0/2	0/4	0/2
35-49yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
50+yr	0/1	0/1	0/1	0/1	0/0	0/0	0/1	0/1
18+yr	0/2	0/3	0/3	0/3	0/2	0/1	0/3	0/3
Total	0/5	0/6	0/7	0/7	0/4	0/3	0/8	0/6
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Male								
7-11yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18-34yr	0/5	0/6	0/5	0/5	0/5	0/4	0/5	1/5 (20)
35-49yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
50+yr	0/2	0/2	0/3	0/3	0/3	0/3	0/3	0/2
18+yr	0/8	0/8	1/7 (14.3)	0/8	0/6	0/	0/7	0/8
Total	0/15	0/16	1/15 (6.7)	0/16	0/14	0/13	0/15	1/15 (6.7)
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Unsexed								
7-11yr	0/2	0/1	0/2	0/1	0/2	0/1	0/2	0/1
12-17yr	0/2	0/1	0/2	0/1	0/2	0/1	0/2	0/2
18-34yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
35-49yr	0/3	0/2	0/2	0/2	0/1	0/0	0/3	0/0
50+yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18+yr	0/2	0/2	0/2	0/2	0/0	0/1	0/2	0/1
Total	0/9	0/6	0/8	0/6	0/5	0/3	0/9	0/4
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**

Combined								
7-11yr	0/2	0/1	0/2	0/1	0/2	0/1	0/2	0/1
12-17yr	0/2	0/1	0/2	0/1	0/2	0/1	0/2	0/2
18-34yr	0/7	0/8	0/8	0/8	0/7	0/6	0/9	1/7 (14.3)
35-49yr	0/3	0/2	0/2	0/2	0/1	0/0	0/3	0/0
50+yr	0/3	0/3	0/4	0/4	0/3	0/3	0/4	0/3
18+yr	0/12	0/13	1/12 (8.3)	0/13	0/8	0/8	0/12	0/12
Total	0/29	0/28	1/30 (3.3)	0/29	0/23	0/19	0/32	1/25 (4)

Table I.5: Prevalence of cranial fractures by sex and age-at-death for non-normative single burials. FB: frontal bone; PB: parietal bone; TB: temporal bone; OB: occipital bone; NB: nasal bone.

TPR Cranial trauma - Mass burials								
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Male								
7-11yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18-34yr	1/10 (10)	9	2/10 (20)	1/11 (9.1)	9	9	11	9
35-49yr	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/1
50+yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18+yr	0/5	0/6	0/5	0/6	0/5	0/5	0/6	0/'2
Total	1/17 (5.9)	0/17	2/17 (11.8)	1/19 (5.23)	0/16	0/16	0/19	0/12
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Unsexed								
7-11yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17yr	0/2	0/2	0/2	0/2	0/1	0/2	0/3	0/1
18-34yr	0/1	0/0	0/2	0/1	0/2	0/0	0/1	0/1
35-49yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
50+yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18+yr	0/3	0/3	0/2	0/3	0/1	0/2	0/3	0/3
Total	0/6	0/5	0/6	0/6	0/4	0/4	0/7	0/5
	L FB	**R FB**	**L PB**	**R PB**	**L TB**	**R TB**	**OB**	**NB**
Combined								
7-11yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
12-17yr	0/2	0/2	0/2	0/2	0/1	0/2	0/3	0/1
18-34yr	1/11 (9.1)	0/9	2/12 (16.7)	1/12 (8.33)	0/11	0/9	0/12	0/10
35-49yr	0/2	0/2	0/2	0/2	0/2	0/2	0/2	0/1
50+yr	0/0	0/0	0/0	0/0	0/0	0/0	0/0	0/0
18+yr	0/8	0/9	0/7	0/9	0/6	0/7	0/9	0/5
Total	1/23 (4.3)	0/22	2/23 (8.7)	1/25 (4)	0/20	0/20	0/26	0/17

Table I.6: Prevalence of cranial fractures by sex and age-at-death for mass burials. No females in the mass burial sample. FB: frontal bone; PB: parietal bone; TB: temporal bone; OB: occipital bone; NB: nasal bone.

II.2. Upper limb trauma

Normative burials

Female														
Element	**Left**							**Right**						
	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Ulna	**2 [7.1]**	28	26	28	**1/25 (4.0)**	**1/24 (4.2)**	11	0	29	23	28	25	25	13
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
18-34yr	**1 [6.3]**	16	15	16	16	**1/16 (6.3)**	5	0	16	14	15	14	14	9
35-49yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
50+yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18+yr	**1 [10.0]**	10	9	10	**1/7 (14.3)**	6	4	0	10	7	11	9	9	2
Radius	**1 [3.7]**	27	17	25	28	**1/26 (3.8)**	17	**3 [11.1]**	27	16	25	26	**2/24 (8.3)**	**1/14 (7.1)**
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	1	1	1	1	1	1	0	1	0	1	1	1	1
18-34yr	0	16	11	16	16	16	11	**1 [6.7]**	15	10	15	15	**1/13 (7.7)**	9
35-49yr	0	1	1	1	1	1	1	0	1	1	1	1	1	0
50+yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0

18+yr	**1 [11.1]**	9	4	7	10	**1/8 (12.5)**	4	**2 [20.0]**	10	5	8	9	**1/9 (11.1)**	**1/4 (25.0)**
Male														
Element	**Left**							**Right**						
	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Ulna	***3 [5.9]***	*51*	49	50	**1/51 (2.0)**	**'2/47 (4.3)**	20	***4 [7.8]***	*51*	46	**1/51 (2.0)**	**1/50 (2.0)**	**2/45 (4.4)**	22
7-11yr	*0*	*0*	0	0	0	0	0	*0*	*0*	0	0	0	0	0
12-17yr	*0*	*1*	1	1	1	1	0	*0*	*1*	1	1	1	1	0
18-34yr	***1 [4.1]***	*24*	24	24	24	**1/22 (4.5)**	11	***2 [7.7]***	*26*	24	26	**1/26 (3.8)**	**1/24 (4.2)**	14
35-49yr	*0*	*2*	2	2	2	1	2	*0*	*2*	2	2	2	1	1
50+yr	***2 [40.0]***	*5*	5	5	**1/5 (20.0)**	**1/5 (20.0)**	3	*0*	*5*	4	5	5	5	2
18+yr	*0*	*19*	17	18	19	18	4	***2 [11.8]***	*17*	15	**1/17 (5.9)**	16	**1/14 (7.1)**	5
Radius	***1 [2.0]***	*51*	32	51	51	46	31	*0*	*51*	32	49	49	46	36
7-11yr	*0*	*0*	0	0	0	0	0	*0*	*0*	0	0	0	0	0
12-17yr	*0*	*1*	1	1	1	1	0	*0*	*1*	1	1	1	1	1
18-34yr	*0*	*25*	19	25	25	23	20	*0*	*25*	19	27	26	23	19
35-49yr	***0***	*2*	2	2	2	1	1	*0*	*2*	2	2	2	2	2
50+yr	*0*	*5*	3	5	5	5	3	*0*	*5*	3	4	4	5	4
18+yr	***1 [5.6]***	*18*	7	**1/18 (5.6)**	18	16	7	*0*	*18*	7	15	16	15	10
Unsexed														
Element	**Left**							**Right**						

	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Ulna	***1 [4.0]***	*25*	17	23	**1/23 (4.3)**	17	5	*0*	*25*	16	22	22	17	3
7-11yr	*0*	*1*	0	1	1	1	0	*0*	*1*	0	1	1	1	0
12-17yr	*0*	*6*	3	5	6	4	2	*0*	*6*	5	6	6	5	1
18-34yr	***1/4 (25.0)***	*4*	3	4	**1/4 (25.0)**	4	1	*0*	*4*	4	4	4	4	1
35-49yr	*0*	*0*	0	0	0	0	0	*0*	*0*	0	0	0	0	0
50+yr	*0*	*0*	0	0	0	0	0	*0*	*0*	0	0	0	0	0
18+yr	*0*	*14*	11	13	12	8	2	*0*	*14*	7	11	11	7	1
Radius	*0*	*25*	11	22	23	21	10	*0*	*23*	9	20	21	20	8
7-11yr	*0*	*1*	0	1	1	1	0	*0*	*1*	0	1	1	1	0
12-17yr	*0*	*6*	3	6	6	6	3	*0*	*6*	4	5	6	4	2
18-34yr	*0*	*4*	4	3	4	3	2	*0*	*4*	3	3	4	4	4
35-49yr	*0*	*0*	0	0	0	0	0	*0*	*0*	0	0	0	0	0
50+yr	*0*	*0*	0	0	0	0	0	*0*	*0*	0	0	0	0	0
18+yr	*0*	*14*	4	12	12	11	5	*0*	*12*	2	11	10	11	2

Table I.7: Prevalence of fractures of upper limb bones for female, male, and unsexed individuals in the normative burials by age-at-death. Ne: number of elements present; Ns: number of element sections present; nf: number of fractures present.

Non-normative single burials

Female														
Element	**Left**							**Right**						
	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Ulna	0	7	4	7	7	7	0	0	7	5	7	7	5	1
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-34yr	0	4	3	4	4	4	0	0	4	4	4	4	3	1
35-49yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50+yr	0	1	0	1	1	1	0	0	1	1	1	1	1	0
18+yr	0	2	1	2	2	2	0	0	2	0	2	2	1	0
Radius	0	7	3	6	7	7	2	0	7	2	7	7	7	2
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-34yr	0	4	3	3	4	4	2	0	4	2	4	4	4	2
35-49yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50+yr	0	1	0	1	1	1	0	0	1	0	1	1	1	0
18+yr	0	2	0	2	2	2	0	0	2	0	2	2	2	0
Male														
Element	**Left**							**Right**						
	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Ulna	**1 [5.9]**	*17*	13	18	18	**1/17 (5.9)**	5	0	16	*12*	15	17	16	7
7-11yr	0	*0*	0	0	0	0	0	0	0	*0*	0	0	0	0

12-17yr	0	*0*	0	0	0	0	0	0	0	*0*	0	0	0	0
18-34yr	**1 [16.7]**	*6*	6	7	7	**1/6 (16.7)**	3	0	7	*6*	6	7	7	5
35-49yr	0	*0*	0	0	0	0	0	0	0	*0*	0	0	0	0
50+yr	0	*3*	2	3	3	3	1	0	3	*2*	3	3	3	1
18+yr	0	*8*	5	8	8	8	1	0	6	*4*	6	7	6	1
Radius		*17*	9	17	17	17	9	0	17	*10*	16	17	17	8
7-11yr		*0*	0	0	0	0	0	0	0	*0*	0	0	0	0
12-17yr		*0*	0	0	0	0	0	0	0	*0*	0	0	0	0
18-34yr		*6*	4	6	6	6	4	0	7	*4*	7	7	7	4
35-49yr		*0*	0	0	0	0	0	0	0	*0*	0	0	0	0
50+yr		*3*	3	3	3	3	2	0	3	*3*	3	3	3	2
18+yr		*8*	2	8	8	8	3	0	7	*3*	6	7	7	2
Unsexed														
Element	**Left**							**Right**						
	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Ulna	0	*9*	2	9	9	9	2	0	8	1	8	7	7	2
7-11yr	0	*0*	0	0	0	0	0	0	*0*	0	0	0	0	0
12-17yr	0	*1*	0	1	1	1	0	0	*1*	0	1	1	1	0
18-34yr	0	*0*	1	1	1	1	0	0	*0*	0	1	1	1	0
35-49yr	0	*3*	1	2	2	2	1	0	*3*	0	2	2	2	0
50+yr	0	*0*	0	0	0	0	0	0	*0*	0	0	0	0	0
18+yr	0	*5*	0	5	5	5	1	0	*4*	1	4	3	3	2
Radius	**1 [11.1]**	*9*	4	7	8	1/8 (12.5)	3	**1 [11.1]**	*9*	4	7	9	1/8 (12.5)	4
7-11yr	0	*0*	0	0	0	0	0	0	*0*	0	0	0	0	0

12-17yr	0	*1*	1	1	1	1	1	0	*1*	1	1	1	1	1
18-34yr	0	*0*	1	1	1	1	0	0	*0*	0	1	1	1	0
35-49yr	**1 [33.3]**	*3*	0	1	2	**1/2 (50)**	1	0	*3*	1	2	2	2	1
50+yr	0	*0*	0	0	0	0	0	0	*0*	0	0	0	0	0
18+yr	0	*5*	2	4	4	4	1	**1 [20.0]**	*5*	2	3	5	**1/4 (25.0)**	2

Table I.8: Prevalence of fractures of upper limb bones for female, male, and unsexed individuals in the non-normative single burials by age-at-death. Ne: number of elements present; Ns: number of element sections present; nf: number of fractures present.

Mass burials

Male											
Element	**Left**				**Right**						
	Fracture total (nf [%])	Element present (Ne)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Ulna	**1 [4.5]**	*22*	**1/20 (5.0)**	9	0	*22*	22	16	22	21	20
7-11yr	0	*0*	0	0	0	*0*	0	0	0	0	0
12-17yr	0	*0*	0	0	0	*0*	0	0	0	0	0
18-34yr	0	*13*	12	7	0	*13*	13	13	12	12	4
35-49yr	0	*2*	2	2	0	*2*	2	2	2	2	1
50+yr	0	*0*	0	0	0	*0*	0	0	0	0	0
18+yr	**1 [14.3]**	*7*	**1/6 (16.7)**	0	0	*7*	1	7	7	6	1
Radius	**1 [4.5]**	*22*	**1/21 (4.8)**	9	0	*22*	13	22	22	22	10
7-11yr	0	*0*	0	0	0	*0*	0	0	0	0	0

12-17yr	0	*0*	0	0	0	*0*	0	0	0	0	0
18-34yr	0	*13*	13	7	0	*13*	9	13	13	12	7
35-49yr	**1 [50.0]**	*2*	**1/2 (20)**	2	0	*2*	1	2	2	2	1
50+yr	0	*0*	0	0	0	*0*	0	0	0	0	0
18+yr	0	*7*	6	0	0	*7*	3	7	7	8	2
Unsexed											
Element	**Left**				**Right**						
	Fracture total (nf [%])	Element present (Ne)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Ulna	0	9	5	3	0	7	1	6	6	4	0
7-11yr	0	*0*	0	0	0	*0*	0	0	0	0	0
12-17yr	0	*3*	2	1	0	*3*	1	3	3	1	0
18-34yr	0	*2*	0	1	0	*1*	0	0	0	0	0
35-49yr	0	*0*	0	0	0	*0*	0	1	1	1	0
50+yr	0	*0*	0	0	0	*0*	0	0	0	0	0
18+yr	0	*4*	3	1	0	*3*	0	2	2	2	0
Radius	0	8	7	2	0	8	1	6	8	6	2
7-11yr	0	*0*	0	0	0	0	0	0	0	0	0
12-17yr	0	*3*	3	1	0	*3*	0	3	3	3	1
18-34yr	0	*2*	1	1	0	*2*	1	1	1	0	0
35-49yr	0	*0*	0	0	0	*0*	0	1	1	1	1
50+yr	0	*0*	0	0	0	*0*	0	0	0	0	0
18+yr	0	*3*	3	0	0	*3*	0	1	3	2	0

Table I.9: Prevalence of fractures of upper limb bones for male and unsexed individuals in the mass burials by age-at-death. Ne: number of elements present; Ns: number of element sections present; nf: number of fractures present.

II.3. Lower Limb Trauma

Normative burials

Female														
Element	**Left**							**Right**						
	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Femur	0	28	23	28	27	22	16	0	26	21	24	25	24	18
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
18-34yr	0	16	14	16	15	14	11	0	15	13	14	14	15	13
35-49yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
50+yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
18+yr	0	9	6	9	9	5	2	0	8	5	7	8	6	2
Tibia	0	23	12	22	21	21	14	0	24	16	21	22	21	16
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	1	0	1	1	1	0	0	1	1	1	1	1	1
18-34yr	0	14	10	14	14	13	10	0	15	9	14	13	13	10
35-49yr	0	1	0	1	1	1	1	0	1	1	1	1	1	1
50+yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
18+yr	0	6	1	5	4	5	2	0	6	4	4	6	5	3
Fibula	**1 [4.3]**	23	**1/4 (25)**	23	22	21	15	**1 [4.3]**	23	**1/2 (50)**	23	22	22	14
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	1	0	1	1	1	0	**1 [100]**	1	**1/1 (100)**	1	1	1	1

18-34yr	**1 [7.1]**	14	**1/4 (25)**	14	14	13	11	0	15	1	15	14	14	10
35-49yr	0	1	0	1	1	1	1	0	1	0	1	1	1	0
50+yr	0	1	0	1	1	1	1	0	1	0	1	1	1	1
18+yr	0	6	0	6	5	5	2	0	5	0	5	5	5	2
Male														
Element	**Left**							**Right**						
	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Femur	0	53	47	53	52	50	38	**3 [5.8]**	52	47	48	**2/49 (4.1)**	48	37
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
18-34yr	0	26	25	26	26	23	18	0	26	26	25	25	24	20
35-49yr	0	2	2	2	2	2	2	0	2	2	1	2	2	2
50+yr	0	5	5	5	5	5	4	**2 [40]**	5	5	5	**1/5 (20)**	**1/5 (20)**	5
18+yr	0	19	14	19	18	19	13	**1 [5.6]**	18	13	16	**1/16 (6.3)**	16	9
Tibia	0	43	22	41	40	36	27	**1 [2.2]**	45	29	43	**1/43 (2.3)**	37	28
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-34yr	0	23	15	23	23	22	17	0	24	16	24	24	23	17
35-49yr	0	2	1	1	2	2	2	0	2	1	1	2	2	2
50+yr	0	5	5	5	4	3	3	**1 [20]**	5	5	5	**1/5 (20)**	3	2
18+yr	0	13	1	12	11	9	5	0	14	7	13	12	9	7
Fibula	0	43	5	41	42	38	20	0	41	8	41	40	38	28

7-11yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18-34yr	0	25	3	24	25	24	13	0	23	7	23	23	23	17
35-49yr	0	2	0	2	2	2	1	0	2	1	2	2	2	1
50+yr	0	5	0	5	5	3	2	0	5	0	5	4	2	3
18+yr	0	11	2	10	10	9	4	0	11	0	11	11	11	7
Unsexed														
Element	**Left**							**Right**						
	Fracture total (nf [%])	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)	Fracture total (nf)	Element present (Ne)	P epiph (nf/Ns)	P1/3 (nf/Ns)	M1/3 (nf/Ns)	D1/3 (nf/Ns)	D epiph (nf/Ns)
Femur	0	31	21	29	28	26	13	0	31	22	28	29	23	15
7-11yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
12-17yr	0	6	6	5	5	5	3	0	6	6	6	6	4	4
18-34yr	0	4	4	4	4	4	1	0	4	4	4	4	4	2
35-49yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50+yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18+yr	0	20	10	19	18	16	8	0	20	11	17	18	14	8
Tibia	0	27	7	24	25	22	11	0	29	7	24	27	26	18
7-11yr	0	1	1	1	1	1	1	0	1	1	1	1	1	1
12-17yr	0	5	2	4	4	4	5	0	5	1	5	5	5	5
18-34yr	0	3	0	3	3	3	1	0	3	0	3	3	3	2
35-49yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50+yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18+yr	0	18	4	16	17	14	4	0	20	5	15	18	17	10
Fibula	0	27	2	25	25	24	11	**1 [3.8]**	26	3	24	24	25	**1/12 (8.3)**
7-11yr	0	1	0	1	1	1	1	0	1	0	1	1	1	0

12-17yr	0	4	0	4	4	4	3	0	5	1	5	5	5	3
18-34yr	0	3	0	3	3	3	1	0	3	0	3	3	3	1
35-49yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
50+yr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18+yr	0	19	2	17	17	16	6	**1 [5.9]**	17	2	15	15	16	**1/8 (12.5)**

Table I.10: Prevalence of fractures of lower limb bones for female, male, and unsexed individuals in the normative burials by age-at-death. Ne: number of elements present; Ns: number of element sections present; nf: number of fractures present.

II.4. Shoulder trauma

Normative burials

	Female			**Male**			**Unsexed**			**Total**		
	Ne	nf	nf (%)	Ne	nf	nf (%)	Ne	nf	nf (%)	Ne	nf	nf (%)
L Clavicle	**24**	**1**	**4.2%**	**52**	**1**	**1.9%**	**21**	**0**	**0**	**97**	**2**	**2.1%**
7-11yr	0	0	0	0	0	0	1	0	0	1	0	0
12-17yr	1	0	0	1	0	0	4	0	0	6	0	0
18-34yr	14	1	7.1%	25	1	4.0%	3	0	0	42	2	4.8%
35-49yr	1	0	0	2	0	0	0	0	0	3	0	0
50+yr	0	0	0	5	0	0	0	0	0	5	0	0
18+yr	8	0	0	19	0	0	13	0	0	40	0	0
R Clavicle	**24**	**0**	**0**	**51**	**3**	**5.9%**	**14**	**0**	**0**	**89**	**3**	**3.4%**
7-11yr	0	0	0	0	0	0	1	0	0	1	0	0
12-17yr	0	0	0	0	0	0	3	0	0	3	0	0
18-34yr	14	0	0	27	1	3.7%	4	0	0	45	1	2.2%
35-49yr	1	0	0	2	0	0	0	0	0	3	0	0
50+yr	0	0	0	5	1	0.2	0	0	0	5	1	20.0%
18+yr	9	0	0	17	1	5.9%	6	0	0	32	1	3.1%
L Scapula	**14**	**0**	**0**	**43**	**0**	**0**	**8**	**0**	**0**	**65**	**0**	**0**
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	0	0	1	0	0	1	0	0	2	0	0
18-34yr	10	0	0	23	0	0	1	0	0	34	0	0
35-49yr	1	0	0	2	0	0	0	0	0	3	0	0
50+yr	0	0	0	4	0	0	0	0	0	4	0	0
18+yr	3	0	0	13	0	0	6	0	0	22	0	0

R Scapula	**18**	**0**	**0**	**39**	**0**	**0**	**9**	**1**	**11.1%**	**66**	**1**	**1.5%**
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0	2	0	0	2	0	0
18-34yr	10	0	0	24	0	0	3	0	0	37	0	0
35-49yr	1	0	0	2	0	0	0	0	0	3	0	0
50+yr	0	0	0	3	0	0	0	0	0	3	0	0
18+yr	**7**	0	0	10	0	0	4	1	25.0%	21	1	4.8%

Table I.11: Prevalence of shoulder trauma in the normative burials by age-at-death category
Ne: number of elements present; nf: number of fractures present.

Non-normative single burials

	Female			**Male**			**Unsexed**			**Total**		
	Ne	nf	nf (%)	Ne	nf	nf (%)	Ne	nf	nf (%)	Ne	nf	nf (%)
L Clavicle	**8**	**0**	**0**	**17**	**2**	**11.8%**	**7**	**0**	**0**	**32**	**2**	**6.3%**
7-11yr	0	0	0	0	0	0	1	0	0	1	0	0
12-17yr	0	0	0	0	0	0	1	0	0	1	0	0
18-34yr	4	0	0	7	1	14.3%	0	0	0	11	1	9.1%
35-49yr	0	0	0	0	0	0	2	0	0	2	0	0
50+yr	1	0	0	3	1	33.3%	0	0	0	4	1	25.0%
18+yr	**3**	0	0	7	0	0	3	0	0	13	0	0
R Clavicle	**7**	**1**	**14.3%**	**15**	**1**	**6.7%**	**8**	**0**	**0**	**30**	**2**	**6.7%**
7-11yr	0	0	0	0	0	0	1	0	0	1	0	0
12-17yr	0	0	0	0	0	0	1	0	0	1	0	0
18-34yr	4	1	25.0%	6	1	16.7%	0	0	0	10	2	20.0%
35-49yr	0	0	0	0	0	0	2	0	0	2	0	0
50+yr	1	0	0	2	0	0	0	0	0	3	0	0

18+yr	2	0	0	7	0	0	4	0	0	13	0	0
L Scapula	**2**	**0**	**0**	**7**	**0**	**0**	**3**	**0**	**0**	**12**	**0**	**0**
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0	0	0	0	0	0	0
18-34yr	2	0	0	3	0	0	0	0	0	5	0	0
35-49yr	0	0	0	0	0	0	2	0	0	2	0	0
50+yr	0	0	0	1	0	0	0	0	0	1	0	0
18+yr	0	0	0	3	0	0	1	0	0	4	0	0
R Scapula	**5**	**0**	**0**	**7**	**0**	**0**	**4**	**0**	**0**	**16**	**0**	**0**
7-11yr	0	0	0	0	0	0	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0	0	0	0	0	0	0
18-34yr	4	0	0	4	0	0	0	0	0	8	0	0
35-49yr	0	0	0	0	0	0	3	0	0	3	0	0
50+yr	1	0	0	1	0	0	0	0	0	2	0	0
18+yr	0	0	0	2	0	0	1	0	0	3	0	0

Table I.12: Prevalence of shoulder trauma in the non-normative single burials by age-at-death category.
Ne: number of elements present; nf: number of fractures present.

II.5. Vertebral trauma

Normative burials

Female						
	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	22	0	0	23	0	0
7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	1	0	0
18-34yr	13	0	0	13	0	0
35-49yr	1	0	0	1	0	0
50+yr	0	0	0	0	0	0
18+yr	7	0	0	8	0	0
T vert	21	1	4.8%	26	0	0
7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	1	0	0
18-34yr	13	0	0	16	0	0
35-49yr	1	0	0	1	0	0
50+yr	0	0	0	0	0	0
18+yr	6	1	16.7%	8	0	0
L vert	22	0	0	26	1	3.8%
7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	1	0	0
18-34yr	15	0	0	17	1	5.9%
35-49yr	1	0	0	1	0	0
50+yr	0	0	0	0	0	0
18+yr	5	0	0	7	0	0
Male						
	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	45	1	2.2%	46	0	0
7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	1	0	0
18-34yr	24	1	4.2%	24	0	0
35-49yr	2	0	0	2	0	0
50+yr	5	0	0	5	0	0
18+yr	13	0	0	14	0	0
T vert	43	4	9.3%	53	0	0
7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	1	0	0
18-34yr	22	2	9.1%	27	0	0
35-49yr	2	0	0	2	0	0
50+yr	4	1	25.0%	5	0	0
18+yr	14	1	7.1%	18	0	0
L vert	36	1	2.8%	48	7	14.6%
7-11yr	0	0	0	0	0	0

12-17yr	1	0	0	1	0	0
18-34yr	20	1	5.0%	24	5	20.8%
35-49yr	1	0	0	2	0	0
50+yr	4	0	0	5	1	20.0%
18+yr	10	0	0	16	1	6.3%

Unsexed

	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	11	0	0	14	0	0
7-11yr	1	0	0	1	0	0
12-17yr	4	0	0	5	0	0
18-34yr	1	0	0	2	0	0
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	5	0	0	6	0	0
T vert	6	0	0	11	0	0
7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	3	0	0
18-34yr	2	0	0	3	0	0
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	3	0	0	5	0	0
L vert	4	0	0	17	2	11.8%
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	4	1	0
18-34yr	1	0	0	2	1	50.0%
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	3	0	0	11	0	0

Total

	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	78	1	1.3%	83	0	0
7-11yr	1	0	0	1	0	0
12-17yr	6	0	0	7	0	0
18-34yr	38	1	2.6%	39	0	0
35-49yr	3	0	0	3	0	0
50+yr	5	0	0	5	0	0
18+yr	25	0	0	28	0	0
T vert	70	5	7.1%	90	0	0
7-11yr	0	0	0	0	0	0
12-17yr	3	0	0	5	0	0
18-34yr	37	2	5.4%	46	0	0
35-49yr	3	0	0	3	0	0
50+yr	4	1	25.0%	5	0	0
18+yr	23	2	8.7%	31	0	0
L vert	62	1	1.6%	91	10	11.0%
7-11yr	0	0	0	0	0	0.0%

12-17yr	2	0	0	6	1	16.7%
18-34yr	36	1	2.8%	43	7	16.3%
35-49yr	2	0	0	3	0	0.0%
50+yr	4	0	0	5	1	20.0%
18+yr	18	0	0	34	1	2.9%

Table I.13: Prevalence of vertebral trauma in the normative burials by age-at-death category.
Ne: number of elements present; nf: number of fractures present.

Non-normative single burial

Female						
	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	7	0	0	7	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	3	0	0	3	0	0
35-49yr	0	0	0	0	0	0
50+yr	1	0	0	1	0	0
18+yr	3	0	0	3	0	0
T vert	2	0	0	4	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	2	0	0	2	0	0
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	1	0	0
18+yr	0	0	0	1	0	0
L vert	4	1	25.0%	5	1	20.0%
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	3	1	33.3%	4	1	25.0%
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	1	0	0	1	0	0
Male						
	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	12	0	0	13	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	5	0	0	6	0	0
35-49yr	0	0	0	0	0	0
50+yr	3	0	0	3	0	0
18+yr	4	0	0	4	0	0
T vert	10	0	0	12	1	8.3%

7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	6	0	0	7	0	0
35-49yr	0	0	0	0	0	0
50+yr	2	0	0	2	1	50.0%
18+yr	2	0	0	3	0	0
L vert	11	0	0	14	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	5	0	0	6	0	0
35-49yr	0	0	0	0	0	0
50+yr	3	0	0	3	0	0
18+yr	3	0	0	5	0	0

Unsexed

	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	7	0	0	5	0	0
7-11yr	1	0	0	1	0	0
12-17yr	2	0	0	2	0	0
18-34yr	0	0	0	0	0	0
35-49yr	2	0	0	2	0	0
50+yr	0	0	0	0	0	0
18+yr	2	0	0	0	0	0
T vert	4	0	0	3	0	0
7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	1	0	0
18-34yr	0	0	0	0	0	0
35-49yr	2	0	0	2	0	0
50+yr	0	0	0	0	0	0
18+yr	1	0	0	0	0	0
L vert	2	0	0	2	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	1	0	0
18-34yr	0	0	0	0	0	0
35-49yr	1	0	0	1	0	0
50+yr	0	0	0	0	0	0
18+yr	1	0	0	0	0	0

Total

	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	26	0	0	25	0	0
7-11yr	1	0	0	1	0	0
12-17yr	2	0	0	2	0	0
18-34yr	8	0	0	9	0	0
35-49yr	2	0	0	2	0	0
50+yr	4	0	0	4	0	0
18+yr	9	0	0	7	0	0
T vert	16	0	0	19	1	5.3%

7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	1	0	0
18-34yr	8	0	0	9	0	0
35-49yr	2	0	0	2	0	0
50+yr	2	0	0	3	1	33.3%
18+yr	3	0	0	4	0	0
L vert	17	1	5.9%	21	1	4.8%
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	1	0	0
18-34yr	8	1	12.5%	10	1	10.0%
35-49yr	1	0	0	1	0	0
50+yr	3	0	0	3	0	0
18+yr	5	0	0	6	0	0

Table I.14: Prevalence of vertebral trauma in the non-normative single burials by age-at-death category.
Ne: number of elements present; nf: number of fractures present.

Mass burials

Male						
	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	11	0	0	16	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	8	0	0	9	0	0
35-49yr	2	0	0	2	0	0
50+yr	0	0	0	0	0	0
18+yr	1	0	0	5	0	0
T vert	11	0	0	18	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	9	0	0	12	0	0
35-49yr	2	0	0	2	0	0
50+yr	0	0	0	0	0	0
18+yr	0	0	0	4	0	0
L vert	13	0	0	19	2	10.5%
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	9	0	0	11	1	9.1%
35-49yr	2	0	0	2	1	50.0%
50+yr	0	0	0	0	0	0
18+yr	2	0	0	6	0	0
Unsexed						
	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)

C vert	3	1	33.3%	5	0	0
7-11yr	0	0	0	0	0	0
12-17yr	2	0	0	3	0	0
18-34yr	0	0	0	1	0	0
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	1	0	0	1	0	0
T vert	3	0	0	6	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	2	0	0
18-34yr	1	0	0	2	0	0
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	2	0	0	2	0	0
L vert	3	0	0	9	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	3	0	0
18-34yr	1	0	0	3	0	0
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	2	0	0	3	0	0

Total

	Body			**Arch**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
C vert	14	1	7.1%	21	0	0
7-11yr	0	0	0	0	0	0
12-17yr	2	0	0	3	0	0
18-34yr	8	0	0	10	0	0
35-49yr	2	0	0	2	0	0
50+yr	0	0	0	0	0	0
18+yr	2	0	0	6	0	0
T vert	14	0	0	24	0	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	2	0	0
18-34yr	10	0	0	14	0	0
35-49yr	2	0	0	2	0	0
50+yr	0	0	0	0	0	0
18+yr	2	0	0	6	0	0
L vert	16	0	0	28	2	7.1%
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	3	0	0
18-34yr	10	0	0	14	1	0
35-49yr	2	0	0	2	1	50.0%
50+yr	0	0	0	0	0	0
18+yr	4	0	0	9	0	0

Table I.15: Prevalence of vertebral trauma in the mass burials by age-at-death category. Ne: number of elements present; nf: number of fractures present.

II.6. Rib Trauma

Normative burials

Ribs 2-12						
	Left			**Right**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
Female	**23**	**4**	17.4%	**25**	**4**	16.0%
7-11yr	0	0	0	0	0	0
12-17yr	1	1	100.0%	1	0	0
18-34yr	14	1	7.1%	14	1	7.1%
35-49yr	1	1	100.0%	1	0	0
50+yr	0	0	0	0	0	0.0%
18+yr	**7**	1	14.3%	9	3	33.3%
Male	**45**	**10**	22.2%	**46**	**10**	21.7%
7-11yr	0	0	0	0	0	0
12-17yr	1	0	0	1	0	0
18-34yr	23	0	0	23	3	13.0%
35-49yr	2	1	50.0%	2	0	0
50+yr	5	2	40.0%	4	3	75.0%
18+yr	**14**	7	50.0%	16	4	25.0%
Unsexed	**11**	**4**	36.4%	**12**	**5**	41.7%
7-11yr	0	0	0	1	0	0
12-17yr	3	0	0	3	0	0
18-34yr	2	1	50.0%	3	2	66.7%
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	**6**	3	50.0%	5	3	60.0%
Total	79	18	22.8%	83	19	22.9%
7-11yr	0	0	0	1	0	0
12-17yr	5	1	20.0%	5	0	0
18-34yr	39	2	5.1%	40	6	15.0%
35-49yr	3	2	66.7%	3	0	0
50+yr	5	2	40.0%	4	3	75.0%
18+yr	27	11	40.7%	30	10	33.3%

Table I.16: Prevalence of fractures to ribs 2-12 in the normative burials by age-at-death category.
Ne: number of elements present; nf: number of fractures present.

Non-normative single burials

Ribs 2-12						
	Left			**Right**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
Female	**4**	**1**	25.0%	**4**	**0**	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0

18-34yr	3	1	33.3%	3	0	0
35-49yr	0	0	0	0	0	0
50+yr	1	0	0	0	0	0
18+yr	**0**	0	0	1	0	0
Male	**9**	**0**	0	**9**	**1**	11.1%
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	6	0	0	4	0	0
35-49yr	0	0	0	0	0	0
50+yr	2	0	0	3	1	33.3%
18+yr	**1**	0	0	2	0	0
Unsexed	**3**	**0**	0	**5**	**0**	0
7-11yr	0	0	0	1	0	0
12-17yr	1	0	0	1	0	0
18-34yr	0	0	0	0	0	0
35-49yr	1	0	0	3	0	0
50+yr	0	0	0	0	0	0
18+yr	**1**	0	0	0	0	0
Total	16	1	6.3%	18	1	5.6%
7-11yr	0	0	0	1	0	0
12-17yr	1	0	0	1	0	0
18-34yr	9	1	11.1%	7	0	0
35-49yr	1	0	0	3	0	0
50+yr	3	0	0	3	1	33.3%
18+yr	2	0	0	3	0	0

Table I.17: Prevalence of fractures to ribs 2-12 in the non-normative single burials by age-at-death category.
Ne: number of elements present; nf: number of fractures present.

Mass burials

Ribs 2-12						
	Left			**Right**		
	Ne	nf	nf (%)	Ne	nf	nf (%)
Female	**0**	**0**	0	**0**	**0**	0
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	0	0	0	0	0	0
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	**0**	0	0	0	0	**0**
Male	**14**	**1**	7.1%	**13**	**1**	7.7%
7-11yr	0	0	0	0	0	0
12-17yr	0	0	0	0	0	0
18-34yr	10	0	0	10	1	10.0%
35-49yr	2	0	0	1	0	0
50+yr	0	0	0	0	0	0
18+yr	**2**	1	50.0%	2	0	0

Unsexed	**5**	**0**	0	**5**	**1**	20.0%
7-11yr	0	0	0	0	0	0
12-17yr	2	0	0	2	0	0
18-34yr	1	0	0	1	0	0
35-49yr	0	0	0	0	0	0
50+yr	0	0	0	0	0	0
18+yr	**2**	0	0	2	1	50.0%
Total	19	1	5.3%	18	2	11.1%
7-11yr	0	0	0	0	0	0
12-17yr	2	0	0	2	0	0
18-34yr	11	0	0	11	1	9.1%
35-49yr	2	0	0	1	0	0
50+yr	0	0	0	0	0	0
18+yr	4	1	25.0%	4	1	25.0%

Table I.18: Prevalence of fractures to ribs 2-12 in the non-normative single burials by age-at-death category.
Ne: number of elements present; nf: number of fractures present.

Appendix II: Catalogue

Burial 5_31

Burial type	pit burial
Burial category	mass burial Z
Completeness	25-50%
Preservation	fair
Biological Sex	ambiguous
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	n/a
Dental disease	
Caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	---

Burial 5_37

Burial type	pit burial
Burial category	no
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	21-44 years
Age category	18-34 years (young adult)
Stature	163.33 ± 4.53 cm
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	R metacarpal 2
Additional	---

Burial 5_77

Burial type	pit burial
Burial category	No
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	18-29 years
Age category	18-34 years (young adult)

Stature	181.66 ± 5.863 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial 5_90

Burial type	pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	good
Biological Sex	indeterminate
Age-at-death	30+ years
Age category	35-49 years (middle adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	---

Burial 5_95

Burial type	pit burial
Burial category	non-normative single burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial 5_100

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	poor
Biological Sex	female
Age-at-death	16-18 years
Age category	14-18 years (adolescent)
Stature	151.51 ± 5.12 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	R fibula and patella L ribs: single fracture
Additional	---

Burial 5_103

Burial type	Pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	Ankylosing spondylitis/DISH (thoracic vertebrae)

Burial 5_109

Burial type	pit burial
Burial category	non-normative single burial
Completeness	25-50%
Preservation	fair
Biological Sex	possible male
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a

CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial 5_117

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	ambiguous
Age-at-death	20-26 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	L ulna (‘parry fracture’)
Additional	---

Burial 5_125

Burial type	Pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	fair
Biological Sex	male
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	cranium: single fracture L metacarpal 4
Additional	---

Burial 5_135

Burial type	Pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	21-26
Age category	18-34 years (young adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	L/R clavicles
Additional	---

Burial 5_139

Burial type	Pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	poor
Biological Sex	male
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	n/a
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial 5_140

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	18-22 years
Age category	18-34 years (young adult)
Stature	154.52 ± 4.607 cm
CO	absent

DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	ankylosis of R sacroiliac joint

Burial 5_149

Burial type	Cremation
Burial category	non-normative single burial
Completeness	75-100%
Preservation	fair
Biological Sex	possible female
Age-at-death	20+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	---

Burial 5_164

Burial type	Pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	18-57 years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	R ulna L ribs: 3 fractures
Additional	---

Burial 5_166

Burial type	Pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	fair
Biological Sex	possible male
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial 5_167

Burial type	Pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	21-26 years
Age category	18-34 years (young adult)
Stature	165.22 ± 5.067 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	absent
AM Trauma	cranium: single fracture L hand phalanx (amputation)
Additional	premature suture closure maxillary sinusitis

Burial 5_173

Burial type	Pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	fair
Biological Sex	possible male
Age-at-death	21+ years
Age category	18+ years (adult)

Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture R hand phalanx
Additional	slight joint disease in R acetabulum and bilateral glenoid fossae

Burial 5_177

Burial type	Pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	18-30
Age category	18-34 (young adult)
Stature	163.9 ± 5.067 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	L5: spondylolysis
Additional	active PNBF on upper limbs and hand bones (systemic condition?)

Burial 5_181

Burial type	Pit burial
Burial category	mass burial Z
Completeness	25-50%
Preservation	fair
Biological Sex	possible male
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	present
AM Trauma	L ulna (‘parry fracture’)
Additional	---

Burial 5_192

Burial type	Pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	good
Biological Sex	indeterminate
Age-at-death	18-42 years
Age category	18+ years (adult)
Stature	168.28 ± 5.551 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	---

Burial 5_193

Burial type	Pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	good
Biological Sex	female
Age-at-death	21-45 years
Age category	18-34 years (young adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	R radius
Additional	maxillary sinusitis

Burial 5_194

Burial type	Pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)

Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	---

Burial 5_197

Burial type	Pit burial
Burial category	non-normative single burial
Completeness	0-25%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	8-13 years
Age category	7-11 years (child II)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	present
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Burial 5_198

Burial type	Pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	37-70 years
Age category	50+ years (mature adult)
Stature	167.46 ± 5.067 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	ankylosis of left sacroiliac joint

Burial 5_202

Burial type	Pit burial
Burial category	non-normative single burial
Completeness	0-25%
Preservation	fair
Biological Sex	possible female
Age-at-death	20+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	---

Burial 5_213

Burial type	Pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	23-70 years
Age category	18+ years (adult)
Stature	169.2 ± 5.377 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture
Additional	---

Burial 5_216

Burial type	Pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	27+ years
Age category	18+ years (adult)
Stature	n/a
CO	present

DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	absent
VJD	present
AM Trauma	absent
Additional	---

Burial 5_218

Burial type	Pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	good
Biological Sex	female
Age-at-death	27-45 years
Age category	18-34 years (young adult)
Stature	152.27 ± 5.12 cm
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	R clavicle
Additional	---

Burial 5_220

Burial type	Pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	20-26 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	L metacarpal 1
Additional	---

Burial 5_222

Burial type	Pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	female
Age-at-death	20-29
Age category	18-34 years (young adult)
Stature	146.51 ± 4.414 cm
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial 5_245

Burial type	Pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	21-36
Age category	18-34 years (young adult)
Stature	150.85 ± 4.425 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	L5: spondylolysis
Additional	joint disease of shoulder, elbow, hip, hands, and feet

Burial 5_253

Burial type	Pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	fair
Biological Sex	male
Age-at-death	24-40 years
Age category	18-34 years (young adult)
Stature	169.3 ± 5.108 cm
CO	present
DEH	present
Dental disease	

caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	L5: spondylolysis
Additional	infection of right hand and arm

Burial 5_266

Burial type	Pit burial
Burial category	mass burial Z
Completeness	0-25%
Preservation	poor
Biological Sex	ambiguous
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_5

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	21-44 years
Age category	18-34 years (young adult)
Stature	167.45 ± 4.607 cm
CO	n/a
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture L3-L5: spondylolysis
Additional	

Burial IV_7

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_11

Burial type	Pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_28

Burial type	Pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	poor
Biological Sex	possible female
Age-at-death	15+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a

Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_34

Burial type	Pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	poor
Biological Sex	possible male
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	L radius
	R ribs: single fracture
Additional	---

Burial IV_35

Burial type	pit burial
Burial category	non-normative burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	n/a
Additional	---

Burial IV_39

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_51

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	poor
Biological Sex	possible male
Age-at-death	21-44 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	L os acromiale

Burial IV_62

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	35-70 years
Age category	50+ years (mature adult)
Stature	162.3 ± 5.067 cm
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	present

Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	L clavicle
	R ribs: multiple fractures
Additional	---

Burial IV_63

Burial type	pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	fair
Biological Sex	possible female
Age-at-death	18-23 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	n/a
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_65

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	20+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_71

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	poor
Biological Sex	possible male
Age-at-death	23+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_86

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	poor
Biological Sex	possible male
Age-at-death	21-25 years
Age category	18-34 years (young adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_90

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	poor
Biological Sex	possible male
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent

Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	---

Burial IV_96

Burial type	pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	poor
Biological Sex	possible male
Age-at-death	21-44 years
Age category	18-34 years (young adult)
Stature	184.73 ± 5.863 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	absent
AM Trauma	L ulna ('parry fracture')
Additional	size difference noted for humeri, bowing of leg bones

Burial IV_98

Burial type	pit burial
Burial category	non-normative single burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	absent
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_100

Burial type	pit burial

Burial category	normative burial
Completeness	0-25%
Preservation	fair
Biological Sex	possible male
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	cranium: single fracture
Additional	---

Burial IV_102

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	37-72 years
Age category	50+ years (mature adult)
Stature	161.64 ± 4.528 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture
	L ulna
	R ribs: multiple fractures
Additional	---

Burial IV_114

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	fair
Biological Sex	ambiguous
Age-at-death	22-40
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	absent

AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	n/a
VJD	absent
AM Trauma	L ribs: multiple fractures
	R rib: multiple fractures
Additional	---

Burial IV_114

Burial type	pit burial
Burial category	non-normative single burial
Completeness	25-50%
Preservation	fair
Biological Sex	ambiguous
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	n/a
VJD	absent
AM Trauma	R radius
Additional	---

Burial IV_120

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	indeterminate
Age-at-death	14-16 years
Age category	12-17 years (adolescent)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_140

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	fair
Biological Sex	possible male
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_147

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	possible female
Age-at-death	21-36 years
Age category	18-34 years (young adult)
Stature	150.58 ± 3.892 cm
CO	present
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	R fibula: osteomyelitis

Burial IV_158

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	20+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent

Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_163

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	poor
Biological Sex	possible male
Age-at-death	17-21 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial IV_169

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	fair
Biological Sex	ambiguous/female
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	n/a
VJD	present
AM Trauma	L/R radius R metatarsal 5 L ribs: multiple fractures R ribs: multiple fractures
Additional	---

Burial IV_170

Burial type	pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	poor
Biological Sex	male
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_180

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	21-44 years
Age category	18-34 years (young adult)
Stature	155.87 ± 4.446 cm
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture R ribs: single fracture T12: compression fracture of the body L5: spondylolysis
Additional	ankylosis of T11 and T12

Burial IV_182

Burial type	Pit burial
Burial category	mass burial 4
Completeness	25-50%
Preservation	fair
Biological Sex	ambiguous
Age-at-death	22+ years
Age category	18+ years (adult)
Stature	n/a

CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	right metacarpal 4
Additional	---

Burial IV_183

Burial type	Pit burial
Burial category	mass burial 4
Completeness	50-75%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	13-15(F)/15-17(M)
Age category	12-17 years (adolescent)
Stature	174.29 ± 5.551 cm
CO	absent
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_187

Burial type	pit burial
Burial category	mass burial 4
Completeness	25-50%
Preservation	fair
Biological Sex	possible male
Age-at-death	18+ years
Age category	18-34 years (young adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_192

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	30+ years
Age category	18+ years (adult)
Stature	n/a
CO	present
DEH	absent
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture
Additional	Ankylosing spondylitis/DISH: 7 thoracic vertebrae

Burial IV_202

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	poor
Biological Sex	male
Age-at-death	42+ years
Age category	50+ years (mature adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	right metacarpal 2
	left ribs: single fracture
Additional	ankylosing spondylitis

Burial IV_209

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	fair
Biological Sex	male
Age-at-death	26+ years
Age category	18+ years (adult)
Stature	n/a

CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	n/a
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_211

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	poor
Biological Sex	possible male
Age-at-death	25-75 years
Age category	18+ years (adult)
Stature	167.2 ± 5.65 cm
CO	n/a
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial IV_215

Burial type	pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	good
Biological Sex	ambiguous
Age-at-death	35+ years
Age category	35-50 years (middle adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_220

Burial type	pit burial
Burial category	non-normative single burial
Completeness	0-25%
Preservation	good
Biological Sex	possible female
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_232

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	18-44 years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	present
PNBF (tibia)	absent
VJD	present
AM Trauma	absent
Additional	---

Burial IV_234

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	21-44 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a

DEH	n/a
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_235

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	good
Biological Sex	possible male
Age-at-death	29+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_241

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	possible male
Age-at-death	20+ years
Age category	18+ years (adult)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	L ribs: single fracture R ribs: three fractures in two ribs
Additional	L tibia: perimortem cut

Burial IV_244

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	ambiguous
Age-at-death	22-38 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	L ribs: single fracture R ribs: single fracture
Additional	---

Burial IV_245

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	23+ years
Age category	18+ years (adult)
Stature	172.14 ± 5.551 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_248

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	14-20 years
Age category	12-17 years (adolescent)
Stature	n/a

CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	active bone formation on the visceral aspect of ribs

Burial IV_249

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_254

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	20-45 years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	R fibula
Additional	ankylosis of R foot bones

Burial IV_255

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	21-24 years
Age category	18-34 years (young adult)
Stature	162.15 ± 4.446 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	L4/5: Spondylolysis
Additional	---

Burial IV_256

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	23-35 years
Age category	18-34 years (young adult)
Stature	155.15 ± 4.446 cm
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	L ulna ('parry fracture')
Additional	active PNBF affecting multiple areas of the skeleton (systemic) Double burial with IV_273

Burial IV_264

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible female
Age-at-death	21-32 years
Age category	18-34 years (young adult)

Stature	149.99 ± 5.12 cm
CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	absent
Additional	---

Burial IV_269

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	poor
Biological Sex	female
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	n/a
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	cranium: single fracture
Additional	---

Burial IV_271

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_273

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	10-15 years
Age category	12-17 years (adolescent)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	reactive bone present on entheses active PNBF on mandible visceral surface of ribs double burial with IV_256

Burial IV_274

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	fair
Biological Sex	possible male
Age-at-death	27-72 years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	absent
VJD	present
AM Trauma	L ribs: 4 ribs fractured (1st rib + 3 ribs 2-12)
Additional	---

Burial IV_278

Burial type	pit burial
Burial category	non-normative single burial
Completeness	25-50%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	6-11 years

Age category	7-11 years (child II)
Stature	n/a
CO	absent
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_282

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	good
Biological Sex	possible male
Age-at-death	20-29 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	active PNBF on R scapula and humerus

Burial IV_283

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	ambiguous
Age-at-death	20+ years
Age category	18-34 years (young adult)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	unidentified L vertebra: spondylolysis
Additional	---

Burial IV_289

Burial type	pit burial
Burial category	mass burial X
Completeness	25-50%
Preservation	fair
Biological Sex	male
Age-at-death	26-65 years
Age category	18+ years (adult)
Stature	173.07 ± 5.65 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	L ribs: 4 fractures
Additional	---

Burial IV_291

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	possible female
Age-at-death	17-20 years
Age category	18-34 years (young adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_294

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	14-18 years (F) /16-18 years (M)
Age category	12-17 years (adolescent)

Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	widespread active and healed PNBF (systemic condition)

Burial IV_295

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	poor
Biological Sex	female
Age-at-death	20-70 years
Age category	18+ years (adult)
Stature	n/a
CO	present
DEH	absent
Dental disease	
caries	absent
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	R ribs: 3 fractures
Additional	---

Burial IV_305

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	good
Biological Sex	male
Age-at-death	16-17 years
Age category	12-18 years (adolescent)
Stature	170.81 ± 4.607 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_310

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	good
Biological Sex	indeterminate
Age-at-death	23+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_317

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	ambiguous
Age-at-death	21+ years
Age category	35-49 years (middle adult)
Stature	169.03 ± 5.919 cm
CO	n/a
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	L radius (Colles fracture)
Additional	---

Burial IV_348

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	156.83 ± 4.769 cm
CO	n/a

DEH	present
Dental disease	
caries	absent
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	present
AM Trauma	L ribs: single fracture R ribs: 3 fractures
Additional	mixed PNBF on ribs (visceral)

Burial IV_356

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	55+ years
Age category	50+ years (mature adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	

Burial IV_360

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	male
Age-at-death	29-52 years
Age category	18+ years (adult)
Stature	167.2 ± 5.65 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	R ulna (‘parry’ fracture)
Additional	---

Burial IV_361

Burial type	pit burial
Burial category	mass burial X
Completeness	25-50%
Preservation	fair
Biological Sex	ambiguous
Age-at-death	33-58 years (F)/27-61 years (M)
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	L ribs: single fracture L ischium
Additional	possible brucellosis

Burial IV_367

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	163.83 ± 4.625 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_369

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	26-43 years

Age category	18+ years (adult)
Stature	n/a
CO	present
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial IV_373

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	25-45 years
Age category	18-34 years (young adult)
Stature	172.7 ± 5.65 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	n/a
VJD	present
AM Trauma	cranium: single fracture
Additional	joint disease affecting R shoulder, both hands, L knee

Burial IV_377

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_378

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	27-41 years
Age category	18-34 years (young adult)
Stature	161.61 ± 4.526 cm
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	R ulna (non-union with reactive bone formation) R ribs: single fracture
Additional	double burial with IV_387

Burial IV_380

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	poor
Biological Sex	female
Age-at-death	31-60 years
Age category	18+ years (adult)
Stature	150.75 ± 5.12 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	

Burial IV_392

Burial type	pit burial
Burial category	non-normative single burial
Completeness	0-25%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	14-17 years

Age category	12-17 years (adolescent)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	

Burial IV_393

Burial type	pit burial
Burial category	non-normative single burial
Completeness	25-50%
Preservation	fair
Biological Sex	possible male
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial IV_396

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	40+ years
Age category	18+ years (adult)
Stature	166.83 ± 5.65 cm
CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	sternum
Additional	---

Burial IV_399

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	female
Age-at-death	20-29 years
Age category	18-34 years (young adult)
Stature	155.63 ± 4.414 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	absent
Periapical lesions	present
PNBF (tibia)	n/a
VJD	present
AM Trauma	possible perimortem cranial fracture
Additional	---

Burial IV_400

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	male
Age-at-death	21-78 years
Age category	18+ years (adult)
Stature	169.8 ± 4.781 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: multiple fractures
Additional	maxillary sinusitis active PNB on R scapula double burial with IV_401

Burial IV_401

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good

Biological Sex	possible male
Age-at-death	45+ years
Age category	50+ years (mature adult)
Stature	148.65 ± 4.607 cm
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	R ribs: single fracture
	T12: body
Additional	L os acromiale
	L femur: osteochondritis dissecans (?)

Burial IV_402

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_405

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	good
Biological Sex	possible female
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent

PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	joint disease: L humerus (distal)

Burial IV_409

Burial type	pit burial
Burial category	mass burial 2
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	18-25 years
Age category	18-34 years (young adult)
Stature	163.3 ± 4.781 cm
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture
Additional	---

Burial IV_421

Burial type	pit burial
Burial category	normative
Completeness	25-50%
Preservation	good
Biological Sex	indeterminate
Age-at-death	26-41 years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_423

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%

Preservation	good
Biological Sex	indeterminate
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	

Burial IV_424

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%
Preservation	poor
Biological Sex	possible male
Age-at-death	21-50 years
Age category	18+ years (adult)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_431

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	33-58 years
Age category	35-50 years (middle adult)
Stature	156.09 ± 3.022 cm
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present

VJD	present
AM Trauma	L ribs: single fracture
Additional	slight joint disease: hip joint, R elbow

Burial IV_446

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	evidence of joint disease in multiple major joints and healing PNBF endocranially and on long bones

Burial IV_454

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	good
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture
Additional	joint disease: R carpals

Burial IV_462

Burial type	pit burial
Burial category	normative burial
Completeness	25-50%

Preservation	good
Biological Sex	possible female
Age-at-death	20-44 years
Age category	18+ years (adult)
Stature	152.01 ± 3.892 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	L ulna
Additional	joint disease in hip joints bilaterally, R proximal radius, L distal radius, R distal femur

Burial IV_471

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	20-26 years
Age category	18-34 years (young adult)
Stature	157.93 ± 4.607 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	irregular cranial shape L os acromiale possible avulsion fracture of R hamate enlarged R metacarpal 1 (infection/fracture?)

Burial IV_472

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	27-45 years
Age category	18+ years (adult)
Stature	163.02 ± 5.067 cm
CO	absent
DEH	present
Dental disease	
caries	present

AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	R clavicle L ribs: 3 fractures (3x early healing stages) R ribs: 4 fractures (1x early healing stages)
Additional	joint disease: hip joints

Burial IV_476

Burial type	pit burial
Burial category	single non-normative burials
Completeness	50-75%
Preservation	fair
Biological Sex	male
Age-at-death	51-83 years
Age category	50+ years (mature adult)
Stature	n/a
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	n/a
VJD	present
AM Trauma	T11: arch fracture
Additional	---

Burial IV_485

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	25-50 years
Age category	18+ years (adult)
Stature	167.67 ± 4.607 cm
CO	n/a
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	slight joint disease in shoulder and hip joints

Burial IV_486

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	21-30 years
Age category	18-34 years (adult)
Stature	166.23 ± 4.607 cm
CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_487

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	fair
Biological Sex	ambiguous
Age-at-death	18-30 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_488

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	21-44 years
Age category	18-34 years (young adult)
Stature	167.78 ± 4.781 cm
CO	n/a
DEH	n/a
Dental disease	

caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	L foot phalanx
Additional	---

Burial IV_489

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	fair
Biological Sex	possible male
Age-at-death	35+ years
Age category	18+ years (adult)
Stature	n/a
CO	present
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_499

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	possible male
Age-at-death	29-52 years
Age category	18+ years (adult)
Stature	159.05 ± 4.781 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	R tibia: perimortem cut small areas of active PNBF on long bones

Burial IV_501

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	indeterminate
Age-at-death	13-15 years (F)/ 16-18 years (M)
Age category	12-17 years (adolescent)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	present
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_503

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	fair
Biological Sex	male
Age-at-death	37-83 years
Age category	50+ years (mature adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	present
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	R femur
	R ilium
Additional	n/a

Burial IV_504

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	possible male
Age-at-death	20-50 years
Age category	18-34 years (young adult)
Stature	155.78 ± 5.067 cm
CO	absent
DEH	absent

Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	L clavicle
Additional	---

Burial IV_510

Burial type	pit burial
Burial category	mass burial X
Completeness	20-50%
Preservation	good
Biological Sex	male
Age-at-death	18-25 years
Age category	18-34 years (young adult)
Stature	162.94 ± 4.754 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	sacralisation of L6

Burial IV_511

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	25-60 years
Age category	18+ years (adult)
Stature	167.8 ± 4.781 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	R femur: 2 fractures
	R tibia
	L ribs: 3 fractures
	R ribs: 3 fractures
	T11: body
Additional	

Burial IV_515

Burial type	pit burial
Burial category	non-normative single burial
Completeness	50-75%
Preservation	fair
Biological Sex	male
Age-at-death	27-42 years
Age category	18+ years (adult)
Stature	166.93 ± 4.528 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	Joint disease: R proximal ulna

Burial IV_521

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	23-50 years
Age category	18-34 years (young adult)
Stature	183.2 ± 5.863 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	Present
VJD	Present
AM Trauma	R ribs: single fracture
Additional	---

Burial IV_524

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	Fair
Biological Sex	Male
Age-at-death	21-44 years
Age category	18-34 years (young adult)

Stature	164.68 ± 4.446 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	increased cranial thickness but no porosity widespread healed and active PNBF (systemic infection)

Burial IV_530

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	18-29 years
Age category	18-34 years (young adult)
Stature	166.0 ± 5.067 cm
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	R clavicle
Additional	---

Burial IV_531

Burial type	pit burial
Burial category	non-normative single burial
Completeness	0-25%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	163.2 ± 4.326 cm
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	absent
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial IV_538

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	Good
Biological Sex	possible female
Age-at-death	18-29 years
Age category	18-34 years (young adult)
Stature	156.36 ± 4.425 cm
CO	Absent
DEH	Present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	Present
VJD	Absent
AM Trauma	L fibula
Additional	---

Burial IV_543

Burial type	pit burial
Burial category	mass burial 3
Completeness	0-25%
Preservation	Fair
Biological Sex	possible male
Age-at-death	26+ years
Age category	18+ years (adult)
Stature	171.3 ± 4.781 cm
CO	n/a
DEH	Absent
Dental disease	
caries	absent
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_546

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	17-29 years
Age category	18-34 years (young adult)

Stature	168.81 ± 5.377 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture
	L ribs: 2 fractures
Additional	incomplete sacralisation of L5

Burial IV_553

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	fair
Biological Sex	male
Age-at-death	18-35 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	L metacarpal 2
Additional	

Burial IV_554

Burial type	pit burial covered by stone slabs (cist like)
Burial category	normative burial
Completeness	75-100%
Preservation	excellent
Biological Sex	male
Age-at-death	37-72 years
Age category	50+ years (mature adult)
Stature	169.03 ± 5.65
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: multiple fractures (SFT and BFT)
	L ulna (‘parry’ fracture)

	R clavicle
	L ribs: 3 fractures
	R ribs: single fracture
	L5: spondylolysis
	L foot: single phalanx
Additional	L os acromiale
	Osteoathritic changes

Burial IV_555

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	24+ years
Age category	18+ years (adult)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	ossified cyst found in thorax region

Burial IV_556

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	fair
Biological Sex	possible male
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_559

Burial type	pit burial
Burial category	mass burial 1
Completeness	50-75%
Preservation	poor
Biological Sex	male
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_560

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	poor
Biological Sex	male
Age-at-death	21-26 years
Age category	18-34 years (young adult)
Stature	163.53 ± 5.067
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	R rib: single fracture
Additional	---

Burial IV_564

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	17-29 years
Age category	18-34 years (young adult)
Stature	171.21 ± 5.172 cm
CO	absent
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent

Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	metopic suture

Burial IV_565

Burial type	pit burial
Burial category	mass burial 1
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	30-50 years
Age category	35-49 years (middle adult)
Stature	154.31 ± 5.067
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_597

Burial type	pit burial
Burial category	normative urial
Completeness	25-50%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	152.68 ± 4.933 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	possible osteitis affecting fibulae

Burial IV_601

Burial type	pit burial

Burial category	normative
Completeness	50-75%
Preservation	good
Biological Sex	male
Age-at-death	18-31 years
Age category	18-34 years (young adult)
Stature	170.9 ± 4.528 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	partial ankylosis of L sacroiliac joint L femur: shaft expansion (likely infectious)

Burial IV_605

Burial type	pit burial
Burial category	normative
Completeness	0-25% (cranium only)
Preservation	good
Biological Sex	indeterminate
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	cranium: single fracture
Additional	ectocranial porosity with increased thickness (possible porotic hyperostosis) healed endocranial NBF

Burial IV_617

Burial type	pit burial
Burial category	mass burial 5
Completeness	25-50%
Preservation	good
Biological Sex	possible male
Age-at-death	17-23 years
Age category	18-34 years (young adult)
Stature	n/a
CO	absent
DEH	n/a
Dental disease	

caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	---

Burial IV_619

Burial type	pit burial
Burial category	mass burial 2
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	21-27 years
Age category	18-34 years (young adult)
Stature	160.97 ±4.607
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	n/a
VJD	present
AM Trauma	cranium: single fracture L5: spondylolysis
Additional	partial ankylosis of R sacroiliac joint

Burial IV_620

Burial type	pit burial
Burial category	mass burial 2
Completeness	75-100%
Preservation	fair
Biological Sex	possible male
Age-at-death	21-29 years
Age category	18-34 years (adult)
Stature	153.81 ± 5.172 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	cranium: multiple fractures
Additional	healed maxillary sinusitis

Burial IV_625

Burial type	pit burial
Burial category	normative
Completeness	75-100%
Preservation	excellent
Biological Sex	possible male
Age-at-death	26-47 years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	absent
VJD	present
AM Trauma	absent
Additional	R shoulder: joint disease R tibia: healed PNBF affecting only distal third

Burial IV_628

Burial type	pit burial
Burial category	mass burial 5
Completeness	25-50%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	ectocranial porosity with slight expansion (possible porotic hyperostosis)

Burial IV_629

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	fair
Biological Sex	possible female
Age-at-death	21-29 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	n/a

Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	present
AM Trauma	L ulna (‘parry’ fracture)
Additional	---

Burial IV_636

Burial type	pit burial
Burial category	mass burial 5
Completeness	0-25%
Preservation	good
Biological Sex	indeterminate
Age-at-death	19-28 years
Age category	18-34 years (young adult)
Stature	154.17 ± 4.933 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_637

Burial type	pit burial
Burial category	mass burial 2
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	21-44 years
Age category	35-49 years (middle adult)
Stature	164.02 ± 4.607 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	L radius L4-5: spondylolysis R ischium
Additional	square indentation in the orbital roof

Burial IV_640

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible female
Age-at-death	21-29 years
Age category	18-34 years (young adult)
Stature	149.99 ± 5.12 cm
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	n/a

Burial IV_642

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	good
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_645

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	poor
Biological Sex	male
Age-at-death	23-38 years
Age category	18-34 years (young adult)
Stature	162.55 ± 4.781 cm
CO	n/a

DEH	absent
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial IV_646

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	21-35 years
Age category	18-34 years (young adult)
Stature	170.68 ± 4.607 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	C6
Additional	---

Burial IV_647

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	24-39 years
Age category	18-34 years (young adult)
Stature	153.39 ± 4.6 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	L ribs: 2 fractures
Additional	---

Burial IV_650

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	absent
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_651

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_654

Burial type	pit burial
Burial category	mass burial 3
Completeness	0-25%
Preservation	poor
Biological Sex	indeterminate
Age-at-death	23-35 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a

Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	absent
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_656

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	possible female
Age-at-death	18-25 years
Age category	18-34 years (young adult)
Stature	150.97 ± 4.6 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	absent
VJD	present
AM Trauma	absent
Additional	active new bone formation on long bones

Burial IV_669

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	ambiguous
Age-at-death	27+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	absent
VJD	present
AM Trauma	absent
Additional	joint disease (OA) in L elbow, R hip, R foot

Burial IV_674

Burial type	pit burial

Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	35-78 years
Age category	18+ years (adult)
Stature	169.8 ± 4.781 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	absent
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture
	L rib: single fracture
Additional	---

Burial IV_675

Burial type	pit burial
Burial category	non-normative single burial
Completeness	25-50%
Preservation	good
Biological Sex	male
Age-at-death	17-20 years
Age category	18-34 years (young adult)
Stature	167.43 ± 4.528 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	absent
AM Trauma	R femur
Additional	---

Burial IV_677

Burial type	pit burial
Burial category	mass burial X
Completeness	25-50%
Preservation	good
Biological Sex	possible male
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	168.79 ± 4.754 cm
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a

Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	absent
VJD	n/a
AM Trauma	absent
Additional	---

Burial IV_684

Burial type	pit grave lined by mud plaster
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	35+ years
Age category	18+ years (adult)
Stature	153.91 ± 4.414 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	R ribs: single fracture
Additional	L tibia/fibula: infection

Burial IV_692

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	17-22 years
Age category	18-34 years (young adult)
Stature	153.98 ± 5.65 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	R ulna (‘parry’ fracture)
	T vertebrae: 1 body
	L vertebrae: 3 bodies
Additional	L femur: shaft expansion (infection/greenstick fracture?)

Burial IV_694

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	21-36 years
Age category	18-34 years (young adult)
Stature	168.31 ± 4.607 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial IV_700

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	ambiguous
Age-at-death	34+ years
Age category	18+ years (adult)
Stature	176.71 ± 4.362 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture R scapula L ribs: 4 fractures R ribs: 3 fractures
Additional	---

Burial IV_701

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	indeterminate
Age-at-death	12-15 years (F)/14-17 years (M)
Age category	12-17 years (adolescent)
Stature	n/a
CO	n/a
DEH	n/a

Dental disease	
caries	n/a
AM tooth loss	absent
Periodontal disease	n/a
Periapical lesions	absent
PNBF (tibia)	absent
VJD	n/a
AM Trauma	L5: spondylolysis R metatarsal 1
Additional	severely stunted growth flared radial epiphyses bowing and torsion of femora and R tibia trabecular bone formation affecting humeri (medullary cavity)

Burial IV_703

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	possible male
Age-at-death	30-60 years
Age category	35-49 years (middle adult)
Stature	165.73 ± 5.65 cm
CO	absent
DEH	absent
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	cranium: single fracture L ribs: 2 fractures
Additional	slight joint disease in shoulder and hip joints

Burial IV_710

Burial type	pit grave covered by slabs
Burial category	normative burial
Completeness	75-100%
Preservation	excellent
Biological Sex	indeterminate
Age-at-death	14-16 years
Age category	12-17 years (adolescent)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent

Additional	---

Burial IV_727

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	18-35 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	present
AM Trauma	R ribs: single fracture
Additional	---

Burial IV_728

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible female
Age-at-death	18-21 years
Age category	18-34 years (young adult)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_732

Burial type	wooden coffin
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	indeterminate (molecular sex: male)
Age-at-death	6-8 years

Age category	7-11 years (child II)
Stature	n/a
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	absent
VJD	n/a
AM Trauma	absent
Additional	nutritional stress, reduced skeletal growth

Burial IV_733

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible male
Age-at-death	21-35 years
Age category	18-34 years (young adult)
Stature	150.46 ± 4.607 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture R foot phalanx
Additional	L tibia: perimortem cut

Burial IV_734

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	possible female
Age-at-death	21-29 years
Age category	18-34 years (young adult)
Stature	152.48 ± 3.892 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	absent
AM Trauma	R metacarpal 3

	L vertebrae: 1 body fracture, 1 spondylolysis sacrum
Additional	---

Burial IV_743

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	fair
Biological Sex	female
Age-at-death	21-59 years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	maxillary sinusitis

Burial IV_754

Burial type	pit burial
Burial category	non-normative single burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	17-20 years
Age category	18-34 years (young adult)
Stature	171.88 ± 4.446 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IV_758

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good

Biological Sex	male
Age-at-death	21-44 years
Age category	35-49 years (middle adult)
Stature	165.66 ± 4.446 cm
CO	present
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	sternum
Additional	joint disease affecting shoulder joints

Burial IV_773

Burial type	jar burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	21-29 years
Age category	18-34 years (young adult)
Stature	158.82 ± 4.526 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	absent
VJD	present
AM Trauma	cranium: single fracture
Additional	maxillary sinusitis

Burial IV_776

Burial type	pit grave covered by slabs
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	female
Age-at-death	24-47 years
Age category	18-34 years (young adult)
Stature	153.68 ± 3.816 cm
CO	absent
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present

AM Trauma	cranium: single fracture
Additional	---

Burial IV_777

Burial type	pit grave covered by slabs
Burial category	normative burial
Completeness	50-75%
Preservation	fair
Biological Sex	possible female
Age-at-death	21+ years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	R radius (impacted fracture) T vertebrae: body fractures
Additional	---

Burial IV_779

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	27-61 years
Age category	18+ years (adult)
Stature	n/a
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	cranium: single fracture (nasal fracture) hand: 3 phalanges L ribs: 2 fractures L vertebrae: spondylolysis
Additional	sternum lesion

Burial IV_782

Burial type	pit burial

Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible female
Age-at-death	21-36 years
Age category	18-34 years (young adult)
Stature	148.155 ± 3.816 cm
CO	absent
DEH	present
Dental disease	
caries	present
AM tooth loss	present
Periodontal disease	present
Periapical lesions	present
PNBF (tibia)	present
VJD	present
AM Trauma	L clavicle
	R rib: single fracture
Additional	sinusitis
	active PNBF on long bones (systemic infectious process)

Burial IV_783

Burial type	pit burial
Burial category	normative burial
Completeness	75-100%
Preservation	good
Biological Sex	possible female
Age-at-death	18-22 years
Age category	18-34 years (young adult)
Stature	158.05 ± 3.761 cm
CO	n/a
DEH	present
Dental disease	
caries	present
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	---

Burial IV_788

Burial type	pit burial
Burial category	normative burial
Completeness	50-75%
Preservation	good
Biological Sex	possible female
Age-at-death	19-32 years
Age category	18-34 years (young adult)
Stature	148.43 ± 3.761 cm
CO	n/a
DEH	absent
Dental disease	
caries	present

AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	present
AM Trauma	absent
Additional	partial sacralisation of L5

Burial IX_818

Burial type	pit burial
Burial category	mass burial Y
Completeness	25-50%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	14-17 years
Age category	12-17 years (adolescent)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	n/a
AM Trauma	L foot phalanx
Additional	L scapula: lytic lesion

Burial IX_826

Burial type	pit burial
Burial category	mass burial Y
Completeness	75-100%
Preservation	good
Biological Sex	male
Age-at-death	20-26 years
Age category	18-34 years (young adult)
Stature	159.73 ± 5.172 cm
CO	absent
DEH	n/a
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	absent
VJD	absent
AM Trauma	cranium: single fracture L rib: single fracture
Additional	mixed PNBF on long bones

Burial IX_827

Burial type	pit burial
Burial category	mass burial Y
Completeness	75-100%

Preservation	poor
Biological Sex	possible male
Age-at-death	16-29 years
Age category	18-34 years (young adult)
Stature	n/a
CO	n/a
DEH	present
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	present
VJD	absent
AM Trauma	absent
Additional	---

Burial IX_829

Burial type	pit burial
Burial category	non-normative single burial
Completeness	25-50%
Preservation	fair
Biological Sex	male
Age-at-death	17-29 years
Age category	18-34 years (young adult)
Stature	n/a
CO	present
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	present
Periapical lesions	absent
PNBF (tibia)	n/a
VJD	present
AM Trauma	absent
Additional	

Burial IX_856

Burial type	pit burial
Burial category	mass burial Y
Completeness	50-75%
Preservation	fair
Biological Sex	indeterminate
Age-at-death	12-16 years
Age category	12-17 years (adolescent)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	absent
Periapical lesions	absent
PNBF (tibia)	absent
VJD	n/a
AM Trauma	C2 (dens)
Additional	---

Burial IX_871

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	good
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	n/a
Dental disease	
caries	n/a
AM tooth loss	n/a
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	present
VJD	n/a
AM Trauma	absent
Additional	---

Burial IX_872

Burial type	pit burial
Burial category	normative burial
Completeness	0-25%
Preservation	excellent
Biological Sex	indeterminate
Age-at-death	18+ years
Age category	18+ years (adult)
Stature	n/a
CO	n/a
DEH	absent
Dental disease	
caries	absent
AM tooth loss	absent
Periodontal disease	n/a
Periapical lesions	n/a
PNBF (tibia)	n/a
VJD	n/a
AM Trauma	absent
Additional	---

Bibliography

Agarwal, K. N., Har, N. D. and Shah, M. M. (1970). Roentgenologic changes in iron deficiency anaemia. *American Journal of Roentgenology,* 110**,** 635-637.

Agarwal, S. C. (2016). Bone morphologies and histories: Life course approaches in bioarchaeology. *American Journal of Physical Anthropology,* 159**,** 130-149. https://doi.org/10.1002/ajpa.22905

Agarwal, S. C. and Wesp, J. K. (eds.) (2017). *Exploring sex and gender in bioarchaeology.* Albuquerque: University of New Mexico Press.

Ajwani, S., Mattila, K., Narhi, T., Tilvis, R. and Ainamo, A. (2003). Oral health status, C-reactive protein and mortality–a 10 year follow-up study. *Gerodontology,* 20**,** 32-40. https://doi.org/10.1111/j.1741-2358.2003.00032.x

Albanese, J., Tuck, A., Gomes, J. and Cardoso, H. F. V. (2016). An alternative approach for estimating stature from long bones that is not population- or group-specific. *Forensic Science International,* 259**,** 59-68. https://doi.org/10.1016/j.forsciint.2015.12.011

Alcock, S. E. and Osborne, R. (eds.) (2012). *Classical archaeology.* Chichester, West Sussex: Wiley-Blackwell.

Alexandridou, A. (2015). Shedding light on mortuary practices in early Archaic Attica: The case of the offering trenches. *In:* Antonaccio, C. M. and Haggis, D. C. (eds.) *Classical archaeology in context. Theory and practice in excavation in the Greek world.* Berlin, München, Boston: De Gruyter, 121-148. https://doi.org/10.1515/9781934078471-009

Alexandridou, A. (2016). Funerary variability in late eighth-century BCE Attica (Late Geometric II). *American Journal of Archaeology,* 120**,** 333-360.

Alexandridou, A. (2020). Funerary variability in Late Geometric Attica & its implications. A closer look at the neglected late 8th-century cremations. *In:* Dimakis, N. and Dijkstra, T. M. (eds.) *Mortuary variability and social diversity in ancient Greece.* Oxford: Archaeopress, 32-49.

Alexandropoulou, A. (2019). Die Kindergräber in Phaleron (Attika). *In:* Frielinghaus, H., Stroszeck, J. and Valavanis, P. (eds.) *Griechische Nekropolen: Neue Forschungen und Funde.* Möhnesee, Germany: Bibliopolis, 261-285.

Alghnam, S., Tinkoff, G. H. and Castillo, R. (2016). Longitudinal assessment of injury recidivism among adults in the United States: Findings from a population-based sample. *Injury Epidemiology,* 3. https://doi.org/10.1186/s40621-016-0071-x

AlQahtani, S. J., Hector, M. P. and Liversidge, H. M. (2010). Brief communication: The London Atlas of human tooth development and eruption. *American Journal of Physical Anthropology,* 142**,** 481-490. https://doi.org/10.1002/ajpa.21258

Anderson, G. (2003). *The Athenian experiment: Building an imagined political community in ancient Attica, 508-490 BC.* Ann Arbor: The University of Michigan Press.

Anderson, G. (2005). Before turannoi were tyrants: Rethinking a chapter of early Greek history. *Classical Antiquity,* 24**,** 173-222. https://doi.org/10.1525/ca.2005.24.2.173

Andrewes, A. (1956). *The Greek tyrants.* Hutchinson University Library.

Angel, J. L. (1946). Social biology of Greek culture growth. *American Anthropologist,* 48**,** 493-533.

Angel, J. L. (1964). Osteoporosis: Thalassemia? *American Journal of Physical Anthropology,* 22**,** 369-373. https://doi.org/10.1002/ajpa.1330220342

Angel, J. L. (1966). Porotic hyperostosis, anemias, malarias, and marshes in the prehistoric eastern Mediterranean. *Science,* 153**,** 760-763.

Angel, J. L. (1967). Porotic hyperostosis or osteoporosis symmetrica. *In:* Brothwell, D. and Sandison, A. T. (eds.) *Diseases in antiquity. A survey of diseases, injuries and surgery of early populations.* Springfield, Illinois: Charles C Thomas, 378-389.

Angel, J. L. (1969). Paleodemography and evolution. *American Journal of Physical Anthropology,* 31**,** 343-353. https://doi.org/10.1002/ajpa.1330310310

Angel, J. L. (1972). Ecology and population in the Eastern Mediterranean. *World Archaeology,* 4**,** 88-105. https://doi.org/10.1080/00438243.1972.9979522

Angel, J. L. (1978). Porotic hyperostosis in the Eastern Mediterranean. *Medical College of Virginia Quarterly,* 14**,** 10-16.

Angel, J. L., Kelley, J. O., Parrington, M. and Pinter, S. (1987). Life stresses of the free black community as represented by the First African Baptist Church, Philadelphia, 1823–1841. *American Journal of Physical Anthropology,* 74**,** 213-229. https://doi.org/10.1002/ajpa.1330740209

Ansell, D. A. (2017). *The death gap: How inequality kills.* Chicago: University of Chicago Press. https://doi.org/10.7208/9780226428291

Arcella, D., Ottolenghi, L., Polimeni, A. and Leclercq, C. (2002). The relationship between frequency of carbohydrates intake and dental caries: A cross-sectional study in Italian teenagers. *Public Health Nutrition,* 5**,** 553-560. https://doi.org/10.1079/PHN2001319

Arden, N. and Nevitt, M. C. (2006). Osteoarthritis: Epidemiology. *Best Practice & Research Clinical Rheumatology,* 20**,** 3-25. https://doi.org/10.1016/j.berh.2005.09.007

Armelagos, G. J., Goodman, A. H., Harper, K. N. and Blakey, M. L. (2009). Enamel hypoplasia and early mortality: Bioarchaeological support for the Barker Hypothesis. *Evolutionary Anthropology,* 18**,** 261-271. https://doi.org/10.1002/evan.20239

Arrington, N. T. (2021). *Athens at the margins. Pottery and people in the early Mediterranean world.* Princeton: Princeton University Press. https://doi.org/doi:10.1515/9780691222660

Arrington, N. T., Spyropoulos, G. and Brellas, D. J. (2021). Glimpses of the invisible dead: A 7th-century B.C. burial plot in northern Piraeus. *Hesperia,* 90, 233-279. https://doi.org/10.2972/hesperia.90.2.0233.

Aspöck, E. (2008). What actually is a deviant burial? Comparing German-language and Anglophone research on deviant burials. *In:* Murphy, E. M. (ed.) *Deviant burial in the archaeological record.* Oxford: Oxbow Books, 17-34.

Aufderheide, A. C. and Rodriguez-Martin, C. (1998). *The Cambridge encyclopedia of human paleopathology.* Cambridge: Cambridge University Press.

Barker, D. J. P. (2007). The origins of the developmental origins theory. *Journal of Internal Medicine,* 261, 412-417. https://doi.org/10.1111/j.1365-2796.2007.01809.x

Barker, D. J. P., Godfrey, K. M., Fall, C., Osmond, C., Winter, P. D. and Shaheen, S. O. (1991). Relation of birth weight and childhood respiratory infection to adult lung function and death from chronic obstructive airways disease. *British Medical Journal,* 303, 671-675. https://doi.org/10.1136/bmj.303.6804.671

Barker, D. J. P. and Osmond, C. (1986). Childhood respiratory infection and adult chronic bronchitis in England and Wales. *British Medical Journal,* 293, 1271-5. https://doi.org/10.1136/bmj.293.6557.1271

Becker, B. and Kromer, B. (1993). The continental tree-ring record — absolute chronology, 14C calibration and climatic change at 11 ka. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 103, 67-71. https://doi.org/https://doi.org/10.1016/0031-0182(93)90052-K

Bérard, R.-M. and Castex, D. (2021). Epidemics and wars: Comparative archaeology and anthropology of ancient Greek mass burials. *Athens Journal of History,* 7, 295-318. https://doi.org/10.30958/ajhis.X-Y-Z

Berrizbeitia, E. L. (1989). Sex determination with the head of the radius. *Journal of Forensic Science,* 34, 1206-1213. https://doi.org/10.1520/JFS12754J

Berryman, H. E. and Haun, S. J. (1996). Applying forensic techniques to interpret cranial fracture patterns in an archaeological specimen. *International Journal of Osteoarchaeology,* 6, 2-9. https://doi.org/10.1002/(SICI)1099-1212(199601)6:1<2::AID-OA244>3.0.CO;2-R

Betsinger, T. K. (2023). Trauma and violence in medieval Poland: An intersectional analysis. *Bioarchaeology International,* 7, 265-281. https://doi.org/10.5744/bi.2023.0007

Betsinger, T. K., Scott, A. B. and Tsaliki, A. (2020). *The odd, the unusual, and the strange. Bioarchaeological explorations of atypical burials.* Gainesville: University of Florida Press.

Biehler-Gomez, L., Moro, C., Mattia, M., Mazzarelli, D., Cappella, A., del Bo, B., Fedeli, A. M. and Cattaneo, C. (2023). Multiple injuries and injury recidivism in Milan over 2,000 years. *Journal of Archaeological Science: Reports*, 49**,** 103945. https://doi.org/10.1016/j.jasrep.2023.103945

Binford, L. R. (1962). Archaeology as anthropology. *American Antiquity*, 28**,** 217-225.

Binford, L. R. (1971). Mortuary practices: Their study and their potential. *Memoirs of the Society for American Archaeology*, 25**,** 6-29. https://doi.org/10.1017/S0081130000002525

Binford, L. R. (1972). An archaeological perspective. *In:* Binford, S. R. and Binford, L. R. (eds.) *Archeology in Cultural Systems*. Abingdon, Oxon: Routledge, 5-28. https://doi.org/10.4324/9781315082165

Blackwell, D. L., Hayward, M. D. and Crimmins, E. M. (2001). Does childhood health affect chronic morbidity in later life? *Social Science & Medicine*, 52**,** 1269-1284. https://doi.org/10.1016/S0277-9536(00)00230-6

Blakey, M. L. (2001). Bioarchaeology of the African diaspora in the Americas: Its origins and scope. *Annual review of Anthropology*, 30**,** 387-422. https://doi.org/10.1146/annurev.anthro.30.1.387

Blakey, M. L. and Rankin-Hill, L. M. (eds.) (2009). *The New York African burial ground: Unearthing the African presence in colonial New York*. Washington DC: Howard University Press.

Blok, J. and Lardinois, A. (2006). *Solon of Athens: New historical and philological approaches*. Leiden: Brill. https://doi.org/10.1163/9789047408895

Boldsen, J. L. (2007). Early childhood stress and adult age mortality. A study of dental enamel hypoplasia in the medieval Danish village of Tirup. *American Journal of Physical Anthropology*, 132**,** 59-66. https://doi.org/10.1002/ajpa.20467

Boldsen, J. L., Milner, G. R., Konigsberg, L. W. and Wood, J. W. (2002). Transition analysis: A new method for estimating age from skeletons. *In:* Hoppa, R. D. and Vaupel, J. W. (eds.) *Paleodemography. Age distributions from skeletal samples*. Cambridge: Cambridge University Press, 73-106.

Boldsen, J. L., Milner, G. R. and Weise, S. (2015). Cranial vault trauma and selective mortality in medieval to early modern Denmark. *Proceedings of the National Academy of Sciences*, 112**,** 1721-1726. https://doi.org/10.1073/pnas.1412511112

Boulding, K. E. (1977). Twelve friendly quarrels with Johan Galtung. *Journal of Peace Research*, 14**,** 75-86. https://doi.org/10.1177/002234337701400105

Bourbou, C. (2005). Biological status in Hellenistic and Roman elites in western Crete (Greece). *Eres. Arqueología/Bioantropología***,** 87-110.

Bourbou, C. (2009). Patterns of trauma in a medieval urban population (11th century A. D.) from central Crete. *Hesperia Supplements,* 43**,** 111-120.

Bourbou, C. (2010). *Health and Disease in Byzantine Crete (7th–12th centuries AD).* London: Routledge.

Bourbou, C. (2014). Evidence of childhood scurvy in a Middle Byzantine Greek population from Crete, Greece (11th–12th centuries A.D.). *International Journal of Paleopathology,* 5**,** 86-94. https://doi.org/10.1016/j.ijpp.2013.12.002

Bourbou, C., Fuller, B. T., Garvie-Lok, S. J. and Richards, M. P. (2013). Nursing mothers and feeding bottles: Reconstructing breastfeeding and weaning patterns in Greek Byzantine populations (6th–15th centuries AD) using carbon and nitrogen stable isotope ratios. *Journal of Archaeological Science,* 40**,** 3903-3913. https://doi.org/10.1016/j.jas.2013.04.020

Bourbou, C., Fuller, B. T., Garvie-Lok, S. J. and Richards, M. P. (2011). Reconstructing the diets of Greek Byzantine populations (6th–15th centuries AD) using carbon and nitrogen stable isotope ratios. *American Journal of Physical Anthropology,* 146**,** 569-581. https://doi.org/10.1002/ajpa.21601

Bourbou, C. and Richards, M. P. (2007). The Middle Byzantine menu: Palaeodietary information from isotopic analysis of humans and fauna from Kastella, Crete. *International Journal of Osteoarchaeology,* 17**,** 63-72. https://doi.org/10.1002/oa.855

Bourgois, P. (2009). Recognizing invisible violence: A thirty-year ethnographic retrospective. *In:* Rylko-Bauer, B., Whiteford, L. and Farmer, P. (eds.) *Global health in times of violence.* Santa Fe, NM: School for Advanced Research Press, 18-40.

Bouwman, A. S., Brown, K. A., Brown, T. A., Chilvers, E. R., Arnott, R. and Prag, A. (2009). Kinship in Aegean prehistory? Ancient DNA in human bones from mainland Greece and Crete. *The Annual of the British School at Athens,* 104**,** 293-309. https://doi.org/10.1017/S0068245400000265

Bradley, K. R. and Cartledge, P. (eds.) (2011). *The Cambridge world history of slavery. Volume 1. The ancient Mediterranean world.* Cambridge: Cambridge University Press.

Braund, D. (2011). The slave supply in classical Greece. *In:* Bradley, K. and Cartledge, P. (eds.) *The Cambridge world history of slavery. Volume 1. The ancient Mediterranean world.* Cambridge: Cambridge University Press, 112-133. https://doi.org/10.1017/CHOL9780521840668.008

Brickley, M. (2006). Rib fractures in the archaeological record: A useful source of sociocultural information? *International Journal of Osteoarchaeology,* 16**,** 61-75. https://doi.org/10.1002/oa.809

Brickley, M. (2018). Cribra orbitalia and porotic hyperostosis: A biological approach to diagnosis. *American Journal of Physical Anthropology,* 167**,** 896-902. https://doi.org/10.1002/ajpa.23701

Brickley, M. and Buckberry, J. (2017). Undertaking sex assessment. *In:* Mitchell, P. D. and Brickley, M. (eds.) *Updated guidelines to the standards for recording human remains.* 33-34.

Brickley, M. and McKinley, J. (2004). Guidelines to the standards for recording human remains. Department of Archaeology, University of Southampton.

Bridges, P. S. (1992). Prehistoric arthritis in the Americas. *Annual Review of Anthropology,* 21**,** 67-91. https://doi.org/10.1146/annurev.an.21.100192.000435

Bridges, P. S. (1994). Vertebral arthritis and physical activities in the prehistoric southeastern United States. *American Journal of Physical Anthropology,* 93**,** 83-93. https://doi.org/10.1002/ajpa.1330930106

Bright, L. N. (2021). Structural violence. *In:* Cheverko, C. M., Prince-Buitenhuys, J. and Hubbe, M. (eds.) *Theoretical Approaches in Bioarchaeology.* London: Routlegde, 131-149.

Brink, O., Vesterby, A. and Jensen, J. (1998). Pattern of injuries due to interpersonal violence. *Injury,* 29**,** 705-709. https://doi.org/10.1016/S0020-1383(98)00176-4

Brooks, S. and Suchey, J. M. (1990). Skeletal age determination based on the os pubis: A comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods. *Human Evolution,* 5**,** 227-238. https://doi.org/10.1007/BF02437238

Brothwell, D. R. (1981). *Digging up bones: The excavation, treatment, and study of human skeletal remains.* Ithaca, NY: Cornell University Press.

Brown, T. A., Brown, K. A., Flaherty, C. E., Little, L. M. and Prag, A. (2000). DNA analysis of bones from Grave Circle B at Mycenae: A first report. *The Annual of the British School at Athens,* 95**,** 115-119. https://doi.org/10.1017/S0068245400004603

Budd, P., Montgomery, J., Evans, J. and Barreiro, B. (2000). Human tooth enamel as a record of the comparative lead exposure of prehistoric and modern people. *Science of The Total Environment,* 263**,** 1-10. https://doi.org/10.1016/S0048-9697(00)00604-5

Buikstra, J. E. (1977). Biocultural dimensions of archaeological study: A regional perspective. *In:* Blakely, R. L. (ed.) *Biocultural adaptation in prehistoric America.* University of Georgia Press, 67-84.

Buikstra, J. E. (2006). A historical introduction. *In:* Buikstra, J. E. and Beck, L. A. (eds.) *Bioarchaeology: The contextual analysis of human remains.* Burlington: Academic Press, 7–25. https://doi.org/10.4324/ 9781315432939.

Buikstra, J. E. (2018). Angel, John Lawrence. *In:* Trevathan, W., Cartmill, M., Dufour, D., Larsen, C. S., O'Rourke, D., Rosenberg, K. and Strier, K. (eds.) *The international encyclopedia of biological anthropology.* https://doi.org/10.1002/9781118584538.ieba0024

Buikstra, J. E. (2023). Inferring ancient human activities through skeletal study: An example from Archaic Greece. *In:* Karakostis, F. A. and Jäger, G. (eds.) *Biocultural Evolution: An Agenda for Integrative Approaches.* Tübingen: Kerns Verlag, 25-54.

Buikstra, J. E., Cerezo-Román, J., Cheever, S., Cormier, A., Hannigan, E., Hayes, L., Liedl, H., Rothwell, J. E. and Velegraki, M. (n.d.). Bioarchaeology. *The Phaleron Burial Ground, Sectors IV MOB36/37.* The American School of Classical Studies at Athens.

Buikstra, J. E., Cormier, A., Hannigan, E., Hayes, L., Hotaling, J., Liedl, H., Siek, T. J. and Widrick, K. (2024). The poetics of violence at Phaleron. *In:* Campbell, R. A. and Osterholtz, A. J. (eds.) *The poetics of violence in Afroeurasian bioarchaeology*. Springer, 157-186.

Buikstra, J. E., DeWitte, S. N., Agarwal, S. C., Baker, B. J., Bartelink, E. J., Berger, E., Blevins, K. E., Bolhofner, K., Boutin, A. T., Brickley, M. B., Buzon, M. R., de la Cova, C., Goldstein, L., Gowland, R., Grauer, A. L., Gregoricka, L. A., Halcrow, S. E., Hall, S. A., Hillson, S., Kakaliouras, A. M., Klaus, H. D., Knudson, K. J., Knüsel, C. J., Larsen, C. S., Martin, D. L., Milner, G. R., Novak, M., Nystrom, K. C., Pacheco-Forés, S. I., Prowse, T. L., Robbins Schug, G., Roberts, C. A., Rothwell, J. E., Santos, A. L., Stojanowski, C., Stone, A. C., Stull, K. E., Temple, D. H., Torres, C. M., Toyne, J. M., Tung, T. A., Ullinger, J., Wiltschke-Schrotta, K. and Zakrzewski, S. R. (2022). Twenty-first century bioarchaeology: Taking stock and moving forward. *American Journal of Biological Anthropology*, 178**,** 54-114. https://doi.org/10.1002/ajpa.24494

Buikstra, J. E. and Lagia, A. (2009). Bioarchaeological approaches to Aegean archaeology. *Hesperia Supplements*, 43**,** 7-29.

Buikstra, J. E. and Prevedorou, E. (2012). John Lawrence Angel (1915-1986). *In:* Buikstra, J. E. and Roberts, C. A. (eds.) *The global history of palaepathology. Pioneers and prospects.* Oxford: Oxford University Press, 3-13.

Buikstra, J. E. and Roberts, C. A. (2012). *The global history of paleopathology: Pioneers and prospects.* Oxford: Oxford University Press.

Buikstra, J. E. and Ubelaker, D. H. (1994). Standards for data collection from human skeletal remains. Arkansas archaeological survey. *Research Series*.

Camp, J. M. (1977). *The water supply of ancient Athens from 3000 to 86 BC.* PhD, Princeton University.

Camp, J. M. (1979). A drought in the late eighth century BC. *Hesperia*, 48**,** 397-411. https://doi.org/10.2307/147843

Camp, J. M. (2001). *The archaeology of Athens.* New Haven, London: Yale University Press.

Carpenter, C. R., Avidan, M. S., Wildes, T., Stark, S., Fowler, S. A. and Lo, A. X. (2014). Predicting geriatric falls following an episode of emergency department care: A systematic review. *Academic Emergency Medicine*, 21**,** 1069-1082. https://doi.org/10.1111/acem.12488

Caruso, A. and Nikita, E. (2024). Dental diseases and dental wear as a proxy for dietary patterns in Hellenistic-early Roman Menainon, Sicily. *International Journal of Paleopathology,* 44**,** 10-19. https://doi.org/10.1016/j.ijpp.2023.11.002

Cavanagh, W. G. (1977). *Attic Burial Customs, c. 2000-700 B.C.* PhD, University of London.

Cecconi, M., Evans, L., Levy, M. and Rhodes, A. (2018). Sepsis and septic shock. *The Lancet,* 392**,** 75-87. https://doi.org/10.1016/S0140-6736(18)30696-2

Chapman, J. (2010). 'Deviant' burials in the neolithic and chalcolithic of central and south eastern Europe. *In:* Rebay-Salisbury, K., Sørensen, M. and Hughes, J. (eds.) *Body parts and bodies whole. Changing relations and meanings.* Oxford: Oxbow Books, 30-45.

Charalambidou, X. and Morgan, C. (2017). Introduction: Interpreting the seventh century BC. . *In:* Charalambidou, X. and Morgan, C. (eds.) *Interpreting the Seventh Century BC : Tradition and Innovation.* Oxford: Archaeopress, 1-8.

Cheverko, C. M. (2021). Life course approaches and life history theory. *In:* Cheverko, C. M., Prince-Buitenhuys, J. and Hubbe, M. (eds.) *Theoretical Approaches in Bioarchaeology.* London: Routlegde, 59-75.

Chilvers, E. R., Bouwman, A. S., Brown, K. A., Arnott, R. G., Prag, A. J. N. and Brown, T. A. (2008). Ancient DNA in human bones from Neolithic and Bronze Age sites in Greece and Crete. *Journal of Archaeological Science,* 35**,** 2707-2714. https://doi.org/10.1016/j.jas.2008.04.019

Chryssoulaki, S. (2020). The excavations at Phaleron cemetery 2012–2017: An introduction. *In:* Graml, C., Doronzio, A. and Capozzoli, V. (eds.) *Rethinking Athens. Interdisciplinary approaches to the polis before the Persian wars.* Munich, 103-114.

Chryssoulaki, S., Aggouras, T. and Pappas, I. (2023). Comportements et émotions face à la mort. Étude de cas: Le cimetière du Phalère. *In:* Patera, M., Stavros, P. and Wallensten, J. (eds.) *La peur chez les Grecs. Usages et représentations de l'Antiquité à l'ére chrétienne.* Rennes: Presses universitaires de Rennes, 155-170.

Chryssoulaki, S. and Pappas, I. (2023). '… For at this place the sea comes nearest to Athens.' Funerary processions in Archaic Athens. *In:* Weingarten, J., Macdonald, C. F., Aruz, J., Fabian, L. and Kumar, N. (eds.) *Processions. Studies of Bronze Age ritual and ceremony presented to Robert B. Koehl.* Oxford: Archaeopress, 239-249.

Clerehugh, V., Tugnait, A. and Genco, R. J. (2013). *Periodontology at a glance.* Chichester: John Wiley & Sons.

Cochran, D. L. (2008). Inflammation and bone loss in periodontal disease. *Journal of Periodontology,* 79**,** 1569-1576. https://doi.org/10.1902/jop.2008.080233

Cohen, M. N. (1998). The emergence of health and social inequalities in the archeological record. *In:* Strickland, S. S. and Shetty, P. S. (eds.) *Human biology and social inequality. Society for the Study of Human Biology symposium.* Cambridge University Press, 249-271.

Coldstream, J. N. (2004). *Geometric Greece: 900–700 BC.* London, New York: Routledge. https://doi.org/10.4324/9780203425763

Cole, G. and Waldron, T. (2019). Cribra orbitalia: Dissecting an ill-defined phenomenon. *International Journal of Osteoarchaeology,* 29**,** 613-621. https://doi.org/https://doi.org/10.1002/oa.2757

Cook, D. C. (2012). Neglected ancestors: Robert Wilson Shufeldt, MD (1850–1934). *In:* Buikstra, J. and Roberts, C. (eds.) *The global history of paleopathology: Pioneers and prospects.* Oxford: Oxford University Press, 192-196. https://doi.org/10.1093/acprof:osobl/9780195389807.003.0029

Corruccini, R. S., Handler, J. S., Mutaw, R. J. and Lange, F. W. (1982). Osteology of a slave burial population from Barbados, West Indies. *American Journal of Physical Anthropology,* 59**,** 443-459. https://doi.org/10.1002/ajpa.1330590414

Corti, M. C. and Rigon, C. (2003). Epidemiology of osteoarthritis: Prevalence, risk factors and functional impact. *Aging Clinical and Experimental Research,* 15**,** 359-363. https://doi.org/10.1007/BF03327356

Costaki, L. and Theocharaki, A. M. (2021). City streets, walls, and gates. *In:* Neils, J. and Rogers, D. K. (eds.) *The Cambridge companion to ancient Athens.* Cambridge: Cambridge University Press, 47-62. https://doi.org/10.1017/9781108614054.005

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimination doctrine, feminist theory and antiracist politics. *University of Chicago Legal Forum,* 8**,** 139–167.

Crenshaw, K. (1991). Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review,* 43**,** 1241-1299. https://doi.org/10.2307/1229039

D'Onofrio, A. M., Charalambidou, X. and Morgan, C. (2017). Athenian burial practices and cultural change: The Rundbau early plot in the Kerameikos cemetery revisited. *In:* Charalambidou, X. and Morgan, C. (eds.) *Interpreting the seventh century BC: tradition and innovation.* Oxford: Archaeopress, 260-280.

D'Agostino, B. and D'Onofrio, A. M. (1993). Review: Ian Morris, Burial and ancient society: The rise of the Greek city-State (Cambridge, 1987). *Gnomon,* 65**,** 41-51.

D'Onofrio, A. M. (1997). The 7th century BC in Attica: The basis of political organization. *In:* Andersen, H. D., Horsnaes, H. W., Houby-Nielsen, S. and Rathje, A. (eds.) *Urbanization in the Mediteranean in the 9th to the 6th centuries BC.* Copenhagen: Museum Tusculanum Press, 63-88.

Da-Gloria, P. and Larsen, C. S. (2014). Oral health of the Paleoamericans of Lagoa Santa, central Brazil. *American Journal of Physical Anthropology,* 154**,** 11-26. https://doi.org/10.1002/ajpa.22467

Darveau, R. P. (2010). Periodontitis: A polymicrobial disruption of host homeostasis. *Nature Reviews Microbiology,* 8**,** 481-490. https://doi.org/10.1038/nrmicro2337

Davies-Barrett, A. M., Antoine, D. and Roberts, C. A. (2019). Inflammatory periosteal reaction on ribs associated with lower respiratory tract disease: A method for recording prevalence from sites with differing preservation. *American Journal of Physical Anthropology,* 168**,** 530-542. https://doi.org/10.1002/ajpa.23769

Davies, J. (2021). Economic inequality and COVID-19 death rates in the first wave. A cross-Country analysis. *Canadian Public Policy,* 47**,** 537-553. https://doi.org/10.2139/ssrn.3812074

Davies, J. K. (1997). The 'origins of the Greek polis': Where should we be looking? *In:* Mitchell, L. and Rhodes, P. J. (eds.) *The development of the polis in Archaic Greece.* London: Routledge, 13-20.

Davies, J. K. (2018). State formation in Early Iron Age Greece. *In:* Duplouy, A. and Brock, R. W. (eds.) *Defining citizenship in archaic Greece.* Oxford: Oxford University Press, 51-78.

De Polignac, F. (2005). Forms and processes: Some thoughts on the meaning of urbanization in Early Archaic Greece. *In:* Osborne, R. and Cunliffe, B. (eds.) *Mediterranean urbanization 800-600 BC.* Oxford: Oxford University Press, 45-69.

Derriennic, J.-P. (1972). Theory and ideologies of violence. *Journal of Peace Research,* 9**,** 361-374. https://doi.org/10.1177/002234337200900406

DeWitte, S. N. (2009). The effect of sex on risk of mortality during the Black Death in London, A.D. 1349–1350. *American Journal of Physical Anthropology,* 139**,** 222-234. https://doi.org/10.1002/ajpa.20974

DeWitte, S. N. (2018). Stress, sex, and plague: Patterns of developmental stress and survival in pre- and post-Black Death London. *American Journal of Human Biology,* 30**,** e23073. https://doi.org/10.1002/ajhb.23073

DeWitte, S. N. and Bekvalac, J. (2010). Oral health and frailty in the medieval English cemetery of St Mary Graces. *American Journal of Physical Anthropology,* 142**,** 341-354. https://doi.org/10.1002/ajpa.21228

DeWitte, S. N. and Bekvalac, J. (2011). The association between periodontal disease and periosteal lesions in the St. Mary Graces cemetery, London, England AD 1350–1538. *American Journal of Physical Anthropology,* 146**,** 609-618. https://doi.org/10.1002/ajpa.21622

DeWitte, S. N. and Hughes-Morey, G. (2012). Stature and frailty during the Black Death: The effect of stature on risks of epidemic mortality in London, A.D. 1348–1350. *Journal of Archaeological Science,* 39**,** 1412-1419. https://doi.org/10.1016/j.jas.2012.01.019

DeWitte, S. N. and Stojanowski, C. M. (2015). The osteological paradox 20 years later: Past perspectives, future directions. *Journal of Archaeological Research,* 23**,** 397-450. https://doi.org/10.1007/s10814-015-9084-1

DeWitte, S. N. and Wissler, A. (2022). Demographic and evolutionary consequences of pandemic diseases. *Bioarchaeology International,* 6**,** 108-132. https://doi.org/10.5744/bi.2020.0024

DeWitte, S. N. and Wood, J. W. (2008). Selectivity of Black Death mortality with respect to preexisting health. *Proceedings of the National Academy of Sciences,* 105**,** 1436-1441. https://doi.org/10.1073/pnas.0705460105

DeWitte, S. N. and Yaussy, S. L. (2021). Bioarchaeological applications of intersectionality. *In:* Cheverko, C. M., Prince-Buitenhuys, J. and Hubbe, M. (eds.) *Theoretical approaches in bioarchaeology.* London: Routledge, 45-58.

Dias, G. and Tayles, N. (1997). 'Abscess cavity'—a misnomer. *International Journal of Osteoarchaeology,* 7**,** 548-554.

Dias, G. J., Prasad, K. and Santos, A. L. (2007). Pathogenesis of apical periodontal cysts: Guidelines for diagnosis in palaeopathology. *International Journal of Osteoarchaeology,* 17**,** 619-626. https://doi.org/10.1002/oa.902

Dickinson, O. T. (2019). Evidence from archaeology. *In:* Lemos, I. S. and Kotsonas, A. (eds.) *A companion to the archaeology of early Greece and the Mediterranean.* Hoboken, NJ: Wiley-Blackwell, 33-53. https://doi.org/10.1002/9781118769966.ch2

Dimitriadou, E. M. (2019). *Early Athens: Settlements and cemeteries in the Submycenaean, Geometric and Archaic periods.* Briston, CT: Cotson Institute of Archaeology Press.

Donlan, W. (1997). The relations of power in the pre-state and early state polities. *In:* Mitchell, L. and Rhodes, P. J. (eds.) *The development of the polis in Archaic Greece.* London: Routledge, 39-48.

Dorling, D. (2015). *Injustice: Why social inequality still persists.* Bristol, England: Policy Press.

Doronzio, A. (2018). *Athen im 7. Jahrhundert v. Chr.: Räume und Funde der frühen Polis.* Berlin, Boston: De Gruyter. https://doi.org/10.1515/9783110526264

Doronzio, A. (2020). A fresh look at the Kerameikos necropolis: Social complexity and funerary variability in the 7th century BC. *In:* Graml, C., Doronzio, A. and Capozzoli, V. (eds.) *Rethinking Athens before the Persian wars.* München: utzverlag GmbH, 89-102.

Duplouy, A. (2018). Pathways to Archaic citizenship. *In:* Duplouy, A. and Brock, R. W. (eds.) *Defining citizenship in Archaic Greece.* Oxford: Oxford University Press, 1-50.

Edeiken, J., Hodes, P. J. and Caplan, L. H. (1966). New bone production and periosteal reaction. *American Journal of Roentgenology,* 97**,** 708-718.

Einhorn, T. A. and Gerstenfeld, L. C. (2015). Fracture healing: Mechanisms and interventions. *Nature Reviews Rheumatology,* 11**,** 45-54. https://doi.org/10.1038/nrrheum.2014.164

El-Najjar, M. Y., Lozoff, B. and Ryan, D. J. (1975). The paleoepidemiology of porotic hyperostosis in the American Southwest: Radiological and ecological considerations. *American Journal of Roentgenology,* 125**,** 918-924. https://doi.org/10.2214/ajr.125.4.918

Étienne, R. (2004). *Athènes, espaces urbains et histoire. Des origines à la fin du IIIe siècle ap. J.C.* Paris: Hachette Education.

Evison, M., Kyparissi-Apostolika, N., Stravopodi, E., Fieller, N. and Smillie, D. (2000). An ancient HLA type from a Palaeolithic skeleton from Theopetra Cave, Greece. *In:* Kyparissi-Apostolika, N. (ed.) *Theopetra Cave: Twelve years of excavation and research, 1987-1998. Proceedings of the International Conference, Trikala, 6-7 November 1998.* Athens: Institute for Aegean Prehistory, 109-117.

Evison, M. P. (2001). Ancient DNA in Greece: Problems and prospects. *Journal of Radioanalytical and Nuclear Chemistry,* 247**,** 673-678. https://doi.org/10.1023/A:1010631905241

Exarchou, S., Lie, E., Lindström, U., Askling, J., Forsblad-d, Elia, H., Turesson, C., Kristensen, L. E. and Jacobsson, L. T. H. (2016). Mortality in ankylosing spondylitis: Results from a nationwide population-based study. *Annals of the Rheumatic Diseases,* 75**,** 1466. https://doi.org/10.1136/annrheumdis-2015-207688

Faccia, K. J. and Williams, R. C. (2008). Schmorl's nodes: Clinical significance and implications for the bioarchaeological record. *International Journal of Osteoarchaeology,* 18**,** 28-44. https://doi.org/10.1002/oa.924

Farmer, P. (2004). An anthropology of structural violence. *Current Anthropology,* 45**,** 305-325.

Farmer, P. (2016). Social inequalities and emerging infectious diseases. *In:* Brown, P. J. and Closser, S. (eds.) *Understanding and applying medical anthropology.* New York: Routledge, 118-126.

Farmer, P., Nizeye, B., Stulac, S. and Keshavjee, S. (2016). Structural violence and clinical medicine. *In:* Brown, P. J. and Closser, S. (eds.) *Understanding and applying medical anthropology.* New York: Routlegde, 336-343.

Felson, D. T., Lawrence, R. C., Dieppe, P. A., Hirsch, R., Helmick, C. G., Jordan, J. M., Kington, R. S., Lane, N. E., Nevitt, M. C. and Zhang, Y. (2000). Osteoarthritis: New insights. Part 1. The disease and its risk factors. *Annals of Internal Medicine,* 133**,** 635-646. https://doi.org/10.7326/0003-4819-133-8-200010170-00016

Fibiger, L. and Knüsel, C. J. (2005). Prevalence rates of spondylolysis in British skeletal populations. *International Journal of Osteoarchaeology,* 15**,** 164-174. https://doi.org/10.1002/oa.766

Finley, M. I. (1968). Slavery. *In:* Sills, D. K. (ed.) *International Encyclopedia of the Social Sciences.* New York: Macmillan.

Finley, M. I. (1980). *Ancient slavery and modern ideology.* New York: Viking Press.

Finley, M. I. (1999). *The ancient economy.* Berkley: University of California Press.

Fleskes, R. E., Ofunniyin, A. A., Gilmore, J. K., Poplin, E., Abel, S. M., Bueschgen, W. D., Juarez, C., Butler, N., Mishoe, G. and Oubré, L. S. (2021). Ancestry, health, and lived experiences of enslaved Africans in 18th century Charleston: An osteobiographical analysis. *American Journal of Physical Anthropology,* 175**,** 3-24. https://doi.org/10.1002/ajpa.24149

Forsdyke, S. (2005). *Exile, ostracism, and democracy. The politics of expulsion in ancient Greece.* Princeton: Princeton University Press. https://doi.org/10.1515/9781400826865

Forsdyke, S. (2006). Land, labor and economy in Solonian Athens: Breaking the impasse between archaeology and history. *In:* Blok, J. and Lardinois, A. (eds.) *Solon of Athens.* Leiden: Brill, 334-350.

Forsdyke, S. (2021). *Slaves and slavery in ancient Greece.* Cambridge: Cambridge University Press.

Foucault, M. (2004 [1976]). Society must be defended. *In:* Bertani, M. and Fontana, A. (eds.) *Lectures at the Collège de France, 1975-76.* New York: Picador.

Fox, S. C. (1997). *Comparative health from paleopathological analysis of the human skeletal remains dating the Hellenistic and Roman periods, from Paphos, Cyprus and Corinth, Greece.* PhD thesis, The University of Arizona.

Fox, S. C. (2005). Health in Hellenistic and Roman times: The case studies of Paphos, Cyprus and Corinth, Greece. *In:* King, H. (ed.) *Health in Antiquity.* Abingdon, Oxon: Routledge, 59-82.

Fox, S. C. (2016). The bioarchaeology of women in Greek antiquity. *In:* Budin, S. L. and Turfa, J. M. (eds.) *Women in antiquity. Real women across the ancient world.* London: Routledge, 647-659.

Fully, G. (1956). Une nouvelle méthode de détermination de la taille. *Annales de médicine légale et de criminologie,* 36**,** 266-273.

Galloway, A. (2014a). The lower extremity. *In:* Wedel, V. L. and Galloway, A. (eds.) *Broken bones. Anthropological analysis of blunt force trauma.* 2 ed. Springfield IL: CC Thomas, 245-313.

Galloway, A. (2014b). The upper extremity. *In:* Wedel, V. L. and Galloway, A. (eds.) *Broken bones. Anthropological analysis of blunt force trauma.* 2 ed. Springfield IL: CC Thomas, 195-244.

Galloway, A. and Wedel, V. L. (2014). The axial skeleton. *In:* Wedel, V. L. and Galloway, A. (eds.) *Broken bones. Anthropological analysis of blunt force trauma.* 2 ed. Springfield IL: CC Thomas, 161-194.

Galtung, J. (1969). Violence, peace, and peace research. *Journal of Peace Research*, 6**,** 167-191. https://doi.org/10.1177/002234336900600301

Galtung, J. (1990). Cultural violence. *Journal of Peace Research*, 27**,** 291-305. https://doi.org/10.1177/0022343390027003005

Garvie-Lok, S. J. (2001). *Loaves and fishes: A stable isotope reconstruction of diet in medieval Greece*. PhD thesis, University of Calgary.

Garvie-Lok, S. J. (2009). Population mobility at Frankish Corinth: Evidence from stable oxygen isotope ratios of tooth enamel. *Hesperia Supplements* 43**,** 245-256.

Garvie-Lok, S. J. (2010). A possible witness to the sixth century Slavic invasion of Greece from the stadium tunnel at ancient Nemea. *International Journal of Historical Archaeology*, 14**,** 271-284. https://doi.org/10.1007/s10761-010-0107-9

Geber, J. (2014). Skeletal manifestations of stress in child victims of the Great Irish Famine (1845–1852): Prevalence of enamel hypoplasia, Harris lines, and growth retardation. *American Journal of Physical Anthropology*, 155**,** 149-161. https://doi.org/10.1002/ajpa.22567

Geller, P. L. (2008). Conceiving sex: Fomenting a feminist bioarchaeology. *Journal of Social Archaeology*, 8**,** 113-138. https://doi.org/10.1177/1469605307086080

Geller, P. L. (2009a). Bodyscapes, biology, and heteronormativity. *American Anthropologist*, 111**,** 504-516. https://doi.org/10.1111/j.1548-1433.2009.01159.x

Geller, P. L. (2009b). Identity and difference: Complicating gender in archaeology. *Annual Review of Anthropology*, 38**,** 65-81. https://doi.org/10.1146/annurev-anthro-091908-164414

Geller, P. L. (2017). *The bioarchaeology of socio-sexual lives: Queering common sense about sex, gender, and sexuality*. Cham: Springer.

Georgiou, M., Zouganelis, G. D., Spiliopoulou, C. and Koutselinis, A. (2009). The application of mt-DNA analysis to the investigation of kinship from skeletal remains. *Hesperia Supplements*, 43**,** 271-277.

Gernet, L. (2004). Capital punishment. *In:* Rhodes, P. J. (ed.) *Athenian democracy*. Edinburgh: Edinburgh University Press, 132-158. https://doi.org/doi:10.1515/9781474471985-011

Getz, S. M. (2020). The use of transition analysis in skeletal age estimation. *WIREs Forensic Science*, 2**,** e1378. https://doi.org/10.1002/wfs2.1378

Giannoulis, D. K., Koulouvaris, P., Zilakou, E., Papadopoulos, D. V., Lykissas, M. G. and Mavrodontidis, A. N. (2015). Atraumatic sacral fracture in late pregnancy: A case report. *Global Spine Journal*, 5**,** 248-251. https://doi.org/10.1055/s-0035-1549429

Gilmour, R. J., Gowland, R., Roberts, C., Bernert, Z., Kiss, K. K. and Lassányi, G. (2015). Gendered differences in accidental trauma to upper and lower limb bones at Aquincum, Roman Hungary. *International Journal of Paleopathology,* 11**,** 75-91. https://doi.org/10.1016/j.ijpp.2015.08.004

Glencross, B. A. (2011). Skeletal injury across the life course: Towards understanding social agency. *In:* Agarwal, S. C. and Glencross, B. A. (eds.) *Social bioarchaeology*. Chichester: Blackwell Publishing 390-409.

Godde, K., Pasillas, V. and Sanchez, A. (2020). Survival analysis of the Black Death: Social inequality of women and the perils of life and death in Medieval London. *American Journal of Physical Anthropology,* 173**,** 168-178. https://doi.org/10.1002/ajpa.24081

Golden, M. (2011). Slavery and the Greek family. *In:* Bradley, K. and Cartledge, P. (eds.) *The Cambridge world history of slavery. Volume 1. The ancient Mediterranean world.* Cambridge: Cambridge University Press, 134-152. https://doi.org/10.1017/CHOL9780521840668.009

Goldstein, L. (2009). Mortuary analysis and bioarchaeology. *In:* Buikstra, J. E. and Beck, L. A. (eds.) *Bioarchaeology: the contextual analysis of human remains.* New York: Routledge, 375 –388. https://doi.org/10.4324/9781315432939

Goodman, A. H. and Armelagos, G. J. (1989). Infant and childhood morbidity and mortality risks in archaeological populations. *World archaeology,* 21**,** 225-243. https://doi.org/10.1080/00438243.1989.9980103

Goodman, A. H. and Martin, D. L. (2002). Reconstructing health profiles from skeletal remains. *In:* Rose, J. C. and Steckel, R. H. (eds.) *The backbone of history: Health and nutrition in the western hemisphere.* Cambridge: Cambridge University Press, 11-60. https://doi.org/10.1017/CBO9780511549953.003

Goodman, A. H., Martin, D. L., Armelagos, G. J. and Clark, G. A. (1984). Indicators of stess from bones and teeth. *In:* Cohen, M. N. and Armelagos, G. J. (eds.) *Paleopathology at the origins of agriculture.* New York: Academic Press, 13-49.

Goodman, A. H. and Rose, J. C. (1990). Assessment of systemic physiological perturbations from dental enamel hypoplasias and associated histological structures. *American Journal of Physical Anthropology,* 33**,** 59-110. https://doi.org/10.1002/ajpa.1330330506

Gowland, R. L. (2006). Aging the past: Examining age identity from funerary evidence. *In:* Gowland, R. L. and Knüsel, C. (eds.) *The social archaeology of funerary remains.* Oxford: Oxbow Books, 143-154.

Gowland, R. L. (2015). Entangled lives: Implications of the developmental origins of health and disease hypothesis for bioarchaeology and the life course. *American Journal of Physical Anthropology,* 158**,** 530-540. https://doi.org/10.1002/ajpa.22820

Gowland, R. L. (2018). Infants and mothers: Linked lives and embodied life courses. *In:* Crawford, S., Shepherd, G. and Hadley, D. (eds.) *The Oxford handbook of the archaeology of childhood.* Oxford: Oxford University Press, 104-119.

Gowland, R. L. and Caldwell, J. L. (2023). The Developmental Origins of Health and Disease. Implications for paleopathology. *In:* Grauer, A. L. (ed.) *The Routledge handbook of paleopathology.* Abingdon, Oxon: Routledge, 520-540.

Gowland, R. L. and Chamberlain, A. T. (2005). Detecting plague: Palaeodemographic characterisation of a catastrophic death assemblage. *Antiquity,* 79**,** 146-157. https://doi.org/10.1017/S0003598X00113766

Gowland, R. L. and Halcrow, S. (2020). *The mother-infant nexus in anthropology. Small beginnings, significant outcomes.* Cham: Springer.

Gowland, R. L. and Thompson, T. (2013). *Human identity and identification.* Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781139029988

Gowland, R. L. and Walther, L. J. (2018). Human growth and stature. *In:* Scheidel, W. (ed.) *The science of Roman history. Biology, climate, and the future of the past.* Princeton: Princeton University Press, 174-204. https://doi.org/10.23943/9781400889730-010

Gowland, R. L. and Western, A. G. (2012). Morbidity in the marshes: Using spatial epidemiology to investigate skeletal evidence for malaria in Anglo-Saxon England (AD 410–1050). *American Journal of Physical Anthropology,* 147**,** 301-311. https://doi.org/10.1002/ajpa.21648

Grauer, A. L. (2018). A century of paleopathology. *American Journal of Physical Anthropology,* 165**,** 904-914. https://doi.org/10.1002/ajpa.23366

Grauer, A. L. (2019). Circulatory, reticuloendothelial, and hematopoietic disorders. *In:* Buikstra, J. E. (ed.) *Ortner's identification of pathological conditions in human skeletal remains.* 3 ed. London: Academic Press Elsevier, 491-529. https://doi.org/10.1016/B978-0-12-809738-0.00014-4

Grauer, A. L. and Roberts, C. A. (1996). Paleoepidemiology, healing, and possible treatment of trauma in the medieval cemetery population of St. Helen-on-the-Walls, York, England. *American Journal of Physical Anthropology,* 100**,** 531-544.

Gravlee, C. C. (2020). Systemic racism, chronic health inequities, and COVID-19: A syndemic in the making? *American Journal of Human Biology,* 32**,** e23482. https://doi.org/10.1002/ajhb.23482

Halcrow, S. E. and Tayles, N. (2008). The bioarchaeological investigation of childhood and social age: Problems and prospects. *Journal of Archaeological Method and Theory,* 15**,** 190-215. https://doi.org/10.1007/s10816-008-9052-x

Hall, J. M. (2007a). *A history of the Archaic Greek world, ca. 1200-479 BCE.* Malden MA: Blackwell Publishing.

Hall, J. M. (2007b). Polis, community and ethnic identity. *In:* Shapiro, H. A. (ed.) *The Cambridge companion to Archaic Greece.* Cambridge: Cambridge University Press, 40-60.

Hallager, B. P. and McGeorge, P. J. P. (1992). *Late Minoan III burials at Khania: The tombs, finds and deceased in Odos Palama.* Göteborg: Astroms.

Hannigan, E. M. (2022). *Stable isotope analysis as a means of exploring the lived experience of Archaic Greek individuals.* MA thesis, California State University, Chico.

Hansen, M. H. (1998). *Polis and city state. An ancient concept and its modern equivalent.* Copenhagen: Munksgaard.

Hansen, M. H. (2003). 95 Theses about the Greek" polis" in the archaic and classical periods. A report on the results obtained by the Copenhagen Polis Centre in the period 1993-2003. *Historia: Zeitschrift für Alte Geschichte***,** 257-282.

Hansen, M. H. (2006). *Polis: An introduction to the ancient Greek city-State.* Oxford: Oxford University Press.

Harper, K. and Scheidel, W. (2018). Roman slavery and the idea of "slave society". *In:* Lenski, N. and Cameron, C. M. (eds.) *What is a slave society? The practice of slavery in global perspective.* Cambridge: Cambridge University Press, 86-105. https://doi.org/10.1017/9781316534908.004

Harris, E. M. (2002). Did Solon abolish debt-bondage? *The Classical Quarterly,* 52**,** 415-430. https://doi.org/10.1093/cq/52.2.415

Harris, E. M. (2004). Notes on a lead letter from the Athenian agora. *Harvard Studies in Classical Philology,* 102**,** 157-170. https://doi.org/10.2307/4150036

Harrod, R. P. and Crandall, J. J. (2015). Rails built of the ancestors' bones: The bioarchaeology of the overseas Chinese experience. *Historical Archaeology,* 49**,** 148-161.

Harrod, R. P. and Crandall, J. J. (2017). The bioarchaeology of violence recidivism and labor abuse in 19th-century Chinese America. *In:* Tegtmeyer, C. E. and Martin, D. L. (eds.) *Broken bones, broken bodies. Bioarchaeological and forensic approaches for accumulative trauma and violence.* Lanham: Lexington Books, 141-152.

Harrod, R. P. and Martin, D. L. (2014). Signatures of captivity and subordination on skeletonized human remains: A bioarchaeological case study from the ancient Southwest. *In:* Martin, D. L. and Anderson, C. P. (eds.) *Bioarchaeological and forensic perspectives on violence. How violent death is interpreted from skeletal remains.* Cambridge: Cambridge University Press, 103-119. https://doi.org/10.1017/CBO9781107051409.010

Harrod, R. P. and Martin, D. L. (2015). Bioarchaeological case studies of slavery, captivity, and other forms of exploitation. *In:* Marshall, L. W. (ed.) *The archaeology of slavery: A comparative approach to captivity and coercion.* Carbondale: Southern Illinois University Press, 41-63.

Harrod, R. P., Thompson, J. L. and Martin, D. L. (2012). Hard labor and hostile encounters: What human remains reveal about institutional violence and Chinese immigrants living in Carlin, Nevada (1885–1923). *Historical Archaeology,* 46**,** 85-111. https://doi.org/10.1007/BF03376880

Hart, D. J. and Spector, T. D. (1993). The relationship of obesity, fat distribution and osteoarthritis in women in the general population: The Chingford Study. *The Journal of Rheumatology,* 20**,** 331-335.

Hartnett, K. M. (2010). Analysis of age-at-death estimation using data from a new, modern autopsy sample. Part I: pubic bone. *Journal of Forensic Sciences,* 55**,** 1145-1151. https://doi.org/10.1111/j.1556-4029.2010.01399.x

Harvati, K. (2009). Petralona: Link between Africa and Europe? *Hesperia Supplements,* 43**,** 31-47.

Hershkovitz, I., Rothschild, B. M., Latimer, B., Dutour, O., Léonetti, G., Greenwald, C. M., Rothschild, C. and Jellema, L. M. (1997). Recognition of sickle cell anemia in skeletal remains of children. *American Journal of Physical Anthropology,* 104**,** 213-226. https://doi.org/10.1002/(SICI)1096-8644(199710)104:2<213::AID-AJPA8>3.0.CO;2-Z

Hidebolt, C. F. (1991). Measurement and description of periodontal disease in anthropological studies. *In:* Kelley, M. A. and Larsen, C. S. (eds.) *Advances in dental anthropology.* New York: Wiley-Liss, 225-240.

Hillson, S. (1996). *Dental anthrology.* Cambridge: Cambridge University Press.

Hillson, S. (2005). *Teeth.* Cambridge: Cambridge University Press.

Hillson, S. (2008). The current state of dental decay. *In:* Irish, J. D. and Nelson, G. C. (eds.) *Technique and application in dental anthropology. Cambridge studies in biological and evolutionary anthropology.* Cambridge: Cambridge University Press, 111-135. https://doi.org/10.1017/CBO9780511542442.006

Hillson, S. (2014). *Tooth Development in Human Evolution and Bioarchaeology.* Cambridge: Cambridge University Press. https://doi.org/DOI: 10.1017/CBO9780511894916

Hillson, S. (2019). Dental pathology. *In:* Katzenberg, A. and Grauer, A. L. (eds.) *Biological anthropology of the human Skeleton.* 3rd ed. Hoboken, NJ: Wiley Blackwell, 295-333.

Hodder, I. (1982). *Symbolic and structural archaeology.* Cambridge: Cambridge University Press.

Hodder, I. (1986). *Reading the past. Current approaches to interpretation in archaeology.* Cambridge: Cambridge University Press.

Hodson, C. M. (2021). New prospects for investigating early life-course experiences and health in archaeological fetal, perinatal and infant individuals. *Childhood in the Past,* 14**,** 3-12. https://doi.org/10.1080/17585716.2021.1905884

Hosek, L. and Robb, J. (2019). Osteobiography: A platform for bioarchaeological research. *Bioarchaeology International,* 3**,** 1-15. https://doi.org/10.5744/bi.2019.1005

Houby-Nielsen, S. (1992). Interaction between chieftains and citizens? 7th century BC burial customs in Athens. *Acta Hyperborea.* Copenhagen: Museum Tusculanum Press, 343-374.

Houby-Nielsen, S. (1995). “Burial language” in archaic and classical Kerameikos. *Proceedings of the Danish Institute at Athens,* 1**,** 129-192.

Houby-Nielsen, S. (1996). The archaeology of ideology in the Kerameikos: New interpretations of the 'Opferrinnen'. *In:* Hägg, R. (ed.) *The role of religion in the early Greek polis. Proceedings of the Third International Seminar on Ancient Greek Cult organized by the Swedish Institute at Athens, 16-18 October 1992.* Stockholm, 41-54.

Hu, J. C.-C., Chun, Y.-H. P., Al Hazzazzi, T. and Simmer, J. P. (2007). Enamel formation and amelogenesis imperfecta. *Cells Tissues Organs,* 186**,** 78-85. https://doi.org/10.1159/000102683

Hughes-Morey, G. (2016). Interpreting adult stature in industrial London. *American Journal of Physical Anthropology,* 159**,** 126-134. https://doi.org/10.1002/ajpa.22840

Hunt, P. (2011). Slaves in Greek literary culture. *In:* Bradley, K. and Cartledge, P. (eds.) *The Cambridge world history of slavery. Volume 1. The ancient Mediterranean world.* Cambridge: Cambridge University Press, 22-47. https://doi.org/10.1017/CHOL9780521840668.004

Hunt, P. (2016). Violence against slaves in Classical Greece. *In:* Riess, W. and Fagan, G. G. (eds.) *The topography of violence in the Greco-Roman world.* Ann Arbor: University of Michigan Press, 136-161.

Hunt, P. (2018a). Ancient Greece as a 'slave society'. *In:* Lenski, N. and Cameron, C. M. (eds.) *What is a slave society? The practice of slavery in global perspective.* Cambridge: Cambridge University Press, 61-85. https://doi.org/10.1017/9781316534908.003

Hunt, P. (2018b). *Ancient Greek and Roman slavery.* Newark: Wiley Blackwell.

Iezzi, C. A. (2009). Regional differences in the health status of the Mycenaean women of East Lokris. *Hesperia Supplements,* 43**,** 175-192.

Iezzi, C. A. (2015). Existence and subsistence in Mycenaean-era East Lokris: The isotopic evidence. *In:* Papathanasiou, A., Richards, M. P. and Fox, S. C. (eds.) *Archaeodiet in the Greek world: Dietary reconstruction from stable Isotope analysis.* Athens: American School of Classical Studies at Athens, 89-104.

Ingvarsson-Sundstrom, A. (2004). *Children lost and found: A bioarchaeological study of Middle Helladic children in Asine with a comparison to Lerna (Greece).* PhD thesis, Uppsala University.

Ingvarsson, A., Bäckström, Y., Chryssoulaki, S., Linderholm, A., Kjellström, A., Lagerholm, V. K. and Krzewińska, M. (2019). Bioarchaeological field analysis of human remains from the mass graves at Phaleron, Greece. *Opuscula,* 12**,** 7-158.

Ioannou, G. and Lorentz, K. O. (2023). Health, stress, and urbanism in the Hellenistic–Roman metropolis of Nea Paphos, Cyprus: A comparative analysis. *International Journal of Osteoarchaeology*, 33**,** 955-966. https://doi.org/10.1002/oa.3257

Irwin, C., Mullally, B., Ziada, H., Byrne, P. J. and Allen, E. (2008). Periodontics 9. Periodontitis and systemic conditions. Is there a Link? *Dental update,* 35**,** 92-101.

Issa, S. N. and Sharma, L. (2006). Epidemiology of osteoarthritis: An update. *Current Rheumatology Reports,* 8**,** 7-15. https://doi.org/10.1007/s11926-006-0019-1

Iyer, A., Sen, G. and Östlin, P. (2008). The intersections of gender and class in health status and health care. *Global Public Health,* 3**,** 13-24. https://doi.org/10.1080/17441690801892174

Jasienska, G. (2009). Low birth weight of contemporary African Americans: An intergenerational effect of slavery? *American Journal of Human Biology,* 21**,** 16-24. https://doi.org/10.1002/ajhb.20824

Jones, C. P. (1987). Stigma: Tattooing and branding in Graeco-Roman antiquity. *The Journal of Roman Studies*, 77**,** 139-155. https://doi.org/10.2307/300578

Jones, O. A. (2018). Mycenaean secondary burial revisited: Legacy data, taphonomy, and the process of burial in Achaia, Greece. *Bioarchaeology International*, 2**,** 217-239. https://doi.org/10.5744/bi.2018.1025

Judd, M. A. (2002). Comparison of long bone trauma recording methods. *Journal of Archaeological Science,* 29**,** 1255-1265. https://doi.org/10.1006/jasc.2001.0763

Judd, M. A. (2008). The parry problem. *Journal of Archaeological Science*, 35**,** 1658-1666. https://doi.org/10.1016/j.jas.2007.11.005

Judd, M. A. (2017). Injury recidivism revisited: Clinical research, limitations, and implications for bioarchaeology. *In:* Tegtmeyer, C. E. and Martin, D. L. (eds.) *Broken bones, broken bodies. Bioarchaeological and forensic approaches for accumulative trauma and violence.* Lanham: Lexington Books, 1-23.

Kamen, D. (2013). *Status in classical Athens.* Princeton: Princeton University Press.

Karakostis, F. A., Buikstra, J. E., Prevedorou, E., Hannigan, E. M., Hotaling, J., Hotz, G., Liedl, H., Moraitis, K., Siek, T. J. and Waltenberger, L. (2021). New insights into the manual activities of individuals from the Phaleron cemetery (Archaic Athens, Greece). *Journal of Archaeological Science,* 131**,** 105415. https://doi.org/10.1016/j.jas.2021.105415

Karligkioti, A., Douni, K., Mexi, M., Michailidi, P. and Nikita, E. (2023). Approaching life (in) equality and social transformations in Eastern Attica from the Classical to the Roman era. *Journal of Archaeological Science: Reports,* 47**,** 103819. https://doi.org/10.1016/j.jasrep.2022.103819

Kassebaum, N. J., Jasrasaria, R., Naghavi, M., Wulf, S. K., Johns, N., Lozano, R., Regan, M., Weatherall, D., Chou, D. P., Eisele, T. P., Flaxman, S. R., Pullan, R. L., Brooker, S. J. and Murray, C. J. L. (2014). A systematic analysis of global anemia burden from 1990 to 2010. *Blood,* 123**,** 615-624. https://doi.org/10.1182/blood-2013-06-508325

Keefer, K. H. (2019). Marked by fire: Brands, slavery, and identity. *Slavery & Abolition,* 40**,** 659-681. https://doi.org/10.1080/0144039X.2019.1606521

Keenleyside, A., Schwarcz, H. P. and Panayotova, K. (2011). Oxygen isotopic evidence of residence and migration in a Greek colonial population on the Black Sea. *Journal of Archaeological Science,* 38**,** 2658-2666. https://doi.org/10.1016/j.jas.2011.06.001

Kelley, J. O. and Angel, J. L. (1987). Life stresses of slavery. *American Journal of Physical Anthropology,* 74**,** 199-211. https://doi.org/10.1002/ajpa.1330740208

Kelley, M. (1989). Infectious disease. *In:* Iscan, M. Y. and Kennedy, K. A. R. (eds.) *Life from the skeleton.* New York: Alan R. Liss., Inc., 129-160.

Kellogg, D. L. (2021). Population and social structure. *In:* Neils, J. and Rogers, D. K. (eds.) *The Cambridge companion to ancient Athens.* Cambridge: Cambridge University Press, 159-172. https://doi.org/10.1017/9781108614054.012

Kendall, J. and Eckner, J. T. (2013). Sacral stress fracture in a young healthy athlete. *American Journal of Physical Medicine & Rehabilitation,* 92**,** 1120. https://doi.org/10.1097/PHM.0b013e31825f1c20

Kerr-Valentic, M. A., Arthur, M., Mullins, R. J., Pearson, T. E. and Mayberry, J. C. (2003). Rib fracture pain and disability. Can we do better? *The Journal of Trauma: Injury, Infection, and Critical Care,* 54**,** 1058-1064. https://doi.org/10.1097/01.TA.0000060262.76267.EF

Kerr, R., Resnick, D., Pineda, C. and Haghighi, P. (1985). Osteoarthritis of the glenohumeral joint: A radiologic-pathologic study. *American Journal of Roentgenology,* 144**,** 967-972. https://doi.org/10.2214/ajr.144.5.967

Kinaston, R., Willis, A., Miszkiewicz, J. J., Tromp, M. and Oxenham, M. F. (2019). The dentition: Development, disturbances, disease, diet, and chemistry. *In:* Buikstra, J. E. (ed.) *Ortner's identification of pathological conditions in human skeletal remains.* 3 ed. London: Academic Press Elsevier, 749-797. https://doi.org/10.1016/B978-0-12-809738-0.00021-1

Kirkpatrick Smith, S. (2013). Bodies of evidence: Skeletal analysis in Roman Greece and Cyprus. *In:* Evans, J. D. (ed.) *A companion to the archaeology of the Roman republic.* Chichester: Wiley-Blackwell, 141-154. https://doi.org/10.1002/9781118557129.ch9

Kistler, E. (1998). *Die Opferrinne-Zeremonie: Bankettideologie am Grab, Orientalisierung und Formierung einer Adelsgesellschaft in Athen.* Stuttgart: Franz Steiner Verlag.

Kistler, E. (2004). 'Kampf der Mentalitäten': Ian Morris' 'elitist-' versus 'middling-ideology'. *In:* Rollinger, R. and Ulf, C. (eds.) *Griechische Archaik. Interne Entwicklungen - Externe Impulse.* Berlin: Akademie Verlag GmbH, 145-175.

Klales, A. R., Ousley, S. D. and Vollner, J. M. (2012). A revised method of sexing the human innominate using Phenice's nonmetric traits and statistical methods. *American Journal of Physical Anthropology*, 149**,** 104-114. https://doi.org/10.1002/ajpa.22102

Klaus, H. D. (2012). Bioarchaeology of structural violence: Theoretical model and case study. *In:* Martin, D. L., Harrod, R. P. and Pérez, V. R. (eds.) *The bioarchaeology of violence*. Gainesville, FL: University Press of Florida, 29-62.

Klaus, H. D. (2014). Frontiers in the bioarchaeology of stress and disease: Cross-disciplinary perspectives from pathophysiology, human biology, and epidemiology. *American Journal of Physical Anthropology*, 155**,** 294-308. https://doi.org/10.1002/ajpa.22574

Klaus, H. D. (2017). Paleopathological rigor and differential diagnosis: Case studies involving terminology, description, and diagnostic frameworks for scurvy in skeletal remains. *International Journal of Paleopathology,* 19**,** 96-110. https://doi.org/10.1016/j.ijpp.2015.10.002

Klaus, H. D., Spencer Larsen, C. and Tam, M. E. (2009). Economic intensification and degenerative joint disease: Life and labor on the postcontact north coast of Peru. *American Journal of Physical Anthropology,* 139**,** 204-221. https://doi.org/10.1002/ajpa.20973

Klaus, H. D. and Tam, M. E. (2010). Oral health and the postcontact adaptive transition: A contextual reconstruction of diet in Mórrope, Peru. *American Journal of Physical Anthropology,* 141**,** 594-609. https://doi.org/10.1002/ajpa.21179

Knudson, K. J. and Stojanowski, C. M. (2008). New directions in bioarchaeology: Recent contributions to the study of human social identities. *Journal of Archaeological Research,* 16**,** 397-432. https://doi.org/10.1007/s10814-008-9024-4

Knüsel, C. (2000). Activity-related skeletal change. *In:* Fiorato, V., Boylston, A. and Knüsel, C. (eds.) *Blood Red Roses: The archaeology of a mass grave from the battle of Towton AD 1461*. Oxford: Oxbow Books, 103-118.

Koren, O., Spor, A., Felin, J., Fåk, F., Stombaugh, J., Tremaroli, V., Behre, C. J., Knight, R., Fagerberg, B. and Ley, R. E. (2011). Human oral, gut, and plaque microbiota in patients with atherosclerosis. *Proceedings of the National Academy of Sciences,* 108**,** 4592-4598. https://doi.org/10.1073/pnas.1011383107

Kourouniotis, K. (1911). Εξ Αττικής: Ανασκαφαί Παλαιού Φαλήρου. *Archaiologikē ephēmeris,* 50**,** 246-56.

Kramaker, M. K. and Ho, A. M. (2003). Acute pain management of patients with multiple fractured ribs. *Journal of Trauma: Injury, Infection and Critical Care,* 53**,** 615-625. https://doi.org/10.1097/01.TA.0000053197.40145.62

Krentz, P. (2007). Warefare and hoplites. *In:* Shapiro, H. A. (ed.) *The Cambridge companion to Archaic Greece.* Cambridge: Cambridge University Press, 61-84.

Kreshover, S. J. (1960). Metabolic disturbances in tooth formation. *Annals of the New York Academy of Sciences,* 85**,** 161-167. https://doi.org/10.1111/j.1749-6632.1960.tb49954.x

Kurtz, D. C. and Boardman, J. (1971). *Greek burial customs.* London: Thames and Hudson.

Kuzawa, C. W. (2005). Fetal origins of developmental plasticity: Are fetal cues reliable predictors of future nutritional environments? *American Journal of Human Biology,* 17**,** 5-21. https://doi.org/https://doi.org/10.1002/ajhb.20091

Kuzawa, C. W. (2007). Developmental origins of life history: Growth, productivity, and reproduction. *American Journal of Human Biology,* 19**,** 654-661. https://doi.org/10.1002/ajhb.20659

Kuzawa, C. W. and Quinn, E. A. (2009). Developmental origins of adult function and health: Evolutionary hypotheses. *Annual Review of Anthropology,* 38**,** 131-147. https://doi.org/10.1146/annurev-anthro-091908-164350

Kwan, R. O., Cureton, E. L., Dozier, K. C. and Victorino, G. P. (2011). Gender differences among recidivist trauma patients. *Journal of Surgical Research,* 165**,** 25-29. https://doi.org/10.1016/j.jss.2010.05.060

Kyle, B. and Reitsema, L. (2020). Social variation in an urban environment and its impacts on stress: Preliminary results from Ancient Greek Himera (Sicily). *In:* Robbins Schug, G. (ed.) *The Routledge handbook of the bioarchaeology of climate and environmental change.* London: Routledge, 205-220.

Kyrtatas, D. J. (2011). Slavery and economy in the Greek world. *In:* Bradley, K. and Cartledge, P. (eds.) *The Cambridge world history of slavery. Volume 1. The ancient Mediterranean world.* Cambridge: Cambridge University Press, 91-111. https://doi.org/10.1017/CHOL9780521840668.007

Laes, C. (2008). Child slaves at work in Roman antiquity. *Ancient Society,* 38**,** 235-283.

Laes, C. (2011). *Children in the Roman empire: Outsiders within.* Cambridge: Cambridge University Press.

Lagia, A. (1993). *Differetial Diagnosis of the three main types of anaemia (thalassaemia, sickle cell anaemia and iron deficiency anaemia) based on macoscopic and radiographic skeletal characteristics.* MSc thesis, University of Bradford.

Lagia, A. (2007). Notions of childhood in the Classical polis: Evidence from the bioarchaeological record. *Hesperia Supplements,* 41**,** 293-306.

Lagia, A. (2014). Health inequalities in the Classical city: A biocultural approach to socioeconomic differentials in the polis of Athens during the Classical, Hellenistic and Imperial Roman periods. *In:* Gillis, A.-C. (ed.) *Corps, travaile et statut social. L'apport de la paléoanthropologie funéraire aux sciences historiques. Corps, travail et statut social.* Villeneuve d'Ascq: Presses Universitaires du Septentrion, 95-115.

Lagia, A. (2015a). Diet and the polis: An isotopic study of diet in Athens and Laurion during the classical, Hellenistic, and imperial Roman periods. *In:* Papathanasiou, A., Fox, S. C. and Richards, M. P. (eds.) *Archaeodiet in the Greek world. Dietary reconstruction from stable Isotope analysis.* Princeton: American School of Classical Studies at Athens, 119-145.

Lagia, A. (2015b). The potential and limitations of bioarchaeological investigations in classical contexts in Greece: An example from the polis of Athens. *In:* Haggis, D. C. and Antonaccio, C. M. (eds.) *Classical archaeology in context: Theory and practice in excavation in the Greek world.* Berlin: De Gruyter, 149-173.

Lagia, A., Eliopoulos, C. and Manolis, S. (2007a). Thalassemia: Macroscopic and radiological study of a case. *International Journal of Osteoarchaeology,* 17**,** 269-285. https://doi.org/10.1002/oa.881

Lagia, A., Papathanasiou, A. and Triantaphyllou, S. (2014). The state of approaches to archaeological human remains in Greece. *In:* O'Donnabhain, B. and Lozada, M. (eds.) *Archaeological human remains.* Cham: Springer, 105-126. https://doi.org/10.1007/978-3-319-06370-6_8

Lagia, A., Petroutsa, E. and Manolis, S. (2007b). Health and diet during the Middle Bronze Age in the Peloponnese: The site of Kouphovouno. *In:* Renard, J. and Mee, C. (eds.) *Cooking up the past: Food and culinary practices in the Neolithic and bronze age Aegean.* Oxford: Oxbow Books, 313-328.

Lagia, A. and Voutsaki, S. (eds.) (2024). *Bioarchaeological perspectives on inequality and social differentiation from the ancient Greek world.* Gainesville: University Press of Florida.

Laine, M. A. (2002). Effect of pregnancy on periodontal and dental health. *Acta Odontologica Scandinavica,* 60**,** 257-264. https://doi.org/10.1080/00016350260248210

Lanzkowsky, P. (1968). Radiological features of iron deficiency anemia. *American Journal of Diseases in Children,* 116**,** 16-29. https://doi.org/10.1001/archpedi.1968.02100020018003

Larsen, C. S. (2015). *Bioarchaeology: Interpreting behavior from the human skeleton.* Cambridge: Cambridge University Press.

Larsen, C. S., Craig, J., Sering, L. E., Schoeninger, M. J., Russell, K. F., Hutchinson, D. L. and Williamson, M. A. (1995). Cross homestead: Life and death on the midwestern frontier. *In:* Grauer, A. L. (ed.) *Bodies of evidence: Reconstructing history through skeletal analysis.* New York: Wiley-Liss, 139-159.

Larsen, C. S. and Crespo, F. (2022). Paleosyndemics: A bioarchaeological and biosocial approach to study infectious diseases in the past. *Centaurus. Journal of the European Society for the History of Science,* 64**,** 181-196. https://doi.org/10.1484/J.CNT.5.130031

Lenski, N. (2018a). Ancient slaveries and modern ideology. *In:* Lenski, N. and Cameron, C. M. (eds.) *What is a slave society? The practice of slavery in global perspective.*

Cambridge: Cambridge University Press, 106-148. https://doi.org/10.1017/9781316534908.005

Lenski, N. (2018b). Framing the question: What Is a slave society? *In:* Lenski, N. and Cameron, C. M. (eds.) *What is a slave society? The practice of slavery in global perspective.* Cambridge: Cambridge University Press, 15-58. https://doi.org/10.1017/9781316534908.002

Lenski, N. and Cameron, C. M. (eds.) (2018). *What is a slave society? The practice of slavery in global perspective.* Cambridge: Cambridge University Press.

Leone, A., Cianfoni, A., Cerase, A., Magarelli, N. and Bonomo, L. (2011). Lumbar spondylolysis: A review. *Skeletal radiology,* 40**,** 683-700. https://doi.org/10.1007/s00256-010-0942-0

Leppard, T. P., Esposito, C. and Esposito, M. (2020). The bioarchaeology of migration in the ancient Mediterranean: Meta-analysis of radiogenic (87Sr/86Sr) isotope ratios. *Journal of Mediterranean Archaeology,* 33**,** 211-241.

Lewis, D. M. (2018). *Greek slave systems in their eastern Mediterranean context, c.800-146 BC.* Oxford: Oxford University Press.

Lewis, M. E. (2000). Non-adult palaeopathology: Current status and future potential. *In:* Cox, M. and May, S. (eds.) *Human osteology in archaeology and forensic science.* Cambridge: Cambridge University Press, 39-57.

Lewis, M. E. (2007). *The bioarchaeology of children: Perspectives from biological and forensic anthropology.* Cambridge: Cambridge University Press.

Lewis, M. E. (2012). Thalassaemia: Its diagnosis and interpretation in past skeletal populations. *International Journal of Osteoarchaeology,* 22**,** 685-693. https://doi.org/10.1002/oa.1229

Liebe-Harkort, C. (2012). Cribra orbitalia, sinusitis and linear enamel hypoplasia in Swedish Roman Iron Age adults and subadults. *International Journal of Osteoarchaeology,* 22**,** 387-397. https://doi.org/10.1002/oa.1209

Lingström, P., van Houte, J. and Kashket, S. (2000). Food starches and dental caries. *Critical Reviews in Oral Biology & Medicine,* 11**,** 366-80. https://doi.org/10.1177/10454411000110030601

Liston, M. A. (2012). Reading the bones: Interpreting the skeletal evidence for women's lives in ancient Greece. *In:* James, S. L. and Dillon, S. (eds.) *A companion to women in the ancient world.* Chichester: John Wiley & Sons, 125-140.

Liston, M. A. (2017). The human skeletal remains. *In:* Papadopoulos, J. K. and Smithson, E. L. (eds.) *The Early Iron Age: The cemeteries.* Princeton: American School of Classical Studies at Athens, 503-560.

Liston, M. A. (2020). Skeletal evidence for the impact of battle on soldiers and non-combatants. *In:* Lee, B. L. (ed.) *New approaches to Greek and Roman warfare.* Hoboken, NJ: Wiley Blackwell, 81-94. https://doi.org/10.1002/9781119248514.ch7

Liston, M. A. (2023). Human remains. *In:* Day, L. P. and Gesell, G. C. (eds.) *Kavousi IV. The Early Iron Age cemeteries at Vronda.* INSTAP Academic Press, 219-234. https://doi.org/10.2307/jj.8441687.10

Liston, M. A. and Day, L. P. (2009). It does take a brain surgeon: A successful trepanation from Kavousi, Crete. *Hesperia Supplements,* 43**,** 57-73.

Lobell, J. A. (2016). Regime change in Athens. *Archaeology Magazine.*

Loesche, W. J. and Grossman, N. S. (2001). Periodontal disease as a specific, albeit chronic, infection: Diagnosis and treatment. *Clinical microbiology reviews,* 14**,** 727-752. https://doi.org/10.1128/cmr.14.4.727-752.2001

Loeser, R. F. (2010). Age-related changes in the musculoskeletal system and the development of osteoarthritis. *Clinics in Geriatric Medicine,* 26**,** 371-386. https://doi.org/10.1016/j.cger.2010.03.002

Lopez, A., Cacoub, P., Macdougall, I. C. and Peyrin-Biroulet, L. (2016). Iron deficiency anaemia. *The Lancet,* 387**,** 907-916. https://doi.org/10.1016/S0140-6736(15)60865-0

Lorentz, K. O., Lemmers, S. A. M., Chrysostomou, C., Dirks, W., Zaruri, M. R., Foruzanfar, F. and Sajjadi, S. M. S. (2019). Use of dental microstructure to investigate the role of prenatal and early life physiological stress in age at death. *Journal of Archaeological Science,* 104**,** 85-96. https://doi.org/10.1016/j.jas.2019.01.007

Lovell, N. C. (1997a). Anaemia in the Ancient Indus Valley. *International Journal of Osteoarchaeology,* 7**,** 115-123. https://doi.org/https://doi.org/10.1002/(SICI)1099-1212(199703)7:2<115::AID-OA323>3.0.CO;2-H

Lovell, N. C. (1997b). Trauma analysis in paleopathology. *American Journal of Physical Anthropology,* 104**,** 139-170.

Lovell, N. C. and Grauer, A. L. (2018). Analysis and interpretation of trauma in skeletal remains. *In:* Katzenberg, M. A. and Grauer, A. L. (eds.) *Biological anthropology of the human skeleton.* 3rd ed. Hoboken, NJ: John Wiley & Sons, 335-383. https://doi.org/10.1002/9781119151647.ch10

Lukacs, J. R. (1989). Dental palaeopathology: Methods of reconstructing dietary patterns. *In:* Iscan, M. Y. and Kennedy, K. A. R. (eds.) *Reconstructing life from the skeleton.* New York: Wiley, 261-286.

Lukacs, J. R. (2007). Dental trauma and antemortem tooth loss in prehistoric Canary Islanders: Prevalence and contributing factors. *International Journal of Osteoarchaeology,* 17**,** 157-173. https://doi.org/10.1002/oa.864

Lukacs, J. R. (2008). Fertility and agriculture accentuate sex differences in dental caries rates. *Current Anthropology*, 49**,** 901-914. https://doi.org/10.1086/592111

Lukacs, J. R. (2017). Bioarchaeology of oral health: Sex and gender differences in dental disease. *In:* Agarwal, S. C. and Wesp, J. K. (eds.) *Exploring sex and gender in bioarchaeology.* Albuquerque: University of New Mexico Press, 263 –290.

Mack, M. E., Goodman, A. H., Blakey, M. L. and Mayes, A. (2009). Odontological indicators of disease, diet, and nutrition inadequacy. *In:* Blakey, M. L. and Rankin-Hill, L. M. (eds.) *The skeletal biology of the New York African burial ground.* Washington DC: Howard University Press, 157–165.

MacKinnon, M. (2007). Osteological research in classical archaeology: State of the discipline. *American Journal of Archaeology,* 111**,** 473-504.

Malama, P. and Triantaphyllou, S. (2001). Ανθρωπολογικές πληροφορίες από το Ανατολικό Νεκροταφείο της Αμφίπολης. *Το Αρχαιολογικό Έργο στη Μακεδονία και Θράκη,* 15**,** 127-136.

Mant, M., de la Cova, C. and Brickley, M. B. (2021). Intersectionality and trauma analysis in bioarchaeology. *American Journal of Physical Anthropology,* 174**,** 583-594. https://doi.org/10.1002/ajpa.24226

Marmot, M. (2015). The health gap: The challenge of an unequal world. *The Lancet,* 386**,** 2442-2444. https://doi.org/10.1016/S0140-6736(15)00150-6

Martin, D. L. (2008). Ripped flesh and torn souls: Evidence for slavery in the prehistoric Southwest, AD 800–1500. *In:* Cameron, C. M. (ed.) *Invisible citizens: Captives and their consequences.* Salt Lake City: University of Utah Press, 159-180.

Martin, D. L. and Harrod, R. P. (2015). Bioarchaeological contributions to the study of violence. *American Journal of Physical Anthropology,* 156**,** 116-145. https://doi.org/10.1002/ajpa.22662

Martin, D. L., Harrod, R. P. and Fields, M. (2010). Beaten down and worked to the bone: Bioarchaeological investigations of women and violence in the ancient Southwest. *Landscapes of Violence,* 1**,** 1-19.

Martin, T. R. (2000). *Ancient Greece: From Prehistoric to Hellenistic times.* New Haven: Yale University Press.

Matot, I. and Sprung, C. L. (2001). Definition of sepsis. *Intensive Care Medicine,* 27**,** 3-9.

Mbembe, A. (2003). Necropolitics. *Public Culture,* 15**,** 11-40. https://doi.org/10.1215/08992363-15-1-11

Mbembe, A. (2008). Necropolitics. *In:* Morton, S. and Bygrave, S. (eds.) *Foucault in an age of terror. Essays on biopolitics and the defence of society.* Basingstoke: Palgrave Macmillan, 152-182.

Mbembe, A. (2019). *Necropolitics.* New York: Duke University Press. https://doi.org/10.1515/9781478007227

McFadden, C. and Oxenham, M. F. (2020). A paleoepidemiological approach to the osteological paradox: Investigating stress, frailty and resilience through cribra orbitalia. *American Journal of Physical Anthropology,* 173**,** 205-217. https://doi.org/10.1002/ajpa.24091

McIlvaine, B. K. (2015). Implications of reappraising the iron-deficiency anemia hypothesis. *International Journal of Osteoarchaeology,* 25**,** 997-1000. https://doi.org/10.1002/oa.2383

McPherson, C. B. (2021). Examining developmental plasticity in the skeletal system through a sensitive developmental windows framework. *American Journal of Physical Anthropology,* 176**,** 163-178. https://doi.org/10.1002/ajpa.24338

Mellanby, M. (1934). *Diet and the teeth. An experimental study. Part 3. The effect of diet on dental structure and disease in man.*

Mendenhall, E., Newfield, T. and Tsai, A. C. (2022). Syndemic theory, methods, and data. *Social Science & Medicine,* 295**,** 114656. https://doi.org/10.1016/j.socscimed.2021.114656

Mensforth, R. P., Lovejoy, C. O., Lallo, J. W. and Armelagos, G. J. (1978). The role of constitutional factors, diet, and infectious disease in the etiology of porotic hyperostosis and periosteal reactions in prehistoric infants and children. *Medical Anthropology,* 2**,** 1-59. https://doi.org/10.1080/01459740.1978.9986939

Merbs, C. F. (1983). *Patterns of activity-induced pathology in a Canadian Inuit population.* Ottawa: University of Ottawa Press.

Merbs, C. F. (2001). Degenerative spondylolisthesis in ancient and historic skeletons from New Mexico Pueblo sites. *American Journal of Physical Anthropology,* 116**,** 285-295. https://doi.org/10.1002/ajpa.1125

Michael, D. E., Eliopoulos, C. and Manolis, S. K. (2017). Exploring sex differences in diets and activity patterns through dental and skeletal studies in populations from ancient Corinth, Greece. *Homo,* 68**,** 378-392. https://doi.org/10.1016/j.jchb.2017.09.002

Michael, D. E., Fibiger, L., Ziota, C., Gkelou, L. and Molloy, B. (2021). Exploring the efficacy of comparative bioarchaeological approaches in providing answers on marginality and networking: The example of Late Bronze Age Achlada in Florina, Northern Greece. *Bioarchaeology International,* 5**,** 21-46. https://doi.org/10.5744/bi.2021.1005

Micheli, L. J. and Curtis, C. (2006). Stress fractures in the spine and sacrum. *Clinics in Sports Medicine,* 25**,** 75-88. https://doi.org/10.1016/j.csm.2005.08.001

Millard, A., Montgomery, J., Trickett, M., Beaumont, J., Evans, J. and Chenery, S. (2014). Childhood lead exposure in the British isles during the industrial revolution. *In:* Zuckerman, M. K. (ed.) *Modern environments and human health. Revisiting the* *second epidemiologic transition.* Hoboken, NJ: Wiley Blackwell, 279-299. https://doi.org/10.1002/9781118504338.ch15

Milner, G. R. and Boldsen, J. L. (2012). Transition analysis: A validation study with known-age modern American skeletons. *American Journal of Physical Anthropology,* 148**,** 98-110. https://doi.org/10.1002/ajpa.22047

Milner, G. R., Boldsen, J. L., Weise, S., Lauritsen, J. M. and Freund, U. H. (2015). Sex-related risks of trauma in medieval to early modern Denmark, and its relationship to change in interpersonal violence over time. *International Journal of Paleopathology,* 9**,** 59-68. https://doi.org/10.1016/j.ijpp.2015.02.002

Mirhadi, S., Ashwood, N. and Karagkevrekis, B. (2013). Factors influencing fracture healing. *Trauma,* 15**,** 140-155. https://doi.org/10.1177/1460408613486571

Moles, A. C. (2020). Urbanism and its impact on human health and diet: A Preliminary study of the human temains from Hellenistic to Late Antique Knossos, Crete. *In:* Dimakis, N. and Dijkstra, T. M. (eds.) *Mortuary variability and social diversity in ancient Greece.* Oxford: Archaeopress Publishing, 63-74.

Moles, A. C. (2023a). Dental disease reflects differential diets and changes in consumption over time at Knossos. *International Journal of Osteoarchaeology,* 33**,** 207-220. https://doi.org/10.1002/oa.3199

Moles, A. C. (2023b). Health, diet and lifeways at Knossos during the Hellenistic, Roman and Late-Antique periods. *In:* Francis, J. E. and Curtis, M. J. (eds.) *Change and transition on Crete. Interpreting the evidence from the Hellenistic through to the Early Byzantine Period. Papers presented in honour of G. W. M. Harrison.* Oxford: Archaeopress, 168-180.

Moles, A. C. (2023c). *Urbanism and its impact on human health. A long-term study at Knossos, Crete.* Oxford: BAR Publishing. https://doi.org/10.30861/9781407360355

Moles, A. C., Reade, H., Jourdan, A.-L. and Stevens, R. E. (2022). Stable isotopes reveal dietary shifts associated with social change in Hellenistic, Roman and Late Antique Knossos. *Journal of Archaeological Science: Reports,* 45**,** 103609. https://doi.org/10.1016/j.jasrep.2022.103609

Moore, J., Williams-Ward, M., Filipek, K. L., Gowland, R. L. and Montgomery, J. (2021). Poisoned pregnancies: Consequences of prenatal lead exposure in relation to infant mortality in the Roman Empire. *In:* Kendall, E. J. and Kendall, R. (eds.) *The family in past perspective. An interdisciplinary exploration of familial relationships through time.* London: Routlegde, 137-158.

Morgan, B., Prakash, K., Mayberry, J. C. and Brickley, M. B. (2022). Thoracic trauma: Clinical and paleopathological perspectives. *International Journal of Paleopathology,* 39**,** 50-63. https://doi.org/10.1016/j.ijpp.2022.09.003

Morgan, C. (2001). Symbolic and pragmatic aspects of warfare in the Greek world of the 8th to 6th centuries BC. *In:* Hannestad, L. and Bekker Nielsen, T. (eds.) *War as a cultural* *and social force: Essays on warfare in antiquity*. Aarhus: Aarhus University Press, 20-44.

Morgan, C. (2003). *Early Greek states beyond the polis.* London: Routledge. https://doi.org/10.4324/9780203417751

Morgan, C. (2009). The Early Iron Age. *In:* Raaflaub, K. A. and van Wees, H. (eds.) *A companion to Archaic Greece.* Chichester: Wiley Blackwell, 43-63.

Morris, I. (1987). *Burial and ancient society. The rise of the Greek city-state.* Cambridge: Cambridge University Press.

Morris, I. (1989). Attitudes toward death in archaic Greece. *Classical Antiquity,* 8**,** 296-320.

Morris, I. (1992). *Death-ritual and social structure in classical antiquity.* Cambridge: Cambridge University Press.

Morris, I. (1996). The strong principle of equality and the archaic origins of Greek democracy. *In:* Ober, J. and Hedrick, C. (eds.) *Dêmokratia: A conversation on democracies, ancient and modern.* Princeton: Princeton University Press, 19-48.

Morris, I. (2000). *Archaeology as cultural history. Words and things in Iron Age Greece.* Oxford: Blackwell.

Morris, I. (2014). *The measure of civilization. How social development decides the fate of nations.* Princeton: Princeton University Press. https://doi.org/10.2307/j.ctt1r2fj0

Mountrakis, C. and Manolis, S. (2014). Entheseal change of the upper limb in a Mycenaean population from Athens. *Mediterranean Archaeology and Archaeometry,* 15**,** 209-220. https://doi.org/10.5281/zenodo.15054

Moutafi, I. (2021). *Towards a social bioarchaeology of the Mycenaean period: A biocultural analysis of human remains from the Voudeni Cemetery, Achaea, Greece.* Oxford: Oxbow Books.

Muller, J. L. (2006). *Trauma as a biological consequence of inequality: A biocultural analysis of the skeletal remains of Washington DC's African American poor.* PhD thesis, State University of New York at Buffalo.

Murphy, E. M. (ed.) (2008). *Deviant burial in the archaeological record.* Oxford: Oxbow Books.

Nafplioti, A. (2008). 'Mycenaean' political domination of Knossos following the Late Minoan IB destructions on Crete: negative evidence from strontium isotope ratio analysis (87Sr/86Sr). *Journal of Archaeological Science,* 35**,** 2307-2317. https://doi.org/10.1016/j.jas.2008.03.006

Nafplioti, A. (2011). Tracing population mobility in the Aegean using isotope geochemistry: A first map of local biologically available 87Sr/86Sr signatures. *Journal of Archaeological Science,* 38**,** 1560-1570. https://doi.org/10.1016/j.jas.2011.02.021

Newman, S. L. and Gowland, R. L. (2015). The use of non-adult vertebral dimensions as indicators of growth disruption and non-specific health stress in skeletal populations. *American Journal of Physical Anthropology*, 158**,** 155-164. https://doi.org/10.1002/ajpa.22770

Nichter, M. (2008). *Global health. Why cultural perceptions, social representations, and biopolitics matter.* Tucson: University of Arizona Press.

Nicklisch, N., Maixner, F., Ganslmeier, R., Friederich, S., Dresely, V., Meller, H., Zink, A. and Alt, K. W. (2012). Rib lesions in skeletons from early neolithic sites in Central Germany: On the trail of tuberculosis at the onset of agriculture. *American Journal of Physical Anthropology*, 149**,** 391-404. https://doi.org/10.1002/ajpa.22137

Nikita, E. and Chovalopoulou, M. E. (2017). Regression equations for the estimation of stature and body mass using a Greek documented skeletal collection. *Homo*, 68**,** 422-432. https://doi.org/10.1016/j.jchb.2017.11.002

Nikita, E., Schrock, C., Sabetai, V. and Vlachogianni, E. (2019). Bioarchaeological perspectives to diachronic life quality and mobility in ancient Boeotia, central Greece: Preliminary insights from Akraiphia. *International Journal of Osteoarchaeology*, 29**,** 26-35. https://doi.org/10.1002/oa.2710

Nikita, E. and Triantaphyllou, S. (2017). Human osteoarchaeology in Greece: Research themes, challenges and potential. *Archaeological Reports*, 63**,** 63-75. https://doi.org/10.1017/S0570608418000066

Nilsson, M. P. (1929). Die Hoplitentaktik und das Staatswesen. *Klio*, 22**,** 240-249. https://doi.org/10.1524/klio.1929.22.22.240

Novak, M. and Šlaus, M. (2011). Vertebral pathologies in two early modern period (16th–19th century) populations from Croatia. *American Journal of Physical Anthropology*, 145**,** 270-281. https://doi.org/10.1002/ajpa.21491

Novak, S. (2007). Battle-related trauma. *In:* Fiorato, V., Boylston, A. and Knüsel, C. (eds.) *Blood Red Roses. The archaeology of a mass grave from the battle of Towton AD 1461.* Oxford: Oxbow Books, 90-102.

Null, C. C., Blakey, M. L., Shujaa, K. J., Rankin-Hill, L. M. and Carrington, S. H. H. (2009). Osteological indicators of infectious disease and nutritional inadequacy. *In:* Blakey, M. L. and Rankin-Hill, L. M. (eds.) *The skeletal biology of the New York African burial ground.* Washington DC: Howard University Press, 169–197.

Nystrom, K. C. (2014). The bioarchaeology of structural violence and dissection in the 19th-century United States. *American Anthropologist*, 116**,** 765-779. https://doi.org/10.1111/aman.12151

Nystrom, K. C., Sirianni, J., Higgins, R., Perrelli, D. and Liber Raines, J. L. (2017). Structural inequality and postmortem examination at the Erie County Poorhouse. *In:* Nystrom, K. C. (ed.) *The bioarchaeology of dissection and autopsy in the United States.* Cham: Springer, 279-300. https://doi.org/10.1007/978-3-319-26836-1_13

Ogden, A. (2008). Advances in the palaeopathology of teeth and jaws. *In:* Pinhasi, R. and Mays, S. (eds.) *Advances in human palaeopathology*. Chichester: John Wiley & Sons, Ltd, 283-307. https://doi.org/10.1002/9780470724187.ch13

Oliver, R. C. and Brown, L. J. (1993). Periodontal diseases and tooth loss. *Periodontology 2000,* 2**,** 117-27. https://doi.org/10.1111/j.1600-0757.1993.tb00224.x

Ortner, D. J. (2003). *Identification of pathological conditions in human skeletal remains.* San Diego: Elsevier Science. https://doi.org/10.1016/B978-0-12-528628-2.X5037-6

Osborne, R. (1989). A crisis in archaeological history? The seventh century BC in Attica. *Annual of the British School at Athens,* 84**,** 297-322. https://doi.org/10.1017/S0068245400020992

Osborne, R. (2007). Archaic Greece. *In:* Scheidel, W., Morris, I. and Saller, R. P. (eds.) *The Cambridge economic history of the Greco-Roman world.* Cambridge: Cambridge University Press, 277-301.

Osborne, R. (2009). *Greece in the making, 1200-469 BC.* London: Routledge.

Osborne, R. (2023). *Athens and Attica.* Oxford: Oxford University Press. https://doi.org/10.1093/oso/9780197644423.001.0001

Owsley, D. W., Orser Jr, C. E., Mann, R. W., Moore-Jansen, P. H. and Montgomery, R. L. (1987). Demography and pathology of an urban slave population from New Orleans. *American Journal of Physical Anthropology,* 74**,** 185-197. https://doi.org/10.1002/ajpa.1330740207

Oxenham, M. F. and Cavill, I. (2010). Porotic hyperostosis and cribra orbitalia: The erythropoietic response to iron-deficiency anaemia. *Anthropological Science*, 118**,** 199-200.

Papadopoulos, J. K. (1993). To kill a cemetery: The Athenian Kerameikos and the Early Iron Age in the Aegean. *Journal of Mediterranean Archaeology,* 6**,** 175-206.

Papadopoulos, J. K. (2014). Greece in the Early Iron Age: Mobility, commodities, polities, and literacy. *In:* Knapp, A. B. and van Dommelen, P. (eds.) *The Cambridge prehistory of the Bronze and Iron Age Mediterranean.* Cambridge: Cambridge University Press, 178-195. https://doi.org/10.1017/CHO9781139028387.014

Papadopoulos, J. K. (2021). The emergence of the polis. *In:* Neils, J. and Rogers, D. K. (eds.) *The Cambridge companion to ancient Athens.* Cambridge: Cambridge University Press, 35-46. https://doi.org/10.1017/9781108614054.004

Papadopoulos, J. K. and Smithson, E. L. (2017). *The Early Iron Age: The cemeteries.* Princeton: American School of Classical Studies at Athens.

Papadopoulou, C. (2017). The living and their dead in Classical Athens: New evidence from Acharnai, Halai Aixonidai and Phaleron. *Archaeological Reports*, 63**,** 151-166. https://doi.org/10.1017/S057060841800011X

Papathanasiou, A. (2001). *A bioarchaeological analysis of Neolithic Alepotrypa Cave, Greece.* Oxford: BAR Publishing. https://doi.org/10.30861/9781841711812

Papathanasiou, A. (2003). Stable isotope analysis in Neolithic Greece and possible implications on human health. *International Journal of Osteoarchaeology,* 13**,** 314-324. https://doi.org/10.1002/oa.705

Papathanasiou, A. (2005). Health status of the Neolithic population of Alepotrypa Cave, Greece. *American Journal of Physical Anthropology,* 126**,** 377-390. https://doi.org/10.1002/ajpa.20140

Papathanasiou, A. (2015). Stable isotope analyses in neolithic and bronze age greece: An overview. *In:* Papathanasiou, A., Fox, S. C. and Richards, M. P. (eds.) *Archaeodiet in the Greek world: Dietary reconstruction from stable isotope analysis.* Princeton: American School of Classical Studies at Athens, 25-55.

Papathanasiou, A., Panagiotopoulou, E., Beltsios, K., Papakonstantinou, M.-F. and Sipsi, M. (2013). Inferences from the human skeletal material of the Early Iron Age cemetery at Agios Dimitrios, Fthiotis, Central Greece. *Journal of Archaeological Science,* 40**,** 2924-2933. https://doi.org/10.1016/j.jas.2013.02.027

Papathanasiou, A., Zachou, E. and Richards, M. P. (2009). Bioarchaeological analysis of the human osteological material from Proskynas, Lokris. *Hesperia Supplements,* 43**,** 223-235.

Park, S. (2012). Clinical analysis for the correlation of intra-abdominal organ injury in the patients with rib fracture. *The Korean Journal of Thoracic and Cardiovascular Surgery,* 45**,** 246-250. https://doi.org/10.5090/kjtcs.2012.45.4.246

Parker, V. (2007). Tyrants and lawgiver. *In:* Shapiro, H. A. (ed.) *The Cambridge companion to Archaic Greece.* Cambridge: Cambridge University Press, 13-39.

Parker, V. (2014). *A history of Greece, 1300 to 30 BC.* Chichester: Wiley Blackwell.

Parrington, M. and Roberts, D. G. (1990). Demographic, cultural, and bioanthropological aspects of a nineteenth-century free Black population in Philadelphia, Pennsylvania. *In:* Buikstra, J. E. (ed.) *A life in science: Papers in honor of J. Lawrence Angel.* Kampsville, IL: Center for American Archaeology 138-170.

Patterson, C. (2006). Citizen cemeteries in Classical Athens? *The Classical Quarterly,* 56**,** 48-56. https://doi.org/10.1017/S000983880600005X

Patterson, O. (1982). *Slavery and social death. A comparative study.* Cambridge, MA: Harvard University Press.

Pearson, M. P. (1993). The powerful dead: Archaeological relationships between the living and the dead. *Cambridge Archaeological Journal,* 3**,** 203-229. https://doi.org/10.1017/S0959774300000846

Pelekidis, S. (1916). Ανασκαφή Παλαιού Φαλήρου. *Archaeologiko Deltio,* 2**,** 13–64.

Perry, M. A. and Gowland, R. L. (2022). Compounding vulnerabilities: Syndemics and the social determinants of disease in the past. *International Journal of Paleopathology,* 39**,** 35-49. https://doi.org/10.1016/j.ijpp.2022.09.002

Petersen, P. E. and Ogawa, H. (2012). The global burden of periodontal disease: Towards integration with chronic disease prevention and control. *Periodontology 2000,* 60**,** 15-39. https://doi.org/10.1111/j.1600-0757.2011.00425.x

Petroutsa, E. I. and Manolis, S. K. (2010). Reconstructing Late Bronze Age diet in mainland Greece using stable isotope analysis. *Journal of Archaeological Science,* 37**,** 614-620. https://doi.org/10.1016/j.jas.2009.10.026

Petroutsa, E. I., Richards, M. P., Kolonas, L. and Manolis, S. K. (2009). Isotope paleodietary analysis of humans and fauna from the Late Bronze Age site of Voudeni. *Hesperia Supplements,* 43**,** 237-243.

Petroutsa, E. I., Richards, M. P. and Manolis, S. K. (2007). Stable isotope analysis of human remains from the Early Helladic site of Perachora, Korinth, Greece. *In:* Mee, C. and Renard, J. (eds.) *Cooking up the past: Food and culinary practices in the Neolithic and Bronze Age Aegean.* Oxford: Oxbow Books, 290-296.

Petry, L. (2020). Echoes in the bones: An osteological analysis of the biological impact of Roman rule at Corinth, Greece. *Chronika,* 10**,** 54-67.

Phenice, T. W. (1969). A newly developed visual method of sexing the os pubis. *American Journal of Physical Anthropology,* 30**,** 297-301. https://doi.org/10.1002/ajpa.1330300214

Pilloud, M. A. and Schwitalla, A. W. (2020). Re-evaluating traditional markers of stress in an archaeological sample from central California. *Journal of Archaeological Science,* 116**,** 105102. https://doi.org/10.1016/j.jas.2020.105102

Powers, N. (2005). Cranial trauma and treatment: A case study from the medieval cemetery of St. Mary Spital, London. *International Journal of Osteoarchaeology,* 15**,** 1-14. https://doi.org/10.1002/oa.733

Prevedorou, E.-A., Buikstra, J. E., Liedl, H., Waltenberger, L. and Hoff, A. (2024). Unwritten histories of ancient Athens: The people of the Phaleron cemetery. *In:* Lagia, A. and Voutsaki, S. (eds.) *Social inequality and difference in ancient Greece: Bioarchaeological perspectives.* Gainesville: University Press of Florida, n/d.

Pritchard, D. M. (2021). Athletics, democracy, and war. *In:* Neils, J. and Rogers, D. K. (eds.) *The Cambridge companion to ancient Athens.* Cambridge: Cambridge University Press, 307-318. https://doi.org/10.1017/9781108614054.023

Pritzker, K. P. H. (2003). Pathology of osteoarthritis. *In:* Brandt, K., D., Doherty, M. and Lohmander, L. S. (eds.) *Osteoarthritis.* 2 ed. Oxford: Oxford University Press, 49-58.

Prowse, T. L., Stark, R. and Emery, M. (2018). Stable isotope analysis and human migration in the ancient Mediterranean and Near East. *In:* Yoo, J., Zerbini, A. and Barron, C.

(eds.) *Migration and migrant identities in the Near East from Antiquity to the Middle Ages*. London: Routledge, 125-152.

Punitha, V. C., Amudhan, A., Sivaprakasam, P. and Rathanaprabu, V. (2015). Role of dietary habits and diet in caries occurrence and severity among urban adolescent school children. *Journal of Pharmacy and Bioallied Sciences*, 7**,** 296-300. https://doi.org/10.4103/0975-7406.155963

Quade, L., Chazot, P. L. and Gowland, R. L. (2021). Desperately seeking stress: A pilot study of cortisol in archaeological tooth structures. *American Journal of Physical Anthropology*, 174**,** 532-541. https://doi.org/10.1002/ajpa.24157

Quade, L. and Gowland, R. L. (2021). Height and health in Roman and Post-Roman Gaul, a life course approach. *International Journal of Paleopathology*, 35**,** 49-60. https://doi.org/10.1016/j.ijpp.2021.10.001

Quintó, L., Aponte, J. J., Menéndez, C., Sacarlal, J., Aide, P., Espasa, M., Mandomando, I., Guinovart, C., Macete, E., Hirt, R., Urassa, H., Navia, M. M., Thompson, R. and Alonso, P. L. (2006). Relationship between haemoglobin and haematocrit in the definition of anaemia. *Tropical Medicine & International Health*, 11**,** 1295-1302. https://doi.org/10.1111/j.1365-3156.2006.01679.x

Raaflaub, K. A. (1997). Soldiers, citizens and the evolution of the early Greek polis. *In:* Mitchell, L. and Rhodes, P. J. (eds.) *The development of the polis in Archaic Greece.* London: Routledge, 49-59.

Raaflaub, K. A. and Wallace, R. W. (2007). 'People's power' and egalitarian trends in Archaic Greece. *In:* Raaflaub, K. A., Ober, J. and Wallace, R. W. (eds.) *Origins of democracy in ancient Greece.* Berkeley: University of California Press, 22-48. https://doi.org/10.1525/9780520932173

Rabino Massa, E., Cerutti, N. and Savoia, M. D. (2000). Malaria in ancient Egypt: Paleoimmunological investigation on predynastic mummified remains. *Chungará (Arica)*, 32**,** 7-9.

Ragsdale, B. D. (1993). Morphologic analysis of skeletal lesions: Correlation of imaging studies and pathologic findings. *Adv Pathol Lab Med*, 6**,** 445-490.

Ragsdale, B. D., Madewell, J. E. and Sweet, D. E. (1981). Radiologic and pathologic analysis of solitary bone lesions. Part II. Periosteal reactions. *Radiologic Clinics of North America*, 19**,** 749-783. https://doi.org/10.1016/S0033-8389(22)01352-5

Rajendran, A. and Sivapathasundharam, B. (2012). Shafer's Textbook of Oral Pathology. New Delhi: Elsevier Health Sciences.

Rankin-Hill, L. M., Blakey, M. L., Howson, J. E., Wilson, S. D., Brown, E., Carrington, S. H. H. and Shujaa, K. J. (2009). Demographic overview of the African burial ground and colonial Africans of New York. *In:* Blakey, M. L. and Rankin-Hill, L. M. (eds.) *The skeletal biology of the New York African burial ground.* Washington DC: Howard University Press, 119–139.

Rathbun, T. A. (1987). Health and disease at a South Carolina plantation: 1840–1870. *American Journal of Physical Anthropology,* 74**,** 239-253. https://doi.org/10.1002/ajpa.1330740211

Raxter, M. H., Auerbach, B. M. and Ruff, C. B. (2006). Revision of the Fully technique for estimating statures. *American Journal of Physical Anthropology,* 130**,** 374-384. https://doi.org/10.1002/ajpa.20361

Raxter, M. H., Ruff, C. B. and Auerbach, B. M. (2007). Technical note: Revised Fully stature estimation technique. *American Journal of Physical Anthropology,* 133**,** 817-818.

Redfern, R. C. (2017). *Injury and trauma in bioarchaeology. Interpreting violence in past lives.* Cambridge: Cambridge University Press. https://doi.org/10.1017/9780511978579

Redfern, R. C. (2018). Blind to chains? The potential of bioarchaeology for identifying the enslaved of Roman Britain. *Britannia,* 49**,** 251-282. https://doi.org/10.1017/S0068113X18000119

Redfern, R. C. and DeWitte, S. N. (2011a). A new approach to the study of Romanization in Britain: A regional perspective of cultural change in late Iron Age and Roman Dorset using the Siler and Gompertz–Makeham models of mortality. *American Journal of Physical Anthropology,* 144**,** 269-285. https://doi.org/10.1002/ajpa.21400

Redfern, R. C. and DeWitte, S. N. (2011b). Status and health in Roman Dorset: The effect of status on risk of mortality in post-conquest populations. *American Journal of Physical Anthropology,* 146**,** 197-208. https://doi.org/10.1002/ajpa.21563

Redfern, R. C., Judd, M. A. and DeWitte, S. N. (2017). Multiple injury and health in past societies: An analysis of concepts and approaches, and insights from a multi-period study. *International Journal of Osteoarchaeology,* 27**,** 418-429. https://doi.org/10.1002/oa.2565

Redfern, R. C. and Roberts, C. (2019). Trauma. *In:* Buikstra, J. E. (ed.) *Ortner's identification of pathological conditions in human skeletal remains.* 3 ed. London: Academic Press Elsevier, 211-284.

Reiner, D., Pastena, J., Swan, K., Lindenthal, J. and Tischler, C. (1990). Trauma recidivism. *The American Surgeon,* 56**,** 556-560.

Resnick, D. (1995). *Diagnosis of bone and joint disorders.* London: Saunders.

Resnick, D. and Niwayama, G. (1978). Intravertebral disk herniations: Cartilaginous (Schmorl's) nodes. *Radiology,* 126**,** 57-65. https://doi.org/10.1148/126.1.57

Richardson, S., Hirsch, J. S., Narasimhan, M., Crawford, J. M., McGinn, T., Davidson, K. W., Barnaby, D. P., Becker, L. B., Chelico, J. D. and Cohen, S. L. (2020). Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *Journal of the American Medical Association,* 323**,** 2052-2059. https://doi.org/10.1001/jama.2020.6775

Riess, W. (2016). Where to kill in Classical Athens: Assassinations, executions, and the Athenian public space. *In:* Riess, W. and Fagan, G. G. (eds.) *The topography of violence in the Greco-Roman world.* Ann Arbor: University of Michigan Press, 77-112.

Rife, J. L. (2011). *The Roman and Byzantine graves and human remains.* Princeton: American School of Classical Studies at Athens.

Robb, J. (2000). Analysing human skeletal data. *In:* Cox, M. and Mays, S. (eds.) *Human osteology in archaeology and forensic science.* Cambridge: Cambridge University Press, 475-490.

Robb, J. (2002). Time and biography. *In:* Hamilakis, Y. P., Mark; Tarlow, Sarah, (ed.) *Thinking through the body. Archaeologies of corporeality.* Boston: Springer, 145-163. https://doi.org/10.1007/978-1-4615-0693-5_9

Robbins Schug, G. and Halcrow, S. (2022). Building a bioarchaeology of pandemic, epidemic, and syndemic diseases: Lessons for understanding COVID-19. *Bioarchaeology International,* 6**,** 1–22. https://doi.org/10.5744/bi.2022.6000

Roberts, C. A. (2007). A bioarcheological study of maxillary sinusitis. *American Journal of Physical Anthropology,* 133**,** 792-807. https://doi.org/10.1002/ajpa.20601

Roberts, C. A. (2019). Infectious disease: Introduction, periostosis, periostitis, osteomyelitis, and septic arthritis. *In:* Buikstra, J. E. (ed.) *Ortner's identification of pathological conditions in human skeletal remains.* 3 ed. London: Academic Press Elsevier, 285-319.

Roberts, C. A. (2020a). Mortui vivos docent: Let the dead teach the living in a post-pandemic landscape. *What makes a community more vulnerable to COVID-19.* 41-46.

Roberts, C. A. (2020b). Words, stigma and the coronavirus: Implications of COVID-19 for holistic approaches to infectious diseases. *Journal of the British Academy,* 8**,** 240-244.

Roberts, C. A., Bourbou, C., Lagia, A., Triantaphyllou, S. and Tsaliki, A. (2005). Health and disease in Greece: Past, present and future. *In:* King, H. (ed.) *Health in antiquity.* Abingdon, Oxon: Routledge, 32-58.

Roberts, C. A. and Buikstra, J. E. (2019). Bacterial infections. *In:* Buikstra, J. E. (ed.) *Ortner's identification of pathological conditions in human skeletal remains.* 3 ed. London: Academic Press Elsevier, 321-439.

Roberts, C. A. and Manchester, K. (2005). *The Archaeology of Disease.* Ithaca, NY: Cornell University Press.

Rodney, N. C. and Mulligan, C. J. (2014). A biocultural study of the effects of maternal stress on mother and newborn health in the Democratic Republic of Congo. *American Journal of Physical Anthropology,* 155**,** 200-209. https://doi.org/10.1002/ajpa.22568

Rojas-Sepúlveda, C., Ardagna, Y. and Dutour, O. (2008). Paleoepidemiology of vertebral degenerative disease in a Pre-Columbian Muisca series from Colombia. *American Journal of Physical Anthropology,* 135**,** 416-430. https://doi.org/10.1002/ajpa.20762

Rönnberg, M. F. (2021a). *Athen und Attika vom 11. bis zum frühen 6. Jh. v. Chr: Siedlungsgeschichte, politische Institutionalisierungs-und gesellschaftliche Formierungsprozesse.* Rahden/Westf.: Verlag Marie Leidorf GmbH.

Rönnberg, M. F. (2021b). Reinterpreting the diachronic variations in the numbers of burials known from Early Iron Age Athens. *Journal of Greek Archaeology,* 6**,** 146-166. https://doi.org/10.32028/9781789698886-8

Rönnberg, M. F. (2023). The new mass grave(s) at Phaleron, Kylon and the increase in elite competition in early Archaic Athens. *BABESCH,* 98**,** 11-30. https://doi.org/10.2143/BAB.98.0.3291700

Rothschild, B. (2012). Extirpolation of the mythology that porotic hyperostosis is caused by iron deficiency secondary to dietary shift to maize. *Advances in Anthropology,* 2**,** 157-160.

Rothwell, J. E. (2024). *Childhood health and social identity in Archaic Athens: A bioarchaeological perspective from Phaleron.* PhD thesis, Arizona State University.

Roumelis, N. (2007). *The palaeopathology of Kirchberg: Evidence of deficiency, inflammatory and tumorous disease in a medieval rural population in Hessia, Germany.* PhD thesis, Stockholm University.

Ruffer, A. (1920). Study of abnormalities and pathology of ancient Egyptian teeth. *American Journal of Physical Anthropology,* 3**,** 335-382.

Runciman, W. G. (1990). Doomed to extinction: The polis as an evolutionary dead-end. *In:* Murray, O. and Price, S. R. F. (eds.) *The Greek city from Homer to Alexander.* Oxford: Clarendon Press, 347-67.

Rylko-Bauer, B. and Farmer, P. (2016). Structural violence, poverty, and social suffering. *In:* Brady, D. and Burton, L. M. (eds.) *The Oxford handbook of the social science of poverty.* Oxford: Oxford University Press, 47-74.

Sairyo, K., Katoh, S., Sakamaki, T., Komatsubara, S., Endo, K. and Yasui, N. (2003). Three successive stress fractures at the same vertebral level in an adolescent baseball player. *The American Journal of Sports Medicine,* 31**,** 606-610. https://doi.org/10.1177/03635465030310042201

Sakai, T., Sairyo, K., Suzue, N., Kosaka, H. and Yasui, N. (2010). Incidence and etiology of lumbar spondylolysis: Review of the literature. *Journal of Orthopaedic Science,* 15**,** 281-288. https://doi.org/10.1007/s00776-010-1454-4

Saul, F. P. (1972). *The human skeletal remains of Altar de Sacrificios. An osteobiographic analysis.* Cambridge, MA: Harvard University Press.

Saunders, S. R. (2008). Juvenile skeletons and growth-related studies. *In:* Katzenberg, A. and Saunders, S. R. (eds.) *Biological anthropology of the human skeleton.* 2 ed. Hoboken, NJ: Wiley-Liss, 117-147. https://doi.org/10.1002/9780470245842.ch4

Saunders, S. R., Herring, A., Sawchuk, L., Boyce, G., Hoppa, R. and Klepp, S. (2002). The health of the middle class: The St. Thomas' Anglican Church cemetery project. *In:* Steckel, R. and Rose, J. C. (eds.) *The backbone of history: Health and nutrition in the western hemisphere.* Cambridge: Cambridge University Press, 130-161.

Saunders, S. R. and Hoppa, R. D. (1993). Growth deficit in survivors and non-survivors: Biological mortality bias in subadult skeletal samples. *American Journal of Physical Anthropology*, 36**,** 127-151. https://doi.org/0.1002/ajpa.1330360608

Saxe, A. (1970). *Social dimensions of mortuary practices.* PhD thesis, University of Michigan.

Schaefer, M., Black, S. M. and Scheuer, L. (2009). *Juvenile osteology. A laboratory and field manual.* Burlington, MA: Elsevier.

Schaps, D. (2004). *The invention of coinage and the monetization of ancient Greece.* Ann Arbor: University of Michigan Press.

Scheidel, W. (2004). Gräberstatistiken und Bevölkerungsgeschichte. Attika im achten Jahrhundert. *In:* Rollinger, R. and Ulf, C. (eds.) *Griechische Archaik. Interne Entwicklungen - Externe Impulse.* Berlin: Akademie Verlag, 177-185.

Schepartz, L. A., Miller-Antonio, S. and Murphy, J. M. (2009). Differential health among the Mycenaeans of Messenia: Status, sex, and dental health at Pylos. *Hesperia Supplement*, 43**,** 155-174.

Schmid, L., Pfirrmann, C., Hess, T. and Schlumpf, U. (1999). Bilateral fracture of the sacrum associated with pregnancy: A case report. *Osteoporosis International*, 10**,** 91-93. https://doi.org/10.1007/s001980050200

Schultz, M. (2001). Paleohistopathology of bone: A new approach to the study of ancient disease. *Yearbook of Physical Anthropology*, 44**,** 106-147.

Selye, H. (1946). The general adaptation syndrome and the diseases of adaptation. *The Journal of Clinical Endocrinology & Metabolism*, 6**,** 117-230. https://doi.org/10.1210/jcem-6-2-117

Selye, H. (1950). Stress and the general adaptation syndrome. *British Medical Journal*, 1**,** 1383-1392. https://doi.org/10.1136/bmj.1.4667.1383

Shea, T. (2021). The Archaic and Classical cemeteries. *In:* Neils, J. and Rogers, D. K. (eds.) *The Cambridge companion to ancient Athens.* Cambridge: Cambridge University Press, 140-156. https://doi.org/10.1017/9781108614054.011

Shennan, S. (2014). *Quantifying archaeology.* Edinburgh: Edinburgh University Press.

Shopfner, C. E. (1966). Periosteal bone growth in normal infants: A preliminary report. *American Journal of Roentgenology,* 97**,** 154-163.

Singer, M. (1994). AIDS and the health crisis of the U.S. urban poor. The perspective of critical medical anthropology. *Social Science & Medicine,* 39**,** 931-948. https://doi.org/10.1016/0277-9536(94)90205-4

Singer, M. (1996). A dose of drugs, a touch of violence, a case of AIDS: Conceptualizing the SAVA syndemic. *Free inquiry in creative sociology,* 24**,** 99-110.

Singer, M. (2006). A dose of drugs, a touch of violence, a case of AIDS, part 2: Further conceptualizing the SAVA syndemic. *Free Inquiry in Creative Sociology,* 34**,** 39-54.

Singer, M. (2009). *Introduction to syndemics: A critical systems approach to public and community health.* San Francisco: John Wiley & Sons.

Singer, M., Bulled, N. and Leatherman, T. (2022). Are there global syndemics? *Medical Anthropology,* 41**,** 4-18. https://doi.org/10.1080/01459740.2021.2007907

Singer, M., Bulled, N., Ostrach, B. and Lerman Ginzburg, S. (2021). Syndemics: A cross-disciplinary approach to complex epidemic events like COVID-19. *Annual Review of Anthropology,* 50**,** 41-58. https://doi.org/10.1146/annurev-anthro-100919-121009

Singer, M., Bulled, N., Ostrach, B. and Mendenhall, E. (2017). Syndemics and the biosocial conception of health. *The Lancet,* 389**,** 941-950. https://doi.org/10.1016/S0140-6736(17)30003-X

Singer, M. and Clair, S. (2003). Syndemics and public health: Reconceptualizing disease in bio-social context. *Medical Anthropology Quarterly,* 17**,** 423-441. https://doi.org/10.1525/maq.2003.17.4.423

Singer, M., Valentín, F., Baer, H. and Jia, Z. (1992). Why does Juan García have a drinking problem? The perspective of critical medical anthropology. *Medical Anthropology,* 14**,** 77-108. https://doi.org/10.1080/01459740.1992.9966067

Skoglund, P., Storå, J., Götherström, A. and Jakobsson, M. (2013). Accurate sex identification of ancient human remains using DNA shotgun sequencing. *Journal of Archaeological Science,* 40**,** 4477-4482. https://doi.org/10.1016/j.jas.2013.07.004

Smith-Guzmán, N. E. (2015a). Cribra orbitalia in the ancient Nile Valley and its connection to malaria. *International Journal of Paleopathology,* 10**,** 1-12. https://doi.org/10.1016/j.ijpp.2015.03.001

Smith-Guzmán, N. E. (2015b). The skeletal manifestation of malaria: An epidemiological approach using documented skeletal collections. *American Journal of Physical Anthropology,* 158**,** 624-635. https://doi.org/10.1002/ajpa.22819

Smithson, E. L. (1968). The Tomb of a Rich Athenian Lady, CA. 850 B.C. *Hesperia,* 37**,** 77-116. https://doi.org/10.2307/147539

Snodgrass, A. M. (1965). The hoplite reform and history. *The Journal of Hellenic Studies,* 85**,** 110-122. https://doi.org/10.2307/628813

Snodgrass, A. M. (1977). *Archaeology and the rise of the Greek state: An inaugural lecture.* Cambridge: Cambridge University Press.

Snodgrass, A. M. (1980). *Archaic Greece. The age of experiment.* Berkley: University of California Press.

Snodgrass, A. M. (2006). Archaeology and the rise of the Greek state. *Archaeology and the emergence of Greece. Collected papers on early Greece and related topics.* Edinburgh: Edinburgh University Press, 198-220.

Sofaer Derevenski, J. R. (2000). Sex differences in activity-related osseous change in the spine and the gendered division of labor at Ensay and Wharram Percy, UK. *American Journal of Physical Anthropology,* 111**,** 333-354.

Sofaer, J. R. (2006). *The body as material culture: A theoretical osteoarchaeology.* Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511816666

Sorci, G., Faivre, B. and Morand, S. (2020). Explaining among-country variation in COVID-19 case fatality rate. *Scientific Reports,* 10**,** 18909. https://doi.org/10.1038/s41598-020-75848-2

Sourvinou-Inwood, C. (1983). A Trauma in Flux. Death in the 8th Century and After. *In:* Hägg, R. (ed.) *The Greek Renaissance of the Eighth Century BC: Tradition and Innovation.* Stockholm: Svenska institutet i Athen, 33-48.

Stahl, M. and Walter, U. (2009). Athens. *In:* Raaflaub, K. A. and van Wees, H. (eds.) *A companion the Archaic Greece.* Chichester: Wiley-Blackwell, 138-161.

Steckel, R. H. (2009). Heights and human welfare: Recent developments and new directions. *Explorations in Economic History,* 46**,** 1-23. https://doi.org/10.1016/j.eeh.2008.12.001

Steckel, R. H., Rose, J. C., Larsen, C. S. and Walker, P. L. (2002a). Skeletal health in the Western Hemisphere from 4000 B.C. to the present. *Evolutionary Anthropology: Issues, News, and Reviews,* 11**,** 142-155. https://doi.org/10.1002/evan.10030

Steckel, R. H., Sciulli, P. W. and Rose, J. C. (2002b). A health index from skeletal remains. *In:* Steckel, R. H. and Rose, J. C. (eds.) *The backbone of history: Health and nutrition in the western hemisphere.* Cambridge: Cambridge University Press, 61-93. https://doi.org/10.1017/CBO9780511549953.004

Steele, P. M. (2020). Script and literacy. *In:* Lemos, I. S. and Kotsonas, A. (eds.) *A companion to the archaeology of early Greece and the Mediterranean.* Hoboken, NJ: Wiley-Blackwell, 247-269.

Stewart, N. A., Gerlach, R. F., Gowland, R. L., Gron, K. J. and Montgomery, J. (2017). Sex determination of human remains from peptides in tooth enamel. *Proceedings of the National Academy of Sciences,* 114**,** 13649-13654. https://doi.org/10.1073/pnas.1714926115

Steyn, M., İŞcan, M., De Kock, M., Kranioti, E., Michalodimitrakis, M. and L'Abbé, E. N. (2010). Analysis of ante mortem trauma in three modern skeletal populations. *International Journal of Osteoarchaeology,* 20**,** 561-571. https://doi.org/10.1002/oa.1096

Stirland, A. J. and Waldron, T. (1997). Evidence for activity related markers in the vertebrae of the crew of the Mary Rose. *Journal of Archaeological Science,* 24**,** 329-335. https://doi.org/10.1006/jasc.1996.0117

Stodder, A. L. W. (2012). Data and data analysis issues in paleopathology. *In:* Grauer, A. L. (ed.) *A companion to paleopathology.* Chichester: Wiley-Blackwell, 339-356.

Stodder, A. L. W. and Palkovich, A. M. (2012). *The bioarchaeology of individuals.* Gainesville: University Press of Florida.

Storoszeck, J. (2012). Grave gifts in child burials in the Athenian Kerameikos: the evidence of Sea Shells. *In:* Hermary, A. and Dubois, C. (eds.) *L'enfant et la mort dans l'Antiquité III. Le matériel associé aux tombes d'enfants.* Aix-en-Provence: Bibliothèque d'Archéologie Méditerranéenne et Africaine, 57-76.

Stout, S. D., Cole, M. E. and Agnew, A. M. (2019). Histomorphology: Deciphering the metabolic record. *In:* Buikstra, J. E. (ed.) *Ortner's identification of pathological conditions in human skeletal remains.* 3 ed. London: Academic Press Elsevier, 91-167. https://doi.org/10.1016/B978-0-12-809738-0.00006-5

Stravopodi, E., Manolis, S. K., Kousoulakos, S., Aleporou, V. and Schultz, M. P. (2009). Porotic hyperostosis in Neolithic Greece: New evidence and further implications. *Hesperia Supplements,* 43**,** 257-270.

Stuart-Macadam, P. (1985). Porotic hyperostosis: Representative of a childhood condition. *American Journal of Physical Anthropology,* 66**,** 391-398. https://doi.org/10.1002/ajpa.1330660407

Stuart-Macadam, P. (1991). Anaemia in Roman Britain: Poundbury Camp. *In:* Bush, H. and Zvelebil, M. (eds.) *Health in past societies. Biocultural interpretations of human skeletal remains in archaeological contexts.* Oxford: British Archaeological Reports, 101-113.

Stuart-Macadam, P. (1987). Porotic hyperostosis: new evidence to support the anemia theory. *American Journal of Physical Anthropology,* 74**,** 521-526. https://doi.org/10.1002/ajpa.1330740410

Stuart-Macadam, P. (1992). Porotic hyperostosis: A new perspective. *American Journal of Physical Anthropology,* 87**,** 39-47. https://doi.org/https://doi.org/10.1002/ajpa.1330870105

Sulosky Weaver, C. L. (2015). *The bioarchaeology of Classical Kamarina. Life and death in Greek Sicily.* Gainesville: University Press of Florida.

Sulosky Weaver, C. L. (2022). *Marginalised populations in the ancient Greek world. The bioarchaeology of the other*. Edinburgh: Edinburgh University Press. https://doi.org/10.1515/9781474415262

Taylor, C. (2017). *Poverty, wealth, and well-being. Experiencing penia in democratic Athens.* Oxford: Oxford University Press.

Tegtmeyer, C. E. and Martin, D. L. (2017). *Broken bones, broken bodies. Bioarchaeological and forensic approaches for accumulative trauma and violence.* Lanham: Lexington Books.

Temple, D. H. (2014). Plasticity and constraint in response to early-life stressors among late/final Jomon period foragers from Japan: Evidence for life history trade-offs from incremental microstructures of enamel. *American Journal of Physical Anthropology,* 155**,** 537-545. https://doi.org/10.1002/ajpa.22606

Temple, D. H. (2015). Caries: The ancient scourge. *In:* Irish, J. D. and Scott, R. G. (eds.) *A companion to dental anthropology*. Chichester: Wiley Blackwell, 433-449. https://doi.org/10.1002/9781118845486.ch26

Temple, D. H. and Goodman, A. H. (2014). Bioarcheology has a 'health' problem: Conceptualizing 'stress' and 'health' in bioarcheological research. *American Journal of Physical Anthropology,* 155**,** 186-191. https://doi.org/10.1002/ajpa.22602

Temple, D. H. and Larsen, C. S. (2007). Dental caries prevalence as evidence for agriculture and subsistence variation during the Yayoi period in prehistoric Japan: Biocultural interpretations of an economy in transition. *American Journal of Physical Anthropology,* 134**,** 501-512. https://doi.org/10.1002/ajpa.20694

Thienpont, E., Simon, J.-P. and Fabry, G. (1999). Sacral stress fracture during pregnancy-a case report. *Acta Orthopaedica Scandinavica,* 70**,** 525-526. https://doi.org/10.3109/17453679909000996

Thompson, F. H. (2003). *The archaeology of Greek and Roman slavery.* London: Duckworth.

Thompson, T. (2015). Fire and the body: Fire and the people. *In:* Thompson, T. (ed.) *The archaeology of cremation: Burned human remains in funerary studies.* Havertown: Oxbow Books, 1-18.

Tilley, L. and Cameron, T. (2014). Introducing the index of care: A web-based application supporting archaeological research into health-related care. *International Journal of Paleopathology,* 6**,** 5-9. https://doi.org/10.1016/j.ijpp.2014.01.003

Tipper, S., Wilson, P. and Roberts, C. A. (2023). Spondylolysis in ancient Nubian skeletal populations. *International Journal of Osteoarchaeology,* 33**,** 876–885. https://doi.org/10.1002/oa.3241

Triantaphyllou, S. (2001). *A bioarchaeological approach to prehistoric cemetery populations from Central and Western Greek Macedonia.* Oxford: British Archaeological Reports. https://doi.org/10.30861/9781841711850

Triantaphyllou, S. and Bessios, M. (2005). A mass burial at fourth century BC Pydna, Macedonia, Greece: Evidence for slavery. *Antiquity,* 79.

Triantaphyllou, S., Richards, M. P., Zerner, C. and Voutsaki, S. (2008). Isotopic dietary reconstruction of humans from Middle Bronze age Lerna, Argolid, Greece. *Journal of Archaeological Science,* 35**,** 3028-3034. https://doi.org/10.1016/j.jas.2008.06.018

Tritsaroli, P. (2014). Human remains from Pigi Athinas, Greece, 1999-2011. *Bioarchaeology of the Near East,* 8**,** 125-137.

Tritsaroli, P. and Karadima, C. (2018). The people of Early Byzantine Maroneia. *Bioarchaeology of the Near East,* 11**,** 29-62.

Trotter, M. and Gleser, G. C. (1952). Estimation of stature from long bones of American Whites and Afroamericans. *American Journal of Physical Anthropology,* 10**,** 463-514. https://doi.org/10.1002/ajpa.1330100407

Trotter, M. and Gleser, G. C. (1958). A re-evaluation of estimation of stature based on measurements of stature taken during life and of long bones after death. *American Journal of Physical Anthropology,* 16**,** 79-123. https://doi.org/10.1002/ajpa.1330160106

Tsai, A. C. (2015). Home foreclosure, health, and mental health: A systematic review of individual, aggregate, and contextual associations. *PLOS ONE,* 10**,** e0123182. https://doi.org/10.1371/journal.pone.0123182

Tsai, A. C. (2018). Syndemics: A theory in search of data or data in search of a theory? *Social Science & Medicine,* 206**,** 117-122. https://doi.org/10.1016/j.socscimed.2018.03.040

Tsai, A. C., Mendenhall, E., Trostle, J. A. and Kawachi, I. (2017). Co-occurring epidemics, syndemics, and population health. *The Lancet,* 389**,** 978-982. https://doi.org/10.1016/S0140-6736(17)30403-8

Tyler, P. A., Madani, G., Chaudhuri, R., Wilson, L. F. and Dick, E. A. (2006). The radiological appearances of thalassaemia. *Clinical Radiology,* 61**,** 40-52. https://doi.org/10.1016/j.crad.2005.07.006

Valdes, A. M. and Spector, T. D. (2008). The contribution of genes to osteoarthritis. *Rheumatic Disease Clinics of North America,* 34**,** 581-603. https://doi.org/10.1016/j.rdc.2008.04.008

Van der Merwe, A. E., Morris, D., Steyn, M. and Maat, G. J. R. (2010a). The history and health of a nineteenth-century migrant mine-worker population from Kimberley, South Africa. *The South African Archaeological Bulletin,* 65**,** 185-195.

Van der Merwe, A. E., Steyn, M. and L'Abbé, E. N. (2010b). Trauma and amputations in 19th century miners from Kimberley, South Africa. *International Journal of Osteoarchaeology,* 20**,** 291-306. https://doi.org/10.1002/oa.1035

Van der Merwe, A. E., Steyn, M. and Maat, G. J. R. (2010c). Adult scurvy in skeletal remains of late 19th century mineworkers in Kimberley, South Africa. *International Journal of Osteoarchaeology,* 20**,** 307-316. https://doi.org/10.1002/oa.1037

van der Plicht, J. (Year) Published. Radiocarbon, the Calibration Curve and Scythian Chronology. *In:* Marian Scott, E., Alekseev, A. Y. and Zaitseva, G., eds. Impact of the Environment on Human Migration in Eurasia, 2005// 2005 Dordrecht. Springer Netherlands, 45-61.

van Wees, H. (2006). Mass and elite in Solon's Athens: The property classes revisited. *In:* Blok, J. and Lardinois, A. (eds.) *Solon of Athens. New historical and philological approaches.* Leiden: Brill, 351-389.

van Wees, H. (2013). *Ships and silver, taxes and tribute. A fiscal history of archaic Athens.* London: I.B. Tauris.

van Wees, H. (2018). Citizens and soldiers in Archaic Athens. *In:* Duplouy, A. and Brock, R. W. (eds.) *Defining citizenship in Archaic Greece.* Oxford: Oxford University Press, 103-144.

Vercellotti, G., Agnew, A. M., Justus, H. M. and Sciulli, P. W. (2009). Stature estimation in an early medieval (XI-XII c.) Polish population: Testing the accuracy of regression equations in a bioarcheological sample. *American Journal of Physical Anthropology,* 140**,** 135-142. https://doi.org/10.1002/ajpa.21055

Vercellotti, G., Piperata, B. A., Agnew, A. M., Wilson, W. M., Dufour, D. L., Reina, J. C., Boano, R., Justus, H. M., Larsen, C. S., Stout, S. D. and Sciulli, P. W. (2014). Exploring the multidimensionality of stature variation in the past through comparisons of archaeological and living populations. *American Journal of Physical Anthropology,* 155**,** 229-242. https://doi.org/10.1002/ajpa.22552

Vercellotti, G., Stout, S. D., Boano, R. and Sciulli, P. W. (2011). Intrapopulation variation in stature and body proportions: Social status and sex differences in an Italian medieval population (Trino Vercellese, VC). *American Journal of Physical Anthropology,* 145**,** 203-214. https://doi.org/10.1002/ajpa.21486

Vergidou, C. (2024). *Diet and differentiation in the Roman province of Macedonia: A bioarchaeological approach.* PhD thesis, University of Groningen.

Vergidou, C., Karamitrou-Mentessidi, G., Voutsaki, S. and Nikita, E. (2021). Oral health and its implications on male-female dietary differences: A study from the Roman Province of Macedonia. *Journal of Archaeological Science: Reports,* 35**,** 102784. https://doi.org/10.1016/j.jasrep.2020.102784

Vergidou, C., Karamitrou-Mentessidi, G., Voutsaki, S. and Nikita, E. (2022). A bioarcheological contribution to the social history of Roman Macedonia: The

Pontokomi-Vrysi site in Kozani Prefecture, Greece. *International Journal of Osteoarchaeology,* 32**,** 1020-1034. https://doi.org/10.1002/oa.3128

Villotte, S., Castex, D., Couallier, V., Dutour, O., Knüsel, C. J. and Henry-Gambier, D. (2010). Enthesopathies as occupational stress markers: Evidence from the upper limb. *American Journal of Physical Anthropology,* 142**,** 224-234. https://doi.org/10.1002/ajpa.21217

Vlanti, A. D. (2020). *The burial rite of Enchytrismos in Attica, Euboea and Boeotia during the Late Geometric and Archaic periods. Towards an understanding of its social significance.* PhD thesis, University of Oxford.

Voutsaki, S. and Valamoti, S.-M. (eds.) (2013a). *Diet, economy and society in the ancient Greek world: Towards a better integration of archaeology and science.* Leuven: Peeters.

Voutsaki, S. and Valamoti, S.-M. (2013b). Institutional framework and ethical obligations: Doing archaeological science in Greece. The round table discussion. *In:* Voutsaki, S. and Valamoti, S.-M. (eds.) *Diet, economy and society in the ancient Greek world: Towards a better integration of archaeology and science.* Leuven: Peeters, 235-241.

Wacquant, L. (2004). Comment on An anthropology of structural violence by Paul Farmer. *Current Anthropology,* 45**,** 322.

Wade, L. (2020). An unequal blow. *Science,* 368**,** 700-703. https://doi.org/10.1126/science.368.6492.700

Waldron, T. (2008). *Palaeopathology.* Cambridge: Cambridge University Press.

Waldron, T. (2012). Joint disease. *In:* Grauer, A. L. (ed.) *A companion to palaepathology.* Chichester: Wiley-Blackwell, 594-612.

Waldron, T. (2019). Joint disease. *In:* Buikstra, J. E. (ed.) *Ortner's identification of pathological conditions in human skeletal remains.* 3 ed. London: Academic Press Elsevier, 719-748.

Walker, P. L. (2001). A bioarchaeological perspective on the history of violence. *Annual Review of Anthropology,* 30**,** 573-596. https://doi.org/10.1146/annurev.anthro.30.1.573

Walker, P. L. (2005). Greater sciatic notch morphology: Sex, age, and population differences. *American Journal of Physical Anthropology,* 127**,** 385-391. https://doi.org/10.1002/ajpa.10422

Walker, P. L. (2014). Wife beating, boxing, and broken noses: Skeletal evidence for the cultural patterning of violence. *In:* Martin, D. L. and Frayer, D. W. (eds.) *Troubled times: Violence and warfare in the past.* Abingdon, Oxon: Routledge, 145-180.

Walker, P. L., Bathurst, R. R., Richman, R., Gjerdrum, T. and Andrushko, V. A. (2009). The causes of porotic hyperostosis and cribra orbitalia: A reappraisal of the iron-deficiency-anemia hypothesis. *American Journal of Physical Anthropology,* 139**,** 109-125. https://doi.org/10.1002/ajpa.21031

Wallace, R. W. (1987). The origin of electrum coinage. *American Journal of Archaeology,* 91**,** 385-397.

Wallace, R. W. (2007). Revolutions and a new order in Solonian Athens and Archaic Greece. *In:* Raaflaub, K. A., Ober, J. and Wallace, R. W. (eds.) *Origins of democracy in ancient Greece.* Berkeley: University of California Press, 49-82. https://doi.org/10.1525/9780520932173

Wallace, R. W. (2009). Charismatic leaders. *In:* Raaflaub, K. A. and van Wees, H. (eds.) *A companion the Archaic Greece.* Chichester: Wiley-Blackwell, 411-426.

Wapler, U., Crubezy, E. and Schultz, M. (2004). Is cribra orbitalia synonymous with anemia? Analysis and interpretation of cranial pathology in Sudan. *American Journal of Physical Anthropology,* 123**,** 333-339. https://doi.org/10.1002/ajpa.10321

Watts, R. (2011). Non-specific indicators of stress and their association with age at death in Medieval York: Using stature and vertebral neural canal size to examine the effects of stress occurring during different periods of development. *International Journal of Osteoarchaeology,* 21**,** 568-576. https://doi.org/10.1002/oa.1158

Watts, R. (2015). The long-term impact of developmental stress. Evidence from later medieval and post-medieval London (AD1117–1853). *American Journal of Physical Anthropology,* 158**,** 569-580. https://doi.org/10.1002/ajpa.22810

Webster, J. (2005). Archaeologies of slavery and servitude: Bringing 'New World' perspectives to Roman Britain. *Journal of Roman Archaeology,* 18**,** 161-179. https://doi.org/10.1017/S1047759400007261

Webster, J. (2008a). Less beloved. Roman archaeology, slavery and the failure to compare. *Archaeological Dialogues,* 15**,** 103-123. https://doi.org/10.1017/S1380203808002596

Webster, J. (2008b). Slavery, archaeology and the politics of analogy. *Archaeological Dialogues,* 15**,** 139-149. https://doi.org/10.1017/S138020380800264X

Weiss, E. and Jurmain, R. (2007). Osteoarthritis revisited: A contemporary review of aetiology. *International Journal of Osteoarchaeology,* 17**,** 437-450. https://doi.org/10.1002/oa.889

Welcker, H. (1888). Cribra orbitalia, ein ethonogisch-diagnostisches Merkmal am Schädel mehrer Menschenrassen. *Arch. Anthropol,* 17**,** 1-18.

Wendell, S., Wang, X., Brown, M., Cooper, M., DeSensi, R., Weyant, R., Crout, R., McNeil, D. and Marazita, M. (2010). Taste genes associated with dental caries. *Journal of Dental Research,* 89**,** 1198-1202. https://doi.org/10.1177/0022034510381502

Wenham, S. J. (1989). Anatomical interpretations of Anglo-Saxon weapon injuries. *In:* Chadwick Hawkes, S. (ed.) *Weapons and warfare in Anglo-Saxon England.* Oxford: Oxford University Committee for Archaeology, 123-139.

Weston, D. A. (2008). Investigating the specificity of periosteal reactions in pathology museum specimens. *American Journal of Physical Anthropology,* 137**,** 48-59. https://doi.org/10.1002/ajpa.20839

Weston, D. A. (2009). Brief communication: Paleohistopathological analysis of pathology museum specimens: Can periosteal reaction microstructure explain lesion etiology? *American Journal of Physical Anthropology,* 140**,** 186-193. https://doi.org/10.1002/ajpa.21081

Weston, D. A. (2012). Nonspecific infection in plaeopathology: Interpreting periosteal reactions. *In:* Grauer, A. L. (ed.) *A companion to paleopathology.* Chichester: Wiley-Blackwell, 492-512.

Whiting, R., Antoine, D. and Hillson, S. (2019). Periodontal disease and 'oral health' in the past: New insights from ancient Sudan on a very modern problem. *Dental Anthropology,* 32**,** 30-50. https://doi.org/10.26575/daj.v32i2.288

Whitley, J. (1991a). Social diversity in Dark Age Greece. *The Annual of the British School at Athens,* 86**,** 341-365. https://doi.org/10.1017/S0068245400014994

Whitley, J. (1991b). *Style and society in dark age Greece. The changing face of a pre-literate society, 1100-700 BC.* Cambridge: Cambridge University Press.

Whitley, J. (1996). Gender and hierarchy in early Athens. The strange case of the disappearance of the rich female grave. *Mètis. Anthropologie des mondes grecs anciens,* 11**,** 209-232.

Whitley, J. (2001). *The archaeology of ancient Greece.* Cambridge: Cambridge University Press.

Whitley, J. (2015). Scholarly traditions and scientific paradigms: Method and reflexivity in the study of ancient Praisos. *In:* Haggis, D. C. and Antonaccio, C. M. (eds.) *Classical archaeology in context. Theory and practice in excavation in the Greek world.* Berlin: De Gruyter, 23-50. https://doi.org/10.1515/9781934078471-005

Whitley, J. (2020). The re-emergence of political complexity. *In:* Lemos, I. S. and Kotsonas, A. (eds.) *A companion to the archaeology of early Greece and the Mediterranean.* Hoboken, NJ: Wiley-Blackwell, 161-186. https://doi.org/10.1002/9781118769966.ch7

WHO (1946). *Constitution of the World Health Organization. Basic Documents.* Geneva: World Health Organisation.

WHO (2001). Iron deficiency anaemia: Assessment, prevention and control, a guide for programme managers.

Więckowski, W. (2021). A rare case of multilevel spondylolysis: A nineteenth century Chinese immigrant to Peru from Castillo de Huarmey archaeological site. *International Journal of Osteoarchaeology,* 31**,** 782-788. https://doi.org/10.1002/oa.2989

Wilczak, C., Watkins, R., Null, C. C. and Blakey, M. L. (2009). Skeletal indicators of work: Musculoskeletal, arthritic, and traumatic effects. *In:* Blakey, M. L. and Rankin-Hill, L. M. (eds.) *The skeletal biology of the New York African burial ground.* Washington DC: Howard University Press, 199-223.

Williams, R. C., Barnett, A., Claffey, N., Davis, M., Gadsby, R., Kellett, M., Lip, G. Y. and Thackray, S. (2008). The potential impact of periodontal disease on general health: A consensus view. *Current Medical Research and Opinion,* 24**,** 1635-1643. https://doi.org/10.1185/03007990802131215

Wissler, A. and DeWitte, S. N. (2023). Frailty and survival in the 1918 influenza pandemic. *Proceedings of the National Academy of Sciences,* 120**,** e2304545120. https://doi.org/10.1073/pnas.2304545120

Woo, E. J. and Sciulli, P. W. (2013). Degenerative joint disease and social status in the terminal late Archaic period (1000–500 bc) of Ohio. *International Journal of Osteoarchaeology,* 23**,** 529-544. https://doi.org/10.1002/oa.1264

Wood, J. W., Milner, G. R., Harpending, H. C., Weiss, K. M., Cohen, M. N., Eisenberg, L. E., Hutchinson, D. L., Jankauskas, R., Cesnys, G. and Česnys, G. (1992). The osteological paradox: Problems of inferring prehistoric health from skeletal samples [and comments and reply]. *Current Anthropology,* 33**,** 343-370.

Wrenhaven, K. L. (2009). The Identity of the 'wool-workers' in the Attic Manumissions. *Hesperia,* 78**,** 367-386.

Wright, J. T. (2010). Defining the contribution of genetics in the etiology of dental caries. *Journal of Dental Research,* 89**,** 1173-1174. https://doi.org/10.1177/0022034510379828

Yaussy, S. L. (2019). The intersections of industrialization: Variation in skeletal indicators of frailty by age, sex, and socioeconomic status in 18th-and 19th-century England. *American Journal of Physical Anthropology,* 170**,** 116-130. https://doi.org/10.1002/ajpa.23881

Yaussy, S. L. (2022). Intersectionality and the interpretation of past pandemics. *Bioarchaeology International,* 6**,** 58–76. https://doi.org/10.5744/bi.2020.0028

Yaussy, S. L., DeWitte, S. N. and Redfern, R. C. (2016). Frailty and famine: Patterns of mortality and physiological stress among victims of famine in medieval London. *American Journal of Physical Anthropology,* 160**,** 272-283. https://doi.org/10.1002/ajpa.22954