AN ANALYSIS OF THE DIETARY PRACTICES OF 9 TO 12 YEAR OLD PHYSICALLY ACTIVE CHILDREN AND THE NUTRITION KNOWLEDGE OF THEIR PARENTS

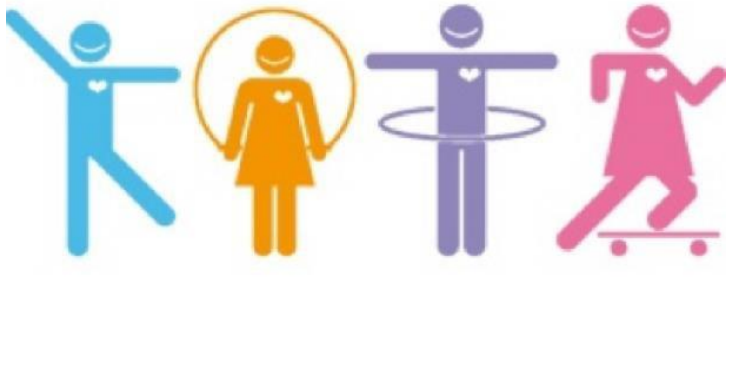
WAUCHOPE, EMMA,CATHERINE

Durham University
School of Applied Social Sciences

AN ANALYSIS OF THE DIETARY PRACTICES OF 9 TO 12 YEAR OLD PHYSICALLY ACTIVE CHILDREN AND THE NUTRITION KNOWLEDGE OF THEIR PARENTS

Emma Catherine Wauchope

2018



An Analysis of the Dietary Practices of 9 to 12 year old Physically Active Children and The Nutrition Knowledge of Their Parents

Emma Catherine Wauchope

Abstract

Healthy eating through a balanced diet is fundamental to good health (Public Health England, 2016a). Active children are of interest given the energy demands of preparing for athletic performance or competition alongside normal growth and development. High energy expenditure, growth spurts and puberty, pressure to hit weight categories and disjointed fluid regulation are but a few factors that may affect their individual nutritional needs. There is minimal research into the requirements of pre-pubescent athletes (Petrie et al., 2004). It is unknown whether findings and recommendations in adult athletes can be extrapolated to their junior counterparts.

Active 9-12 year-old children (n=18) from the North-East of England completed a three-day estimated food diary. To contextualise findings, data was compared to national recommendations and to findings of the National Diet and Nutrition Survey (2016). Secondary outcomes compared nutrition to scores of the Physical Activity Questionnaire for Children, and to parental scores of the General Nutrition Knowledge Questionnaire (n=17). Energy intake (7.2 MJ/day) was higher than children nationally but lower than recommended. This is principally driven by low intake of carbohydrates (233.5 g/day) and fat (61.5 g/day). Intake of protein was comparatively high (69.49 g/day) and total fibre (9.44 g/day) low. Intake of Vitamin C (112.04 mg/day), iron (12.56 mg/day) and calcium (732.43 mg/day) was sufficient and Vitamin D (2.46 µg/day) low. There were no significant relationships ($p<0.05$) between energy intake and physical activity level or nutrition knowledge score of parents. These findings suggest active 9-12 year olds have low energy intake and may be deficient in some macronutrients and micronutrients. The power of this study does not allow for statistical conclusions to be drawn but the implications of these findings may be important to understanding and nutritionally supporting this population.

AN ANALYSIS OF THE DIETARY PRACTICES OF 9 TO 12 YEAR OLD PHYSICALLY ACTIVE CHILDREN AND THE NUTRITION KNOWLEDGE OF THEIR PARENTS

Emma Catherine Wauchope

A thesis submitted to Durham University for the Degree of Masters of Research

Department of Sociology (Sport and Exercise Sciences),

Durham University

2018

Contents

List of Tables ix

List of Figures xi

Statement of Copyright xii

Acknowledgments xii

Chapter 1. Introduction 1

1.1. Aims and Objectives 1

1.2. Introduction 2

Chapter 2. Literature Review 8

2.1. Physical Activity – An Introduction 8

2.2. Physical Activity Guidelines 8

2.2.1. Guidelines in Early Childhood 9

2.2.2. Uptake of UK Guidelines 10

2.2.3. Uptake of Guidelines in Early Years 10

2.3. Benefits of Exercise in Childhood 11

2.3.1. Prevention of Chronic Disease 12

2.3.2. Psychosocial Effect 13

2.4. The Assessment of Physical Activity 14

2.4.1. Primary Forms of Measurement 14

2.4.2. Objective Measurements 16

2.4.3. Subjective Measurements 16

2.4.4. The Physical Activity Questionnaire 18

2.5. Physical Activity – In Conclusion 19

2.6. Nutrition – An Introduction 20

2.7. Nutrition National Guidelines 20

2.8. Differences in Nutrition for Active Children 21

2.8.1. Differences in Nutrition for Young Athletes 22
2.9. Energy Requirements 23
2.10. Macronutrient Requirements.. 24
2.10.1. Protein 24
2.10.2. Carbohydrate 25
2.10.3. Fat 26
2.11. Micronutrient Requirements... 27
2.11.1. Vitamins 28
2.11.2. Minerals 29
2.12. Free Sugars 33
2.12.1. International Comparison... 35
2.13. Summarising Macronutrient and Micronutrient Requirements in Children 35
2.14. Fluid Intake and Requirements... 36
2.14.1. The Effect of Diet on Hydration 37
2.15. Nutritional Supplements 38
2.15.1. Prevalence of Supplement Use.. 39
2.15.2. Reasons for Supplement Use 40
2.15.3. Sports Drinks 41
2.15.4. Energy Drinks and Caffeine... 43
2.15.5. Protein 44
2.15.6. Multivitamins and Minerals... 46
2.15.7. Echinacea 47
2.15.8. Iron 48
2.15.9. Nutritional Supplements – In Conclusion 49
2.16. Nutritional Knowledge 49
2.16.1. Public Health Policy and the Promotion of Nutritional Knowledge 49
2.16.2. The Effect of Nutritional Education 51
2.16.3. The Literature Base in Athletes... 53

2.16.4. Nutritional Knowledge Assessment 54
2.16.5. Nutrition Knowledge Assessment Tools 55
2.16.6. The General Nutrition Knowledge Questionnaire........ 56
2.16.7. Nutrition Knowledge in Children 58
2.16.8. Influences on Nutrition Choice of Children........ 58
2.16.9. Studies on Nutrition Knowledge in Children........ 58
2.17. Assessing Nutrition........ 60
2.17.1. Nutritional Assessment Systems 60
2.17.2. Nutritional Assessment Methods 62
2.17.3. Nutritional Assessment in Children 64
2.17.4. The 3-day Food Diary used in the National Diet and Nutrition Survey 66
Chapter 3. Methodology........ 68
3.1. The Utility of Quantitative Techniques to Nutritional Research 68
3.2. Considering the Importance of Qualitative Methods to Nutrition Research 70
3.3. Mixed-Methods Research 72
Chapter 4. Methods
4.1. Study Design........ 74
4.2. Participants and Sampling 74
4.2.1. Participants........ 74
4.3. Participants and Ethical Approval........ 75
4.3.1. Gatekeepers 76
4.3.2. Obtaining Permissions 77
4.3.3. Written Information and Informed Consent........ 77
4.4. Anonymity and Confidentiality........ 78
4.5. An Informal Focus Group........ 78
4.5.1. The Stakeholder Meeting 78
4.5.2. Potential Harm and Benefits of the Study 81
4.5.3. Understanding Written Information and Informed Consent of Children...... 82

4.6. Survey Design ... 82
4.7. Data Collection ... 86
4.7.1. Secondary Phase of Data Collection ... 87
4.7.2. Return of Surveys ... 88
4.8. Analysis of data ... 89
Chapter 5. Results ... 90
5.1. Introduction ... 90
5.2. Research Question 1 – Informal Focus Group Results ... 90
5.3. Research Questions 2-6 – Data Screening ... 92
5.3.1. Outliers ... 92
5.4. Research Questions 2 and 3 – Descriptive Statistics ... 92
5.4.1. Energy ... 92
5.4.2. Macronutrients ... 93
5.4.3. Percentage Contribution of Macronutrients to Total Daily Energy Intake ... 95
5.4.4. Carbohydrates ... 96
5.4.5. Total Fat ... 96
5.4.6. Saturated Fat ... 97
5.4.7. Dietary Fibre ... 98
5.4.8. Protein ... 99
5.4.9. Total sugars ... 100
5.4.10. Micronutrients ... 100
5.4.11. Vitamin C ... 101
5.4.12. Vitamin D ... 102
5.4.13. Iron ... 102
5.4.14. Calcium ... 103
5.4.15. Sodium ... 104
5.4.16. Dietary Supplements ... 105
5.5. Research Question 4 - Physical Activity Levels of 9-12 Year Old Children Identified

as Gifted and Talented in PE and Sport 105

5.6. Research Question 5 - Relationship Between Physical Activity Levels and Energy, Macronutrient and Key Micronutrients 108

5.6.1. Relationship of Energy to PAQ-C score 109

5.6.2. Macronutrients and PAQ-C score 109

5.7. Research Question 6 - Nutrition Knowledge of Parent/Guardians 109

5.8. Research Question 7 – The Relationship Between Nutritional Knowledge Level and Energy, Macronutrient and Key Micronutrient Intakes 110

5.8.1. Energy and GNKQ 110

5.8.2. Macronutrients and GNKQ 110

Chapter 6. Discussion 111

6.1. An Exploration of Participant Beliefs 111

6.2. The Energy Intake of Athletic 9-12 Year Old Children and its Relationship to Physical Activity and Nutritional Knowledge of Parents 112

6.3. The Nutrient Intakes of Athletic 9-12 Year Olds and their Comparison to National Guidelines and National Survey Data 114

6.3.1. Carbohydrate Intake of Athletic 9-12 Year Old Children 114

6.3.2. Fat Intake of Athletic 9-12 Year Old Children 115

6.3.3. Protein Intake of Athletic 9-12 Year Old Children 117

6.3.4. Dietary Fibre Intake of Athletic 9-12 Year Old Children 118

6.3.5. Sugar Intake of Athletic 9-12 Year Old Children... 119

6.4. The Micronutrient Content of the Diets of Athletic 9-12 Year Old Children 120

6.4.1. Vitamin Intake of Athletic 9-12 Year Old Children 120

6.4.2. Iron Intake of Athletic 9-12 Year Old Children 122

6.4.3. Calcium Intake of Athletic 9-12 Year Old Children 123

6.4.4. Sodium Intake of Athletic 9-12 Year Old Children...................................... 125

6.5. Dietary Supplement Use in Physically Active 9-12 Year Old Children 126

6.6. The Physical Activity Levels of Active 9-12 Year Old Children............................ 128

6.7. The Relationship Between Physical Activity Levels and Energy, Macronutrient and

Micronutrient Intake 129

6.8. The Nutrition Knowledge Level of Parents/Guardians of Active 9-12 Year Old Children 131

6.9. The Relationship Between General Nutrition Knowledge Levels and Energy, Macronutrient and Micronutrient Intake 132

6.10. A Reflection on Nutritional Research Methods 132

Chapter 7. Conclusions 138

Chapter 8. Appendices 141

8.1. Appendix A – Survey Information Sheet: Adult 142

8.2. Appendix B – Consent Form: Adult 145

8.3. Appendix C – Survey Information sheet and consent form: child 147

8.4. Appendix D – Three-day nutrition Diary, example diary and supplementary information 149

8.5. Appendix E – PAQ-C 173

8.6. Appendix F - GNKQ 179

8.7. Appendix G – Follow up letter to participants distributed by GTP staff 194

Chapter 9. References 196

List of Tables

Table 2.1 - The procedure for measuring energy and nutrient intake (Rutishauser and Black, 2013) 63

Table 3.1 - Qualitative Research Applications in Dietetics (Harris et al., 2009) 71

Figure 3.2 - A Comparison of Quantitative and Qualitative Methods (Harris et al., 2009) ...73

Table 5.1 - Energy consumption (MJ/day) of 9-12 year old children compared to Dietary Reference Values and national data 93

Table 5.2 - Mean Macronutrient Intakes of Participants 94

Table 5.3 - Percentage contribution of energy of the main macronutrients of 9-12 year old children compared to Dietary Reference Values and national data 95

Table 5.4 – Mean carbohydrate consumption (g/day) of 9-12 year old children compared to Dietary Reference Values and national data 96

Table 5.5 – Mean total fat consumption (g/day) of 9-12 year old children compared to Dietary Reference Values and national data 97

Table 5.6 – Mean saturated fat consumption (g/day) of 9-12 year old children compared to national data 98

Table 5.7 –Saturated fat consumption (percentage of total energy intake) of 9-12 year old children compared to Dietary Reference Values and national data 98

Table 5.8 – Mean total dietary fibre/non-starch polysaccharide consumption (g/day) of 9-12 year old children compared to Dietary Reference Values and national data 99

Table 5.9 – Mean protein consumption (g/day) of 9-12 year old children compared to Dietary Reference Values and national data 99

Table 5.10 – Mean total Sugar consumption (g/day) of 9-12 year old children compared to Dietary Reference Values 100

Table 5.11 - Mean micronutrient intakes of 9-12 year old children 101

Table 5.12 – Mean Vitamin C consumption (mg/day) of 9-12 year old children compared to

Dietary Reference Values and national data 101

Table 5.13 – Mean Vitamin D consumption (µg/day) of 9-12 year old children compared to Dietary Reference Values and national data 102

Table 5.14 - Mean iron consumption (mg/day) of 9-12 year old children compared to Dietary Reference Values and national data 103

Table 5.15 – Mean calcium consumption (mg/day) of 9-12 year old children compared to Dietary Reference Values and national data 104

Table 5.16 – Mean sodium consumption (mg/day) of 9-12 year old children compared to Dietary Reference Values and national data 104

Table 5.17 – Mean scores from the Physical Activity Questionnaire for Children by age and gender of 9-12 year old children compared to national data 105

Table 5.18 – Popularity of the different sports reported by participants in the Physical Activity Questionnaire for Children of 9-12 year old participants 107

Table 5.19 - The relationship between key macronutrients and micronutrients and Physical Activity Questionnaire for Children and General Nutrition Knowledge Questionnaire scores of 9-12 year old children 108

List of Figures

Figure 4.1 – Economic and Social Research Council Principles of Ethical Standards 76

Figure 4.2 - Topics covered in the Nutrition for Young Athletes Lecture 79

Figure 4.3 - The Eatwell Plate (Public Health England, 2016a) 80

Figure 4.4 - Components of the survey given to potential participants 83

Figure 4.6 - Information tested in, and the score for each section of the GNKQ................. 84

Figure 4.5 - Information collected to determine physical activity level used in the PAQ-C.. 85

Figure 4.7 - Example questions from the GNKQ.. 86

Figure 5.1 - Findings from a meal planning exercise in GTP participants 91

List of Abbreviations

AFHC – Adolescent Food Habits Checklist

BMI – Body Mass Index

BCAAs – Branched Chain Amino Acids

CEBQ – Child Eating Behaviour Questionnaire

CSEP - The Canadian Society for Exercise Physiology

DLW – Doubly-Labelled Water

EAR - Estimated Average Requirement

EFSA – European Food Standards Agency

FFQ – Food Frequency Questionnaires

GNKQ – General Nutrition Knowledge Questionnaire

HSE - Health Survey for England

IPAQ – International Physical Activity Questionnaire

KAP – Knowledge, Attitudes and Practice

NICE – National Institute for Clinical Excellence

MVPA - Moderate-Vigorous Physical Activity

NSP – Non-Starch Polysaccharides

PA -Physical Activity

PAQ-A – Physical Activity Questionnaire for Adolescents

PAQ-C – Physical Activity Questionnaire for Children

PDPAR - Previous Day Physical Activity Recall

SACN – Scientific Advisory Committee on Nutrition

SASS – School of Applied Social Sciences

SES – Socio-Economic Status

SD – Standard Deviation

UK – United Kingdom

WHO – World Health Organisation

Statement of Copyright

Acknowledgements

I would like to acknowledge the unwavering support and advice I have received from both my supervisors, Caroline Dodd-Reynolds and Emily Oliver. Having not written an undergraduate dissertation and coming from a clinical background, conducting a large Master's thesis did not come naturally and I would have struggled without their continuing patience, praise and problem-solving. I am indebted to them for the time they have dedicated to me and to my project. Further, to the staff at the Gifted and Talented Program and the Durham Summer Holiday Camps for not allowing me access to their participants but for all their advice and assistance.

I would also like to thank my team of cheerleaders in Newcastle, Izi, Rachael, Rowan, Charlie, Killian, Claudia, Cliodna and Katherine for their endless supplies of encouraging words, hugs and sweet treats, they have helped me with the feat of finishing both a master's thesis and a medical degree concurrently.

Finally, I would like to acknowledge my family, as always, they manage to keep me grounded and build me up in equal measures.

Chapter 1. Introduction

1.1. Aims and Objectives

The research of this thesis was undertaken to understand the dietary practices of 9 12 year old children identified as gifted and talented in PE and sport. Furthermore, this thesis aimed to determine any association between macronutrients or key micronutrients, and physical activity levels as well as nutrition knowledge scores of the children's main meal provider.

Therefore, the main aims of the study are as follows:

1. Can an informal focus group help to understand current knowledge of potential participants and therefore inform the design of tools for quantitative study?
2. What are the daily energy, macronutrient (carbohydrate, protein, sugar and fat) and key micronutrient (vitamin and mineral) intakes of athletic 9-12 year old children?
3. How do the results compare to national guidelines and national survey data?
4. Is there any relationship between energy, macronutrient or key micronutrient intakes and self-reported physical activity levels?
5. What is the level of nutritional knowledge for the parent/guardians of this study population?
6. Is there any relationship between nutritional knowledge level and energy, macronutrient or key micronutrient intakes of the study population?

1.2. Introduction

Children are inherently active, physical activity can include any form of bodily movement that expends energy (Department of Health, 2011). It includes everyday activities such as walking or playing as well as structured activity such as recreational cycling, sports, dancing and fitness training

Physical activity has far-reaching benefits in childhood. A dose-response relationship has been seen between physical activity, good cardiovascular health and the growth and maintenance of muscle and bone, evidence further suggests a positive association with mental health (Janssen and LeBlanc, 2010). Activity behaviors developed in early childhood track through adolescence to adulthood. Establishing healthy practices in childhood is important for prevention of non-communicable diseases in adulthood (Telama et al., 2014).

One of the most studied benefits of physical activity is its role in the prevention and reduction of adiposity (Janssen and LeBlanc, 2010). In the United Kingdom, the population of children overweight and obese is now considered endemic. There is further concern that childhood obesity tracks into adolescence and further into adulthood (Rey-López et al., 2008). Public survey data shows almost a third of children aged between two and fifteen years old are obese or overweight. This poses a substantial burden on physical and psychological health services, schools and the British economy (HM Government, 2017). Although there are a multitude of factors that impact child weight status, at its core, it is an imbalance in energy intake and energy expenditure, or in practical terms between diet and physical activity (Dehghan et al., 2005).

There are both national and international guidelines to help enable optimal physical activity in childhood. The World Health Organisation's (WHO) guidelines provide scientifically-informed recommendations relevant to all children irrespective of race, gender or socio-economic status. They have 3 key recommendations:

- “Children and youth aged 5-17 should accumulate at least 60 minutes of moderate-to-vigorous intensity physical activity daily.
- Amounts of physical activity greater than 60 minutes provide additional health benefits
- Most of the daily physical activity should be aerobic. Vigorous – intensity activities should be incorporated, including those that strengthen muscle and bone, at least 3 times per week“(World Health Organisation, 2010, pg. 7).

Many developed countries have expanded on these guidelines, for example, the UK has developed ‘Start Active, Stay Active’ which encourages the same principles as the WHO guidance for children and young people (5-18 years) (Department of Health, 2011). The UK guidelines go further than those produced by WHO however to encourage that children minimise the time they spend sedentary. Moreover, Start Active, Stay Active includes additional recommendations for children under 5. (Department of Health, 2011).

Physical education has been included in governmental policy since the Education Reform Act of 1988 which resulted in the production of the National Curriculum for Physical Education. The specifics of physical education in children remained a topic of much discussion for the next two decades and more recently included the development of School Sport Partnerships under the New Labour government in 2000. An SSP involved a partnership of several local schools, both secondary and primary, overseen by a School Sport Coordinator. They aimed to improve opportunities for children to participate in organised physical activity. (Smith, 2015a, Flintoff et al., 2011).

A further part of this policy was the development of the Gifted and Talented Program. Targeted at the most talented 10% of schoolchildren in years 5 and 6, the Department for Education and Skills aim to “improve the range and quality of teaching, coaching and learning for talented sports people in order to raise their aspirations and improve their performance, motivation and self-esteem” (Department for Education and Skills and Department of Culture, 2002, pg. 8). The Gifted and Talented Program was further intended as a grass-roots project for young athletes who might advance to the international stage (Department for Education and Skills and Department of Culture, 2002). It represented a positive policy change towards competitive sport in addition to encouraging physical activity for health.

The effect of physical activity to change body stores is however, only one part of the energy balance equation: energy balance = energy intake – energy expenditure (Schoeller, 2009).

Healthy eating through a balanced diet is fundamental to good health in any age. In conjunction with being active and decreasing poor lifestyle habits it enables optimal health and wellbeing (Public Health England, 2016a). The British Nutrition Foundation states that during growth, children have higher requirements of energy and nutrients. As such it is important to ensure they are offered adequate nutrition to meet these extra demands (British Nutrition Foundation, 2015a).

This topic has received growing interest in academia in the last few decades which has driven the need for compelling public health campaigns. Originating with ‘The Balance of Good Health’ model in 1994, based on early research in the COMA report, “Diet and Cardiovascular Disease” (Wheelock, 1984), guidance has been based upon subsequent dietary reports and the rolling results of the National Diet and Nutrition Survey. To further guide understanding of public health and habits, the National Diet and Nutrition Survey (NDNS) collects quantitative data on food and nutrient intake of the UK population (Public

Health England, 2016c). National guidance was updated in 2016 to reflect growing evidence-based knowledge in the form of The Eatwell Guide which offers a widely accessible and comprehensible guide for all ages (Public Health England, 2016c). It was based on the NDNS and the conclusions of the Scientific Advisory Committee in their report “Carbohydrates and Health.”(Scientific Advisory Committee on Nutrition, 2015)

Despite the emergence of clearer guidelines for paediatric nutrition, at present these are generalised and focused on healthy development. There is less known about optimal nutritional approaches for non-typical children, with child athletes of particular interest given the energy demands of preparing for and producing athletic performance. Several studies have been conducted to estimate what these additional requirements may be, outlined best in the review articles by Purcell et al. (2013) and Petrie et al. (2004). High energy expenditure, growth spurts and puberty, pressure to hit weight categories and disjointed fluid regulation are but a few factors in junior athletes that may affect their individual nutritional needs (Petrie et al., 2004, Purcell et al., 2013). Meyer et al. (2007) discuss several factors that affect energy requirements in young athletes. Higher energy expenditure naturally causes a higher intake requirement (Schoeller, 2009) but there is evidence that during cardiovascular exercise, energy requirements in children can be up to 30% higher than those in adults due to the differing kinetics and physiology in the utilisation of energy in children (Meyer et al., 2007). However there is evidence to suggest compensation in children engaging in heavy training regimes by increased sedentary behaviour during the rest of the day (Petrie et al., 2004). There is minimal research into the requirements of pre-pubescent athletes (Petrie et al., 2004). It is unknown whether findings and recommendations in adult athletes can be extrapolated to their junior counterparts.

A knowledge of good nutritional practices is also essential to ensuring children understand how they can consume the correct diet for their activity level. The Food and Agriculture Organisation of the United Nations suggests that in middle childhood (ages 6-10) children have limited understanding of abstract concepts such as nutrients (Fautsch Macias, 2014). Sodexho (2005) found that 70% of children aged 8-16 rated their diet as 'quite healthy' or 'very healthy'. However when asked to explain why, the majority of answers were associated with eating fruit or vegetables. Only 24% said their healthy diet was because they ate a good balanced diet. Young athletes, like those involved in the Gifted and Talented Partnership, may have been exposed to dietary education at a higher level through formal teaching or from other sources such as through communication with coaches and other athletes (Cotunga et al., 2005). The national school curriculum ensures all children have basic food and nutrition teaching at school from the age of 5 (British Nutrition Foundation, 2015b).

To best facilitate athletic children to gain optimal nutrition, one must first understand the composition of daily diets in a typical week. A large scale, longitudinal study started in the 1990's by Bellisle and Rolland-Cachera (2007) surveyed nutritional intake of 9 to 11 year old French children and how it related to nutritional knowledge and physical activity, among other variables. They report a weak association between a high body mass index (BMI) and lower physical activity levels but not whether the nutrition of those with high physical activity levels changed.

To date most research has been concerned either with adolescent athletes or younger athletes involved in elite programs. There is a limited knowledge concerning the diets of pre-pubescent children and how it relates to their physical activity levels. The majority of the literature base is concerned with obesity or disordered eating, or is from studies conducted in the 1990's.

Pre-pubescent aged schoolchildren provide an interesting group to study. This an age where children start to take more responsibility for their own nutrition and behaviours may be affected by a multitude of influences (Fautsch Macias, 2014). For example, a study by Folta et al. (2006) found a portrayal of increased athletic ability was associated with food in one in every three food adverts, they raise concerns that this may lead to an overconsumption of calorie-rich foods compared to energy requirements. It is imperative to establish good habits at an early age so as children begin to mature and develop, they can reach their full physiological and athletic potential. The Gifted and Talented group chosen for analysis in this thesis have been pre-selected by schools as showing athletic potential. They are not all elite junior athletes but instead consist of a range of sporting attainment levels. This is more likely to be representative of general highly active schoolchildren and thus more useful for future recommendations. They represent children with nutritional requirements above the norm but not at the extremes.

Chapter 2. Literature Review

2.1. Physical Activity – An Introduction

Physical activity is essential for maintaining and improving health in children and young people, however physical inactivity has now been identified as the fourth leading risk factor for global mortality (World Health Organisation, 2010). The World Health Organisation (WHO) (2010) emphasises the importance of physical activity, which they define as 'any bodily movement produced by skeletal muscles that requires energy expenditure' (World Health Organisation, 2010, pg. 53). They stress that 'sport' and 'physical activity' differ and the terms should not be used interchangeably

Physical activity (PA) plays a crucial role in the prevention of non-communicable diseases (NCDs) and reduction of time spent sedentary is a focus of public health (World Health Organisation, 2010). Scientific evidence supports the knowledge that PA increases cardiorespiratory and metabolic health in children and is an important factor in development during early childhood (Poitras et al., 2016, Chaput et al., 2016). PA in children can be varied and is often a part of daily life, such as play, transport, physical education or family activities (World Health Organisation, 2010). The Department for Health has released guidelines based on findings by the WHO, Start Active, Stay Active (2011), which aim to enable the general public to achieve recommended levels of physical activity in order to prevent NCDs and improve quality of life (Department of Health, 2011).

2.2. Physical Activity Guidelines

The UK guidelines are based in part on those developed previously in the USA and Canada. The Canadian Society for Exercise Physiology has released novel guidance intended to be a holistic approach to the 24 hour day of children and youth. They promote 'sweat, step, sleep, sit' to advocate 1 hour in moderate to vigorous PA, several hours of light PA, age-appropriate sufficient sleep hours and no more than 2 hours of screen time in a 24 hour period (Canadian Society for Exercise Physiology, 2016a). This approach integrates several behaviours other than PA that, such as the reduction of sedentary screen time, that are now known to impact on child health and to improve on stand-alone guidance like currently implemented in the UK (Canadian Society for Exercise Physiology, 2016b).

2.2.1. Guidelines in Early Childhood

The Start Active, Stay Active guidelines published recommendations for children under 5 years old for the first time, following on from recent changes to Canadian and Australian recommendations (Canadian Society for Exercise Physiology, 2016a, Australian Government, 2014). Previously, recommended PA levels were extrapolated from older children to those under 5. This age group undergoes unique psychological and physical development and as such there is an apparent need to adequately support them from birth (Neaum, 2010). There is evidence to suggest that chronic disease in adulthood is linked to early health and risk factors for such diseases can be found in children at this young age (Timmons et al., 2012). Physical activity is recommended from birth in a developmental appropriate manner, such as floor-based play or water-based activities. Once children are walking unaided, the Department of Health encourages 3 hours activity spread over a day. Again, sedentary activities should be minimised, for example, being restrained or sitting, but excluding time spent sleeping (Department of Health, 2011).

Similar to older children, increased physical activity has a positive effect on adiposity, bone and skeletal health, motor skill development, psychosocial health, cognitive development and cardio-metabolic health (Timmons et al., 2012). Unlike their older counterparts however, the risk of injury is greatly diminished in this age, possibly due to the gentler activity type and the higher level of guardian supervision. It seems that adequate levels of PA are needed from a very early age to reduce the risk of NCDs.

2.2.2. Uptake of UK Guidelines

The success of guidance such as Start Active, Stay Active is heavily reliant on national uptake and whether children and young people manage to meet the suggested standards. The Health Survey for England (2015) and the corresponding publications in Scotland and Wales, the Scottish Health Survey and the Welsh Health Survey, allow conclusions to be drawn about national PA levels. The most recent data suggests that only 33% of boys and 21% of girls are meeting the national recommendations (Lifestyles Statistics Team, 2015). When compared to past data from 2008 and 2012 there is a concerning trend of overall decline in those meeting PA guidelines. These reports are based on self or parent-reported data however and objective studies suggest that they may be overestimating. A longitudinal study in the North-East, for example, found that parental reports of moderate – vigorous physical activity (MVPA) were overestimated by 122 minutes per day when compared with accelerometer data (Basterfield et al., 2008).

2.2.3. Uptake of Guidelines in Early Years

A UK study on mother's perceptions of the new Start Active, Stay Active guidelines shows possible barriers to meeting such recommendations. Ninety percent of mothers in a small study by Bentley et al. (2015) said they were unaware of the guidance 4 years after it was published. However, two-thirds reported that they thought their pre-schooler met the target of 180 minutes per day. The majority felt that because of this the guidance was not relevant to their family but that it might be useful for others. Many of the mothers in this study commented that more specific guidance would be useful; they suggested splitting recommendations into gender and age groups (Bentley et al., 2015). Contrary to the mother's in the Bentley study, the most recent Health and Safety Executive report shows that using self-reported physical activity data only 10% of 2-4 year olds met the recommended 3 hours per day (Fat, 2014).

The disparity in opinion about public health policy in this group is representative of a wider problem. Although the 'Start Active, Stay Active' campaign was based on a strong scientific background (Department of Health, 2011) and was a large part of the UK public health drive to increase physical activity and reduce sedentary behaviour it appears ready for a revision already. Further, Kay (2016) outlines the need to further engage with lower socio-economic groups, even though this was a focus for this campaign. She argues social determinants of health have been overlooked and with the help of social scientists and health behaviourists as well as sound scientific evidence, closing the health gap may be much easier. The potential benefits of PA in childhood are well-documented but it appears that when UK policy adopts more of a multi-disciplinary approach, it will be truly effective at employing physical activity as a health intervention at home and receive standing on the international stage. (Kay, 2016).

2.3. Benefits of Exercise in Childhood

An active childhood is essential for maintaining good physical health and there are multiple benefits to ensuring children do enough daily physical activity. Establishing good physical activity practices in childhood will help to reduce conditions such as cardiovascular diseases, type 2 diabetes, cancer, obesity and musculoskeletal conditions in later life (Department of Health, 2011).

Optimal skeletal development in early life prevents age-related bone loss and associated osteoporosis later on. MVPA and weight-bearing exercise increase muscle mass and subsequently the muscle strength acting on bone (Herrmann, 2015). A study by Janz et al.

(2010) showed that 30 minutes of extra MVPA at age 5 led to a 6.7% increase and a 4.4% increase in hip bone mineral content at ages 8 and 11 years respectively.

Much work has been done in the past decade into the effect of exercise on the immune system in adults. Moderate volumes of exercise are believed to enhance immune health however high intensity volumes reduce immune function and hence increase infection risk (Janssen and LeBlanc, 2010). Emerging evidence suggests a similar effect in children and adolescents (Gleeson, 2006). The relationship remains unclear but physical activity seems to be both a positive and negative influence on paediatric immunity.

2.3.1. Prevention of Chronic Disease

An abundance of evidence suggests a dose-response relationship between PA, sedentary activity and obesity. Aerobic exercise has been shown to prevent obesity by reducing low density lipoproteins and increasing high-density lipoproteins and improve glucose metabolism in patients with type II diabetes (Sothern et al., 1999). Even small amounts of physical activity can have health benefits in obese and overweight youth (Janssen and LeBlanc, 2010). The relationship between blood lipids and exercise in children is unclear but suggests that MVPA is important in reducing the cholesterol gap (Janssen and LeBlanc, 2010).

An association with sedentary activity is less clear but there is weak evidence to suggest a link between decreased sedentary time and lower obesity rates (Davison et al., 2006, Berkey et al., 2003). Rey-López et al. (2008) concluded better outcomes were achieved when interventions focused on prevention rather than reducing sedentary time as a treatment in obese children. Interestingly, they discovered that playing video or computer games do not present the same risk as other sedentary activities as they do not supplant PA. The evidence-base is weak though, studies appear to contradict each other and such research may become important in tackling the high paediatric obesity rates.

High blood pressure is an issue more commonly associated with the adult population; yet it appears that over the past decade mild hypertension and pre-hypertension has been underestimated in children and adolescents and has been gradually rising in tandem with obesity rates (Muntner et al., 2004). Emerging research provides positive results however that aerobic training may have a significant impact on lowering systolic blood pressure (Janssen and LeBlanc, 2010).

Current research points towards the theory that it is fitness as a physiological state rather than PA rate as a behaviour that really creates a positive impact on cardiovascular health although the two are undeniably linked.

2.3.2. Psychosocial Effect

The link between physical activity and positive psychological wellbeing has been well documented, the Royal Collage of Psychiatrists clearly asserts that being more active makes an adult less likely to be depressed, anxious or tense (Taylor, 2012). Emerging evidence does not quite reflect this effect in children and adolescents. A small evidence base suggest a modest effect on depression and anxiety, (Janssen and LeBlanc, 2010, Taylor, 2012) but there are more positive results for the effect of PA on self-esteem and self-concept. PA was an effective stand-alone intervention in these areas in children and adolescents especially when performed in a school-based or gymnasium-based setting (Mingli Liu, 2015).

There is now an increased emphasis on integrating exercise into daily classroom activities in the UK as advocated by the Start Active, Stay Active report (Department of Health, 2011). This strategy has far-reaching benefits and doesn’t negatively impact on academic performance (Centers for Disease Control and Prevention, 2010). Such benefits include a positive influence on BMI, reduced weight in girls, increased health-related fitness, improved on-task behaviour, increased academic test scores, increased enjoyment and positive affect, increased perceived competence and effort as well as improved cognitive function (Webster et al., 2015).

Inclusion of daily PA is important to reaping the physical and psychosocial benefits of PA to child health and for translating these benefits into adulthood. However it is important to remember that physical activity only represents one part of the energy balance equation and energy expenditure must be balanced by energy intake. A range of benefits are seen not only in childhood but also through adolescence and into adulthood.

2.4. The Assessment of Physical Activity

PA in children continues to be of considerable interest when deciding which factors best constitute a healthy lifestyle. A balanced diet is independently important but may also correlate and interact with children’s physical activity levels. Sallis et al. (2000) found on review of several behavioural variables, that a healthy diet consistently showed positive associations to physical activity in children but was unrelated in adolescents.

Accurate measurement of physical activity level can aid understanding of the paediatric population and subgroups within it, in order to effectively administer suitable education programs. Assessment of physical activity in children may be conducted in several different ways (Sirard and Pate, 2001). Lower cognitive understanding in children means the research tool required for a project may differ depending on the age and activity level of the participants (Welk et al., 2000).

2.4.1. Primary Forms of Measurement

Simple measures of data collection often produce a higher standard of data in children. Direct observation, doubly-labelled water and indirect calorimetry are all tools considered the primary standard in this population (Sirard and Pate, 2001).

Direct observation offers a simple and practical method of data collection. It enables the researcher to produce qualitative and quantitative data on the nature of the activity and allows for examination of the behavioural attributes of children during PA. Direct observation also acts to validate the criterion measures of other research tools. However it is a time intensive method, both in terms of data collection and researcher training and is highly dependent on the expertise of the researcher (Sirard and Pate, 2001, Welk, 2002).

Doubly-labelled water (DLW) is a biochemical assessment that allows for very accurate measurement of energy expenditure through the use of isotopic biomarkers. It directly measures the carbon dioxide production of an individual after ingestion of stable isotopes in water. DLW is very popular, it is considered a gold-standard technique as it is precise but non-invasive. This makes it a popular choice in studies conducted in children (Welk et al., 2000). DLW allows for data collection over 1-2 weeks duration and does not interfere with normal activity. However it does accumulate a high cost and the need to obtain isotopic water. It is limited as it does not allow for qualitative analysis of activity behaviour or the determination of energy expenditure due specifically to PA (Welk et al., 2000).

To overcome these limitations, the DLW technique has increasingly been combined with indirect calorimetry. This is the analysis of respiratory gases to accurately measure energy expenditure. Resting metabolic rate and the thermic effect of food can be determined this way for an individual (Welk, 2002). This does involve highly controllable test conditions for extended periods of time however. When combined with DLW, indirect calorimetry allows researchers to determine energy expenditure during physical activity through both lab-based and free-living research. The two methods in conjunction create a gold-standard test (Welk et al., 2000).

2.4.2. Objective Measurements

Heart rate monitoring has long been a popular method of analysing the physiological response to physical activity. Advances in heart rate monitor technology allow for data on the intensity, frequency and duration of activity and allow it be easily transferred into computer software. Heart rate monitors provide an acceptable objective method due to the low burden to participants and cost-effectiveness. This method is limited however, by its inability to discriminate between physical, biological and psychological stresses to heart rate (Welk, 2002) but evidence suggests it is still a valid measure of energy expenditure in certain situations (Sirard and Pate, 2001). Several new techniques aim to overcome this effect by discriminating between active and resting energy expenditure, for example, the FLEX HR and the use of absolute heart rates (Sirard and Pate, 2001).

Motion sensors, such as pedometers and accelerometers are popular for measuring PA in a free-living environment. Generally they are considered a good method of PA measurement rather than of energy expenditure (Welk et al., 2000). Pedometers are an extremely cost-effective and available resource for objective measurement of daily step-based activity volume and duration. Accelerometers provide analysis of the intensity of physical activity, as they are usually attached at the hip however, they generally only measure lower-body movement (Welk, 2002, Welk et al., 2000). Limitations of accelerometers include certain activities, cycling, incline-walking and those requiring mostly upper-body movement (Welk, 2002). Pedometers only record locomotor motion and do not detect rate or intensity. Both activity monitors cannot be used to measure water-based activities and generally underestimate activity during normal daily activities (Welk, 2002).

2.4.3. Subjective Measurements

Subjective methods offer a financially viable method with low burden to participants, making self-reported surveys popular in adults (Welk, 2002). Subjective sampling with the use of a survey, however, is often avoided in children. PA in childhood is generally not organised and activity may be difficult to recall, describe and quantify. (Sirard and Pate, 2001). Studies in the validation of self-reporting, find children tend to over-estimate and hence such methods are less suitable in the paediatric population (Welk et al., 2000).

Several tools for self-reported physical activity levels are available and widely used in children, popular examples being the International Physical Activity Questionnaire, the Physical Activity Diary and the Previous Day Physical Activity Recall (Rachele et al., 2012). There has been a more concerted effort to validate these methods against DLW, with some success, but results are inconsistent and differ across age-groups (Sirard and Pate, 2001, Rachele et al., 2012). Self-report questionnaires are low-cost and easily administered and hence are advantageous in large studies. However they do not assess energy expenditure and light or moderate activity is reported poorly, a considerable limitation also is that they are inherently subjective and dependent on the reporter (Sylvia et al., 2014, Rachele et al., 2012).

Interviewer-administered questions, proxy-reports and physical activity diaries have all been used as alternate subjective tools (Sirard and Pate, 2001). Interviewer-administered questionnaires offer little benefit over self-reported questionnaires due to the introduction of response and reporter bias and increased cost. Proxy-reports similarly may introduce reporter bias; usually from a parent or teacher. They do overcome the issue of children's recall errors and with sound validation may be a useful tool (Sirard and Pate, 2001). Diaries are considered the most accurate measurement of physical activity when completed fully (Sirard and Pate, 2001). However they incur a large participant burden which may be unacceptable with children and again are subject to inconsistency in accurate reporting (Sirard and Pate, 2001).

2.4.4. The Physical Activity Questionnaire

Kowalski et al. (2004) published two versions of the Physical Activity Questionnaire, the first for Older Children (PAQ-C) and the second for adolescents (PAQ-A). They consist of 7 day recall, self-administered questionnaires. Kowalski and colleagues developed these tools in order to provide a valid and reliable self-reported measure of general physical activity in Canadian subjects under the age of 18. They are primarily intended for use in longitudinal research and large-scale studies on moderate-vigorous activity.

This tool provides a general overview of physical activity levels and hence is useful for comparison with other variables. The PAQ-C uses time-frame memory cues which increase recall in children and is a cost and time efficient tool (Kowalski et al., 2004). Strong internal consistency and test-retest reliability have been shown (Kowalski et al., 2004). The PAQ-C has been shown to correlate with several other measures of physical activity (Moore et al., 2007). However it is limited by its inability to measure intensity, frequency, time or duration of activity. It is also designed to only be used during school time and therefore cannot be used during school-holidays (Kowalski et al., 2004).

Crocker et al. (1997) published preliminary evidence on the PAQ-C. They conducted 3 studies to further development of the psychometric properties of the tool. They concluded that the test efficiently determined gender differences and differences across different seasons and showed preliminary evidence for acceptable validity in schoolchildren between 9 and 14 years old. In the same year, the tool developers published research which showed convergent and divergent validity (Kowalski et al., 1997).

More recent research has focused on validating the PAQ-C in different populations. It has been translated and validated for use in Chinese children (Wang et al., 2016) and Dutch children (Bervoets et al., 2014). It has also proved useful in disease populations, Voss et al. (2017) validated both the PAQ-C and PAQ-A in children with congenital heart disease.

Moore et al. (2007) examined validity in American children from differing races. Unlike other studies, they concluded that modifications may be necessary to utilise the PAQ-C in differing ethnic groups, specifically in children of Hispanic or African-American descent.

The PAQ-C was designed for children in Canada in the late 1990's. A part of the test, the activity checklist, involves ticking sports the respondent participates in. This made it inappropriate for current use in UK children as some sports listed are less popular in this population, baseball and cross-country ski-ing for example (Kowalski et al., 2004). Voss et al. (2013) modified the PAQ-C and PAQ-A to enable them to be used in the current English population. They updated the activity checklist to include popular sports based on results from sport and activity surveys in England. The researchers compared results in a sample of 10-15 year olds from the East of England to those in North American youths and were confident of the construct validity of this update. In addition to the new activity checklist, the researchers developed new cut-off scores for boys and girls in their population that they stated should be achieved to be sufficiently active.

2.5. Physical Activity – In Conclusion

Physical activity assessment in children has been extensively studied since the 1990's and as such there are a range of tools available. DLW when combined with direct calorimetry provides a gold-standard but may be impractical to implement. No objective measurement currently provides an accurate tool for use in free-living environments, with technological advances however, they may become more popular in future research. Subjective tools are being increasingly used to determine PA in children. There is concern for the reliability of such methods in children but due to their ease of use and availability they are commonly used. One of the most popular tools is the PAQ-C, now updated and validated for use in English children, and therefore the most appropriate tool for the present study.

2.6. Nutrition – An Introduction

A correct, balanced diet is fundamental to good health in any age, defined as "eating a wide variety of foods in the right proportions, and consuming the right amount of food and drink to achieve and maintain body weight" (NHS Choices, 2016). In conjunction with being active, a balanced diet enables optimal health and wellbeing (Dehghan et al., 2005).

2.7. Nutrition National Guidelines

In the UK, there are general guidelines for both adults and children in the form of the 'Eatwell Guide' (Public Health England, 2016c). This guide aims to provide a model for the general population, regardless of age, ethnicity or culture that shows how to properly balance daily food intake. This update replaces the 'eatwell plate' which was the previous health campaign released in 2007. It is the current guidance for all children over the age of two (Public Health England, 2016a).

The main messages of the new guidance are highlighted by the British Nutrition Foundation (2016) and are as follows:

- "Eat at least 5 portions of a variety of fruit and vegetables every day.
- Base meals on potatoes, bread, rice, pasta or other starchy carbohydrates; choosing wholegrain versions where possible.
- Have some dairy or dairy alternatives (such as soya drinks); choosing lower fat and lower sugar options.
- Eat some beans, pulses, fish, eggs, meat and other proteins (including 2 portions of fish every week, one of which should be oily).
- Choose unsaturated oils and spreads and eat in small amounts.
- Drink 6-8 cups/glasses of fluid a day.

- If consuming foods and drinks high in fat, salt or sugar have these less often and in small amounts."

The guidance was updated in line with emerging research from the Scientific Advisory Committee on Nutrition (SACN), specifically the Carbohydrate and Health report. Some of the updates included the removal of high fat, salt and sugar foods and inclusion of a hydration message.

This review aims to highlight the literature on the diets of UK children. In view of current public health recommendations, it outlines trends in macronutrient and key micronutrient consumption and analyses how and why these may differ in active children.

2.8. Differences in Nutrition for Active Children

There are undoubtedly many benefits to being active throughout childhood as outlined in Chapter 3. However it is often unclear when energy loss through PA is high enough to require a parallel increase in daily nutrition (Kimber et al., 2002). It is well documented in adult literature that to achieve good health there must be a balance between energy consumption through diet and loss through exercise (Schoeller, 2009, Lanham-New, 2011b). This may even require the need for diets out-with the national recommendations to promote muscle growth or to maintain weight (Lanham-New, 2011c). Children are inherently active and when provided with the correct encouragement and environment should develop good PA patterns (Sothern and Gordon, 2003). As children grow and develop it is important to ensure they receive adequate nutrition through a balanced diet. In highly active children, a lack of calorific energy intake can lead to weight loss, increased injury risk and fatigue which in turn may cause an inability to perform both mentally and physically. Further, long term implications of insufficient energy intake have been shown to include stunted linear growth, delayed bone health and pubertal development including menstruation (European Food Information Council, 2011, Purcell et al., 2013). Conversely an excess of inappropriate nutrients can lead to a child becoming overweight or obese (Purcell et al., 2013). It appears especially pertinent therefore to ensure children achieving high activity levels balance a raised energy expenditure with appropriate energy intake through nutrition (Purcell et al., 2013). This becomes of further raised importance when considering the subgroup of young, elite athletes.

2.8.1. Differences in Nutrition for Young Athletes

The diet of an athlete has to reflect the physiological requirements of a highly active lifestyle. It is important not only to eat to maintain an energy balance but also to provide fuel for maximal athletic performance. We have only limited evidence concerning the energy demands of young athletes, for example Cavadini (2000) documented the differences in PA, food habits and some lifestyle factors in 3450 athletic and non-athletic teenagers in Switzerland. In a subgroup of 246 11-16 year olds they analysed dietary content and concluded that the athletic cohort had a higher energy intake overall but that the difference between cohorts was statistically non-significant. The researchers found that in the pre-adolescent age group there were no habitual differences between athletic and non-athletic cohorts or genders. However in the adolescent group, athlete's food habits were healthier and they consumed dairy products, cereals, fruit, fruit juices and salad more frequently than the non-athletic cohort. Cavadini (2000) speculates that this is the reason athletes were found to have consumed more micronutrients.

However there is still a small evidence base surrounding the nutrition of athletic pre-adolescent children and it is difficult to ascertain whether their nutritional needs differ from other children or athletes. Petrie et al. (2004) reviewed much of the relevant literature regarding nutrition in athletic children. They state committed young athletes are, on the whole, not concerned with the concepts of energy balance or obesity. They speculate this phenomenon may be explained as naturally lean, athletic children tend to thrive at sport, they are therefore, more likely to continue to go on to become elite young athletes. Petrie et al. (2004) outline nutritional requirements of young athletes as they relate to endurance sports, strength and weight-class sports and team sports. This review aims to expand further on such macronutrients and key micronutrients found in the diets of children and how those requirements may change in highly active children and those involved with elite programs.

2.9. Energy Requirements

A careful balance between energy expenditure and energy intake is necessary in childhood to ensure optimal growth, health and academic achievement. In young athletes, as well as optimising training and recovery, the right amount of energy is also needed to minimise fatigue and the risk of injury and disease. An energy deficit can cause defects in growth and development such as stunted height, loss of muscle mass, delayed puberty and menstrual dysfunction. Further it can lead to increased sensitivity to fatigue, injury or illness (Purcell et al., 2013).

The estimated daily energy requirements for children vary with age and gender from 1291 kcal at 5 years old, to 3155 kcal at 18 years old. For 9 to 12 year olds, the recommended daily amount is 1721-2127 kcal per day (Committee on Medical Aspects of Food and Nutrition Policy, 1991). It is difficult to ascertain the energy needs of young athletes as there are a multitude of factors to consider including growth rate, pubertal status and daily variations in energy expenditure and metabolism rate. Children generally are less metabolically efficient than adult counterparts, therefore requiring a higher relative energy intake, but in athletically trained children this effect is estimated to be lower (Meyer et al., 2007). There is further evidence to suggest that young athletes actually compensate for high energy losses during training by being more sedentary during the rest of the day

(Petrie et al., 2004). The effect of psychosocial pressures to maintain a weight higher or lower than normal must not be overlooked either. Such pressures, whether they be internal or from an external source, may lead to a young athlete to adjust their diet according to what they perceive will benefit them most.

There are a multitude of biopsychosocial factors at play that can affect energy intake of an active child and as such, maintaining an appropriate energy balance can be complex.

2.10. Macronutrient Requirements

2.10.1. Protein

Protein is essential for the repair and building of muscle and is a useful source of long-term energy release during exercise (Purcell et al., 2013). If an individual does not consume adequate energy from other sources, protein will be used instead and hence less is available for synthesising tissues (Petrie et al., 2004). Sufficient protein intake is essential to child growth in conjunction with an adequate energy supply from other macronutrients. The recommended daily intake for 7-10 year olds is 28.3 grams per day for an average child (Committee on Medical Aspects of Food and Nutrition Policy, 1991). The Institute of Medicine (2006) suggests that protein should make up 10-30% of the total daily energy intake for children which is similar to recommended values for adults.

A higher energy expenditure and pressure to increase lean tissue mass in some sports would suggest a need for a higher protein consumption. Many sources however state that it is unnecessary to increase the requirement for active children over their peers. Research by Petrie et al. (2004) suggests that the average estimated requirement for 9-13 year olds is 0.77 g/kg and 0.73 g/kg and for 14-18 year olds 0.75 g/kg and 0.73 g/kg for boys and girls respectively. This is in line with general UK recommendations that suggest 0.75 g/kg for children over 10 years (Committee on Medical Aspects of Food and Nutrition Policy, 1991).

However, when reviewing data for 9-18 year old athletes participating in several different sports, Petrie et al. (2004) found that there may be a significantly higher requirement. For endurance sports protein requirement rose to 1.2 g/kg – 2.32 g/kg, strength and weight-class sports were 0.96 g/kg – 1.89 g/kg and in team sports values were between 1.0 g/kg and 2.2 g/kg. Although there is much disparity between subject groups in terms of age, gender and sport there was a clear trend for a higher requirement in young athletes than the government recommended value (Petrie et al., 2004).

2.10.2. Carbohydrate

Carbohydrates are seen as the most important fuel source in adult athletes (Lanham-New, 2011a). Glucose provided by this macronutrient is stored as glycogen in muscles and the liver and is the source that provides a quick release and the majority of energy to working muscle (Purcell et al., 2013). However, there is evidence that children don't develop the same capacity for glycaemic regulation until adulthood due to an immature glucose regulatory system. Children depend less on carbohydrates for fuel and place a greater reliance on fat until puberty (Riddell, 2008a).

Current recommendations suggest that 50% of total daily food energy should be from carbohydrate sources for anyone over 2 years of age, this equates to a minimum of 227 g and 242 g per day for boys and girls respectively between 7 and 10 years of age (Committee on Medical Aspects of Food and Nutrition Policy, 1991, Beek, 1991). A review for the Canadian Paediatric Society widens this recommendation to 45% - 65% (Purcell et al., 2013). Sports nutrition guidelines have long encouraged good carbohydrate availability to ensure maximum energy stores for competition (Burke, 2015). However, it has never been determined whether there is any use to a high-carbohydrate diet in children and most literature advocates normal recommended intake for athletic children as for non-athletic children.

2.10.3. Fat

Fat is important in children for more than just energy; it aids in the absorption of some vitamins (A, D, E, K), provides essential fatty acids, protection of vital organs and insulation of the body (Purcell et al., 2013). Fat provides a high source of calories compared to other macronutrients, specifically every 1 gram of fat provides 9 kcal whereas protein or carbohydrates provide 4 kcal for every 1 gram (Purcell et al., 2013).

Government-recommended fat intake is a maximum, set at 71 g and 66 g per day for boys and girls respectively aged 7-10 years. This requirement is greatly increased during puberty to the same levels needed for adults, at age 11 this is 97 g and 78 g for males and females respectively, this should represent up to 35% of daily energy intake with no more than 11% coming from saturated fat (Committee on Medical Aspects of Food and Nutrition Policy, 1991, British Nutrition Foundation, 2015c)

Along with upper limits for the levels of energy that should be derived from fat in the diet, consideration should be given to the minimum that may be required, recommendations for athletes are as low as 20% of total energy intake (Hoch et al., 2008). A low-fat diet could be assumed damaging to growth and in infancy, diets containing less than 25% energy from fat frequently instigate a failure to thrive (Uauy and Dangour, 2009). However, this does not appear to continue after mid-childhood. Uauy and Dangour (2009) reviewed past and present literature and found several studies conducted in the 1990's that showed in age groups from 6 months to 18 years, diets restricted to 25-30% of energy from fat sources did not adversely affect growth or development provided overall energy intake was sufficient. Dietary fat restriction may be beneficial for the purpose of weight management but specific care must be given to young athletes. Restriction below 15% of total energy intake may inhibit storage of intramuscular triglycerides, a major energy source for exercise, provoking a limited athletic performance (Spear, 2005). Further, inadequate dietary fat may lead to a deficit in fat-soluble vitamins and other micronutrients found in fat sources. Calcium and iron are especially crucial in childhood and adolescent development along with magnesium, zinc, Vitamin B12 and chromium, all of which are found in good dietary fat (Petrie et al., 2004). Fat is an important fuel source, especially in children. Inadequate intake may cause micronutrient deficiencies but it is unsure whether straying from recommended values might be beneficial to young athletes.

2.11. Micronutrient Requirements

Vital metabolic functions are performed by vitamins and minerals, micronutrients are as essential in the athlete as in the non-athlete. At different stages of development there are increased demands for several micronutrients, for example calcium in younger children and iron in females during puberty (British Nutrition Foundation, 2016). In young athletes particular attention should be given to ensuring adequate amounts of calcium for muscle contraction, iron for oxygen delivery to tissues and Vitamin D for bone health and calcium absorption (Purcell et al., 2013).

There is an assumption, based on self-reported food intake, that athletes consume higher rates of fruit and vegetables and hence micronutrients (Diehl et al., 2012, Cavadini, 2000). A review by Diehl et al. (2012) found however, that when only studies utilising biochemical tests are considered, both high and low involved athletes had insufficient mineral intakes when compared to recommended guidelines. Many factors may affect whether sufficient micronutrients are consumed. Smith et al. (2015a) suggests that young athletes may be at a higher risk of deficiencies due to daily time pressures making regular, balanced meals difficult. However, they counter-argue that due to the higher overall food intake of a young athlete, they are actually more likely to achieve daily requirements of vitamins and minerals.

It appears unclear whether being a young athlete makes you at a greater or lesser risk of micronutrient deficiencies. In order to analyse this further, it is pertinent to individually consider different vitamins and minerals.

2.11.1. Vitamins

Vitamins act to regulate metabolism, this has several effects on the physiology important to exercise performance as outlined by Williams (2004). B vitamins are essential for oxygen delivery during aerobic exercise due to their role in haemoglobin formation, they are thus an especially important factor in endurance activities. Other vitamins have an anti-oxidant roles and are important for minimising oxidative damage that can negatively impact training, specifically Vitamins C and E (Williams, 2004). Deficiencies in some vitamins therefore impair exercise performance. For example, Beek (1991) found that if athletes consume less than a third of the recommended daily amount of Vitamins B_1, B_2, B_6 and C it led to a significant decrease in VO_2 max and anaerobic threshold in under 4 weeks.

Vitamin D is important in active children for promoting bone health and absorption and through its role in regulation of both phosphate and calcium. Requirements vary depending on age, gender and geographical location (Burke, 2016). New data suggests further physiological roles, Vitamin D may aid in injury prevention, rehabilitation, improved neuromuscular function, increased type II muscle fibre size, reduced inflammation and decreased risk of stress fractures and acute respiratory illness (Burke, 2016). The UK recommendation is 7 µg/day from 7-9 months through to adulthood (Committee on Medical Aspects of Food and Nutrition Policy, 1991). However, in the joint position statement from the Dietitians of Canada, the Academy of Nutrition and Dietetics and the American College of Sports Medicine (2016) it is stated that several groups of athletes may not be gaining enough Vitamin D through both diet and UVB exposure. Such groups include those in weight-controlled sports and those training indoors or predominately during the early morning such as gymnasts, swimmers or divers (Burke, 2016). In conclusion, there is opportunity for young athletes to become deficient in several vital vitamins although further research is needed in children to identify specific at risk populations.

2.11.2. Minerals

A general consensus in adult-focused literature shows that there is not an elevated mineral requirement during exercise due to the associated increased metabolism (Williams, 2004). The only exception being following increased losses during high amounts of sweating (Petrie et al., 2004). Requirements in children similarly are not affected directly by PA and generally there is an adequate mineral intake in those involved in exercise programs (Petrie et al., 2004). However some research reports deficiencies in calcium, iron, folate and zinc in young athletes (Nisevich, 2008) which is reviewed further in the following sections.

Calcium in athletes is especially important for growth, maintenance and repair of tissue, regulation of muscle contraction, nerve conduction and normal blood clotting (Burke, 2016). In the young athlete, it is especially crucial to ensure adequate calcium intake as growing bones are less able to handle the stresses of exercising than mature adult bones. Inadequate calcium in the diet can increase the risk of overuse and overtraining injuries (Nisevich, 2008). Many dietary sources of calcium come from dairy products. The perishability of this food group could be a reason why young athletes don’t include adequate calcium rich snacks in their diet.

A regular breakfast routine normally provides good calcium intake (Deshmukh-Taskar et al., 2010). However, a study by Sandercock et al. (2010) in 10-16 year olds found breakfast consumption is inadequate in some English schoolchildren. They found that only 73.4% of boys and 61.4% of girls always ate breakfast but that a positive correlation was seen between these children and those who scored higher on their physical activity questionnaire.

The recent UK report, the National Diet and Nutrition Survey suggests that there is a worrying level of teenagers not meeting daily requirements of calcium. On average children aged 4-10 were achieving greater than the recommended daily intake and only 1% were below the lower recommended level. However this was not reflected in 11-18 year olds. On average, boys achieved 89% and girls 88% of the recommended nutritional intake. 12% of boys and 19% of girls also consumed below the lower recommended intake level (Public Health England, 2016d). Risk of insufficient calcium intake appears to grow with age and it appears extra emphasis is needed to translate good behaviours established in childhood through the crucial adolescence period.

The function of iron in the body is multifold, but the majority is used for oxygen delivery to tissues, two thirds of total iron present in the body is in the form of haemoglobin (Hoch et al., 2008). Heme iron from haemoglobin is found mainly in animal products and is absorbed much more efficiently in the gut than non-heme iron found in plant foods. Absorption of non-heme iron can pose a problem to those following a vegetarian diet. It can be increased by consumption of Vitamin C or meat protein and by avoiding calcium tannins and soy proteins that inhibit absorption (Hoch et al., 2008).

Daily iron recommendations again vary with age and gender. Children aged 1-6 years old should consume 6-7 mg/day and children aged 7-10 years old should consume 8.7 mg/day. Males 11-18 require 11.3 mg/day and females 14.8 mg/day. This gender difference is to compensate for iron lost through menstruation in pubertal females (Committee on Medical Aspects of Food and Nutrition Policy, 1991, Public Health England, 2016b). During adolescence there is an increased requirement for iron associated with increased linear growth, lean muscle mass and blood volume (Hoch et al., 2008). One study suggest requirements in female athletes may be as much as 170% of the normal recommended values (Burke, 2016).

Exercise affects many aspects of iron physiology in the body including increased requirements, decreased absorption, and elevated loss. The main mechanism affecting iron balance is microischaemia of the gut during exorbitant exercise training (Clenin et al., 2015). Recent research suggests there is also an increase in hepcidin release during intense training which leads to a blockage of iron absorption (Peeling, 2010). Other proposed mechanisms include loss through sweating and through urinary blood loss, although these play a minor and possibly non-significant role (Clenin et al., 2015). Iron deficiency in athletes is an increasing problem, especially in female and adolescent athletes, Clénin et al. (2015) suggested that rates may be as high as 52% in female adolescent athletes in Switzerland. This is a finding repeated in several different sports including distance-runners and gymnasts (Petrie et al., 2004). Sandstrom et al. (2012) found that it is not a problem exclusive to young female athletes, high levels of iron deficiency are also seen in their non-athletic counterparts. Sandstrom et al. state that the likely cause of high iron deficiency rates is due to an imbalance between dietary intake and losses and that lifestyle factors play a crucial role. They suggest amongst other lifestyle factors, young athletes may have a better iron status due to increased frequency of breakfast consumption and lower menstrual volume. This balances the increased losses incurred during exercise and, although caused by differing mechanisms, prevalence of iron deficiency is then similar in both cohorts.

Hoch et al. (2008) interestingly describes how sub-clinical iron-deficiency anaemia often may not affect a person during rest, but during strenuous exercise may cause symptoms due to the reduced oxygen availability. Therefore, iron-deficiency is often discovered more frequently in those with an increased exercise routine and therefore may be better reported in this population.

Management of iron deficiency is similar in athletes as it is to non-athletes, the overarching principle is to maintain the balance between intake and loss. Much of the literature (Hoch et al., 2008, Burke, 2016, Petrie et al., 2004, Clenin et al., 2015) recommends the initial step to improve iron consumption in the diet by increasing haem sources (if non-vegetarian) and improving digestion of non-haem sources either by increasing volume or avoiding concurrent intake of products that impair absorption. Supplementation of oral iron is a less clear-cut solution, although a well-recognised option, a consideration must be given to correct dosage and the reality that reversal of deficiency may take 3-6 months using this method due to a slow build-up of iron stores. (Burke, 2016)

The literature stresses the importance of regular screening, especially in female adolescent athletes and endurance athletes to enable discovery of low iron levels before they manifest as a clinical problem. Hoch et al. (2008), Sandstrom et al. (2012) and Clenin et al. (2015), (2012) all advocate regular screening in these groups while Burke (2016) in the most recent of these reviews, suggests extending screening to all athletes that are distance runners, vegetarians or regular blood donors.

In conclusion, iron deficiency is a growing problem affected by many different physiological and social variables. There are recognised subpopulations at an increased risk but this doesn’t appear to include prepubertal children. This age-group should maintain iron consumption in line with recommendations whereas other at risk populations may need to increase iron consumption either through diet or supplementation.

2.12. Free Sugars

Dietary sugar can be classified into two different consumable groups, either intrinsic or free sugars. Intrinsic sugars are those normally coming from carbohydrate sources, fruit, vegetables and sugars from milk in the form of glucose, lactose, sucrose and fructose. Carbohydrates are an essential macronutrient and a main source of energy in the diet (Scientific Advisory Committee on Nutrition, 2015). However much of daily sugar intake is not consumed from intrinsic sugars, but from free sugars, defined by the WHO as "monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates" (World Health Organisation, 2015, pg. 4). Free-sugars were previously termed non-milk extrinsic sugars (NMES) but are the same nutrient.

Addition of free sugars to the diet may be beneficial if the aim is to maintain a positive energy balance in the diet of those with inadequate intrinsic sugar intake (World Health Organisation, 2015). Johnson et al. (2009) in a statement from the American Heart Association outline a possibility for an improved diet quality in children and adolescents with particular reference to consumption of sugar-sweetened dairy products such as flavoured milk.

Almost all recent literature however shows increasing evidence of a negative effect from daily consumption of free sugar, for example on body weight, dentition and cardiovascular health (Te Morenga et al., 2013, Sheiham and James, 2015, Te Morenga et al., 2014). The WHO report, Sugar Intake for Adults and Children (2015), emphasises two key detrimental effects of excessive free sugar intake. Firstly, they warn of a of daily energy intake above that required by an individual, leading to an unbalanced diet and the potential for free sugar rich foods to replace calories normally consumed from more appropriate nutrients. Such an unhealthy diet has the potential to cause weight gain and increase the risk of non-communicable diseases. The second concern discussed is the strong association between free-sugars and high levels of dental carries, which is a problem of particular relevance in children (Sheiham and James, 2015).

The WHO report prompted the UK SACN to produce a similar report. Daily recommended values of free sugars in the UK should not exceed 10% of total dietary intake. However the SACN (2015) found that on average intakes in children were 14.7% for 4-10 year olds and 15.4% for 11-18 year olds, which was the highest of all age groups. Common sources of free-sugars in children and adolescents were soft drinks, fruit juice, cereal and cereal products (biscuit, cakes, pastries and breakfast cereals) and table sugar. The authors further the concerns of the WHO by stating there is significant scientific evidence to link the detrimental effects of sugar and sugar-containing foods on dental caries and poor dentition in children. In conjunction with that, they consider the evidence that sugar-sweetened beverages specifically, cause a significant trend in increased weight gain and raised body BMI (Scientific Advisory Committee on Nutrition, 2015).

Recommendations from the WHO report suggest reducing free-sugar intake to less than 10% for both adults and children (World Health Organisation, 2015). The SACN further recommends that in the UK, effort should be made to achieve the lower target of 5% for the population older than 2 years. They give particular emphasis to achieving this through the reduction in consumption of sugar-sweetened beverages (Scientific Advisory Committee on Nutrition, 2015).

In young athletes, these recommendations may be especially pertinent. Due to the demands of competition and training, individual energy expenditure is raised and they are more likely to be at an energy deficit. Young athletes may, therefore, require consumption of higher-energy diets to maintain an energy balance. The sport supplement industry is currently thriving and many of these products contain high-levels of added free-sugars

(Petróczi and Naughton, 2008a). Efforts have been made to discourage children from consuming carbohydrates that might contain free sugars, such as fruit juices, and to date the literature does not suggest clear guidelines of the use of free-sugars in athletic children (Sacheck and Schultz, 2016).

2.12.1. International Comparison

The need for public health change is apparent internationally as well as in the UK. A study conducted on behalf of the Global Burden of Diseases Nutrition and Chronic Diseases Expert Group (NutriCoDE) compared the dietary quality of 187 countries over a 20 year span ending in 2010. They concluded that higher national income countries, such as the UK, had higher scores for healthy diets but concurrently found that unhealthy diets were of a decreased quality (Imamura, 2015).

An addition to compelling public health campaigns can be policy change. One such strategy internationally praised for its effect on improved child nutrition, is a tax on foods high in sugar, fat and salt. The Global Nutrition Report (2016) outlines the benefits of such an approach in the 14 countries that have adopted it. Specifically, the positive impact seen in Mexico where a decline has been seen in expenditure on sugar-sweetened beverages, especially in lower-income households. The UK is set to implement a similar tax in 2018 (Haddad 2016).

2.13. Summarising Macronutrient and Micronutrient Requirements in Children

This review has so far outlined the need for a balanced energy intake in children in order to support their developmental needs. This is especially pertinent in children who are highly active or competing at an elite level with increased daily energy expenditure. Protein, fat and carbohydrate are important energy sources and as yet, the literature does not give a compelling reason for consumption that falls outside recommended values, even for more active children. Similarly, adequate micronutrients are essential to maintaining health through nutrition in children. However, there are concerns that some subgroups are at higher risk of deficiencies and young athletes, in particular may be at risk of Vitamins B and D, calcium and iron deficiencies. A higher energy requirement may lead young athletes to increase consumption of free sugars, a problem already endemic in the paediatric population, which is enabled by the growing influence of the sports supplement industry. The best nutrition for a child must be determined individually, their energy expenditure must be regarded in context with personal physiological and social variables.

2.14. Fluid Intake and Requirements

Children of prepubertal age are of particular interest and their fluid replacement requirements during exercise must not be considered the same as other age groups. Differing physiology means children are more susceptible to dehydration and subsequent reduced athletic performance (Rowland, 2011). The Eatwell Guide recommends six to eight glasses of fluid a day for all UK inhabitants including children, emphasising that this should come from water, low-fat milk or sugar-free drinks (British Nutrition Foundation, 2016). The European Food Safety Authority (EFSA) (2010) has produced more comprehensive guidelines that include recommendations for specific age groups between 2 and 14 years of age. For optimal hydration in an average child, fluid consumed should be 1,300 mL, 1,700 mL and 1,520 mL respectively for boys and girls 4-8 years old, girls 9-13 and boys 9-13 years old.

Hydration status may be maintained through drinking fluids, with 70-80% coming from drinks and with the remainder maintained from consuming from food (EFSA Panel on Dietetic Products and Allergies, 2010). There is emphasis from both regulatory bodies that the plain water should be the main fluid consumed and shouldn’t be replaced in abundance by any other drink containing sugar, calories or additives.

Rowland (2011) outlines the differing thermoregulatory processes. Child athletes have lower sweat losses relative to body size and show equal or greater voluntary intake through drinking per body size than adults. There is evidence though to suggest that children may lack motivation for adequate fluid replacement post-exercise (Rowland, 2011). Overall dehydration in child athletes appears to be similar to adults during the acute exercise period. However, several factors affect hydration in the child athlete in differing ways to adults and children are not effective at self-maintaining euhydration. Emphasis therefore must fall to parents and coaches to ensure hydration is maintained.

EFSA states three main influences on fluid balance that should be considered. These are dietary factors, physical activity and climate and abnormal pathophysiological situations.

2.14.1. The Effect of Diet on Hydration

Fluid intake and diet have a concurrent relationship on the uses and requirements of each other in human pathophysiology. Dietary protein intake can increase water requirements through an increased requirement for excretion of their metabolites, specifically urea which requires water for excretion by the kidneys (EFSA Panel on Dietetic Products and Allergies, 2010). Initial research by (Luft et al., 1983) analysed the effect of increased sodium and protein intake in adult men. They concluded that although there were appropriate pathophysiological responses, such as increased solute and urea excretion, there was no effect on water intake or urinary volume. Generally the literature supports that during *ad libitum* water consumption settings, neither water intake nor urinary volume are affected by increased dietary protein (Otten, 2006). Fibre similarly causes water excretion through an increased requirement in faecal matter during metabolism of dietary fibre. Carbohydrate intake however, has the opposing effect. Consumption of dietary carbohydrates above the level required to prevent ketosis, decreases water requirements by decreasing the amount of ketones that need to be excreted (Otten, 2006). Often athletes may increase carbohydrate or protein in their diets and such the effect this may have on their fluid status becomes increasingly important.

Sodium intake is evidently a key factor in body fluid volumes. Fluid balance between extra and intra-cellular spaces is maintained by the ionic concentration in these spaces of which sodium ions play a fundamental role (Popkin et al., 2010). Consumption of sodium containing foods and fluids stimulates thirst and encourages fluid-retention, helping to maintain this homeostasis. This is especially important in the rehydrating athlete as sweating during exercise may cause higher than normal rates of fluid loss (Purcell et al., 2013). Popkin et al. (2010) estimates that 6-10% of body-weight can be lost through sweat in adult athletes. A review by Rowland (2011) found that there is evidence that prepubertal children may have a lower sweat rate however. Overall Rowland concluded that the effect of such sweat rates in children and young adults compared to their adult counterparts was similar such that after accounting for body size, rates of dehydration would be similar. Furthermore, children show lower sodium concentrations in sweat than adults do. Meyer et al. (1992) looked at the differences in sweat rates and composition in prepubescent, pubescent and young adults when asked to complete exercise at 50% peak VO_2. They concluded that not only did the prepubescent group have lower sweat rates but also lower sodium ion concentrations. This has direct implications for focused rehydration in child and adolescent athletes; it appears that they may not possess the same requirement as adults for sodium replacement post-exercise. The relationship between nutrition and hydration status is complicated and more focused research is needed to really understand how to effectively maintain euhydration in prepubescent children and athletes.

2.15. Nutritional Supplements

Dietary supplements are products consumed by athletes in order to complement their diet, they are often readily available and are generally not considered as a form of doping. This term has come to encompass products containing macronutrients like carbohydrates, lipids and proteins, and micronutrients such as vitamins, minerals and caffeine. These are available in several different forms and of varying efficacy. Athletes often believe they can gain a competitive advantage or maximise training by adding supplements into their diet (Knapik et al., 2016). Ergogenic aids is a similar term that is often used in reference to performance enhancing drugs, some of which can be abused to create an unfair advantage, such as anabolic steroids (Thein et al., 1995).

Concerns about supplement use in children have become of more interest since the emergence of readily available products. DiPalma and Ritchie (1977) warned of the potential for toxicity from larger than recommended doses of vitamins and minerals in an early review. Caffeine for example, one of the few popular supplements that has been extensively studied and provides a wealth of information. Common major health effects include sleep dysfunction, obesity and dental carries and there are a wide range of other negative impacts (Temple, 2009). Concerns for allergic reactions and the potential of unknown side-effects have also been raised (O'Dea, 2003). Other supplements are less studied and there is increasing concern regarding the potential for harmful effects.

2.15.1. Prevalence of Supplement Use

Supplement use in adults is becoming increasingly common. A study undertaken by UK Sport found that 59% of high-performing athletes used at least one nutritional supplement and on average 3.22 supplements were used by athletes. (Petróczi and Naughton, 2008a) A similar study in young athletes aged 12-21 found 48.1% used at least one supplement, providing evidence of a similar trend in this population (Petróczi et al., 2008b). In an even more elite group, of the junior athletes selected to represent GB at the World Junior Championships, 75% of females and 55% of males used supplements suggesting widespread use in this high-performing population (Nieper, 2005).

Use of many different forms of supplements have been reported in young UK athletes. The most popular as reported in both the Petrózi and Naughton (2008) and Nieper (2005) studies, included sports drinks, multivitamins, Vitamin C, whey protein and creatine, echinacea, caffeine and iron.

Supplement use in the general population is less-researched. In a 2016 Welsh study it was reported that 89.4% of 12-14 year olds drank sports drinks and half of that group drank them at least twice a week (Broughton et al., 2016). In the US, the 2007 National Health Interview Survey revealed some data for the paediatric population as a whole, defined here as between 4 and 17 years old. The most popular supplements were multivitamin minerals, used by 31%, echinacea, used by 35% and fish oil and omega-3 supplements used by 30%. They found that only 1.6% of participants reported using creatinine (Wu et al., 2013). It appears that supplement use in one form or another is prevalent in general, athletic and elite populations of children.

2.15.2. Reasons for Supplement Use

With a rise in prevalence, it seems important to discuss why athletes feel the need to supplement their normal diet. A sample of junior national athletics athletes in the UK stated the principal reasons for supplement use were health (45%), enhancement of the immune system (40%) and improving performance (25%) (Nieper, 2005).

A study by O'Dea (2003) of 11-18 year old adolescents found that a major reason for taking vitamins, minerals and herbal supplements was to improve short-term health and immunity. Many of the adolescents in this study reported they received these from their mother and some further reported not fully knowing why they were effective. The irrefutable influence of parents is well exhibited by O'Dea (2003) but she also argues the impact of the phenomenon coined 'dietary insurance' as an explanation. This is when nutritional supplements are consumed by an individual to make-up for a perceived poor quality diet. O'Dea (2003) further noted that many adolescents reported that they received an energy boost from supplements and that they aided in conserving energy. She displays concern that this group did not accurately appreciate the role of stimulants in drinks with many believing there was an 'energy creation' effect. It is also likely there is an overarching influence of elite and professional athletes. Not only due to overt supplement endorsement but with heavily publicised reports of doping becoming increasingly common. McDowall (2007) states that the public use of ergogenic aids and banned substances is acting to glamorize doping and Calfee and Fadale (2006) further acknowledges that the fame and respect of athletes found using steroids makes such practises appear acceptable and even necessary to achieving success.

As with all dietary choices, there are wide-ranging influences. However, those who advocate and encourage supplement use should be regulated as the use of different supplements by children can have both negative and positive effects.

2.15.3. Sports Drinks

Energy drinks and sports drinks are often used interchangeably in lay language but are separate products with separate effects and consequences. Sports drinks are marketed as products that enable electrolyte replacement during and following exercise and aim to improve athletic performance through increasing energy, concentration and mental alertness and by decreasing fatigue. They generally consist of carbohydrates, minerals and electrolytes in the form of a flavoured fluid (Schneider and Benjamin, 2011).

There has been a great increase in the consumption of sports drinks, not only by young athletes but the younger population as a whole. Mintel (2014) a market intelligence agency, reported that 78% of 16-24 year olds in the UK have consumed a sports drink in the past 12 months and 39% drank them at least once a week. However, they do project that the UK sugar tax, due to be implemented in 2018 will have a significant effect on lowering this statistic. They estimate 52% of current consumers of sports and energy drinks would decrease consumption or stop drinking them altogether if the price increased. (Mintel, 2016)

UK sales of sports drinks have similarly continued to increase in the past decade although, with a slowing rate of increase in consumption, in 2013, there was an average consumption of 2.4 litres per person (British Soft Drinks Association, 2014). In the United States of America, sports drinks were the 3rd fastest growing beverage group in 2006 and, in the same period, market sales in schools rose to 20%. This is alongside a concurrent decrease in soda drinks which has lead the American Academy of Paediatrics to warn of the implications of unnecessary increased consumption of sports drinks in schools. They have encouraged the restriction of selling sports drinks in schools (Schneider and Benjamin, 2011). In the UK, policy bans the sale of any fizzy or sugary drinks inside schools, this includes sports drinks (Broughton et al., 2016).

The benefits of sports drinks have been well studied in adults. They have been shown to be more than just water either when an athlete has low body glycogen initially or when exercise duration exceeds one hour at a high intensity (Coombes, 2005). Further evidence suggests that better euhydration is maintained with flavoured sports drinks indirectly, due to being more appealing and tasty than water (Johnson et al., 1988). However in the majority of users there has been no proven benefit over water (Coombes and Hamilton, 2000). There may be benefits to consumption of sports drinks in elite paediatric athletes, however in the general paediatric population, there is no indication that sports drinks should be used in place of hydration with water (Schneider and Benjamin, 2011, Steen, 1996). Several adverse effects have been associated with consuming sugary drinks, such as sports drinks, including obesity, diabetes, heart disease and gout when drank frequently and in a social context (Department of Nutrition at Harvard School of Public Health, 2012).

In children, there is particular concern for the hazardous effect sugary drinks have on their dentition. Even drinks marketed as being sugar-free may be harmful as they have a higher acid content that can cause erosion of teeth enamel. (Broughton et al., 2016)

The reason behind the high prevalence of sales and consumption of sports drinks appears not to be the benefits associated with sports performance. Broughton et al. (2016) studied reasons for sports drink consumption in 12-14 year olds in Wales. They reported that 90% of participants consumed sports drinks because of the taste but only 18% said the performance enhancing effect was a factor. For emphasis, the authors point out that 72% of girls and 87% of boys in the study reported taking part in regular exercise. The same study also noted that half of respondents reported drinking sports drinks socially, as well as during periods of exercise. This report concurs with findings in several other studies including the US Healthy Eating Research Review, 2012, the Food Standards Australia and New Zealand report on sports foods and a large study in north-west England (Story and Klein, 2012, Food Standards Australia New Zealand, 2010, Milosevic et al., 2004).

2.15.4. Energy Drinks and Caffeine

Energy drinks have a widespread use in both athletes and non-athletes. They are described as ‘beverages that contain caffeine, taurine, vitamins, herbal supplements, and sugar or sweeteners and are marketed to improve energy, weight loss, stamina, athletic performance, and concentration’ (Seifert et al., 2011, pp.512). The American Academy of Paediatrics released a recent review on energy drinks and state that they show no therapeutic benefit and have a high potential to cause harm in children (Seifert et al., 2011). Petróczi et al. (2008b) found energy drinks were the most commonly reported supplement used, 86.6% of supplement users and 41.7% of young athletes consumed energy drinks. Children are also one of the fastest-growing consumers of caffeine, mostly through soft drinks (Turley, 2014).

One of the main selling points of energy drinks is their stimulating effect, due normally to high quantities of caffeine or caffeine containing products. Many drinks around 3 times the quantity found in Cola soft drinks (Thomson and Schiess, 2010). A New Zealand study investigated the caffeine exposure of energy drinks or shots. They found that 70% of children (5-12 years old) and 40 % of teenagers (13-19 years old) had exceeded the adverse-effect level of caffeine after consuming a single drink or shot (Thomson and Schiess, 2010).

The acute use of caffeine in sport has been studied more recently but the literature is inconclusive. Overall a low-dose appears to have a positive effect on aerobic activity (Ruxton, 2014, Turley, 2014). During anaerobic exercise in children, moderate to high doses of caffeine appears to lower heart rate and raise blood pressure, there is an unclear effect on respiration and no effect on metabolism (Turley, 2014). Conversely, studies into the adverse effects of caffeine use in children are more common. An increased risk of caffeine toxicity, poor dental health, disturbed sleeping pattern and anxiety have all been reported (Ruxton, 2014).

However, studies are mostly small, and USA-based and as such, overarching conclusions on the negative health effects in children are hard to draw. In light of the increase in consumption and marketing of soft-drinks and energy drinks to children, many regulatory bodies are cautious of the negative effects and actively aim to discourage consumption by children. There are no proven benefits in children during sport and it does not seem pertinent to extrapolate data from adults due to the differing physiological responses to caffeine.

2.15.5. Protein

Protein is essential for the synthesis of tissues in the body, it enables the production of hair, nails and skin as well as the building and repairing of muscle (Purcell et al., 2013, Smith et al., 2015a). There is a belief that due to high training demands of the child athlete there is corresponding higher protein requirement in this population and some young athletes consume a high-protein diet to replenish energy stores lost in training. However, there is no conclusive evidence in children that an intake above the daily recommended values of protein shows a significant benefit (Petrie et al., 2004, Smith et al., 2015a). In elite young athletes, especially those currently experiencing a growth spurt, there may be call for an intake of protein that is difficult to achieve purely through diet, further research is needed to quantify whether protein supplements might be beneficial in this group. Popular forms of protein supplements include creatine, whey protein and branched-chain amino acids (Calfee and Fadale, 2006).

Creatine is naturally synthesised in the human body and although used by both the heart and brain, 95% is stored in muscle (Calfee and Fadale, 2006). It is considered beneficial in the diet as it is a dominant energy source over the first 10 seconds of anaerobic exercise. The use of creatine as a supplement has been well studied and positive effects have been seen in short duration strength exercise. There appears to be no benefit to endurance or aerobic exercise (Engelhardt et al., 1998). In adult athletes, negative effects have been described, such as unwanted weight gain, gastrointestinal irritation and muscle cramps. Interestingly McDevitt (2003) describes a phenomenon of ‘non-responders’ where up to 30% of athletes who use creatine report no benefits. This is explained by the theory that these individuals naturally have maximal creatinine stores and any extra creatine ingested is merely surplus.

Broadly, whey protein and amino acids are consumed post-exercise to encourage muscle building. Extensive research of the physiological effects suggest they act by promoting protein synthesis in the anabolic recovery phase post-exercise. Further, there is evidence to suggest that whey proteins may promote fat loss by decreasing body fat deposition (Zemel et al., 2000). Whey protein contains high quantities of Branched-Chain Amino Acids and in particular leucine which has made it a very popular and effective supplement (Ha and Zemel, 2003). There are few reported side-effects of diet supplementation with whey protein. Minor gastrointestinal irritation has been reported and caution must be advised in those with lactose intolerances (Marshall, 2004).

There appears a common prevalence in the adolescent population. Petróczi et al. (2008b) found in 12-21 year old UK elite athletes that whey protein was used by 21.3% and creatine by 13.4%. Interestingly however, they found that when testing the knowledge of this population there was a large degree of uncertainty as to whether these two products maintained strength, even in users.

Overall many experts are hesitant to recommend protein supplementation to children and adolescents (Petróczi and Naughton, 2007, LaBotz and Griesemer, 2016). A review of several studies on the macronutrient requirements of young athletes found that regardless of protein requirements for their weight, on average the majority of athletes comfortably met the higher estimated protein requirements (Petrie et al., 2004). Therefore, not only may it be pertinent to advise caution when speculating the benefits of protein supplementation in children, it appears such use may be wholly unnecessary.

2.15.6. Multivitamins and Minerals

Vitamins are one of the most popular forms of supplements taken by both the general population and athletes, in particular, high rates of Vitamin C and multivitamin use has been observed (Knapik et al., 2016, McDowall, 2007). An early review by Sobal and Marquart (1994) found that multivitamins were the most prevalent supplement and Vitamin C the second most prevalent in the athletic population. They reported that reasons for this were female athletes on weight-control diets and adolescent boys who believed multivitamin supplementation would improve performance. A recent review by Knapik et al.

(2016) that this trend still prevails with multivitamins and Vitamin C commonly used by athletes but being used less than sports drinks. An analysis of the supplement use of track and field athletes in the UK competing at the 2004 World Junior Championships found that multivitamins were used by 45% and Vitamin C by 35% of participants (Nieper, 2005).

Concern has been raised in the junior population as many young athletes do not fully understand the correct effects of vitamins and may have inadequate knowledge of potential harmful effects (Nieper, 2005, McDowall, 2007). Unfortunately, there is little current information on the perceptions of child athletes as to what effects multivitamins and Vitamin C have. In general though, vitamin and mineral supplementation has been associated by children with positive health much more than improving sporting performance which suggests a better supplement knowledge. However, this still doesn't make clear the reason for the significantly higher rates of vitamin supplementation in elite athletes of all ages, such an explanation is yet to be proved (McDowall, 2007, Knapik et al., 2016).

2.15.7. Echinacea

Echinacea is a supplement that traditionally comes from the roots of the plant of the same name. It is an herbal remedy used to stimulate the immune system and to treat and prevent cold and flu infections (Ernst, 2002). In the 2007 National Health Interview Survey of children and adolescents in the USA, it was the most commonly used herbal supplement, consumed by 35.3% of the studied population (Wu et al., 2013). It does appear more popular in the USA than the UK but Petróczi et al. (2008b) found that in young elite UK athletes it was used by 7.7% of all participants and 16% of supplement users.

The efficacy of echinacea is unclear but the variation in products for sale under the umbrella heading of echinacea is broad and can contain a wide discrepancy of bioactive compounds (Ernst, 2002). A 2014 Cochrane review concluded that no research showed a significant positive effect of echinacea in treating or preventing the common cold but the research did show a weak association for a small beneficial effect during illness (Karsch - Völk et al., 2014).

2.15.8. Iron

Iron requirements in a highly active individual may be raised above those normally seen, especially in females. As previously discussed, iron deficiency is a growing problem in the athletic population (Clenin et al., 2015). Many turn to iron supplementation as a subsidiary to their diet.

Sobal and Marquart (1994) found that iron was the 3rd most common supplement consumed by athletes, on average by 26%. More recent research by Nieper (2005) similarly they found iron supplements were used by 30% of UK junior athletes competing at the 2002 World Junior Championships. Petróczi et al. (2008b) however, found a usage rate of only 4.7% of elite young athletes, in their study which contained a much larger pool of participants. In several pieces of literature it is agreed that the rate of use by females was much higher than by males (Burke, 2016, Sobal and Marquart, 1994, Knapik et al., 2016).

Iron is one of the few dietary supplements consumed by athletes that has been extensively studied and clear conclusions about efficacy, safety and need have been determined. Unlike other supplements, it appears consumption is generally on the recommendation of health professionals (Petróczi et al., 2008b). One of the main benefits of iron supplementation in athletes is to prevent depletion of iron stores. This deficiency is especially seen in female athletes with some reporting up to 60% of female athletes being affected (Cowell et al., 2003). There is evidence to suggest that regardless of gender, athletes have similar rates of iron-deficiency anaemia as the general female population (Burke, 2016). In those who have depleted iron stores, supplementation will help to maintain general health and physical and intellectual wellbeing. In adult athletes there is evidence to suggest further positive changes such as increased oxygen uptake, reduced heart rate and decreased lactate concentration during exercise which all aid in improved athletic performance (Burke, 2016).

2.15.9. Nutritional Supplements – In Conclusion

The use of dietary supplements is widespread in the athletic population although prevalence in children is unclear. Sports drinks and energy drinks are becoming increasingly popular in children. Due to the lack of an evidence base for benefits outweighing potential harms to children, caution is advised when including them in the diet of children. Other supplements that may be found in the diets of young athletes include protein products, vitamins, echinacea and iron. Although prevalence rates vary, each of these carries a risk of harm to a child as well as a potential for benefit. Generally, supplementation with any of these products is likely to be unnecessary if maintaining an adequate diet. Dietary supplementation is an under-researched area in children, child athletes in particular, data should not be extrapolated from adults and, as such, more in-depth research is needed.

2.16. Nutritional Knowledge

2.16.1. Public Health Policy and the Promotion of Nutritional Knowledge

Improving population health is a continual focal point worldwide, and within the UK has long been a focus of government policy (Spronk et al., 2014, Parmenter et al., 2000a). A group of conditions is causing a current epidemic in the western world including heart disease, stroke, cancer, diabetes and chronic respiratory diseases, termed collectively as non-communicable diseases (NCDs). The UN High-Level Meeting on NCDs in 2011 identified physical activity and salt reduction in conjunction with improved diets and as two of its five priority interventions. They particularly emphasise the importance of public health nutrition programs aimed at obesity prevention in children (Beaglehole et al., 2011).

Public health policy in the UK has often targeted improving knowledge and understanding of a problem, how this knowledge and understanding impacts an individual, and measures that may be taken for prevention or cure (Bryant, 2002). The development of several models of health promotion over the last century has included health literacy as “the personal, cognitive and social skills which determine the ability of individuals to gain access to, understand, and use information to promote and maintain good health” (Nutbeam, 2000, pp263). One of the major components that make up health literacy being improved knowledge and understanding

Theoretical promotion of the need for higher levels of health literacy concerning nutrition has led to the UK government conducting several public health campaigns, culminating in the most recent, the ‘Eatwell Guide’ that aims to educate on how to consume a balanced diet (Public Health England, 2016c). There was particular focus on distributing this tool to children in schools to supplement their normal food education. This effort was aimed at improving children’s understanding and knowledge of nutrition and how to obtain a healthy and balanced diet (Buttriss, 2016). The new recommendations would appear achievable, analysis by Scarborough et al. (2016) outlines using optimisation modelling how, although ambitious shifts in diet would be required to meet recommendations, these are possible and would not incur a price increase on the current average UK diet. Further, such changes may have a positive health and environmental effect (Carbon Trust, 2016, Scarborough et al., 2016). Harcombe (2016) raises concern for the influence of the food industry on the design of the Eatwell Guide. The lack of an evidence base for a diet based on these guidelines and absence of a clear message to consume non-processed food could cause a shortcomings in the effectiveness of this campaign. Longitudinal studies and time are required before any conclusions regarding the efficacy of the Eatwell Guide can be succinctly drawn. Despite its prominence in policy and national interventions, evidence concerning the effects of such nutritional education is limited.

2.16.2. The Effect of Nutritional Education

Nutrition information is widespread in the UK as it is in many developed countries, education by schools, governments and health promotion agencies targets many communities (Spronk et al., 2014). There is however, an abundance of information in the form of consumer advertising, making clear information on a healthy diet difficult to find (Rozin, 2006). Nutrition knowledge is influenced by many different factors other than public health campaigns. Age, gender, education and socio-economic status have all been shown to impact knowledge (Spronk et al., 2014).

For example, with respect to gender, women are commonly reported to have a higher nutrition knowledge than men (Parmenter et al., 2000b, Hendrie et al., 2008a, Sapp and Jensen, 1997). In his review of nutrition knowledge and its association with dietary intake, Spronk et al. (2014) attributes this disparity either to women having traditionally a more pivotal role in food purchase and preparation or the finding that men simply have a lower interest in nutrition. This gender effect was more recently researched by deconstructing the concept of knowledge into more specific domains in a large, multi-national study by Grunert et al. (2012). They found women were more knowledgeable on expert recommendations and energy content but males had superior knowledge on salt, sugar, and saturated fat content. Overall Grunert et al. (2012) concur that women have higher nutrition knowledge.

Nutrition knowledge further differs across socio-economic groups. Higher socio-economic status (SES) has been shown to directly correlate with higher nutrition knowledge. Education level is intrinsically linked to SES and a similar trend is observed (Parmenter et al., 2000a, Grunert et al., 2012, Darmon and Drewnowski, 2008). A reporting bias for this demographic makes sound conclusions difficult. Those with lower SES and education attainment generally have much lower response rates in an already small literature base

(Spronk et al., 2014). Those with lower SES are at a greater risk of lifestyle diseases, but they are also less likely to engage with education programs due to a lower health literacy. Evidence on the effect of health education may be hard to obtain in the lower SES demographic and any conclusions drawn about the effect this has on nutrition knowledge level should take this into account (Schillinger et al., 2006).

Age is additionally a characteristic that must be considered when analysing the impact of nutrition education. Early research identified that those of middle-age attained higher nutrition knowledge levels than those at the younger or older end of the spectrum (Crawford and Baghurst, 1990, Levy et al., 1993). More recent research by Parmenter et al. (2000) in English participants showed that those in the middle 3 groups (35 – 64 years old) scored highest followed by the youngest group (18 – 34 years old) and the over 65 age group scored lowest in all 5 parts of their nutrition knowledge survey. The researchers further analysed whether age was an independent factor or linked to a lower SES and education level. They concluded that age was only a significant factor in a population with lower levels of education or SES, both variables which are seen in the oldest and youngest age groups.

In a sample of 18 – 74 year olds in Australia, Hendrie et al. (2008a) found that participants over 35 years old scored higher on the General Nutrition Knowledge Questionnaire (GNKQ) than those under 35 years old, however they did not split the age groups further so no conclusion can be drawn about the older population. This research although inconclusive, does appear to show that nutrition knowledge level does not simply increase with age and may not be an independent factor in the population as whole. Education programs must consider their target audience and adjust accordingly.

2.16.3. The Literature Base in Athletes

The nutrition knowledge of athletes has long been a topic of interest (Douglas and Douglas, 1984), it is well founded that good nutrition enables good health and athletic performance (American College of Sports Medicine et al., 2000). The small literature base, primarily in collegiate athletes from the USA shows a positive but weak correlation between nutrition quality and nutrition knowledge in athletes (Heaney et al., 2011, Trakman et al., 2016). Nutritional information comes from a variety of sources for athletes including online and print media, other athletes and coaches (Trakman et al., 2016).

Nutrition education is key to achieving a balanced and appropriate diet in athletes, nutrition knowledge must be assessed to improve education and update guidance (Henry, 2001). Studies of nutrition knowledge in differing athletic groups have been conducted since the 1980's (Douglas and Douglas, 1984, Perron and Endres, 1985) with interest highest in the mid 1990's (Spronk et al., 2014). However current research shows that the diets of athletes are still nutritionally inadequate with room for improvement (Heaney et al., 2011).

Heaney et al. (2011) compared research on athlete's nutrition knowledge to their non-athletic counterparts. They found evidence that knowledge level may be higher in females, those in tertiary education and those competing at an elite level, further sport-nutrition knowledge was higher in the athletic cohort. However half of the reviewed research was conducted prior to 2000 and does not reflect the growing knowledge base on sports nutrition since. A very recent review by Trakman et al. (2016) analysed current research on nutrition knowledge in athletes and their coaches. In a novel approach, they dissected several different questionnaires to ascertain specific sub-sections of poor knowledge across several studies. They found that energy density, vitamin and mineral supplementation, energy sources and protein synthesis and supplementation may be topics of particular confusion for athletes. There are several limitations to this technique of reviewing e.g. a lack of meta-analysis and heavy reliance on the interpretation of researchers but it is an important step in guiding further research.

Heaney et al. (2011) along with others (Trakman et al., 2016, Heaney et al., 2008), call for larger, comparable and up-to-date research to broaden the knowledge base around athlete's nutrition knowledge. A detailed analysis of the limitations of current tools is needed with the possibility of development of a standardised, validated tool to measure sports nutrition alongside general nutrition. Such a development would be of great importance to focusing information provided on sports nutrition.

2.16.4. Nutritional **K**nowledge **A**ssessment

It is clear that nutrition knowledge is an important part of health literacy as it relates not only to diet but to chronic conditions and the general health of an individual. However to ascertain the impact and effectiveness of education programs, one needs to have the ability to accurately measure the outcomes.

Much information around health knowledge in the 1980's and 1990's was explained by theories such as the Health-Belief model (Janz and Becker, 1984), Social Learning Theory (Bandura and Walters, 1977) and the Theory of Rational Expectations (Sapp and Jensen, 1997). The authors review two of the earliest nutrition knowledge tools. Both studies surveyed the nutrition of a large sample of participants and compared that to nutrition knowledge and beliefs amongst other variables. The reliability of these two tests was poor with Cronbach's alpha below 0.70 for nutrition knowledge; this was considered the minimum score required for nutrition research in 1997. A larger analysis of 19 early tests from 1967 through to 1991 found almost half to have a reliability less than 0.70 (Axelson and Brinberg, 1992). This called for further research to enable the formulation of a reliable and valid measure of nutrition knowledge in able to further guide the development of nutrition education programs.

2.16.5. Nutrition Knowledge Assessment Tools

The Food and Agriculture Organisation (FAO) of the United Nations published a manual in 2014 to provide guidelines for assessing nutrition-related Knowledge, Attitudes and Practices (KAP). It was produced in response to the disparity in research of KAP. There are several different studies, using both qualitative and quantitative methods, often of their own design, which makes comparison of the literature complex and research difficult to reproduce (Fautsch Macias, 2014). Over the last two decades there has been increasing interest in a nutrition knowledge tool, Barbosa et al. (2016), in a recent review found that from 2005 there have been on average three different studies published per year, suggesting growing interest in the role of knowledge, attitudes and practice on nutrition.

The FAO guidelines aim to provide a more standardised tool for use by non-governmental organizations and international agencies to conduct KAP surveys at a community level. It has been used effectively, for example, in Bangladesh to evaluate nutrition-specific interventions in new mothers (Billah et al., 2017) and in the Gaza Strip to assess education interventions around iron –deficiency anaemia in female adolescents (Jalambo. et al., 2017). There are a large number of adapted versions of the FAO questionnaire and it appears a popular resource in studies in developing countries.

Demographic variables including age, gender, education and socio-economic status all play an important role in the level of nutrition knowledge. It appears pertinent then, that a good knowledge tool would need to acknowledge the effect of these variables when considering results. Further, sociodemographic information creates context from the overall characteristics of the studied population (Fautsch Macias, 2014). Barbosa et al. (2016) found other frequently assessed sociodemographic variables included occupation, marital status, number of children and ethnicity as well as anthropometric data such as BMI. The demographics assessed will of course depend on the study population and the research aims, but the use of a standardised tool would facilitate such decisions and increase comparability. In studies in developed nations many researchers prefer to design their own evaluation tools. This allows the questionnaire to be designed specifically for purpose and results are directly relevant to the aims of the study. Due to a disparity in nutrition assessment tools available, many researchers may find no option but to design their own tool, especially when working in a previously unstudied area or population. Parmenter and Wardle (2000) warn however, of the disadvantages of such an approach. There would be a large time commitment, and researchers would be limited by their own knowledge and resources. Moreover it makes comparison to other research extremely difficult.

A review of 25 nutrition knowledge assessment studies by Barbosa et al. (2016) found that 44% of studies designed questionnaires expressly to suit their own research. In the same sample, 44% of the studies did not describe how the questionnaires were assessed, allowing for no reproducibility. Unfortunately the authors do not state whether these are the same studies. There is definitely reason for a collection of available resources for the assessment of nutrition knowledge. Only when research consistently uses validated and reproducible tools will the literature be truly comparable and educational to a wider range of organisations.

2.16.6. The General Nutrition Knowledge Questionnaire

Parmenter and Wardle (1999), developed a nutrition knowledge assessment tool called the General Nutrition Knowledge Questionnaire (GNKQ) for use in adults over 18 years of age. At this time, several tools had been used in varying research but had either been inadequate or used only to analysis knowledge of a specific nutrient, for example, Steenhuis et al. (1996)'s research to develop a tool for discovering knowledge surrounding fat. The aim of the development of the GNKQ was ‘to develop a psychometrically reliable and valid questionnaire covering all aspects of practical nutrition knowledge’ (Parmenter and Wardle, 1999, pp 301). The authors included four different topic areas, dietary recommendations, sources of nutrients, everyday food choices and diet-disease relationships. They also included demographic variables to allow for comparison to other research. The test they developed had construct validity, reliability and covered a range of aspects of nutrition knowledge and was therefore useful as a general tool for other research projects (Parmenter and Wardle, 1999). The GNKQ has proved popular, it was the single most commonly used nutrition knowledge tool in a review of studies by Barbosa et al. (2016), used by 32% of included studies.

One of the major limitations of The GNKQ is that it was designed for use in the UK adult population. Parmenter and Wardle used the UK guidelines in the 1990’s, hence the original GNKQ could not be used directly in those from other nations and younger populations. Adjusting for national guidelines and emerging scientific knowledge has allowed for wide-reaching use. For example, in Turkish students, Australians at a community level, Ugandan adults and Californian adults (Alsaffar, 2012, Hendrie et al., 2008b, Bukenya et al., 2017, Jones et al., 2015) and it has been used as a base for adaptations in other samples (Bradette-Laplante et al., 2016, Dickson-Spillmann et al., 2011).

The GNKQ was updated by Kliemann et al. (2016) as scientific advances since the 1990’s led to a new understanding of the role of diet in disease and changes to government recommendations. This update not only allowed for a tool that was again up to date with current knowledge but also proved a good opportunity to revalidate the GNKQ as show its reliability in current British society .

2.16.7. Nutrition Knowledge in Children

The importance of food knowledge for a healthy diet is not only important in the adult population but for children and adolescents too. However, as yet there is no comparative tool for use in those aged under 18. Worsley (2002) summarises the reasons for the lack of a literature base in children, citing: poor understanding of the concepts of nutrition knowledge, a lack of relevance to children, substandard measurements, designs that inadequately match study aims and knowledge and a low statistical power as reasons that all make advancement of comprehension of this topic difficult. Although not recently published, the issues outlined in this review are still relevant.

2.16.8. Influences on Nutrition Choice of Children

The dietary habits and eating behaviours of children are well recognised to be strongly influenced by the environment provided by their parents (Scaglioni et al., 2008). Current literature suggests habits and practices acquired in childhood are carried through to affect diets in adulthood (Kelder et al., 1994). Child athletes are the same as their peers, with a strong social influence from parents but with an added influence from coaches (Nieper, 2005, Cotunga et al., 2005). The American Dietetic Association produced a statement providing guidance specifically targeted at aiding parents and coaches to help advise the nutrition choices of child athletes. They emphasis the multiple pressures parents, coaches and nutritionists may deliberately or inadvertently place on the decisions child athletes make concerning their diet (Steen, 1996). The young athlete may be exposed to several different routes of knowledge. Ensuring they receive good information that enables them to consume a balanced diet may be of heightened importance.

2.16.9. Studies on Nutrition Knowledge in Children

Similar to the literature in adults, much of the research on child nutritional knowledge has used tools designed specifically for a particular study. Many have involved small questionnaires or have focused on a particular aspect of knowledge, often they are guided by the FAO guidelines on KAP (Fautsch Macias, 2014). This guideline breaks down the knowledge that can be expected from children of 3 differing age ranges, for example in early childhood (ages 2-5) children can identify foods as healthy but not explain why, in middle childhood (6 -10 year old) children may understand more functional attributes: healthy food makes you strong, healthy and grow; and by adolescence (age 11-18 years) they will have a much more complex understanding, such as of the role of differing nutrients. Kigaru et al. (2015) conducted a full KAP study in primary aged children in Kenya and provide an example of a good adaptation of the FAO guidelines to analyse nutrition knowledge in their population

Research in children has often focused more on child preferences and behaviours as opposed to knowledge. Johnson et al. (2002) developed the Adolescent Food Habits Checklist and Wardle et al. (2001) designed both the Child Eating Behaviour Questionnaire and the complementing versions for adults and babies. Both tools have been widely used in studies to inform improved nutrition in children. The Adolescent Food Habits Checklist includes a section on nutrition knowledge, this was modified from the original GNKQ and the found to be valid and of use in a population of 13 - 16 year olds in England. However the authors of the Child Eating Behaviour Questionnaire, administered to children between 2 and 7 years of age, did not consider nutrition knowledge one of their six important study variables. Development of tools other than a multiple choice questionnaire in children may be more fitting. Calfas et al. (1991) successfully developed a tool utilising 'healthful' and 'unhealthful' photos to assess food knowledge in 4 to 8 year olds this tool was used successfully in another project in 9 to 11 year old children in the UK (Kopelman et al., 2007). Although established as a reliable and valid test, it does only consist of 10 questions which does not allow for comprehensive discrimination of participants.

2.17. Assessing Nutrition

Nutritional assessment has long been a focus of international public policy as it is necessary to understand the nutritional intake of a population to be able to develop national intervention programs. Therefore, to understand a factor, we must utilise methods that can produce reliable and valid data, such methods were first introduced by the League of Nations' Health Organisation in 1932 and have developed significantly since (Gibson, 2005).

If we wish to study dietary content, is it simpler to do so from a positivist perspective whether a project is basic or applied in nature it allows for effective explanatory research (Neuman, 2014). Quantitative methods can be utilised to measure what nutrients enter an individual if nutrients are viewed as specific sources of energy to be utilised in the body, an especially useful approach in athletes where the balance of energy is of paramount importance. This allows for specific analysis and comparison of data. It is pertinent however, to remember that a purely quantitative design may not provide the context and full picture of the results, as discussed further in Chapter 3.

Dietary analysis is considered a difficult assessment to perfect, especially in children (Shim et al., 2014, Burrows et al., 2010), many tools have been developed which aim to enable examination of the diets of individuals. Nutritional assessment can broadly be split into four categories, surveys, surveillance, screening and interventions which will now be discussed in turn (Gibson, 2005).

2.17.1. Nutritional Assessment Systems

Large scale, health surveys are popular methods used globally to assist in the determination of the nutritional status of a population. Often used to collect national data, they have been used to inform and assess national policy as well as academia for decades (Andersen, 2008). As described eloquently by de Vaus (2002 pg. 6), quantitative survey research may be described as "sterile and unimaginative but well suited to providing certain types of factual, descriptive information – the hard evidence."

Such surveys may be used primarily in two ways, either to determine baseline data on nutrition or to assess nutritional status of a specific population. They may be used for both purposes in one population to determine the effectiveness of an intervention if implemented both before and after to provide a direct comparator (Gibson, 2005). They are normally done as cross-sectional studies in large populations using subjective reporting (Shim et al., 2014). Surveys can produce information on populations who are at risk of chronic malnutrition or to determine the extent of existing problems.

Nutrition surveillance is defined as "means to watch over nutrition in order to make decision that lead to improvements in nutrition in populations" (Mason, 1983, pg. 745). It differs from surveying as continuous monitoring over an extended time period allows for identification of acute and chronic malnutrition. Nutritional surveillance is utilised in lower-income countries to aid the planning of and monitoring of interventions at population or sub-population level (Gibson, 2005, Mason and Mitchell, 1983). Examples include the National health and Nutrition Examination Survey in the USA and the Family Food Survey in the UK.

Nutrition screening is a further system that is used to identify malnourishment in individuals who are part of a larger target population. Compared to surveys and surveillance they are less comprehensive as they aim more to identify risk factors, and those who possess them, than malnutrition itself (White et al., 1992, Gibson, 2005). For example, they are extensively used in the healthcare setting to identify patients at need of formal nutritional assessment and intervention (Anthony, 2008). They can also be used on a larger scale, in the US, simple indicators such as height and birth weight are used to assess those who might benefit from state-sponsored aid and who should be included in the Paediatric Nutrition Surveillance System (Gibson, 2005).

Finally, nutrition interventions may be considered a system of assessment as well as measures of implanting change. They follow-on from screening programs by targeting the identified at-risk populations. Gibson (2005) splits interventions into 3 categories; supplementation, fortification and dietary approaches. It's essential for policy makers to collect evidence to ensure that interventions are having their desired effect or if they may be cost-inefficient or unable to enforce a change. This monitoring, therefore provides a system of researching nutrition (Gibson, 2005).

2.17.2. Nutritional Assessment Methods

Dietary assessment, either by objective observation or subjective reporting provides direct assessment of dietary intake. They are normally conducted in free-living environments and as such, provide informative and practical methods of understanding diets of an individual (Gibson, 2005).

There are a multitude of methods and tools used by dietary methods but several features common to most are outlined in Table 2.1. Some research also uses specific biomarkers or anthropometric measurements as a proxy to determine malnutrition and ecological factors to identify those at risk of chronic malnutrition (Gibson, 2005). Some of the most popular methods for dietary assessment are outlined in Table 2.1.

Table 2.1 - The procedure for measuring energy and nutrient intake (Rutishauser and Black, 2013)

1	A report of all food consumed by an individual
2	Identification of all the foods such that an appropriate item can be chosen from standard food tables. In details studies a duplicate portion of the food may be chemically analysed to find out the nutrient content.
3	Quantification of the portion size of each item
4	Determination of the frequency with which to each food is eaten
5	Calculation of the nutrient intake (portion size (g) x frequency x the nutrient content per g)

Food Frequency Questionnaires were a popular method of assessing diet in epidemiological studies. It consists of a subjective estimate of usual intake over a long time period (for example, 6 months or a year.) It allows for a cost and time effective way to assess dietary intake in a large population. However, they normally have low accuracy due to recall bias and need to be designed with the population culture, economic status and preferences in mind. They are used less frequently now however as newer tools are increasing being validated.

The 24-hour dietary record or dietary history are in comparison, open-ended surveys. 24-hour recall involves complete remembrance of the last day's consumption with an interviewer collecting data based on estimated amounts. It is inherently limited by the memory of the participant and requires multiple days to determine usual intake however does provide detailed data with minimal participant burden that is not reliant on the literacy of the respondent. Improvements to this method have included the multiple pass recall which uses several levels of questioning repeated over 3 to 5 days (Wrieden et al., 2003). The dietary record is similar except that participants record food eaten in real time themselves. It places a high responsibility onto the participant so adequate training and motivation are often required. These methods are most effective when sampling diverse populations for a wide-range of information about short-term intake (Shim et al., 2014).

Dietary record involves completion of over a longer time period, typically 3 to 7 days in the form of a food diary. It provides detailed nutrient intake data without requiring an interviewer and with minimal recall bias. However due to this, a high burden is placed on the respondent and there is a tendency to report values closer to societal norms. This method can be made highly accurate if participants weigh food consumed (Ortega et al., 2015).

Several objective measures also exist to establish nutritional intake. The duplicate diet method, for example, involves collecting a duplicate sample of a participant's nutrient intake for analysis. A food consumption record is a technique that involves observation by trained staff which can be completed either in a laboratory setting or in a free-living environment. These methods however require a high staff burden and as such are difficult for large-scale research (Shim et al., 2014).

2.17.3. Nutritional Assessment in Children

Dietary methods have not been validated and utilised with the same accuracy as they have done in adults or adolescents. It is understood that assessing diet is complex and may provide undependable results, even described by Faggiano et al. (1992, pg.379) as "one of the most challenging activities in epidemiology." Assessment in children may be difficult primarily due to lower literacy and writing skills, food knowledge or interest in participating (Livingstone et al., 2004). Or secondarily as there may be multiple caregivers involved in the provision of food and what they believe constitutes an adequate diet (Foster and Adamson, 2014, Livingstone et al., 2004). Therefore dietary recording by children likely relies heavily on the help of their parents or caregivers (Livingstone et al., 2004). Further, assessment is often difficult due to the lack of a variety of validated tools (Burrows et al., 2010).

Tools for use in children may be considered valid when they are assessed against the gold-standard method of doubly-labelled water (Burrows et al., 2010). Weighed food records (Davies et al., 1994), estimated food records (O'Connor et al., 2001), diet history interviews (Sjoberg et al., 2003) and 24-hour multiple pass recall (Johnson et al., 1996) have been validated for use in adolescents or children of certain ages. In a review of these validation studies, (Burrows et al., 2010) found that 24 hour multiple pass recall when reported by parents was most the most accurate in children aged 4 to 11 and diet histories best in those aged over 16 years. Over reporting of energy intake was common except when food diaries were used in children aged 3-12 years old, where energy intake tended to be under-reported, this trended towards over reporting with increased age however. They propose that cases of misreporting may be linked to weight or ethnicity.

Factors that limit accuracy of reporting in children are complex past simply the tool used. Moderators of accuracy may include age, body weight, ability to estimate food portions and general cognitive ability. Increasing age appears to correlate with an increased rate of underreporting, this appears to be most prominent in the 15-18 year-old age group when compared to children aged between seven and nine (Livingstone et al. 2004). Livingstone et al. (2004) suggests this is likely due to an increased independence to complete dietary assessments with age and younger children are more likely to both have their assessment completed by a care-giver and to have a more supervised food intake. Body weight similarly impacts on reliability as children and adolescents with higher body fatness tend to be more likely to underreport energy intake and children with less body fat are more likely to over-report energy intake (Fisher et al., 2000). Variability in children may be twice that seen in adults with literature traditionally suggesting boys appearing to underreport compared to girls (Livingstone et al., 2000). One review found significant underreporting (19%-41%) of energy intake in estimated food record studies (Burrows et al. 2010). However this difference between boys and girls may not significantly influence underreporting bias, (Livingstone et al., 2004). In six to nine year old children using an estimated weight food diary, boys misreported energy intake by 4% (± 23) and girls 5% (±24) which was non-significant ($p<0.05$) (O'Connor et al., 2001). Further, a study conducted on ten year olds found boys underreported energy intake by 25% (±2.5) and girls by 22% (±2.4). A more recent review found underreporting in both boys and girls independent of dietary assessment method (Burrows et al. 2010). It is hard to discern the impact of gender in the younger age group as there are many confounding variables and the literature draws differing conclusions. Furthermore, estimating food portions is not an easy task and is often poorly completed by children (Baranowski et al., 1986) and is a skill that even adults may struggle to master (Chambers et al., 2000).

It is also important to consider who might actually completing a nutritional assessment when intake of a child is being assessed. Parents or other caregivers often complete dietary intake records as a proxy for younger participants (Livingstone and Robson, 2000) due to the children's limited ability to complete dietary assessments themselves. The literature suggests that children do not become accurate reporters until age 12 but start to develop the ability to recall foods and estimate portion sizes once they reach 8 years of age (Livingstone et al., 2004). Therefore, to a varying degree, parents are likely to complete and hence influence the results of dietary assessments. Parents may accurately recall food eaten at home (Livingstone et al., 2004) but are less likely to know what children consume outside of the home (Baranowski et al., 1986). Despite the limitations that may be associated with reporting of food intake by children that might be overcome with assistance from a parent, Burrows et al. (2013) found that children aged 8 to 11 were actually more accurate at reporting energy intake than either their mothers or fathers using a food frequency questionnaire. Livingstone et al. (2004) also warn against assuming that parents are more accurate reporters of their child's energy intake.

2.17.4. The Food Diary used in the National Diet and Nutrition Survey

The National Diet and Nutrition Survey (NDNS) is a cross-sectional survey designed to analyse and report on nutrient intake of the British population, the updated Rolling Program has been collecting information since 2008 (Public Health England, 2016d). It allows for the collation of high-quality data on nutrient intake of a representative sample of the UK population over time. There are several arms to the survey, energy and nutrient intake is determined utilising a dietary record. When this survey was initially designed in 1999, researchers chose this method and conducted both a feasibility study to ensure all components in the survey would provide adequate results and validated their survey using the double-labelled water technique to ensure it enabled accurate reporting of energy intake (Henderson et al., 2003). For the introduction of the rolling program, it was noted that the previous seven-day weighed diary incurred a significant burden on respondents. Hence through comparison against an interviewer-administered 24-hour recall, it was decided to use a four day unweighted food diary as response rates for the two were similar and it was felt the food diary would be more appropriate for both children and adults (Lennox et al., 2014).

2.17.5. The Validity of a 3-day Food Diary

Food diaries normally consist of three to seven days of estimated food intake (Yang et al., 2010). In addition to the NDNS, the three day food diary has been used in other large-scale nutrition assessments (Rissansen et al. 2003, Crawford et al., 1994). This method has come under some scrutiny as it is not the most accurate way of recording energy intake, the NDNS has been shown to underestimate energy intake in the elderly population (Cook et al., 2000, Pryer et al., 1997). In children however, the use of food diaries has proven popular and useful for sampling on a population scale due to a combination of factors (McPherson et al., 2000). Further, it appears that the three day-diary is a 'methodologically and scientifically viable option' (Kolar et al. pg. 581, 2005) without the need for post-collection augmentation in the form of an interview. Yang et al. (2010) concluded that a three day record showed relatively high validity when compared to a nine-day record and a food frequency questionnaire. Crawford et al. (1994) compared a three-day record to a five-day record and 24-hour recall questionnaire in 9-10 year old girls, they found that the percentage absolute errors, proportion of missing food and phantom foods was lowest in participants allocated the three day record. When considering the active, pre-pubescent population, there is concern that higher energy expenditure may relate to lower accuracy of reporting. Bandini et al. (1997) compared a seven-day diary to DLW in eight to twelve year old girls and concluded that older age and greater energy expenditure contributed to underreporting. One main weakness of this dietary method is its use in analyzing a population against an individual diet. It appears that a 3-day diary may be used to determine energy intake in populations but care must be given to sub-dividing this population into very small demographic groups or indeed for analyzing individual data as more than 3-days of data is likely required to maintain validity (Yang et al. 2010, Basiotis et al. 1987).

There remains little consensus on how to balance optimal validity of nutritional assessment with a tool that is acceptable to the target population and the researcher. The shorter estimated food diary is a valid tool despite some weaknesses and is considered to carry substantial decrease in participant burden (McPherson et al., 2000, Kolar et al., 2005, Yang et al., 2010, Lennox et al., 2014).

2.17.6 Determining Key Nutrition Variables

Nutritional intake or energy intake is wide-ranging and encompasses many macronutrients and micronutrients. The variables chosen for this study were sub-divided into overall energy intake, macronutrients (carbohydrates, protein, dietary fibre, total sugar, total fat and saturated fat) and key micronutrients where chosen for analysis (Vitamins C and D, Iron, Calcium and Sodium). Micronutrients were determined as key for this study when they were vital to growth and general well-being or where disordered intake had been described previously in the literature or both. Furthermore, variables were considered with a thought to study practicality, they had to be measurable and for there to be comparators available in the NDNS and current national recommendations therefore complying with study aim three (Chapter 1.1).

Vitamin C was chosen as it is a vital vitamin for growth and repair of tissues, in the absorption of iron and as an antioxidant (Williams et al. 2004). Intake in UK children is disordered in the form of excessive intake (Public Health England, 2016d).

Vitamin D was chosen as there is concern that both UK children and young athletes may have an insufficient intake (Public Health England, 2016d, Burke, 2016, Thomas et al. 2016). It has an important role in bone health but further may impact athletic performance (Burke, 2016) as described in Chapter 2.11.1.

Iron similarly was chosen due to its importance in regular maintenance physiology but also the way it may be affected by exercise regimes. Further there is concern of deficiency in young athletes and young females generally as outlined in Chapter 2.11.2.

Calcium intake may be dysregulated to excess or deficiency dependent on age (Public Health England, 2016d). Calcium may be of especial importance in the active population due to its role in bone and tissue maintenance (Burke, 2016).

Sodium was chosen as a variable as a marker of nutritional salt intake. Although not the most reliable method of assessing salt intake, it does provide a valuable marker for population analysis of mean intake, a particular public health target of the WHO who have a target of 30% relative population reduction (McLean, 2014). In active children, the role of sodium in euhydration may have increased importance (Meyer et al., 1992) as described in Chapter 2.14.1.

Chapter 3. Methodology

Methodology for any form of research can stem from several differing epistemological perspectives. Public health research methods can be understood by categorising into two main paradigms as described by Ulin et al. (2005). Each of these theoretical frameworks can be applied in different contexts and together, they have shaped much of the current knowledge on social and behavioural health. These phenomological approaches are first, a positivist perspective customary in quantitative research and second, an interpretivist perspective principally, used to shape qualitative research. These approaches will be reviewed in turn in relation to their relevance to this project (Ulin et al., 2005).

3.1. The Utility of Quantitative Techniques to Nutritional Research

Nutrition research is often in the pursuit of data, numbers and measurements produced with reliability and validity to determine set outcomes or to inform and improve interventions. Such methods lend themselves efficiently to easily measured phenomena and neatly quoted facts (Harris et al., 2009), ‘sugar still makes up 13% of children’s daily calorie intake’ for example (BBC News Online, 2016). Quantitative methods generally involve highly standardised tools with precise, closed questions (Ulin et al., 2005) which allow for accurate analysis of macronutrient and micronutrient components of diet. Schubert et al. (2011) describe how this is the dominant approach to social research in the nutritional sciences and historically it has long been favoured (Durrheim and Painter, 2006). Statistical analyses are used to contribute to the scrutiny of results to gain the closest estimation of reality. Much of the development of quantitative research has grown from a philosophical approach from the nineteenth century, termed positivistism (Ulin et al., 2005).

The positivist viewpoint is underpinned by the assumption that 'the social world is composed of observable facts. Reality is objective, independent of the researcher' (Ulin et al., 2005, pg. 16). Quantitative research underpinned by this principle has been used extensively in social science. Morgan and Smircich (1980) stated that a positivist view demands an analysis of the social world through knowledge of concrete facts about relationships and regularities. They further assert that the determination of laws concerning these parameters is essential to forming a basis for effective research. Schubert et al. (2011 pg.353) note that although much effort such as this has been made to push nutrition from being a social issue to a biomedical one, they argue in fact that 'nutrition as a discipline in modernity emerged from nutrition as a social issue.' In comparison to qualitative methods, control of variables is important when incorporating social and environmental factors. Context under a positivist paradigm is perceived as a nuisance and has the potential to introduce bias to a study through hidden determinants. Control of extraneous variables prevents detraction from the original research problem (Ulin et al., 2005).

Thus, the quantitative researcher aims to study the relationships between variables from the viewpoint that reality is impartial and measurable. The primary objectives of a quantitative analysis is to find the extent to which such variables relate to each other and how and why they do so (Punch, 2003). For this project, these values underpinned the core aims of this study as this research aims to quantify variables associated with nutrition by assigning a measured value of intake by weight per day for macronutrient and micronutrients. In addition, an interpretivist approach allows a researcher to reduce physical activity level and nutritional knowledge levels, for example, down to quantifiable variables and then further, allows for statistical evaluation of the relationships between them.

3.2. Considering the Importance of Qualitative Methods to Nutrition Research

The use of qualitative methods in social science research is a newer concept than the traditionally used quantitative methods (Erickson, 1996). Epistemologists endorse the need for a different approach when a variable is not easily measured or, when the literature about a specific culture is limited or when the researcher requires a reason for a particular outcome evaluated (Erickson, 1996, Carter and Little, 2007, Draper, 2007). Qualitative research is often inductive and undertaken with a theoretical framework as the driving force or, the research itself is initiated to generate theory (Harris et al., 2009).

Most qualitative research is shaped by an interpretivist perspective (Denzin and Lincoln, 2011). This paradigm is underpinned by context, objective facts and behaviours. It is based on a subjective knowledge of how participants attribute meaning to these facts and how these three factors interact (Ulin et al., 2005). In nutrition for example, a decision by an athlete to change their diet to contain higher fat and lower carbohydrate per day will be affected by their beliefs regarding efficacy, safety and necessity, the social influence of the perceptions of media, coaches and friends and even the cultural significance of such an intervention in their environment (Burke, 2015). Qualitative research allows understanding of the meaning research participants place on their nutrition experiences. In dietetics, especial importance must be placed on the reasoning behind food behaviours and behaviour change. Possible applications of qualitative research in the study of nutrition are outlined by Harris et al. (2009) and summarised below in Table 3.1.

Application	Research Question
Decision making processes	How do dietitians make decisions about discontinuing tube feedings?
Sociocultural factors that affect food and nutrition-related behaviors	What are motivators and barriers to urban African-Americans consuming fruits and vegetables?
Reasons for a dietetics-related phenomenon	Why didn't a technology based, interactive diabetes education program improve diabetes self management compared to a traditional diabetes education program?
Teaching effectiveness in dietetics	Which are best practices among dietetics educators who have been identified as excellent in their field?
Consumer and employee behavior, attitudes, and perspectives in foodservice	What are the behaviors, attitudes, and perspectives related to food safety among community hospital foodservice workers?
Exploring unfamiliar cultures regarding their mores, traditions, and beliefs related to food and nutrition	What mores, traditions, and beliefs promote obesity among the Pima Indians?
Evaluation of dietetics education programs	What is the process used by a particular dietetic internship to educate their students?
Task-related processes	To what degree is the Nutrition Care Process applied in community and clinical environments?
Theory development and modification	To what degree does Social Learning Theory apply in explaining the choice between soda and milk?

Table 3.1 - Qualitative Research Applications in Dietetics (Harris et al., 2009)

For this research, the context of the project must be considered: does the studied variable incur an unreasonable financial or time cost to that individual in lieu of their economic status? What importance do they place on the relationship between diet and physical activity or athletic performance? An interpretivist perspective allows the researcher to sensitively consider the many factors that underpin an individual's decision regarding their health which, more specifically for this project, is represented by nutritional intake (Ulin et al., 2005). Fade (2004) outlines how the use of qualitative techniques can be tricky for the nutritional researcher, describing how utilising an interpretivist framework to produce interview data may prove beneficial. This became the underpinning principle for the development of the stakeholder interview in this project, where potential participants who had experienced the 'phenomenon' of being an athletic child provided insight and context into their understanding regarding their nutritional choices. The way the qualitative process was utilised in this project is nicely summarised by Harris et al. (2009, p. 83): interviews or focus groups 'generate tentative theories and hypotheses are developed that are tested by quantitative methods'.

3.3. Mixed-Methods Research

A belief in the application solely of one of these two opposing paradigms however forces a researcher to conduct a study where the methods do not allow for a thorough understanding of a phenomenon. A conflict of paradigms only seeks to divide the power of available research (Gorard, 2003). A growing movement in social research advocates a mixed-method approach to overcome the increasingly outdated 'paradigm war' (Abusabha and Woelfel, 2003, Ulin et al., 2005, Harris et al., 2009)

Combining methods allows for qualitative data to complete the quantitative findings of a project. Quantitative researchers argue that without a distinct separation of subject and researcher, the results will be distorted. In comparison quantitative research is condemned for being too objective, forcing participants and their behaviour into strict categories (Gorard, 2003, Abusabha and Woelfel, 2003). The contrary argument says that without this understanding of the connections surrounding the object of the study, the results may be distorted (Abusabha and Woelfel, 2003). Harris et al. (2009) shows how the weaknesses in one approach to social methods can be overcome by the strengths of the other to form a symbiotic option for complete understanding of a topic, as outlined in Table 3.2. Leech and Onwuegbuzie (2009) outline a framework of eight differing typologies of mixed-methods that each design might fall into. These are based on the interaction of three different dimensions, 'level of mixing…; time orientation… and emphasis of approaches' (Leech and Onwuegbuzie 2009, p. 268). Mixed methods was chosen for this project, in the form of an initial qualitative stakeholder interview followed by a larger quantitative survey. This approach falls into the category of partially mixed, sequential, dominant status design with the dominant arm being the quantitative element.

Quantitative	Qualitative
Deductive	Inductive
Studies well-known phenomena	Often studies unknown or little-known phenomena
Testing of hypotheses and theories	Development of hypotheses and theories
Conducted in controlled settings	Conducted in naturalistic settings
Large number of subjects	Smaller number of targeted participants
Standardized numerical data collection	Textual, audio, and visual data collection
Data gathered first, then analyzed	Data gathering and analysis occur simultaneously
Statistical analysis	Content (textual, audio, and video) analysis
Explore outcomes due to treatments, manipulations and outcomes	Explore complex issues and interactions between humans, reasons for outcomes, and processes

Table 3.2 - A Comparison of Quantitative and Qualitative Methods (Harris et al., 2009)

This study focused on specific outcomes that were measurable by defined criteria. The qualitative aspect was necessary to understand the context in which the study population make decisions regarding their dietary practices as well as elucidate specific influences concerning nutrition and physical activity practices.

The theory behind the use of a mixed-methods approach of this project was not determined by a necessity to balance the weaknesses of one approach to the strengths on the other but rather an ideology as described by Harris et al. (2009) that they are used in conjunction to form a complete picture of the phenomenon to be studied.

Chapter 4. Methods

4.1. Study Design

A mixed-methods approach consisted of two stages. The first stage of the study adopted a qualitative approach by conducting an informal focus group interview with the study population. This allowed for design of the second stage of the project, a cross-sectional survey of nutrition, physical activity and nutrition knowledge of parents. This was chosen to understand naturally-occurring variation in a sample of athletic 9-12 year old children. The collected data were then analysed for possible relationships. Each stage is further outlined in the following chapter.

4.2. Participants and Sampling

Sampling aims to provide a group of participants that are representative and symbolise the population as a whole in order to generalise results to the wider population (Harris et al., 2009). In this study, a group of children from the North-East, identified as active or gifted and talented in PE and sport were recruited using opportunistic sampling and were expected to represent a much larger population of pre-pubescent school children who are very active, both in their daily life and through sporting activities.

4.2.1. Participants

Participants were recruited from the Gifted and Talented Program run by the Durham and Chester-Le-Street School Sports Partnership. This program is described as 'focusing not only on high achievers but also on those who show sporting potential' on the Durham City Schools Partnership website (Durham and Chester-Le-Street School Sports Partnership, 2017b). The program encompasses all schools in the Durham and Chester-Le-Street area and is for academic years 5 and 6. Boys and girls range in age from 9 to 11 years old. In the 2016-17 academic year 164 year 6 students and 110 year 5 students participated from 47 different schools (Durham and Chester-Le-Street School Sports Partnership, 2017b).

It was considered that to give the study sufficient weighting, a sample size estimate of 50-100 participants would be required to analysis nutritional intake with recruitment of double this number likely to be required for sufficient participation. This was based on a power calculation, analysis of similar studies of nutritional intake in children and consultation with senior researchers involved in child dietetics research. This study aimed to target children in both Years 6 and 5 so after discussion with the GTP staff, it was decided to sample both groups. In further consultation with GTP staff, it was decided to aim to recruit all attendees at the first Year 5 group. Some children were expected not to participate on the day which brought the sample size close to that required and staff felt logistically it was easier to distribute to each GTP participant rather than exclude some. Response rates were low from the Year 5 day, therefore it was decided to apply the same principles to the Year 6 day and aim to recruit all attendees.

The first round of recruitment did not yield the number of responses expected. Due to this a secondary group of participants was recruited to increase survey numbers. The researcher attended several weeks of the Durham University Holiday Camps 2017 where children from local schools were in attendance. The project was discussed with parents during pick-up and drop-off times and those who wished to engage were given a survey pack to complete. The issues posed by poor recruitment and the steps taken to overcome them is discussed further in Chapter 6.6.

4.3. Participants and Ethical Approval

Ethical approval was sought by submitting the Durham University School of Applied Social Sciences (SASS) Ethics and Risk Assessment application. The application was approved on the 15th May 2017 prior to commencement of data collection

The Economic and Social Research Council (ESRC) Framework for Research Ethics proposes six key principles which should be followed to maintain high ethical standards, including by students, as outlined in **Figure 4.1**. These principles were used to guide my ethical application and underpin the decisions regarding the methodology of this project. (Economic & Social Research Council, 2015b).

Oliver (2003) outlines several considerations that need to be addressed prior to commencing research, relevant to this project I outline the processes involving gatekeepers, obtaining permissions, written information, informed consent, and potential harm and benefits to respondents.

1. Research should be designed, reviewed and undertaken to ensure integrity, quality and transparency.
2. Research staff and participants must normally be informed fully about the purpose, methods and intended possible uses of the research, what their participation in the research entails and what risks, if any, are involved
3. The confidentiality of information supplied by research participants and the anonymity of respondents must be respected.
4. Research participants must take part voluntarily, free from any coercion.
5. Harm to research participants must be avoided in all instances.

Figure 4.1 – Economic and Social Research Council Principles of Ethical Standards

4.3.1. Gatekeepers

Oliver (2003a) defines a gatekeeper as 'individuals who have management or administrative control in an organisation, and who can decide in absolute terms whether you be permitted to carry out your research' (p.39-40). The involvement of the GTP in a possible research project was discussed with staff at the earliest stage of research design with a positive result. A gatekeeper, in this case, GTP staff, will be fundamentally concerned with protecting their organisation and the possible impacts of involvement in a research project (Oliver, 2003). A very similar role is displayed by event organisers during secondary recruitment, this project was made possible by the enthusiastic participation of gatekeepers.

Effort was made to consult and inform staff whenever possible throughout the project to ensure their continued, informed permission. Any stipulations by the staff, especially those involving consent were adhered to. This also gave the added benefit of being able to access the most knowledgeable source of information regarding the GTP and the children involved in it.

4.3.2. Obtaining Permissions

The ESRC impresses the need for maintenance of independent research and resolution of conflicts (Economic & Social Research Council, 2015b). This research is inherently linked with the GTP and was designed with careful consultation with them. Further advice came from SASS at Durham University and their ethical process. Recommendations were taken into account however all aspects of the project were ultimately determined by the researcher. This project was not sanctioned or funded by any external party.

Permission to undertake the project from SASS was obtained through ethical approval. Permission for completion of this project was obtained from the GTP through verbal consent of senior staff members, initially at smaller meeting and then further during the stakeholder meeting.

4.3.3. Written Information and Informed Consent

The Nuremberg Code outlined a standard for medical research on human participants for moral, ethical and legal experimentation (The Nuremberg Trials, 1949). The first standard states:

"The voluntary consent of the human subject is absolutely essential."

Following the principles of the Nuremberg Code (The Nuremberg Trials, 1949) and the ESRC (Economic & Social Research Council, 2015a), the template 'Participant Information Sheet' from the Health Research Authority (2017) was used to form a detailed information sheet (Appendix A) for parents/guardians of possible participants. This was followed by a parental/guardian consent form which in writing, gave both their participation and their agreement for participation of their child in the proposed study. Amended copies of consent forms provided by the GTP organisers were used (Appendix B). This was raised by the GTP staff as necessary to comply with requirements by their governing body, Durham County Council.

4.4. Anonymity and Confidentiality

The Gifted and Talented program stipulate that personal data on the children is subject to strict anonymity. Each child was assigned a study number by GTP staff when receiving their survey packs. Children in the secondary round of collection were randomly assigned a number by the researcher. When completed diaries and questionnaires are returned, they were labelled only by number not name and this system is how data was recorded and used by the researcher.

Once the surveys were collected the only identifiable information was consent forms. Consent forms were removed from the survey pack and stored separately. If a participant wished to withdraw from the project, the correct data could be removed by checking participant number against name. Regardless all data was seen only by the researcher. All forms were kept in a locked office and online electronic data kept only on password-protected computers.

4.5. An Informal Focus Group

Focus groups provide a method for exploring the beliefs and feelings people have regarding health and illness (Wilkinson, 1998). As stated by Williams and Popay (1994, pg. 123): “understanding the nature of lay knowledge requires an approach to data collection that is, in a sense, egalitarian, and most certainly phenomenologically open”.

4.5.1. The Stakeholder Meeting

An informal stakeholder meeting was held prior to survey design; this was utilised to provide insight into the daily nutrition content and beliefs of the potential study population.

Potential participants were attending an education day as part of their involvement with the GTP on the 12th of January 2017. One hundred and twenty three attendees, both male and female, in Year 6 (ages 10-11) were split into two groups and attended one of two nutrition workshop sessions. Year 5 students (ages 9-10) attended a separate GTP education day later in the year and hence were not included in this meeting. The children were firstly given a short lecture entitled 'Nutrition for Young Athletes'. The purpose of this lecture was primarily as part of the continued education of participants within the GTP and was structured in the form of a 30 minute PowerPoint presentation on a projector utilizing updated slides previously used for this session. The topics covered in this lecture. In the order they were delivered are seen in Figure 4.2. However, this session also allowed for informal, qualitative analysis of the nutrition knowledge of attendees.

- Why you are unique! The importance of considering age, growth and activity level
- Energy balance – the difference between energy intake and energy expenditure
- Energy requirements of a young athlete
- The Eatwell Plate (**Figure 4.3**) introduced and explained with relation to food groups and portion size
- Milk and dairy – Calcium requirements and high calcium foods
- Meal examples based on these principles – breakfast, lunch and dinner
- Meals and snacks for young athletes – when and what to eat
- Unbalanced nutritional intake – possible symptoms and how to spot them
- Drinking – daily requirements, when and what is best to drink

Figure 4.2 - Topics covered in the Nutrition for Young Athletes Lecture

At the end of the lecture, children completed a task in small groups in order to consolidate their learning and to provide a qualitative analysis of their opinions and nutritional behaviors. Three adults were required to attend and facilitate this session in order to provide a wider thematic analysis. They were asked to plan a day's food intake in groups of 2-3 based on the principles they had just learnt and the Eatwell Plate (**Figure 4.3**) by writing on paper a full day's nutritional intake, for themselves or for their families in the form of foods and drinks consumed. A copy of **Figure 4.3** was displayed on the screen during this so that they might use it as an aid to complete the task. The research arm of this session was conducted through informal, direct conversation and observation of group discussions by the three members of staff to provide an idea of the knowledge and beliefs of the proposed study population. The three members of staff then discussed specific findings from their observations and to produce a collaborative record of results. This meeting, in the form of an informal focus group, explored the importance the children placed on their nutrition through completion of an exercise where they planned a full day's energy intake.

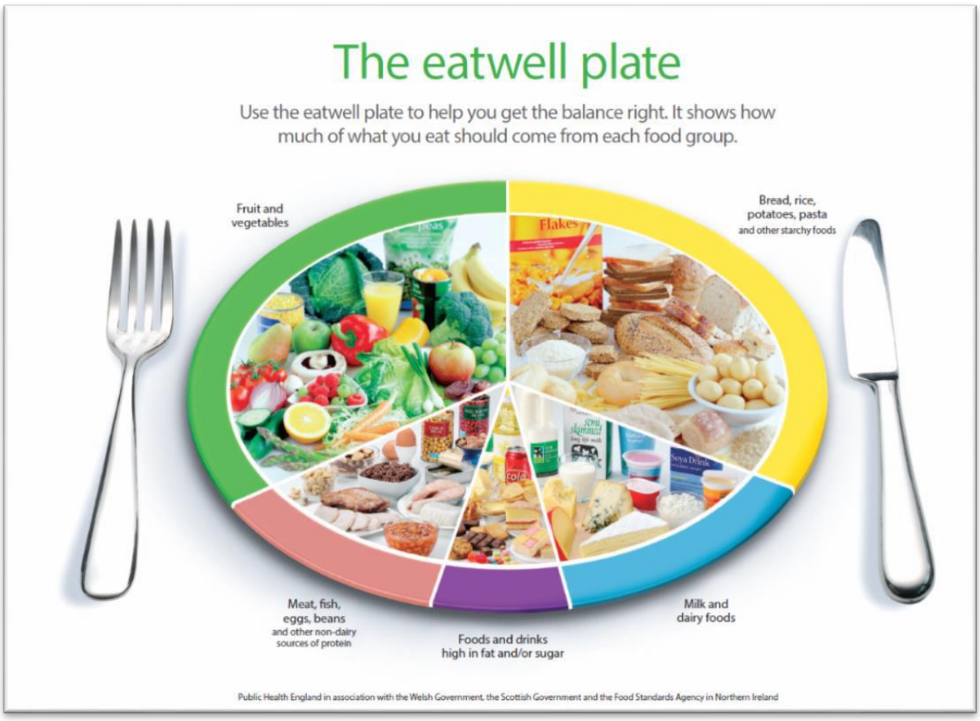


Figure 4.3 - The Eatwell Plate (Public Health England, 2016a)

4.5.2. Potential Harm and Benefits of the Study

An underlying premise of this project was to provide information that would directly benefit the GTP and hence indirectly a wider population of schoolchildren. The ESRC (2015) specify that there must be a positive risk-benefit ratio in order for research to be ethical. There were no risks to the researcher identified. Identification of risk and benefits of the project was also undertaken through discussion with experienced GTP staff both in the planning of and at, the stakeholder meeting.

In an effort to minimise risk to participants, the GTP staff were consulted on any perceived harm to participants from engaging in the proposed study. Possible stress from an increased awareness of dietary content and habits was raised. This risk might incur a small psychological harm but was considered unlikely. To reduce the possibility of this risk, in both information sheets (appendices A and C), it was stated that participants may refuse to complete the food diary. Parents were informed that this study was purely observational and they should not reflect on diet more than normal. It was further asserted that children can withdraw from participation in the project without compromising their place on the GTP program.

It is the view of the researcher that the potential benefits of this project would greatly outweigh the risk of harm, this was determined through gathering information from the literature and from first-hand accounts at the stakeholder meeting. The potential benefits as outlined in the information documents (Appendices A and C) were both for current and potential participants. It is also hoped that the results, once published will be able to inform further research and interest in this study population with a view to improving public health of active pre-pubescent schoolchildren, as outlined in the study rationale in Chapter 1. To ensure a direct benefit to the study participants, it was agreed that anonymised results would be shared with GTP staff as requested, and to prepare a follow-up document with a summary of the results to be distributed to teachers and all current parents whether or not they engaged with the study.

4.5.3. Understanding Written Information and Informed Consent of Children

It was decided that full consent must be obtained from the children following the recommendations of the Durham University SASS Ethics and Risk Assessment Committee. Gillick competence outlines the view that when a child has sufficient maturity and understanding of a treatment and its implications they legally have the right to give or refuse consent by themselves (Griffith, 2016). During the stakeholder meeting, it was clear that the children were all interested in their daily diet. There was a range of knowledge on what constituted a balanced diet, but overall it was a topic that actively engaged this population. The meal-planning task demonstrated that participants had an ability to understand and retain relevant information on nutrition and therefore were able to consent to involvement in a nutrition survey.

Following these principles, a supplementary information sheet was prepared specifically for children with a corresponding consent form. This was input to an online 'readability checker,' www.thewriter.com, which stated the material was appropriate for 11-12 year olds. Although the study population is marginally younger, it was decided not to alter the information any further as oversimplification may dilute the extent of informed consent. The Child Information and Consent form can be found in Appendix C.

4.6. Survey Design

To meet with the aims and methodological underpinning of the study, a survey pack was designed to be given to each child. This survey contained three parts to meet each aim, a 3-day food diary and completion instructions, a Physical Activity Questionnaire for Children

(PAQ-C) and General Nutrition Knowledge Questionnaire (GNKQ) (Figure 4.4). It also contained information and consent forms for participants and their parents/guardians.

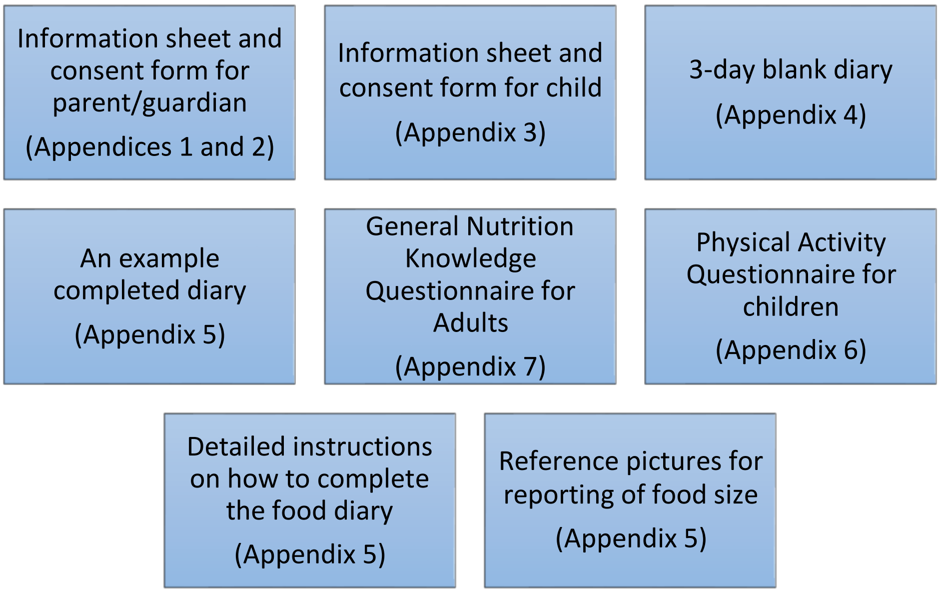


Figure 4.4 - Components of the survey given to potential participants

The survey collected both discrete and continuous data. Demographic variables including age, gender and primary school as well as confirmation of informed consent from both the parent/carer and child and contact information were collected on the consent forms.

The 3-day diary (Appendix D) asked participants to record their daily food intake by name and brand name, the amount was estimated by packet, number of individual items spoons or portion size, supporting documentation explained how to do this (appendix D). Information on meal patterns was also collected by filling in the time and writing in the correct slot from morning until night. Where food was eaten, for example, home, school or away and with whom was also recorded. Further, participants were asked to record whether they ate at a table or whilst watching TV. Drink consumption was also included as either weight or volume or glass size. Supplementary information from the food diary included whether this was a ‘typical’ day or if consumption was greater or lesser than normal and if not normal, why not. Participants were also asked to record any supplements consumed including quantity, name, brand and strength.

The PAQ-C is a quantitative measure of physical activity of a child in the past week (Kowalski et al., 2004). The version used for this study was a one updated and validated for English children (Voss et al., 2013) (appendix E). By subjectively recalling the last 7 days activity, children record it gives an overall score out of 5 for physical activity. The first question collected information on which physical activities the participant did and how many times in a week and the total time spent doing that activity, this were scored according to how many times they did an activity per week, none=1 point, 1-2 = 2 points, 3-4 = 3 points, 5-6 = 4 points and 7+ = 5 points. The following eight questions asked about activity undertaken from none (1) to always (5) or asked about type of activity, from sitting down (1) to 'ran and played hard most of the time (5) in varying situations (Figure 4.5) which then gave a maximum score between one and five for each question. The score from all the questions is averaged to give the overall score.

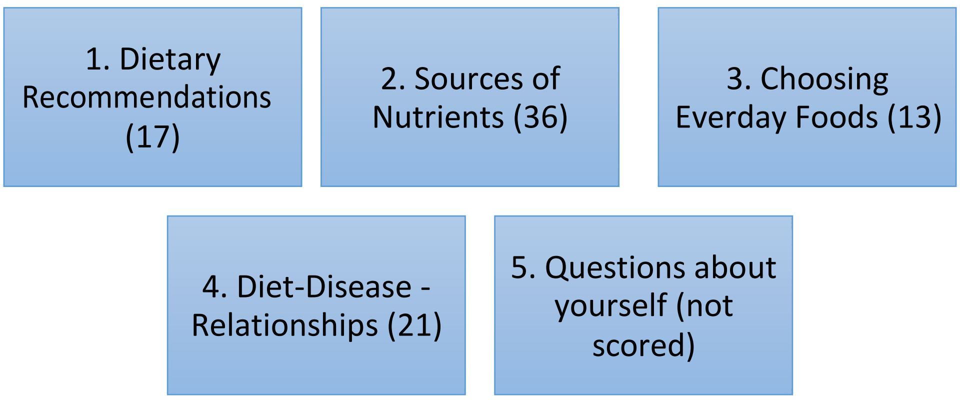


Figure 4.5 - Information tested in, and the score for each section of the GNKQ

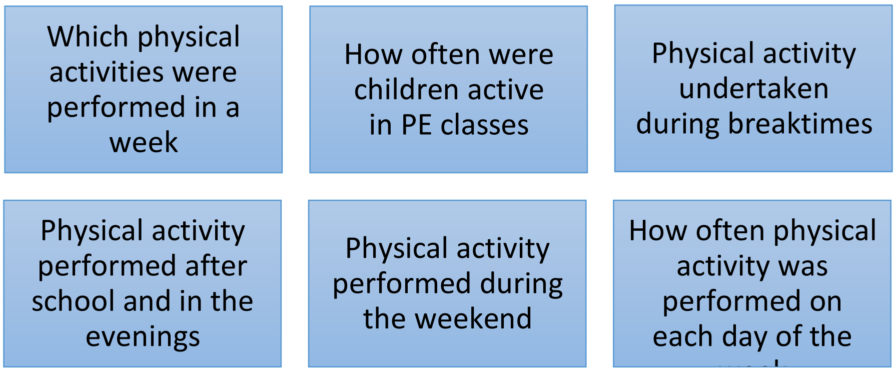


Figure 4.6 - Information collected to determine physical activity level used in the PAQ-C

The GNKQ was developed by Parmenter and Wardle (1999) to determine nutrition knowledge. The version used for this study was one updated and validated by Kliemann et al. (2016) (appendix F). The GNKQ has a total of 87 questions, the first four sections surveys four domains, these are outlined Figure 4.5**.** with the maximum possible marks for each. Each mark is tallied and the overall score given as a percentage.

The fifth section asked respondents to disclose their gender, relationship to the child participant, their belief of the level of their general health and their ethnic origin.

Questions were in a multiple choice format with some asking one question about several foods where there was a right answer for each, for example, question 1 in Figure 4.7; or questions asked one question corresponding to one right answer, for example question 2 in Figure 4.7. Participants were encouraged not to guess and to mark 'not sure' if appropriate but this did not carry any added points.

1. Do health experts recommend that people should be eating more, the same amount, or less of the following foods? (tick one box per food)

	More	Same	Less	Not Sure
Fruit	☐	☐	☐	☐
Food and drinks with added sugar	☐	☐	☐	☐
Vegetables	☐	☐	☐	☐
Fatty foods	☐	☐	☐	☐
Processed red meat	☐	☐	☐	☐
Wholegrains	☐	☐	☐	☐
Salty foods	☐	☐	☐	☐
Water	☐	☐	☐	☐

2. How many servings of fruit and vegetables per day do experts advise people to eat as a minimum? (One serving could be, for example, an apple or a handful of chopped carrots) (tick one)

2	☐
3	☐
4	☐
5 or more	☐
Not sure	☐

Figure 4.7 - Example questions from the GNKQ

4.7. Data Collection

The survey pack (Figure 4.4) was given out to each child present at a Year 6 and then Year 5 GTP day in prepared envelopes at the end of the day. Each child was instructed to take the envelope home and to open it there with their parent/guardian. Children involved in the program but not present on that day were sent a copy by post by GTP staff.

This study comparatively had a poor response rate for the total surveys distributed and consequently, the distribution method was adapted several times. Initially around 120 children at the Year 5 GTP day were given a survey each which they were asked to take home. This yielded very few returned surveys so a meeting was held with GTP staff to consider reasons for this and ways in which it could be improved for the Year 6 student day. As key stakeholders in the project, they were likely to be able to assist with shared decision making and offer expertise on how to make effective decisions (Deverka et al., 2012). It was concluded that a large portion of the surveys had likely never been shown to parents and that without understanding the survey and their role in it, the children may never open the survey pack to read the information sheet or to pass it on to their parents. Therefore, for the second GTP for Year 6 students, all potential participants were addressed at the very end of the day, directly before pick-up, when the project and the possible benefits of it were explained to children and they were encouraged to approach the researcher with questions, which a few did. These two approaches allowed the researcher to reach as many GTP participants as possible but the surveys returned were still insufficient for the project. So, having exhausted this resource, a second round of recruitment was started.

4.7.1. Secondary Phase of Data Collection

Secondary data distribution was completed through Durham University Summer Holiday camps and Durham City Harriers and AC Junior club. Parents were recruited in person in 2017 from July through to September through verbal communication of the project, including risks and benefits and an explanation of what was involved. Through this discussion, parents were able to make an informed decision as to whether they would like to participate, this often concurrently offered a chance for children to offer or refuse verbal consent at the outset. The Summer Holiday Camps were run over five days, the initial recruitment took place on day one, day five was used to collect completed surveys in person and to be available to encourage participants to continue with the study and involvement on day three was useful to conduct both. Many children attended more than one week so this phase was run over four weeks of holiday camps and provided good opportunity for repeated contact with participants. A similar structure was used for Durham Harriers, the researcher attended weekly training over three weeks and was able to offer information to parents in a convenient manner to them.

4.7.2. Return of Surveys

In order to make return of survey's as easy as possible, a consultation was held with GTP staff. In the primary phase of distribution, it was suggested that surveys could be returned to the child's school and once parents had notified the researcher by text or email it could be picked up from there. Further tools were used to increase return of surveys. Firstly, any children who had not attended the GTP day but were involved in the program were sent a digital copy of the survey via email. Secondly, GTP staff kindly distributed two follow-up emails to all the parents/guardians of children who had been recruited. These emails re-stated the aims and benefits of the study whilst still reminding respondents that it was voluntary and that there would be no consequences if they chose not to participate. These also included digital copies of the survey in case participants had lost all or part of the survey pack. It's not possible to ascertain the exact effect of all these measures as the change to collection method and the email reminders applied to participants who attended both GTP days.

In the secondary phase of distribution, surveys could be returned to the researcher or to organisers of the holiday camp. This was decided as the least burdensome option for participants, both physically and economically. Alternatively, they could be scanned and emailed to the researcher or posted back to the School of Applied Social Sciences (SASS) department at Durham University.

4.8. Analysis of data

The MicroDiet software program (University of Salford, 1999) was used to analyse the food diaries. It was chosen as it was easily accessible to the researcher and utilises McCance and Widowson's Composition of Foods (Roe et al., 2015), which provides an extensive dataset of the energy, macronutrient and micronutrient components of foods found in the UK diet. From this, daily averages of consumed energy (MJ), carbohydrates (g), fat (g), saturated fat (g), protein (g), dietary fibre (g), total sugars (g), Vitamins C (mg) and D (µg), iron (mg), calcium (mg) and sodium (mg) were ascertained.

Both the PAQ-C and the GNKQ were scored according to the scoring system designed for them by their developers. The PAQ-C was scored as detailed by Kowalski et al. (2004) but using the version updated for English youth by Voss et al. (2013). The GNKQ was similarly scored according to the original design by Parmenter and Wardle (1999) but utilising the updated answers by Kliemann et al. (2016). The scoring systems for these two questionnaires are outlined in detail in Chapter 2.4.4 and 2.16.6for the PAQ-C and GNKQ respectively.

Statistical analysis was completed to test for normality and outliers of each variable. To assess whether each variable is normally distributed, each set of results was analysed using the Ryan-Joiner test. This established whether the population was normally distributed. Analysis of a difference between the test population and general population macronutrient and micronutrient intake was completed descriptively. The Pearson correlation co-efficient was calculated to see the association and strength of any association between variables. Significance was determined as $p<0.05$. The values for recommended intakes were taken from British Nutrition Foundation (2016b) and Food Standards Agency (2007). The comparison value for the general population scores of PAQ-C was taken from Voss et al. (2013). The population mean for GNKQ was taken from Kliemann et al. (2016).

Chapter 5. Results

5.1. Introduction

The following chapter tests six research questions:

1. Can an informal focus group help to understand current knowledge of potential participants and therefore inform the design of tools for quantitative study?
2. What are the daily energy, macronutrient (carbohydrate, protein, sugar and fat) and key micronutrient (vitamin and mineral) intakes of athletic 9-12 year old children?
3. How do the results compare to national guidelines and national survey data?
4. Is there any relationship between energy, macronutrient or key micronutrient intakes and self-reported physical activity levels?
5. What is the level of nutritional knowledge for the parent/guardians of this study population?
6. Is there any relationship between nutritional knowledge level and energy, macronutrient or key micronutrient intakes of the study population?

Participant's returned 18 data sets for analysis corresponding to 18 food diaries and 18 PAQ-Cs completed by children and 17 GNKQs completed by a parent/guardian. Both male (n=10) and female (n=8) participants responded. Average age was 10.6 years, participants were split into into 9-10 years (n=7): males (n=2) and females (n=5); and 11-12 years old (n=11): males (n=8) and females (n=3) for analysis.

5.2. Research Question 1 – Informal Focus Group Results

123 children, both boys and girls aged ten to eleven were able to compose a meal plan for a whole day in groups of 2 or 3 and mostly apply the principles of recommended

macronutrients of the Eatwell Plate. The researcher, one member of GTP staff and one additional facilitator with an academic background in nutrition aided in facilitation of the task and collection of qualitative data from this session. Results indicated that confusion over several themes arose (**Figure 5.1**).

Although most children grasped the concept of a balanced diet, they were less able to apply it in practically. As the focus group was undertaken as part of a whole day of activities for gifted and talented participants, it was possible to informally discuss these findings with experienced gifted and talented staff. They discussed how a formal analysis of the nutrition or physical activity levels of participants had not before been undertaken but that they felt there was likely to be a large range in both quality of nutrition and daily physical activities. Possible reasons for this included differing attention to health of both parents and children, differing cultures and financial status of families. A qualitative analysis of the beliefs of staff and parents was not an aim of this focus group but this did provide valuable information to contextualise the findings in **Figure 5.1** and together suggested that an analysis of the diet of potential participants in a free-living environment would be necessary to understand their energy intake in real terms. Such a survey would reveal how well they managed to balance their diet and correctly manage their energy intake. This focus group also shaped the methods of the quantitative element of the project by showing that it would also be important to try to quantify physical activity levels and the knowledge level of the primary caregiver and the associations these might have with the nutrient intake of participants.

- Good grasp of the concept of macronutrients, sources and individual uses in the body
- Good knowledge of ‘healthy’ and ‘unhealthy foods’
- Difficulty recalling a recipe for a dish suitable for an evening meal
- Neglecting to include condiments in a meal plan
- Neglecting to include drinks, either as a way to consume vitamins and minerals e.g. fruit juice or as a source of free sugars e.g. cans of soda
- Difficulty choosing a protein-rich snack post exercise. Milk was common but is impractical to transport to a training session
- Inappropriate protein consumption – protein shakes or bars were occasionally included but on probing, understanding of their role in the diet was poor
- Crisps and free-sugar snacks e.g. biscuits were rarely included but in reality are commonly consumed

Figure 5.1 - Findings from a meal planning exercise in GTP participants

5.3. Research Questions 2-6 – Data Screening

In 11 variables (energy, carbohydrates, fat, saturated fat, dietary fibre, protein, total sugars, calcium, sodium, PAQ-C and GNKQ) the study data was found to be normally distributed with p-values of > 0.1. For three variables, Vitamin C, Vitamin D and iron, the variables where found to not be normally distributed with a p-value <0.01. Findings concerning these variables should be interpreted with caution. To attempt to refine distributions, outliers were explored for removal.

5.3.1. **Outliers**

Tests for outliers in the data were performed on each variable using Dixon's Q test to determine whether the smallest or largest value is an outlier. For four variables, the null hypothesis that all data values come from the same normal population could be rejected. Vitamin C, Vitamin D and iron each had an outlier as the largest data entry (p=0.032, p=0.001 and p<0 respectively). The g value indicating standard deviations from the mean were 2.7, 3.3 and 3.3, again respectively. The food diaries corresponding to each outlier were checked and determined as true values so it was decided not to remove them for further analysis. Dixon's Q test of protein showed an outlier as the smallest data point, p=0.04, g=2.7. A two-tailed T test for the a significant difference with the outlier removed showed that this did not significantly affect the mean (t=-0.53, p=0.60), using this result, plus the normal distribution of the data and the knowledge that the outlier was a true value, the outlier was left in for further analysis.

5.4. Research Questions 2 and 3 – Descriptive Statistics

5.4.1. Energy

The daily energy intake of participants was on average 7.2 MJ/day (SD 1.9). The breakdown for age and gender is shown in **Table 5.1**. Males consumed slightly more energy than females and 11-12 year olds consumed more energy than 9-10 year olds. On average, participants did not consume the estimated average requirement (EAR) (Scientific Advisory Committee on Nutrition, 2011); achieved by only three participants (1 male, 2 females). 9-10 year old participants consumed more than the national average for their age but 11-12 year olds consumed very slightly less.

Table 5.1 - Energy consumption (MJ/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		*Ages 11-12*	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Estimated average requirement	8.5	8.1	8.9	8.5
Average population	6.4	5.9	8.1	6.8
Study population	7.2	6.6	7.7	6.7
S.D. study population	0.4	2.3	1.7	2.7

5.4.2. Macronutrients

Macronutrient data was obtained as a daily average for each child from the 3 day food diary. The overall mean and the mean for age and gender groups for each nutrient are presented in **Table 5.2**. Each macronutrient will subsequently be discussed with comparison to UK dietary reference values taken from *Dietary Reference Values for Energy* (Scientific Advisory Committee on Nutrition, 2011) and *Carbohydrates and Health* (Scientific Advisory Committee on Nutrition, 2015) and population intake data from the National Diet and Nutrient Survey (Public Health England, 2016d).

Table 5.2 - Mean Macronutrient Intakes of Participants

Average	Energy (MJ)	Carbohydrates (g/day)	Fat (g/day)	Saturated Fat (g/day)	Dietary Fibre (g/day)	Protein (g/day)	Total Sugars (g/day)	% Carbohydrates	% Fat	% Protein
Total (n=18)	7.2	233.5	61.5	21.7	9.44	69.5	96.3	51.3	32.2	16.5
Male (n=10)	7.6	249.1	65.2	24.2	9.35	73.1	108.9	50.6	32.4	16.6
Female (n=8)	6.6	214.1	56.8	22.6	9.57	64.9	80.6	51.8	31.9	16.4
11-12 years (n=11)	7.4	248.5	61.6	21.8	10.03	70.8	86.9	52.1	31.4	16.6
9-10 years (n=7)	6.8	210.0	61.4	21.5	8.52	67.4	87.2	50.0	33.4	16.4
Standard Deviation	1.9	71.0	19.3	7.4	3.34	18.6	37.1	5.9	4.7	3.3

5.4.3. Percentage Contribution of Macronutrients to Total Daily Energy Intake

The percentage contribution of carbohydrate, fat and protein to the average diet of participants was 51.3%, 32.2% and 16.5% respectively. Government recommendations are given as a percentage of total energy intake which is 50%, 35% and 15% again for carbohydrate, fat and protein respectively (Committee on Medical Aspects of Food and Nutrition Policy, 1991). 11-12 year olds consumed more carbohydrates and less fat than recommended and 9-10 year olds more fat and less carbohydrates. Eleven participants in this study consumed greater than the recommendation for carbohydrate with three exceeding fat and ten exceeding protein recommendations. A breakdown by age and gender is seen in Table 5.3.

Table 5.3 - Percentage contribution of energy of the main macronutrients of 9-12 year old children compared to Dietary Reference Values and national data

		Estimated Average Requirement	Average population		Study population	
Age			*9-10*	*11-12*	*9-10 (n=7)*	*11-12 (n=11)*
% Carbohydrate	Males	50	51.2	52.2	49.0	51.4
	Females	50	51.2	51.1	47.8	54.0
%Fat	Males	35	33.0	33.0	34.5	31.8
	Females	35	33.9	33.9	29.7	30.0
%Protein	Male	15	15.6	14.8	16.0	16.8
	Female	15	14.7	15.0	16.6	16.0

5.4.4. Carbohydrates

Carbohydrate consumption was on average 234 g/day (SD 70.95) (Table 5.2). Males consumed more than females and 11-12 year olds more than 9-10 year olds (Table 5.4). Again all age and gender groups did not consume the EAR (Scientific Advisory Committee on Nutrition, 2011) with only 2 individuals meeting this target. Carbohydrate consumption was higher than the population average (Public Health England, 2016d) with the exception of 11-12 year old males.

Table 5.4 – Mean carbohydrate consumption (g/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Estimated average requirement	242	227	333	267
Average population	212	191	262	220
Study population	225.5	203.8	255.0	231.3

5.4.5. Total Fat

Participants consumed on average 61.5 g/day of fat (SD 19.33) (Table 5.2). There was a small disparity between consumption by males, 65.2 g/day and females, 56.8 g/day. Both age groups had similar fat intakes at 61.6 g/day and 61.3 g/day for 11-12 year olds and 9-10 year olds respectively (Table 5.5). The government daily recommendations for fat are a maximum. They recommend no more than 35% of daily energy intake from fat for children aged 5 and over (Committee on Medical Aspects of Food and Nutrition Policy, 1991). This is given as a value in grams for each group in (Table 5.5). On average, each group consumed less than recommended maximum value with 3 individual participants consuming over this target. In comparison to results from d, 9-10 year old participants consumed slightly more fat than their peers in the NDNS and 11-12 year olds consumed slightly less.

Table 5.5 – Mean total fat consumption (g/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Maximum recommended intake	71.0	66.0	97.0	78.0
Average population	55.8	52.8	71.4	61.2
Study population	66.4	59.3	64.9	52.9

5.4.6. Saturated Fat

The average intake of saturated fat in the study population was 21.7 g/day (SD 7.36) (Table 5.2). Males and females consumed 24.2 g/day and 22.6 g/day respectively; participants aged 11-12 years old consumed 21.8 g/day and participants 9-10 years old consumed 21.5 g/day. Males aged 9-10 years old consumed more saturated fat per day than their peers in the NDNS (Public Health England, 2016d). Recommended values for saturated fat are less than 11% of total energy intake (Committee on Medical Aspects of Food and Nutrition Policy, 1991) which is shown in as a conversion from the value in grams in

Table 5.7 –Saturated fat consumption (percentage of total energy intake) of 9-12 year old children compared to Dietary Reference Values and national data. Eight individual participants consumed below recommendation, with a slightly lower intake of 9-10 year old females and a more marked lower consumption of 11-12 females when compared to the maximum recommended intake. Contribution of saturated fat to energy intake was less than or equal to the children sampled in the NDNS (Table 5.7) but for males aged 9-10, daily intake in grams was greater in the study population

Table 5.6 – Mean saturated fat consumption (g/day) of 9-12 year old children compared to national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Average population	22.4	21.1	27.1	23.0
Study population	26.8	19.4	22.8	17.0

Table 5.7 –Saturated fat consumption (percentage of total energy intake) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Maximum recommended intake	11	11	11	11
Average population	13.2	13.5	12.5	12.6
Study population	13.2	10.5	12.1	9.2

5.4.7. Dietary Fibre

Study participants had an average intake of 9.44 g/day of total dietary fibre (SD 3.34) (Table 5.2). Children aged 11-12 on average consumed 1.51 g/day more than those aged 9-10 years old (Table 5.8). Government dietary reference values for fibre are in terms of non-starch polysaccharides (NSP), which is a type form of dietary fibre (Committee on Medical Aspects of Food and Nutrition Policy, 1991) as such, a value for the recommended intake of total fibre intake is taken from Te Morenga et al. (2013). No individual children met the recommended levels of total dietary fibre intake and all groups consumed less than the recommended value. The authors of the NDNS also recorded fibre as NSP so average population intake of NDNS is included in Table 5.8 but is not a direct comparison.

Table 5.8 – Mean total dietary fibre/non-starch polysaccharide consumption (g/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Dietary recommended value (total dietary fibre)	20.0	20.0	25.0	25.0
Average population (NSP)	11.5	9.9	12.9	11.4
Study Population (total dietary fibre)	7.2	9.0	9.9	10.5

5.4.8. Protein

On average, participants consumed 69.5 g/day of protein (SD 18.6) (Table 5.2). Males consumed more per day than females, 73.1 g/day and 64.9 g/day respectively. 11-12 year olds consumed more than 9-10 year olds, 70.8 g/day and 67.4 g/day respectively. Participant protein consumption was much greater than the estimated average requirement for all groups (Committee on Medical Aspects of Food and Nutrition Policy, 1991) with 17 children consuming above the EAR. Participants in the NDNS (Public Health England, 2016d) consumed more protein per day than recommended but participants in this study consumed a greater amount still, with the exception of 11-12 year old males (Table 5.9).

Table 5.9 – Mean protein consumption (g/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Estimated average requirement	28	28	42	42
Average population	56.0	52.2	75.0	58.7
Study population	69.5	66.6	74.0	62.2

5.4.9. Total sugars

Mean total sugar consumption was 96.27 g/day (SD 37.0). Boys consumed 28.3 g/day more than females on average (Table 5.2). A breakdown of total sugar intake by age and gender is seen in Table 5.10. Recommended sugar intake is given as a maximum (Scientific Advisory Committee on Nutrition, 2015), eight children consumed less sugar per day than recommended for their age and gender, five of these were female. Total sugar intake is not reported in the NDNS surveys but total sugar intake for children aged 4-10 as quoted by Newens and Walton (2016) was 97.4 g/day, the comparable group of study participants consumed 87.2 g/day.

Table 5.10 – Mean total Sugar consumption (g/day) of 9-12 year old children compared to Dietary Reference Values

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Maximum recommended intake	85.0	85.0	120.0	90.0
Study Population	96.6	83.5	111.9	75.7

5.4.10. Micronutrients

Micronutrients were taken as a daily average from the self-reported food diaries. Where children consumed multivitamins those were included in the daily total. Mean values for participants are presented in Table 5.11.

Table 5.11 - Mean micronutrient intakes of 9-12 year old children

Average	Vitamin C (mg)	Vitamin D (µg)	Iron (mg)	Calcium (mg)	Sodium (mg)
Total (n=18)	112.0	2.5	12.6	732.4	2468.0
Males (n=10)	116.5	3.1	11.7	892.0	2499.2
Female (n=8)	103.7	1.7	13.7	533.0	2428.9
Aged 11-12 (n=11)	95.8	2.4	13.4	797.7	2590.2
Aged 9-10 (n=7)	129.5	2.5	11.3	629.8	2275.9
Standard Deviation	59.9	2.9	6.2	287.2	633.5

5.4.11. Vitamin C

The average Vitamin C consumption was 112.0 mg/day (SD 59.9), boys consumed slightly more than the mean and girls slightly less (Table 5.11). There was a disparity in age as 9-10 year olds consumed 129.5 mg/day on average and 11-12 year olds consumed less than this, 95.8 mg/day. These values are higher than the recommended nutrient intake of 30 mg/day and 35 mg/day for 9-10 year olds and 11-12 year olds respectively (Table 5.12). The average UK population consumed over 2 times the EAR (Public Health England, 2014) and the study population consumed even greater amounts still, with the exception of 11-12 year old females.

Table 5.12 – Mean Vitamin C consumption (mg/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Estimated average requirement	30.0	30.0	30.0	30.0
Average population	87.2	84.5	83.7	73.8
Study Population	175.2	122.5	104.5	72.6

5.4.12. Vitamin D

Vitamin D consumption was on average 2.5 μg/day (SD 2.9). Males consumed more than females, 3.1 μg/day and 1.7 μg/day respectively (Table 5.11). The study population consumed less than the recommended intake of 10 μg/day (Public Health England, 2016d) as can be seen in **Table 5.11**. Only one child surveyed consumed over the RNI. The average population also consumed considerably below this RNI, in particular children aged 9-10. The study population aged 9-10 however, consumed more Vitamin D than their peers in the NDNS. Females 11-12 years old, in comparison, consumed less than their peers in the NDNS but all other groups consumed more.

Table 5.13 – Mean Vitamin D consumption (μg/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Recommended nutrient intake	10.0	10.0	10.0	10.0
Average population	1.9	1.9	2.6	2.1
Study Population	3.6	2.0	2.9	1.1

5.4.13. Iron

Intake of iron was 12.6 mg/day on average with a standard deviation of 6.2. Males and 11-12 year olds consumed more than this mean and females and 9-10 year olds less (Table 5.11). Guidelines for iron consumption are given as both an RNI and a Lower RNI (Committee on Medical Aspects of Food and Nutrition Policy, 1991). On average, each respective group consumed over the RNI. When looking at each individual, all participants consumed over the LRNI but only 10 consumed over the RNI. Participants in this study consumed more iron per day than their peers in the NDNS (Public Health England, 2016d). Males consumed more than females in the NDNS which is reversed in this sample.

Table 5.14 - Mean iron consumption (mg/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Lower Recommended Nutrient Intake	4.7	4.7	6.1	8.0
Recommended Nutrient Intake	8.7	8.7	11.3	14.8
Average population	8.9	7.5	10.6	8.6
Study population	10.3	11.7	12.0	17.0

5.4.14. Calcium

Average calcium consumption was 732.4 mg/day (SD 287.2). Males consumed 892.0 mg/day and females 533.0 mg/day on average (Table 5.11). Recommended intake is again given as both an RNI and an LRNI (Committee on Medical Aspects of Food and Nutrition Policy, 1991). All children sampled consumed over the LRNI but only seven children managed to meet the RNI. Males had a greater calcium than females. 9-10 year males were the only group to consume higher than the guideline RNI (5.15). Compared to their peers in the NDNS survey (Public Health England, 2016d), male participants aged 9-10 years old consumed more and male 11-12 year olds slightly less calcium. Females of both ages, consumed less than their peers with a marked difference between 9-10 year old females.

Table 5.15 – Mean calcium consumption (mg/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Lower Recommended Nutrient Intake	325.0	325.0	480.0	450.0
Recommended Nutrient Intake	550.0	550.0	1000.0	800.0
Average population	811.0	749.0	889.0	706.0
Study population	967.4	495.8	873.1	597.8

5.4.15. Sodium

Participants consumed 2468.0 mg/day on average of sodium (SD 633.5). 11-12 year olds consumed greater than this total mean and 9-10 year olds less; 2590.2 mg/day and 2275.9 mg/day respectively (Table 5.11). The guidelines for sodium intake are quoted as a maximum of 1200mg/day for 9-10 year olds and 1600 mg/day for 11-12 year olds (Committee on Medical Aspects of Food and Nutrition Policy, 1991). Only two children studied consumed less than this recommendation. All groups consumed more than the recommended amount on average (Table 5.16). In the NDNS (Public Health England, 2016d), males consumed more than females but in the study population, this was reversed. A marked difference was seen between 9-10 year old females and their peers in the NDNS.

Table 5.16 – Mean sodium consumption (mg/day) of 9-12 year old children compared to Dietary Reference Values and national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Maximum recommended amount	1200.0	1200.0	1600.0	1600.0
Average population	1660.0	1538.0	2225.0	1860.0
Study population	2211.1	2301.8	2571.2	2640.7

5.4.16. Dietary Supplements

Children were asked to include in the nutrition survey anything they used to supplement their diet other than food products. Four participants reported consuming a multivitamin tablet daily. One of this group also consumed a Feroglobin supplement, which contained iron and folate as well as further Vitamin C once daily. He was the only child to meet daily recommended Vitamin D intake. His average consumption of Vitamin C was 150.3 mg/day which is five times the recommended intake. One child also reported taking daily insulin and glucose tablets as required, due to being a Type I diabetic. In the data from the NDNS, prevalence of supplement use was recorded as 16% for 4-10 year olds and 4% for 11-18 year olds. Multivitamins were the most commonly reported supplement consumed in these age groups. No children in this study reported consuming any macronutrient or non-nutrient supplements which is the same as in the NDNS (Public Health England, 2014).

5.5. Research Question 4 - Physical Activity Levels of 9-12 Year Old Children Identified as Gifted and Talented in PE and Sport

All 18 participants completed and returned the PAQ-C. Benitez-Porres et al. (2016) investigated a cut-off value of the PAQ-C based on accelerometry data that would relate to children receiving the recommended 60 minutes of MVPA a day, they concluded that a score of >2.75 would identify active children. Eleven participants achieved this. Each child receives an overall score with 5 being the highest possible level of activity. The mean score for all participants was 2.98 and there was a range of 1.89 to 4.22 (Table 5.17). On average males scored higher than females and 9-10 year olds scored higher than 11-12 year olds although neither of these was statistically significant (p>0.05). Values for the average population was taken from Voss et al. (2013). Values for '9-10 year olds' taken from 10.0-10.9 years and values for '11-12 year olds' taken from 11.0-12.9 years. 9-10 year olds scored higher in the PAQ-C and 11-12 year olds scored less than the average population.

Table 5.17 – Mean scores from the Physical Activity Questionnaire for Children by age and gender of 9-12 year old children compared to national data

	Ages 9-10		Ages 11-12	
	Male (n=5)	Female (n=2)	Male (n=8)	Female (n=3)
Mean	3.05	3.17	3.04	2.47
Standard Deviation	1.6	0.6	0.7	0.5
Range	1.89 - 4.22	2.33 - 3.89	2.00 - 3.89	2.20 - 3.00
Average population	3.21	3.04	3.07	2.48

21 different sports were sampled in the PAQ-C, the study sample participated in 18, as no children participated in hockey, skateboarding or sailing/windsurfing. Two sports not listed were kayaking and long-jump which were each reported by one participant. The sports and their popularity are reported in Table 5.18. The most popular activities were games/skipping and football followed by walking for exercise and cycling (Table 5.18).

Table 5.18 – Popularity of the different sports reported by participants in the Physical Activity Questionnaire for Children of 9-12 year old participants

Sport	Number of children participating per sport	Average number of times per week of those participating
Games/skipping	13	5.1
Walking for exercise	12	2.5
Cycling	6	1.5
Jogging and/or running	10	2.6
Aerobics	2	1.0
Football	13	3.4
Rugby/touch/7's	1	1.0
Netball or basketball	4	1.0
Hockey	0	0
Cricket	4	2.0
Rounders/base/softball	6	1.2
Badminton/tennis/squash	4	3.0
Rowing/canoeing	1	2.0
Martial Arts	1	4.0
Gymnastics	4	1.8
Dance/Cheerleading	2	1.0
Roller or inline skating	1	1.0
Skateboarding	0	0
Horse-riding	2	1.5
Swimming	9	1.6
Sailing/Windsurfing	0	0
Kayaking	1	3.0
Athletics (long-jump)	1	1.0

5.6. Research Question 5 - Relationship Between Physical Activity Levels and Energy, Macronutrient and Key Micronutrients

Pearson's correlation coefficient was used to determine if there was a relationship between the PAQ-C and the different nutrient variables as shown in Table 5.19. The strength of the relationship was gauged using Cohen (1977) who states effect size in terms of *r* can be interpreted as small $\geq$0.10, medium $\geq$ 0.30 or large $\geq$ 0.50 with values <0.10 being negligible.

Table 5.19 - The relationship between key macronutrients and micronutrients and Physical Activity Questionnaire for Children and General Nutrition Knowledge Questionnaire scores of 9-12 year old children

	PAQ-C		GNKQ	
	Pearson correlation coefficient	*P-Value*	*Pearson correlation coefficient*	*P-Value*
Energy	-0.07	0.79	-0.19	0.49
Carbohydrate	-0.01	0.96	-0.32	0.21
Fat	-0.14	0.59	0.13	0.62
Saturated Fat	-0.19	0.46	0.14	0.60
Total Fibre	0.40	0.10	-0.04	0.88
Protein	-0.03	0.90	-0.17	0.52
Total Sugars	0.15	0.54	-0.26	0.32
Vitamin C	0.54	0.02	-0.12	0.65
Vitamin D	0.41	0.09	-0.41	0.10
Iron	-0.03	0.90	-0.57	0.02
Calcium	0.07	0.79	0.33	0.19
Sodium	-0.08	0.74	0.03	0.91

5.6.1. Relationship of Energy to PAQ-C score

Mean energy intake was not significantly correlated to physical activity score (Table 5.19).

5.6.2. Macronutrients and PAQ-C score

Of the macronutrients studied, none were significantly related to physical activity score.

5.6.3 **Micronutrients and PAQ-C score**

The relationship between physical activity and Vitamin C is significant and would be significant for Vitamin D only when we consider $p<0.1$. There was a positive correlation between PAQ-C scores and intake of vitamin C and Vitamin D. Iron, calcium and sodium intake was not significantly correlated with PAQ-C score. The strength of the relationship between physical activity levels and Vitamin D was medium; and a strong relationship seen between physical activity level and Vitamin C.

5.7. Research Question 6 - Nutrition Knowledge of Parent/Guardians

Of the 18 participants, all had a parent or guardian complete and return the GNKQ. 17 GNKQs were used for analysis as one was removed from the study as it was not sufficiently completed. All respondents were females, 14 were the mother of the participant, one was a foster carer, and 2 were unknown in terms of their relationship to the child. Knowledge scores were determined according to the criteria outlined in Chapter 4 – Methods. Scores were as a total out of 88 and are given as a percentage for this study; scores ranged from 69% to 93%. The average score of participants was 84% (SD 7.5). During their validation of the revised version of the GNKQ, Kliemann et al. (2016) determined the mean score for females was 71%.

5.8. Research Question 7 – The Relationship Between Nutritional Knowledge Level and Energy, Macronutrient and Key Micronutrient Intakes

5.8.1. Energy and GNKQ

The relationship of mean energy intake to GNKQ scores followed a similar pattern as to PAQ-C scores. Energy intake was not significantly related to the GNKQ (Table 5.19).

5.8.2. Macronutrients and GNKQ

The relationship between all the studied macronutrients and GNKQ scores was non-significant for all variables.

6.8.3 **Micronutrients and GNKQ**

The relationship between GNKQ score and iron consumption was found to be significant but this relationship was not significant for any other micronutrient. There was a large negative correlation between GNKQ scores andiron.

Chapter 6. Discussion

This project aim was to determine the content of nutritional intake of active 9-12 year old children and to study potential relationships between this and physical activity levels or nutritional knowledge of parents/guardians. This chapter discusses the results of the study in the order set out by the aims and then subsequently followed by the results within current understanding and literature. It aims to contextualise these findings with regards to the methodological approach and limitations of the project.

Throughout this and the previous chapter, there is occasionally reference to data from a small group or from an individual. Although this is sometimes an unusual approach, it was felt this was appropriate. Given the small participant numbers, this was sometimes necessary to optimize understanding and meaning of the results an individual may affect the group analysis. Further, when outliers were determined, these were determined to not be due to incorrect data and therefore discussion of this was important for understanding. There is concern that this may increase the likelihood of a potential participant however, where this occurs every effort is given to maintain anonymity of the participant guided by principles described in the literature (Ohmann et al., 2017).

In this study, there was a consideration to how low sample size can lead to bias when statistical analysis is applied. A statistically significant result is reduced in reliability when the power of a study is low. This lower statistical power can lead to the misinterpretation of the true effect of the data being discovered (Button et al. 2013). As such, statistical analysis was only applied when it was believed this was an ethical approach to displaying the results over descriptive analysis.

6.1. An Exploration of Participant Beliefs

The first stage of this study was a qualitative analysis of the proposed study population. This process not only helped to pilot and shape the design and development of the rest of the research project but was additionally useful to ‘sense-check’ the personal beliefs of the researcher against stakeholder’s experiences and beliefs. The results of this stage might be considered with mind to Gitlin et al. (1989 p.245): “the question is not whether the data are biased; the question is whose interests are served by the bias”. The interests of the researcher were determined by pre-conceptions but qualitative analysis allowed for refinement and development. For example, investigation of whether the children had any autonomy of food choice showed that most children probably did but with the impact of external influences, such as parents, coaches or culture, being present to differing degrees for each child.

Further, an appropriate knowledge of macronutrients and how to balance them in the diet was portrayed but children were prone to giving the ‘correct’ answers and less what they truly consumed in a free-living environment. It is recognised that underreporting of food intake is common in children, Livingstone et al. (2007) concluded that in children and adolescents 20% of subjects under-estimate when reporting energy intake, although noted that underreporting does appear to increase with age. Baranowski and Domel (1994) explained this poor reporting in terms of the cognitive-processing model by categorising errors into six areas, attention, perception, organisation, retention, retrieval and response. In the context of the interview where a hypothetical planning exercise was conducted with non-specific elements of memory recall, 'response' was likely the most important confounding variable. On a day where participants were representing gifted and talented athletes during a nutrition seminar, there likely was pressure to fulfil this stereotype and a social desirability to be portray a 'healthy' diet (Podsakoff et al., 2011) as described by Klesges et al. (2004).

The main discovery of the stakeholder interview was that children possessed good knowledge but they were less able to apply this to a practical scenario. Similar findings by Fitzgerald et al. (2010) showed that even when knowledge of a 'healthy' diet was good, the reasons for food choice were multifactorial and included developmental stage, preferences, parental influence and home environment. Although an assessment of behavioural influences on nutrition was not a focus of this project, recall of their existence helps to place the quantitative findings of this research in context.

6.2. The Energy Intake of Athletic 9-12 Year Old Children and its Relationship to Physical Activity and Nutritional Knowledge of Parents

The findings of this study showed participants did not consume enough energy to meet UK estimated average requirements for their age. The results showed that participant's intake was higher than the average population of children aged 9-10 but lower than the average energy intake of children aged 11-12. As discussed in Chapter 2.9, it is logical to argue that athletic children may have a higher energy intake requirements due to their higher expenditure (Smith et al., 2015a). However, there is also research to show that young athletes are actually more capable of compensating for energy losses in other ways (Meyer et al., 2007, Petrie et al., 2004) and hence energy intake may not change from a less-active population. Studies other than this one have found no-difference between athletic and non-athletic groups (Mariscal-Arcas et al., 2015) but a much larger study would be needed to be able to draw more definitive conclusions regarding these theories. In both this study and the NDNS, energy intake was recorded as being below the recommended daily requirement suggesting that whether or not the intake of athletic children should be higher, it is still not at adequate levels for growth or physical activity requirements and, it is therefore likely most participants in this study were running an overall energy deficit.

The NDNS is a reliable and useful study but it is not a perfect comparator. A consideration should be given to geographical variation in energy intake which occurs across the UK. Some of the highest adult obesity rates are seen in the Country Durham area (Moon et al., 2007) suggesting energy intake is high in this population. However 75.1% of children in the County Durham area were found to be of a normal weight which was marginally less than the national average of 76.9% however (NHS Digital, 2016).

The relationship between energy intake of children and GNKQ scores of parents was negatively associated although the strength of this relationship was weak. This trend corresponds to some older research (Gibson et al., 1998) but is contrary to more recent findings (Vereecken and Maes, 2010). Yabancı et al. (2014) proposed that higher nutritional knowledge of mothers may actually lead to them restricting fat intake of their children and hence overall energy intake being lower. The explanation of this association is unclear and there is currently insufficient research to determine what effect nutrition knowledge level has on children in the UK, let alone this specific, physically active population.

6.3. The Nutrient Intakes of Athletic 9-12 Year Olds and their Comparison to National Guidelines and National Survey Data

Energy intake can usefully be broken down by analysis of the macronutrients that comprise it. Eleven and twelve year old participants and females consumed more of their energy through carbohydrate sources. All children in this sample consumed more of their energy intake through protein than recommended amounts, which corresponded to lower energy intake through fat than recommended (Committee on Medical Aspects of Food and Nutrition Policy, 1991). Each macronutrient will be discussed in turn with thought to the possible reasons for the relationships seen.

6.3.1. Carbohydrate Intake of Athletic 9-12 Year Old Children

Carbohydrate intake in this population was consistently lower than the estimated average requirement (Scientific Advisory Committee on Nutrition, 2015) but it was higher than the intake per day of their peers in the NDNS (Public Health England, 2016d). All children who participated in this study were meeting the 50% carbohydrate recommendation within 2 standard deviations and no major differences were seen for any demographic group, so this apparent low intake of carbohydrates is more likely associated to the low overall energy intake than a specific deficit in the intake of this macronutrient. It may be more useful to consider a range of normality, 45%-65% of energy through carbohydrate consumption, as outlined by the Canadian Paediatric Society (Purcell et al., 2013). Seventeen children from this study were within this range with only one being below it. However, Petrie et al. (2004) states that for young athletes, values should not fall below 50%. Seven participants in this study was met that recommendation. Proportionately therefore it is unclear whether the study population have low carbohydrate consumption but we can conclude that their overall energy intake from carbohydrates is low compared to recommended values. This is likely to have an overall effect on the energy levels of the study population and may cause an energy deficit leading to poor athletic performance as well as growth and development (Purcell et al., 2013).

6.3.2. Fat Intake of Athletic 9-12 Year Old Children

Total fat intake is of increased importance as an energy source for pre-pubertal children due to their immature glucose regulatory system (Riddell, 2008b) and intakes of less than 15% of energy intake may affect storage of intramuscular triglycerides and hence athletic performance (Spear, 2005). A review by Purcell et al. (2013) recommends a range of 25-35% for young athletes. In this cohort, 15 children consumed between 25-35% of energy as fat, suggesting appropriate energy intake from fat in the majority of this population. The finding of dietary fat-restriction in young athletes as described in other research (Meyer et al., 2007, Soric et al., 2008, Hinton et al., 2004) does not appear to be an issue in this population. Three children however, consumed a diet that proportionately consisted of a higher fat and lower carbohydrate intake. The effect of such a diet in young athletes is unclear. In adults, there was much interest in a high-fat, low-carbohydrate diet due to the belief that this might cause an improvement in athletic performance, however the research around this theory is now unclear and has even shown such a diet may be detrimental to performance (Burke, 2015). No qualitative analysis was undertaken to determine whether this was a deliberate dietary modification in these children, however the common preference for high-fat foods in children (Birch, 1992) is a more likely co-founding factor. In this study, the participant’s total fat consumption per day was not considerably different from the population mean as described in the NDNS. Overall, this group appear to consume adequate fat, therefore not negatively affecting growth and development or athletic ability. Further, it has positive implications for consumption of fat-soluble vitamins and calcium (discussed in Chapter2.10.3) as they are intrinsically linked (Milner and Allison, 1999) and, as will be discussed later, may be an area for health improvement.

Although adequate fat intake is encouraged in 9-12 year old children, intake of saturated fat is recommended to make up no more than 11% of total energy intake. In this study ten out of eighteen children exceeded this recommendation. The mean daily totals for each group surveyed show intake under the recommendations for saturated fat, however, the high degree of individual variability (8.26 g/day -33.20 g/day) and low sample size means that these are not hugely reliable for analysis.

Overall saturated fat as a proportion of energy intake is therefore more useful for analysis and intake was found to be lower than recommended for girls and higher than recommended for boys. It was also seen that all demographic groups consumed less saturated fat than the average population sampled in the NDNS. The lower intake of 11-12 year old girls showed a notable difference between both recommended levels and the average population which was a finding reflected for total fat intake of this group. Thøgersen-Ntoumani et al. (2016) described how pre-pubescent girls concerned about their weight may restrict their diet in order to achieve a healthier intake without necessarily concurrently changing exercise behaviours to match. A possible cause for the lower fat intake of 11-12 year old girls this study, may be related as saturated fat intake may be viewed as a marker of healthy eating (Talvia et al., 2011). Low saturated fat intake has been noted in post-pubertal female athletes (Benson et al., 1996) and non-athletes (Snow et al., 1990) in relation to amenorrhea but it’s unclear if this is a new finding in this population and its possible significance.

These results overall suggest that in context of the total fat and energy intake, saturated fat intake is lower but appropriate for females in this population but may be too high in males, this relationship for females is different to national trends (Public Health England, 2016d). This finding is important as high saturated fat may affect children in the same way as adults, predisposing them to cardiovascular disease (Milner and Allison, 1999). Although not apparent in this study, intake of saturated fat should also be viewed with caution due to the possibility it may be coupled with a low total fat intake (Te Morenga and Montez, 2017) and therefore low energy intake from fat.

6.3.3. Protein Intake of Athletic 9-12 Year Old Children

Protein consumption of children in the UK is generally higher than recommended values (Public Health England, 2016d) which was a finding reflected in this research as 17 out of 18 children consumed above the EAR. The intake of 9-10 year olds was over twice the recommended amount. Interestingly, 11-12 year old girls had the lowest intake of protein per day of participants although this was still above the recommended intake. Overall, protein consumption of this study group was higher than the national average as seen in NDNS, only 11-12 year old boys consumed marginally less.

Like other macronutrients, we can contextualise these results by considering protein as a source of total energy intake. The Institute of Medicine (2006) recommends that protein should make up 10-30% of total energy intake which, all children in this study achieved. An adequate protein intake is required for muscle growth and repair as well as for use as an energy source (Purcell et al., 2013) and high intake through diet is of especial importance in the study group as it is highly likely they have a higher energy expenditure and higher muscle composition (Deheeger et al., 1997, Ara et al., 2006, Lazaar et al., 2007). Further, a positive impact of a high protein intake during pre-pubertal years on the trajectory of bone development was noted by Chevalley et al. (2017) as they describe a finding of increased bone mass and strength during early adulthood with increased protein consumption in the pre-pubertal period. They further discuss the positive effect of high physical activity on bone response. Conversely, there may be negative consequences of a high protein diet, specifically the link with obesity in children (Koletzko et al., 2016). High protein intake has been shown to increase cardio-metabolic disease in adults. Although there is currently insufficient evidence to show a similar effect in children, this risk should not be dismissed (Voortman et al., 2015). A major concern regarding a high protein diet is the relationship with low calcium. When protein intake is too high it can cause increased urea, higher dehydration risk and hence increased excretion of urinary calcium (Millward, 2004). As a consequence of this, there is a possibility for poor calcium balance and hence an effect on peak bone mass (Manz et al., 1999). The interplay of the consequences of high protein consumption appears to swing in favour of the risks to a young athlete being greater than the benefits. Further, the positive effects appear to not be infinite as there as there is a limit to the protein synthesis that can occur, even with higher dietary intakes (American College of Sports Medicine et al., 2000). In this population it would be important not to encourage excessive consumption as baseline protein consumption of pre-pubescent children in the UK is already high and to be aware of the possible negative effects that this diet may cause.

6.3.4. Dietary Fibre Intake of Athletic 9-12 Year Old Children

Dietary fibre intake in the UK is persistently below recommendations (Scientific Advisory Committee on Nutrition, 2015), the study population similarly consumed less than recommendations, this difference was remarkable for all 11-12 year olds and 9-10 year old girls. In the NDNS, fibre consumption is recorded as non-starch polysaccharides, these are a form of dietary fibre but are not a directly equivalent variable. Fibre intake values for an individual would therefore be lower for NSP than for total dietary fibre. Although not a direct comparator, children in the NDNS survey consumed more NSP per day than study children consumed dietary fibre. We can therefore conclude children in this study consumed less than the average population their age, as their total fibre intake was less than the NSP intake in the NDNS, although it’s not possible to determine the extent of this trend. The major implication of a low fibre intake in children is a higher rates of constipation (Kranz et al., 2012). This is of especial importance when considering an active population as they are likely already at risk of constipation due to low water intake (Jennings et al., 2009). In adults, lower constipation rates and a higher fibre intake has been observed with higher rates of physical activity, possibly due to the mechanical action of increased colonic motility or higher dietary energy intake and hence fibre intake (Jennings et al., 2009). However, this may be the opposite in children. Jennings et al. (2009) found that children with higher physical activity levels had higher rates of constipation symptoms and proposed this was likely due to concurrent lower water intake. This study did not assess the physiological effects of dietary trends but the relationship between physical activity and fibre intake appears important. The opposite effect, the impact of low fibre and constipation on physical activity levels has not been studied in this population but would be interesting to determine. Furthermore, low fibre may correlate to a higher body fatness when combined with a high-fat diet (Johnson et al., 2008). The implications of this are far-reaching, both on general health for children due to high adiposity (Williams et al., 1992) and impaired physical performance (Smith et al., 2014).

6.3.5. Sugar Intake of Athletic 9-12 Year Old Children

Sugar intake of children in the UK is a current public health concern with 15% of daily energy coming from total sugar intake in children (Tedstone et al., 2015). In this study, over half of participants consumed above the recommended daily intake of sugar (Scientific Advisory Committee on Nutrition, 2015). Consumption by males was greater which is most likely due to the slightly higher total energy intake of males. When considered as individual demographic groups however, only 9-10 year old boys consumed over the recommended amount. 11-12 year old girls consumed the lowest amount of total sugar. The reason for this may be similar to the reasons discussed in Chapter 6.3.2 to explain lower saturated fat content in this group and an overall healthier diet.

Comparison to the general population was not included in the results as the NDNS publishes sugar consumption as NMES and not total sugar. NMES and free sugars are often used interchangeably in the UK (Scientific Advisory Committee on Nutrition, 2015), NMES is part of total sugar intake but is not a direct comparator to the total sugar results collected in this survey and therefore was not used for comparison. There is limited recent data on intakes of total of sugar in the UK for comparison. Newens and Walton (2016) found that total sugar intake of children 4-10 years old was 97.4 g/day, intake of participants of this study was slightly less, and they found that children 12-18 years old consumed 103.4 g/day which again is higher than children sampled in this study. It is unclear why they have not reported intake for 11-12 year olds. The results in this study are unexpected as sugar in UK children of this age group is high and intake in young athletes has been recorded as higher than recommended values in footballers (Naughton et al., 2017) and Canadian young athletes (Parnell et al., 2016) with sports drinks being reported to contribute greatly to these findings (Galemore, 2011). This apparent lower sugar intake for the study population needs to be considered in context of the results that energy intake and carbohydrate intake were also lower than expected. Regardless, it is still interesting and a much closer analysis of the sources of sugar intake, especially those contributing to NMES would determine if this population had a healthy sugar intake. Further, it might determine whether there was a deliberate effort to reduce sugar intake and if reasons for this were linked to the participant's status as being more athletic than the general population.

6.4. <u>The Micronutrient Content of the Diets of Athletic 9-12 Year Old Children</u>

6.4.1. Vitamin Intake of Athletic 9-12 Year Old Children

Vitamins play important roles in metabolism and have wide-ranging uses, for normal physiological functioning but also during physical activity (Williams, 2004). Children in the UK generally have a high intake of Vitamin C (Public Health England, 2016d), a finding reflected in this study as all participants consumed over the recommended daily requirement and many consumed 2-3 times the average requirement. The benefits of consuming Vitamin C have largely been attributed to its anti-oxidant properties (Padayatty et al., 2003) and in athletes its role in hormone transport is even more crucial. The literature does not clearly distinguish the benefits of high Vitamin C intake in young athletes but it may include enhanced immune function, improved lung function and help counter a higher physiological requirement during exercise (Lukaski, 2004). There have been reports of low Vitamin C intake in some athletes (Lukaski, 2004) but that doesn't appear to be an issue in this cohort.

Low Vitamin D intake could impact absorption of calcium and phosphate and negatively affect maintenance of bone health (Thomas et al., 2016). Appropriate intake would be especially important in this cohort as there is new evidence to suggest that Vitamin D may have a role in several physiological processes impacting performance, including injury prevention and rehabilitation (Thomas et al., 2016). Children in the UK consume much less on average than the recommended intake of 10 µg/day (Public Health England, 2016d) and participants in this study similarly consumed considerably less than the recommended intake. Children in this study, with the exception of 11-12 year old females, did consume more Vitamin D than their peers in the NDNS, however, there was only one child sampled who met recommendations. This is likely because this child supplemented their diet with a multivitamin tablet daily that contained Vitamin D.

This study did not assess whether participants were Vitamin D deficient, however there was evidence children sampled in the NDNS had levels below the threshold for deficiency in all age groups on biochemical blood sampling. It is highly possible a similar trend would be seen in participants in this study. Current evidence suggests that Vitamin D supplementation is needed to prevent insufficiency as intake from food is insufficient

(Holick et al., 2011, Misra et al., 2008). For a population of athletic children, this may be especially pertinent. There is a possible link between Vitamin D deficiency and muscle, soft-tissue and bone injuries (Willis et al., 2008, Cannell et al., 2009) which this cohort are already at risk of; the consequences of these injuries and their rehabilitation are likely to significantly impact training and performance. Farrokhyar et al. (2015) found that 70% of adolescent athletes in the UK showed Vitamin D inadequacy. There is a clear evidence to show an increased requirement for Vitamin D, especially for those involved in indoor sports and during winter and spring (Farrokhyar et al., 2015) and there is increasing evidence to suggest this is likely best achieved through supplementation (Saggese et al., 2015). Therefore, in light of the low Vitamin D intake of both children in this study and those in the NDNS (Public Health England, 2016d), there may be a need for Vitamin D supplementation in young athletes.

6.4.2. Iron Intake of Athletic 9-12 Year Old Children

Iron intake of this group was of particular interest in this study for several reasons; firstly adequate levels are required for oxygen delivery and also linear growth and increased lean muscle, all of which are of greater relevance in an athletic child (Hoch et al., 2008). Secondly, iron deficiency has been noted as an increasing problem in athletes, particularly female adolescent athletes (Clenin et al., 2015) which many of this population will soon become. Finally, children in the UK tend to have adequate levels between ages 4-10 but then these drop between 11-18 and rates below the LNRI increase, especially for females (Public Health England, 2016d). These trends are likely due to the changes in recommended levels at this to match the change in physiology associated with puberty, rather than solely a decreased intake between ages 10 and 11, but this does indicate that this age is at a significance risk of iron deficiency. In this study, all demographic groups consumed over the RNI and individually, children consumed above the LNRI. The mean intake was significantly higher than those in the NDNS (Public Health England, 2016d). Interestingly, in the NDNS males consumed more iron than females but that trend was reversed in this sample, with especially high intake by 11-12 year old females. This finding is generally the opposite to most of the literature on intake in pre-pubertal and adolescent girls (Public Health England, 2016d, Abbaspour et al., 2014). However, this is likely explained as this demographic subgroup consists of only three participants in this study and one was an outlier consuming 32.97 mg of iron per day. This is much higher than any other participant's iron intake but appears to be a true value of intake from food. With it removed, the mean intake for 11-12 year old girls drops to 9.1 mg/day which is then only marginally greater than females from the NDNS this age. Therefore, although this is very interesting, it is likely an anomaly and a much more detailed analysis would be needed to determine whether it is as a result of deliberate dietary modification and a larger sample would be required to determine if it was prevalent finding especially as the 11-12 year old female group is most at risk of iron deficiency (Lopez et al., 2016) and it has been shown that requirements in female athletes may be much greater than normal recommended values (Thomas et al., 2016).

The data for the rest of the participants leads us to conclude that iron intake of participants in this study was sufficient to meet requirements as outlined by the RNI. This sufficiency is not overly surprising, Sandstrom et al. (2012) explained this finding by showing that young athletes generally have better breakfast consumption and hence iron intake, this was reflected here as all participants recorded consuming breakfast on each day surveyed.

6.4.3. Calcium Intake of Athletic 9-12 Year Old Children

Calcium is another important mineral that has been noted as deficient in the diets of some young athletes (Brenner, 2016, Rankinen et al., 1995). Inadequate intake could lead to decreased bone strength and an increased risk of overuse or over-training injuries (Nisevich, 2008); this may have lasting effects on bone mineral density and hence future sporting performance (Tenforde et al., 2017). The UK trend is that calcium intake is high in children aged 4-10 but then decreases with increased age. In this study, all children consumed over the LNRI but far fewer (n=7) consumed over the RNI.

In this study, males consumed more than their peers in the NDNS but girls consumed less. The reason for low intake of 9-10 year old females compared to both the average population and older females was not clear and the literature on intake in young physically active children equally does not offer an adequate explanation specifically for females or information on whether this finding has been noted before. Causes of low calcium intake in athletes may be due to a deliberate energy restriction, with or without disordered eating or the avoidance of dairy products or foods containing high amounts of calcium (Thomas et al., 2016).

Calcium intake of the study population was sufficient to meet the lower recommended intake but on average did not meet the recommended intake. Lower calcium intake in childhood can lead to abnormal bone growth and lower prevention and healing of stress fractures (Brenner, 2016) however, when this occurs, children are able to compensate by more efficiently retaining calcium (Abrams et al., 1997). Therefore, the effect of lower intake may not be proportional to the increased risk of adverse bone effects. Other research has previously noted that adequate intake of calcium can be difficult for the young athlete as much of dietary calcium comes from dairy sources; the perishability of this food group makes intake throughout the day tricky (Smith et al., 2015a). A low calcium intake must also be viewed in context of Vitamin D consumption as low Vitamin D causes decreased absorption of calcium from the diet (Cribb et al., 2015, Christakos et al., 2015). As already discussed, this cohort did have a low intake of Vitamin D, which may cause lower absorption in the gut and hence less calcium would be available for bone growth. In conclusion, calcium intake in this study was adequate for minimal recommendations but intake at least equal to current levels should be encouraged in active 9-12 year old children to prevent poor bone health and its possible consequences on future sporting performance.

6.4.4. Sodium Intake of Athletic 9-12 Year Old Children

Sodium consumption of the study population was high. Only two children consumed under the maximum daily recommended allowance (Committee on Medical Aspects of Food and Nutrition Policy, 1991). Data on sodium intake was recorded in this study as there are current public health concerns regarding the intake of sodium in childhood and its effect on blood pressure and obesity (Appel et al., 2015, Grimes et al., 2016). High sodium in the diet is important for three reasons, firstly it begins to have a negative effect on blood pressure and cardiovascular disease from infancy (Appel et al., 2015). Secondly, children have been noted to develop a preference for salty tasting foods which then tracks into their food choices as an adult (Liem, 2017). Finally, higher salt-intake is also associated with higher consumption of sugar-sweetened drinks.

As mentioned in Chapter 6.3.5 and2.15.3, consumption of sugar-sweetened sports drinks is an area of particular concern in young athletes however in the study population this appeared to be less of an issue. Children in this study consumed more sodium than their counterparts in the NDNS study. High sodium intake is encouraged in young athletes in proportion to losses incurred during sweating in order to maintain extracellular fluid balance (Petrie et al., 2004). Although sweat losses are less in children of this age, there is evidence to suggest total losses of sodium through sweat may be equal to daily intakes (Petrie et al., 2004) and for young athletes training either in the heat, for prolonged periods (greater than one hour) or for large parts of their week high sodium consumption is necessary (Smith et al., 2015a, Meyer et al., 2007). To accurately comment on the intake of sodium in the study population we would need to know the relationship to sweating in relation to physical activity and hydration to determine whether these high intakes are proportional to losses or if they are pre-disposing the children to cardiovascular disease. Future research should seek to replicate previous findings in this regard, in a range of climatic conditions and training regimes.

6.5. Dietary Supplement Use in Physically Active 9-12 Year Old Children

During the stakeholder meeting, some children discussed uses of protein supplementation inappropriately in their diets by including protein shakes or bars when doing the daily meal-planning exercise (**Figure 5.1** - Findings from a meal planning exercise in GTP participants Figure). A further topic of consideration within this study was multivitamin supplements as there is concern regarding the low intake of some micronutrients (Public Health England, 2016d), however there is evidence to suggest young athletes might consume higher intakes of multivitamins than required (McDowall, 2007). The food diary included a prompt to remind participants to include any supplements; four participants reported supplementing their food intake in this section. The prevalence of supplement use in this sample is higher the average population in the UK (Public Health England, 2016d) but proportionately, the types of supplement consumed are very similar. The prevalence of supplement use in child and adolescent athletes is unclear but has been recorded as 22-71% (McDowall, 2007); this population would sit on the lower estimate of 22%. The supplements recorded in the food diaries were multivitamin or iron tablets and no children reported consuming macronutrient supplements like the aforementioned protein shakes or bars. The use of a mixed-methods approach was useful regarding protein consumption, the stakeholder interview indicated that some potential participants believed that this was part of an ideal balanced diet and therefore may be likely to consume protein supplements and therefore necessitated inclusion in dietary analysis. In comparison, quantitative analysis showed no protein consumption in the form of supplements but a high protein intake from food and therefore it is likely knowledge regarding the correct level of protein consumption was inappropriate. As protein supplementation is common in adolescent athletes (Whitehouse and Lawlis, 2017), it may be pertinent to educate active children on this topic at this age.

Micronutrient intakes of Vitamin D and calcium in this population were shown to be low. Supplementation with Vitamin D has both negative and positive consequences but if adequate levels are not being consumed through the diet, it may be appropriate to consume Vitamin D through supplements (Pludowski et al., 2018). Although calcium intake could possibly be increased in this population, calcium supplements are generally not encouraged as an alternative to adequate dietary intake but there may be a role in those who cannot achieve recommended intake through their diet (Shin and Kim, 2015). Intake of Vitamin C and iron were found to be normal in this study and hence suggesting no role for supplements of these micronutrients in this population. In fact, supplements consumed by one participant led to intake of Vitamin C over five times the recommended amount as he was consuming both a multivitamin and a feroglobin liquid that both contained Vitamin C. No children reported consumption of any ergogenic aids and the stakeholder interview did not indicate that any potential participants might consider supplementing their diet in this way. However it is pertinent to record this information as the implications of their use, both physiologically and on the reputation of an athlete can be great and the use of ergogenic aids is increasingly being recorded in younger populations (Calfee and Fadale, 2006, Harmer, 2010).

In conclusion, supplement use in this population does not appear to be an issue, whether than be macronutrient or micronutrient. These findings concur with results in young athletes and the average population in the UK that suggest that supplement use is seen and is normally in the form of multivitamins.

6.6. The Physical Activity Levels of Active 9-12 Year Old Children

This study was originally designed to study a specific population of children selected to the Durham and Chester-Le-Street Gifted and Talented Program. Through investigation of the aims of the GTP (Durham and Chester-Le-Street School Sports Partnership, 2017a), it was assumed that potential participants would have a high level of physical activity. However through informal interviews with program staff during the qualitative arm of this study, it appeared that this might not be true for all participants and it became apparent that what constituted 'gifted and talented' varied. After holding the stakeholder meeting, the researcher had the opportunity to informally observe potential participants involvement in physical activity testing at activity days for both Year 5 and Year 6 students and there was a clear range of both motivation and ability. These combined influences impressed the need to properly quantify physical activity level as an aim of this study and hence participants completed the PAQ-C questionnaire as part of the survey.

On average, scores of participants in this study suggested that they are an active population. Individually, 11 children reported activity levels above recommended. However there was a large range of results suggesting that generalising these findings may not be a completely true representation of how active this population are.

This survey also collected information on the popularity of different physical activities and how often children undertook them per week. The children in this study most frequently participated in games/skipping and football which was followed by walking for exercise, jogging and/or running then swimming in descending popularity. Participation in all other activities were reported by less than half of participants. Voss et al. (2013) found in a sample of 10-16 year old children that games/skipping, walking for exercise and jogging and/or running were all similarly popular and swimming, football and cycling were the most reported sports. In this study, physical activity scores were slightly higher for 9-10 year olds compared to 11-12 year olds. These findings again reflect the data from Voss et al. (2013) and The Gateshead Millennial Study that found that physical activity levels start declining with age from pre-adolescence and this is most marked in females (Farooq et al., 2017). The study population appeared to follow this trend.

The value of this questionnaire may be limited by its use during summer vacation period after the second phase of recruitment (the first phase of data collection was collected during the late winter and spring seasons); the PAQ-C was originally designed to be used during school term-time and was not validated for use in school holidays. The participants that used this tool in the holiday period may therefore have recorded physical activity level inaccurately. Atkin et al. (2016) described seasonal variation in MVPA of UK children. They reported higher MVPA in spring than winter and autumn and, in boys and children of a normal weight lower MVPA in summer compared to spring. When considering the results of this part of the study therefore we must be aware of these limitations.

In conclusion, the study population do class as physically active according to national recommendations but whether these results class them as a highly active population is less clear and would likely need to be investigated using non-subjective measures.

6.7. The Relationship Between Physical Activity Levels and Energy, Macronutrient and Micronutrient Intake

The fourth aim of this project was to distinguish whether there was a relationship between diet and physical activity level. The energy balance equation (Schoeller, 2009) states that energy intake must equal energy expenditure in order to maintain equilibrium. When energy intake is not sufficient to meet energy demands, this could lead to a negative balance and weight loss; when energy intake is greater than required for expenditure, this can cause the opposite, weight gain (Schoeller, 2009). Therefore, we would expect that as physical activity levels increase, we should see a concurrent increase in energy intake. In fact, in this study mean energy intake was not associated with physical activity levels. It is possible there may not be a correlation between energy intake and physical activity level in children at this age. Fisher et al. (2011) found that total physical activity was not associated with lower weight gain in 8-10 year old children and Vissers et al. (2013) found unclear relationships between physical activity and health in 9-10 year old children which they struggle to explain. It is difficult to conclude the significance of the results of energy balance in this population without further rigorous quantitative analysis of both energy expenditure and energy intake and a qualitative understanding of the reasons behind it or simply, whether participants and their parents have an awareness of this negative energy balance. However, the risks of a negative energy balance to a physically athletic child on both health and performance may be substantial and therefore this negative direction of the non-significant relationship observed should not be overlooked.

The macronutrients carbohydrate, fat, saturated fat and protein were not associated with physical activity scores. As energy intake is primarily from carbohydrates, fats and proteins it is not surprising that this mirrors the findings of overall energy intake and physical activity.

Physical activity levels were significantly negatively correlated to Vitamin C only. Requirements of Vitamin C may be higher with high physical activity (Thomas et al., 2016), so this would be a concerning trend. Low Vitamin C intake has been reported in athletes (Lukaski, 2004}, however overall Vitamin C intake in this group easily surpassed recommendations (Table 5.12) therefore although this is an interesting finding, practically the implications are not likely to have much of an impact

In conclusion, it appears that physical activity level may not have an important relationship with intake of energy, macronutrients and most micronutrients in this population. The strong relationship between physical activity and Vitamin C warrants further investigation but is unlikely to be of practical importance. Although the relationships in this study were not statistically significant, this knowledge in itself may be significant in the pursuit to optimise physiological functioning and energy balance in young, active children.

6.8. The Nutrition Knowledge Level of Parents/Guardians of Active 9-12 Year Old Children

The fifth aim of this study was to try to quantify the level of nutrition knowledge of parents or guardians of participants. The need for this aim came from conversations undertaken at the stakeholder meeting. The stakeholder session provided an informal understanding of the nutrition knowledge level of participants but a quantitative analysis of their nutrition knowledge level would help to better contextualise the results from the dietary assessment as to whether more active children were more educated in nutrition. However, at the time of the study design, there were no validated tools for qualitative analysis of nutrition knowledge in this age group and so nutrition knowledge of parents was sampled instead.

There is no cut-off score for the GNKQ as to what level might correspond to an adequate knowledge level. Compared to a large survey by Kliemann et al. (2016), scores of parents/guardians of participants in this study were found to be higher than those of a representative population and both English and nutrition students. However, it is important not to presume that good nutritional knowledge of parents directly equates to good nutrient intake of children. Such an association has been shown by Zarnowiecki et al. (2011), Vereecken et al. (2004), Variyam et al. (1999) and Gibson et al. (1998). But there are likely several co-founding factors as to how parents influence food intake of their children, especially as they age towards adolescence (Vereecken et al., 2004, Savage et al., 2007).

6.9. The Relationship Between General Nutrition Knowledge Levels and Energy, Macronutrient and Micronutrient Intake

Higher nutrition knowledge of parents/guardians was hypothesised to correlate to dietary intake values of children closer to national recommendations. The relationship between nutrition knowledge and energy, macronutrients and most micronutrients was not significant. The only statistically significant relationship was seen with iron consumption such that as GNKQ scores increased, daily intake of iron significantly decreased. Variyam et al. (1999) describes that the nutritional knowledge of mothers should have a beneficial effect on iron intake of their children. However they found this was non-significant in children aged 6-17. It is unclear why then these study findings show a significant effect to the opposite but indicates that this may be an important target for nutritional education of parents/guardians if it were found to still be apparent in a larger, more representative sample of parents in the UK. Given that all other intakes were not significantly related to nutritional knowledge, it is possible this could be a spurious finding.

6.10. A Reflection on Nutritional Research Methods

Prior to starting data collection for this project, the ontological stance of the researcher was of almost complete realism, the GTP participants offered an easily accessible population which fit the category of physically active 9-12 year old children. It was believed they were an accessible population, ready to be measured, without thought to the practical implications of engaging my target population. The methodological underpinnings of this study were used to develop project aims that would directly target where there were perceived a gap in the literature. On reflection, it is now believed this stance acted as a precursor to this project being limited due to failings with the research methods and the resulting effects that this had on the data collected in the process of this study.

As described in Chapter 2.17.4 the dietary assessment method for this study was chosen to balance an academically valid and reliable method (Kliemann et al., 2016) but also one that was perceived would be acceptable to the target study population. It was understood that this would be a time-consuming exercise for participants but it was hoped reducing the data collection to 3 days in one week would be acceptable. However initial recruitment in the GTP population had produced around a 5% return rate which was greatly lower than hoped for, and did not even reach the lower conservative estimate of return rates.

This project had bene designed with the GTP in mind and therefore it felt crucial to endeavor to continue to increase return rates from this population for far longer than initially planned. Several ploys were implemented as described in Chapter 4.7. It's not possible to ascertain the exact effect of all these measures as the change to collection method and the email reminders applied to participants who attended both GTP days. However, five surveys were returned in the initial period after the first GTP day and seven from the second GTP day when around 120 had been distributed at each. This is a 20% increase in survey returns which was pleasing but in real terms, this resulted in a burden to myself as it stalled the project and more importantly to GTP staff who were kindly accommodating despite not being required to aid the project. Schilpzand et al. (2015) describes how the implementation of a multi-level approach to data collection, such as this one, can be an effective strategy to increase response rates in parents therefore it appears this was an appropriate approach if not as effective as I had hoped.

The difficult decision to enter a secondary phase of recruitment outside of the GTP program was taken as it was felt they had been exhausted them as a resource. Oliver (2003) describes how gatekeepers are often key to accessing difficult populations and hence initially multiple gatekeepers were contacted in order to gain access to a wider population. Several unsuccessful avenues including local councils, a large number of primary school staff through the School Games Program (County Durham Sport, 2017) and sports clubs. It was believed the non-personal approach of this was a major shortcoming, it had been easier to engage GTP staff as the project had been designed to benefit them. Data collection was aided at the time by close personal connections to primary school staff and coaches who encouraged the researcher to reflect on this and to understand why it would have been hard for these gatekeepers to see why they should devote time and effort to something they were not directly interested in or likely to benefit from.

From this continual reflective process, the methodological stance to recruitment changed somewhat to considering recruitment and its resulting consent as a more of a continuing process and aided in continuing to take a proactive approach to recruitment until two gatekeeping organisations were found that proved beneficial, Durham University Summer Holiday camps and Durham City Harriers and AC Junior club. The response rate from participants of these two organisations was still low but significantly higher than in the first phase of recruitment. The reasons for this are likely multifold, recruitment skills had been honed through an extensive trial and error approach but also, the second phase was outside of school term time, parents therefore, were more likely inclined to participate as the burden of completing the survey was lower when diaries did not have to be taken to school or completed during busy schooldays.

The secondary recruitment brought its own advantages and disadvantages. The advantages of this second phase were actually several fold. It allowed for fully informed consent to take place as more of a continuing process through several verbal interactions with participants and their parents in addition to written consent. It was able to ensure potential participants and their parents were properly informed and being a physical presence at the holiday camps for distribution, provided an opportunity for the researcher to be a reminder to parents and hence increase survey return. However it also brought with it limitations. The project was designed to target a special population, those involved with the GTP. Although it was believe there was an overlap between children involved in the GTP and those undertaking summer sporting activities, the original target population was diluted. Further, by using the GTP initially, it was hoped to ensure that there was minimal selection bias. By its nature, selection to the GTP is based on physical activity merit, participants come from all schools in the Durham and Chester-Le-Street area. Participation is organised through classroom teachers and is affected by a far lesser extent by finance as it is a government funded organisation or parental interest. This was not the case for the organisations utilised in the secondary phase and it may be that some bias was introduced as parents of higher socio-economic status are more likely to participate in research (Heinrichs et al., 2005).

However it is pertinent to realise that this extended process may have positive effects as well as negative ones. Although this stage was in the pursuit of quantitative data, the mixed-methods approach became strengthened through this process. Lincoln and Guba (1985) state that the trustworthiness of a study is important to decipher its worth. Credibility of this study was increased by a prolonged engagement and persistent observation in the field which enabled the researcher to rise above preconceptions, and to contextualise the results and methodological issues of the survey. “If prolonged engagement provides scope, persistent observation provides depth” (Lincoln and Guba, 1985, pg. 304), secondary recruitment resulted in both prolonged and persistent observation. Further, credibility was increased through triangulation of slightly different sources of data at different points in the year. Although not formally studied or reported in the conclusions of the findings, this more interpretivist underpinning aided in the writing and understanding of the results of the study.

7.11 Limitations of this study

In addition to the limitations of the adaptive sampling strategy outlined above and in the methodology section, the study was limited in terms of sample size. A prospective power analysis indicated that 50 participants would be required. Therefore, the impact of this study is greatly reduced as the results documented do not carry enough power to evidence whether relationships are statistically significant or not in all instances.

Further there is a two-fold reason for caution when applying the findings of this research. Firstly, the results of this study are cross-sectional in nature and therefore caution is advised when aiming to determine causal links inside of just infering them from the associations seen. The principles of the Bradford-Hill criteria are a useful guide in aiding to establish possible causal relationships. Data analysis of the effect size between the study variable could be performed statistically, and in the future, reproducibility of the results in a further study would all further this analysis. Further, possible options for aiding in determining the relationship between cause and effect in cross-sectional analysis could have included an effect measure such as an odds ratio or relative risk equation.

In addition, comparisons drawn against national survey data as quoted in the NDNS should be viewed with some caution as the data per age is quoted for larger groups, 4-10 and 11-18 year olds. As the children surveyed in this study were aged 9-12, their intake is possibly poorly represented by means of the age ranges used in the NDNS.

7.12 Recommendations for future work

This study has allowed for descriptive analysis of the research aims. Several interesting findings have been shown, some which complement previous research and some novel findings. The intake of total sugar in this population was recorded as lower than national data, a larger scale study of total sugar and NMES intake in young, athletic children may help to determine whether they truly are consuming under recommended amounts and an analysis of why this was the case may provide valuable information for public health intervention programs. Another finding that may require further investigation due to the possibility of significant negative consequences are the low Vitamin D intake in the study population. Further, the analysis of iron status in 11-12 year old girls likely requires a much better analysis than this study was able to provide, which would again be important due to the negative consequences of a chronic low intake.

Chapter 7. Conclusions

In the wave of post-Olympic policy in the UK, much interest and economical power was devoted to developing a legacy of sporting excellence but also, to wide-scale engagement in physical activity (Crouch, 2015). Initiatives such as the School Games and Youth Sport Trusts opened up competitive sport to a vast number of school children and started to produce some impressive alumni (Crouch, 2015, England, 2016). This study was conducted as, after a thorough literature review of nutrition in school aged children, it was apparent there was limited data on the diets of physically active children. Research has focused on the effects of diet, both in obese children and teenage elite athletes, but it appeared we were missing information on the middle ground, which seems of increased importance in the context of this shift in governmental policy.

This study has conducted an in depth analysis of the diets of active 9-12 year old children in the context of national recommendations (Committee on Medical Aspects of Food and Nutrition Policy, 1991, Scientific Advisory Committee on Nutrition, 2015) and mean intakes of a nationally representative sample of children (Public Health England, 2016d). The energy intake of these children was found to be below national recommendations but higher than intake seen for UK children nationally. In light of the high physical activity of this population, it is likely that participants are at risk of running an overall energy deficit, as well as specific nutritional deficits. This finding is related to the proportionately low reported intake of carbohydrates and total fat which were consequently both lower than recommended per day. However, protein intake of participants was well above estimate average requirements. Compared to the nationally representative sample of children (Public Health England, 2016d), intake of carbohydrates, total fat and protein was higher in participants although this varied depending on age and gender. Intake of saturated fat in this study was greater than the maximum recommended as a proportion of total energy intake although this was lower than the intake reported in national data. Similar to reports on the national population, intake of dietary fibre was substantially lower than the daily recommended intake. Total intake of sugar of participants was lower than recommended, except in 9-10 year old boys and this possibly relates to lower intakes than have been reported nationally.

Micronutrient intake of participants in this study was mixed. Vitamin C consumption was markedly above both the estimated requirement and the intake reported of children nationally. However this finding was not repeated for intake of Vitamin D where intake of this population was well below recommendations, it was however higher than the national average. Iron intake of this population was sufficient to meet the recommended intake and was also greater than the national intake reported in the NDNS. Calcium intake in this study was adequate to meet lower recommended requirements but could be greater to meet overall recommended intake. Intake of calcium by participants was lower than reported nationally. Intake of sodium was vastly greater than the maximum recommended amount and the average intake of children nationally.

Participants in this study had an overall physical activity score that classed them as active according to government recommended targets for MVPA. The relationship of physical activity to energy or macronutrient intake was not found to be significant. However it did appear that with increasing physical activity levels, there was a trend towards lower energy intake which may have far-reaching effects if there is a chronic negative energy balance. The only significant relationship was seen between physical activity and Vitamin C intake although this is unlikely to have an impact in this population in light of the overall high intake.

The nutrition knowledge of parents/guardians of the participants in this study was overall sufficient with the average score above that recorded previously in the UK (Kliemann et al., 2016). The only significant relationship between increased nutrition knowledge and diet was a positive correlation to iron intake of participants, it appears odd that this was an isolated significant findings and likely warrants further investigation into possible causes and implications to be able to fully understand this relationship

Overall, this study has produced data that might guide those caring for, and working with, active pre-pubertal children. This is of great importance as public policy aims for children to expend more energy, and we as caregivers and information providers must remember to aim to balance this with children’s energy intake for maximal health outcomes.

Chapter 8. Appendices

8.1. Appendix A – Survey Information Sheet: Adult

Durham University
School of Applied Social Sciences

The Gifted and Talented Nutrition Survey

Dear Parent/Guardian

My name is Emma Wauchope and I am currently undertaking a Masters by Research degree (Social Sciences: child nutrition) at Durham University. In partnership with the Gifted and Talented Program we would like to know more about what your child's daily nutrition and eating habits are. I delivered the nutrition seminar at the last G&T day in Durham and was very impressed by the level of nutrition knowledge of the children. I'm interested in looking into this further and as such I'd really appreciate your participation in my project.

Why has my child been chosen?

As you may be aware, the nutrition of your child is very important. They require good nutrition for not only growth and development but also to do as well as they can at their sport. We believe therefore that there is extra importance in sporty children to get it right. There is unclear data around what an active child should eat and therefore it is hard to know the best things to encourage them to eat.

What is the research about?

This research is about discovering what Gifted and Talented children eat and how that compares to government guidelines and national statistics for other children their age.

Are there any potential risks or benefits?

There are no perceived risks to your child. We hope however they will benefit greatly in the future. We will be able to inform you of our results and any recommendations we have at the end of the project. We will also be able to advise the Gifted and Talented program in the future so they can deliver a more tailor-made service.

What about confidentiality?

Strict confidentiality will be maintained throughout as with the rest of the Gifted and Talented Program. I as the researcher will only share collected data with my supervisors who are both academic staff members at Durham University. All information collected will be anonymised and no identifying information will be associated with the questionnaires that you return to us. All data collected will be stored on a password-protected computer.

What will the data be used for?

We hope the data will primarily benefit children like yours, with higher than average physical activity levels, through gaining information about what they currently eat and what changes they might need to make to maximise their diet. Information will be used to produce a report which may be published in academic journals, and will form part of a Masters by Research thesis, however there will never be any information that will identify your child. This will hopefully help other children in the rest of the country and hopefully can benefit understanding of the unique nutritional needs of children such as yours.

What if I choose not to take part?

You are under no obligation to take part. If you choose not to partake in the study then simply don't return the forms. You also can withdraw at any point from the survey, if you wish to do this please contact me at the details found below.

I'm willing to participate, what next?

Thankyou! You will find lots of information included with this letter. Please read it all carefully and make sure you and your child understand everything before beginning, if you have any queries, please don't hesitate to contact me.

The study requires you to complete in three different elements.

1. A 3-day food diary. It also contains a physical activity questionnaire. This is so we know how much sport they take part in. As the parent/guardian, please complete this in a **normal week** for your children (e.g. not a half term week.). It would be best if you could complete this alongside your child and encourage their participation. When completed please take all the documents back to your G&T co-ordinator at school and notify me at the email address or phone number provided below, that it is ready for collection. I will collect it from the school.

2. A physical activity questionnaire for your child. Please encourage your child to complete this as much as possible by themselves. It has been designed for their age-group and lets me know how active your child is.
3. The Nutrition Knowledge Questionnaire. This should be filled in by the primary carer for your child. We would like to know a little more about your understanding of nutrition and then we may be able to understand a little about your influence on your child's nutrition. This is a widely used questionnaire and will be extremely helpful to the study. If however you wish not to participate in this part of the study that is completely fine, please just return the other documents without it.

I really appreciate your participation. Hopefully this project will serve to benefit your child and other children of similar athletic potential in the future.

Yours Sincerely,

Emma Wauchope emma.c.wauchope@dur.ac.uk

Durham University 07527981330

8.2. Appendix B – Consent Form: Adult

PARENTAL CONSENT FORM

Name of School/Youth Group: **Durham & Chester-le-Street School Sport Partnership**

Proposed project: **Durham Gifted and Talented Program Nutrition Survey**

First Name of Parent/Guardian		**Surname of Parent/Guardian**	
Date of Birth of child			
School Attended by child			
Address Including postcode			
Tel Number (s)			
Parent/Guardian Email Address			

Please initial boxes

1. I am the parent/guardian of the child named above and I confirm that I have read and understand the Nutrition Survey Information sheet (s) for the above study. ☐

2. I understand that my child's participation is voluntary and that s/he is free to withdraw from any part of the study, at any time, without giving a reason and without their involvement in the Gifted and Talented Program being affected. ☐

3. I give my consent for my child to be involved in the Gifted and Talented Program Nutrition Survey. ☐

4. I give my consent to be involved in the survey by completing the General Nutrition Knowledge Questionnaire ☐

Signed:__________________________________Date:___________________

(parent or guardian)

8.3. Appendix C – Survey Information sheet and consent form: child

Durham & Chester-le-Street SSP
House of Sport
School House
Haworth Building
Leazes Road,
Durham, DH1 1TA
(0191) 334 7209

Durham & Chester-le-Street School Sport Partnership
Working in collaboration with Durham Sixth Form Centre

Durham University
School of Applied Social Sciences

CHILD CONSENT FORM

Project title - **Durham Gifted and Talented Program Nutrition Survey**

My name is Emma Wauchope and I am doing a research study about the nutrition of children in the Gifted and Talented Schools Partnership. A research study is a way to learn more about people. If you decide you want to be part of this study, you will be asked to fill in a food diary and questionnaire about how much physical activity you do.

There are some things about this study you should know:

- The diary helps me understand more about your diet, it is not a test and there are no wrong answers.
- It will take a few days to fill in the food diary.
- The best way to fill it in is as often as possible. If you do forget what you have eaten, just fill in the diary the best you can or ask an adult to remind you.
- You do not have to fill it in alone, your parents, guardian or teachers can all help.
- The Physical Activity Questionnaire is also not a test, please fill it in the best you can.
- Only myself and my two teachers at Durham University will know your answers

I am asking you to take part as we don't know much about what children like you eat.

The aim of this study is that it will help the Gifted and Talented Partnership in the future. We hope it will give us some information that will benefit you and other children who do a lot of physical activity. When we are finished with this study I will write a report about what I learned. This report will not include your name or that you were in this study.

If you do not want to be in this research study, that is okay. You will not hear from me again and nobody else will know that you did not choose to participate unless you tell them. If you decide to stop after you begin that is okay too. Your parent/guardian also knows about the study.

If you have any questions you can email me at emma.c.wauchope@durham.ac.uk

If you decide you want to be in this study, please sign your name:

I ,______________________________, want to be in this research study.

(write your name clearly)

Signed:______________________________________

Date:___________________

8.4. Appendix D – Three-day nutrition Diary, example diary and supplementary information

Durham University

Gifted and Talented Programme Nutrition Survey

Food and Drink Diar

Diary Start Date:

Participant Number:

Participant Age:

Sex: Male/Female

Contents Page

How to fill in your diary 2-3

Diary example 4-5

Spoons size guide..8

Drink volume guidance... 9

How to fill in your diary

It is very important that you do not change what you normally eat or drink just because you are keeping a diary. Try to write down what you are eating or drinking as soon as you can and not leave it until the end of the day. Record food and drink eaten at home and away from home, such as at school or at a friend's house.

Whenever you have something to eat or drink write down:

When: Each day is divided into time slots from first thing in the morning until late at night until the following morning. Find the appropriate time slot and record the exact time when you eat or drink something the "time" column.

Where: This could be

- Home – Bedroom
- Away – Street, car/bus, café/restaurant, (please specify e.g. McDonalds, Pizza Express ect.)
- School – Canteen, classroom, playground

With Whom - This could be

- Alone
- With friends
- With family

At table: Were you sitting at a table whilst eating or drinking? If yes record **at Table**. If no, record **not at a table.**

Watching TV: Were you watching TV whilst you were eating or drinking? If yes, record **TV on**. If no, record **No TV**

What: Describe your food and drink giving as much detail as you can. Include any **extras** like sugar and milk in your tea or cereal, butter or other spreads on your bread and sauces such as ketchup and mayonnaise.

Do not forget to include drinking water.

If you know how your food was cooked (e.g. roast, baked, boiled, fried) please record this. If you're unsure about how the food was cooked, please ask the person who prepared the food if possible.

If you have eaten any homemade dishes e.g. a stew or sponge cake, please make sure the ingredients and cooking method are recorded in the space provided. You may need to ask the person who prepared the dish to help you with this. If you have eaten any take-aways or any made up dishes not prepared at home such as at a friend's house or in a restaurant, please record as much detail as you can about what was in the dish e.g. vegetable curry containing chickpeas, aubergine, onion and tomato.

Brand: Please make a note of the **brand name** (e.g. Heinz, Walkers, Hovis,) if you know it. Most packaged foods will list a brand name

Amount eaten:

You can specify packet (e.g. crisps, yoghurt) or number of individual items (e.g. biscuits) or slices (e.g. cake, pizza, ham) or teaspoons (e.g. sugar) or dessert spoons (e.g. peas). Be careful when describing amounts in spoons. Compare the spoon you are using with the life size spoons in the diary so you can use the correct name.

You can also write S (small) M (medium) L (large) portion.

For drinks, you can write glass (tell us the size of the glass or volume), cup or mug. You can also write the **weight or volume from the labels** on the packaging.

We would like to know the **amount that you actually ate**, so you need to think about how much you **leftover.** You can do this in 2 ways:

1. Record how much you were served and then how much you ate e.g. 3 dessert spoons of peas, only 2 dessert spoons eaten; 1 large sausage roll, ate only half
2. Only record how much you actually ate e.g. 2 dessert spoons of peas, half a large sausage roll

Was it a typical day?

After each day of recording you will be prompted to tell us whether this was a usual day or whether there were any reasons why you ate and drank more or less than usual e.g. I did eat less because I was sick; I drank a lot because I did more sports than normal. Please tick the correct box for your intake. We have provided a list of commonly forgotten food and drink to help jog your memory at the end of each day for anything you may have forgotten to record.

Supplements

At the end of each recording day you need to tell us about any supplements you took. If you didn't take any just tick NO. If yes then please tell us the name of the supplements (e.g. Vitamin C) brand (e.g. Boots) and strength (it will tell you on the label e.g. 50mg) and how many you took (e.g. 1 tablet).

If you have any queries on how to complete the diary please contact

emma.c.wauchope@dur.ac.uk

We have included an example day to show you what to do

Day Example			Day: Wednesday	Date: March 29th
Time	**Where? With whom? TV on? Table?**	**What**	**Brand name**	**Amount eaten**
		6 am to 9am		
7.30 am	Kitchen Family No TV At table	Orange juice, unsweetened Tea Milk, semi-skimmed Sugar white Weetabix Milk, semi-skimmed	Tesco Yorkshire Tesco Silverspoon Tesco	Large glass Mug A little 2 level teaspoons 2 Drowned
		9am to 12 noon		
11am 12 noon	School Playground With friends School Corridor Alone	Diet Coke Potato crisps, salt and vinegar Water from water cooler Mars Bar	Coca Cola Walkers	330ml can 25g packet from a multipack Small plastic cup 1 kingsize
		12 noon to 2pm		
12.45pm 1.50pm	School Canteen With friends At table School PE With friends	Sandwich from home White bread , large loaf Margarine Ham unsmoked Cheddar cheese Branston pickle Apple with skin Ribena Light, ready to Drink, Blackcurrant Flavour, from Canteen Kitkat from home Lucozade Light, orange flavour	 Kingsmill Flora Light Tescos "	 2 medium slices Thin spread on both slices 1 slice 2 medium slices 1 teaspoon 1 (left core) 220ml carton 2 fingers 1 bottle

Day Example

Day Example			Day:	Date:
Time	**Where? With whom? TV on? Table?**	**What**	**Brand name**	**Amount eaten**
		2pm to 5pm		
3.45pm 4.30pm	Bus, Alone Home, Sitting room With family, TV on Not at table	Wine gums Tea (as before) Chocolate Hob nobs	Maynards McVities	140g packet
		5pm to 8pm		
6.00pm 7pm	Friends Kitchen With Friends No TV At Table At swimming pool	Chicken in tomato sauce made by friends mum Tomato fresh Sweetcorn tinned Peach yoghurt low fat Lemon squash No Added sugar Lemon squash as before	See recipe Muller Light Sainsbury's	3 tablespoons 3 slices 1 dessertspoon 200g pot Medium glass 2 litres
		8pm to 10pm		
8pm 9.30pm	Car With family Kitchen, Alone No TV, At table	Satsuma Thick cut, frozen chips fried in vegetable oil Brown sauce	 McCains's HP	1 Small portion 1 dessertspoon
		10pm to 6am		
10.30pm	Bedroom Alone, TV on Not at table	Hot chocolate made with water	Cadbury's drinking powder	Mug (4 tsp of powder)

1. Was the amount of **food** that you had today about what you usually have, less than usual, or more than usual?

Usual ☐

Less than usual ☐ **More** than usual ☒

If your intake was not usual, please explain why:

Ate at a friend's house

2. Was the amount you had to **drink** today, including water, tea and coffee and soft drinks, about what you usually have, less than usual, or more than usual?

Usual ☒

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

3. Did you **finish all the food and drink** that you recorded in the diary today?

Usual ☒

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

If you have forgotten to record any food or drink today, please go back and **add them to the diary**

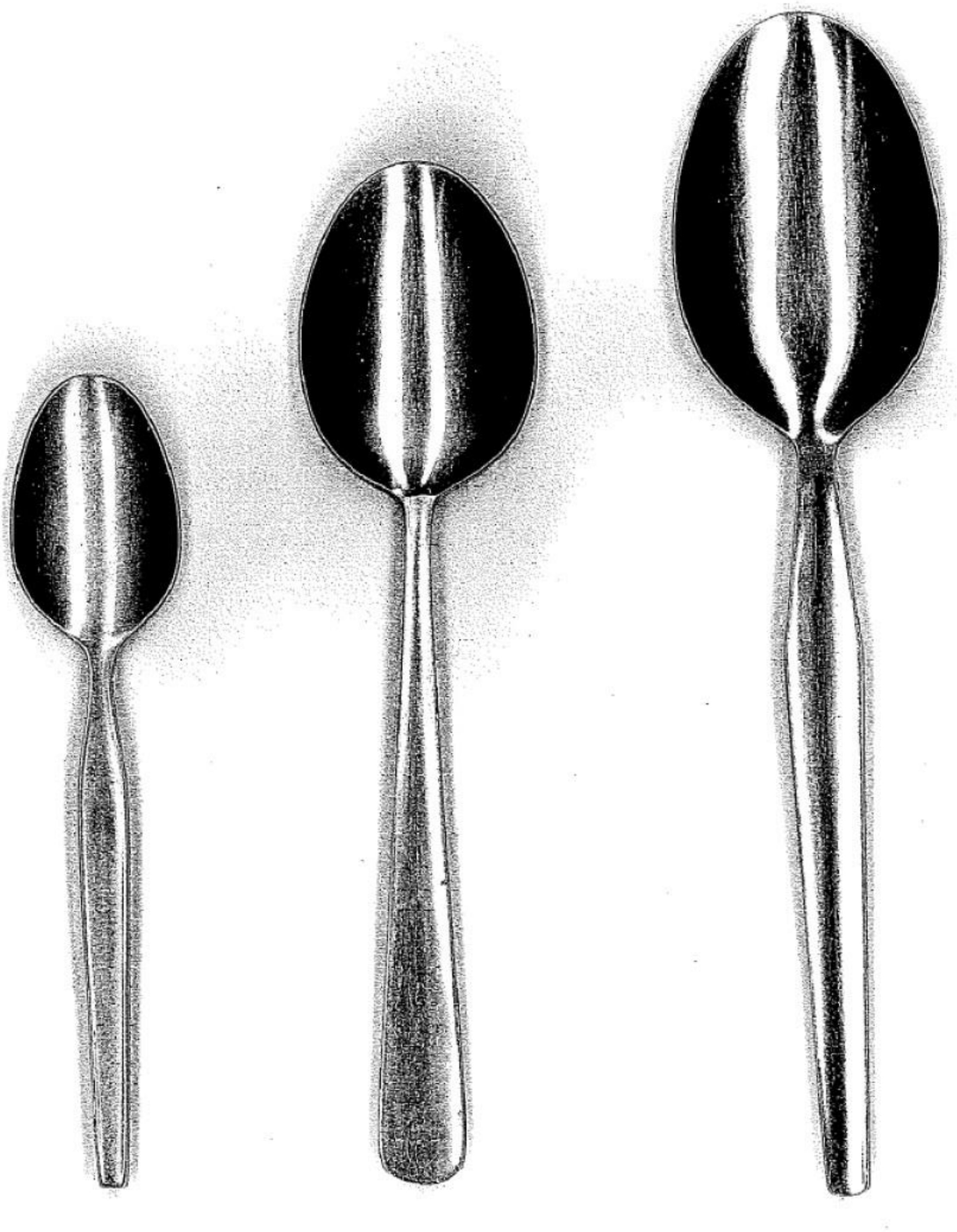
4. Did you take any **vitamins, minerals or other food supplements** today?

Yes [X] No [ ]

If yes **please describe the supplements you took below**

Brand	Name (in full) including strength	Number of pills, capsules, teaspoons
Bassets	Soft and chewy vitamins A (800ug), C (60mg), D (5 ug) and E (10mg)	1 pastille
Haliborange	DHA Omega-3 blackcurrant chewy caps (each capsule contains 200mg fish oil providing 130mg omega-3)	2 capsules

Please record on the next pages details of any recipes or (if not already described) ingredients of made up dishes or take-away dishes



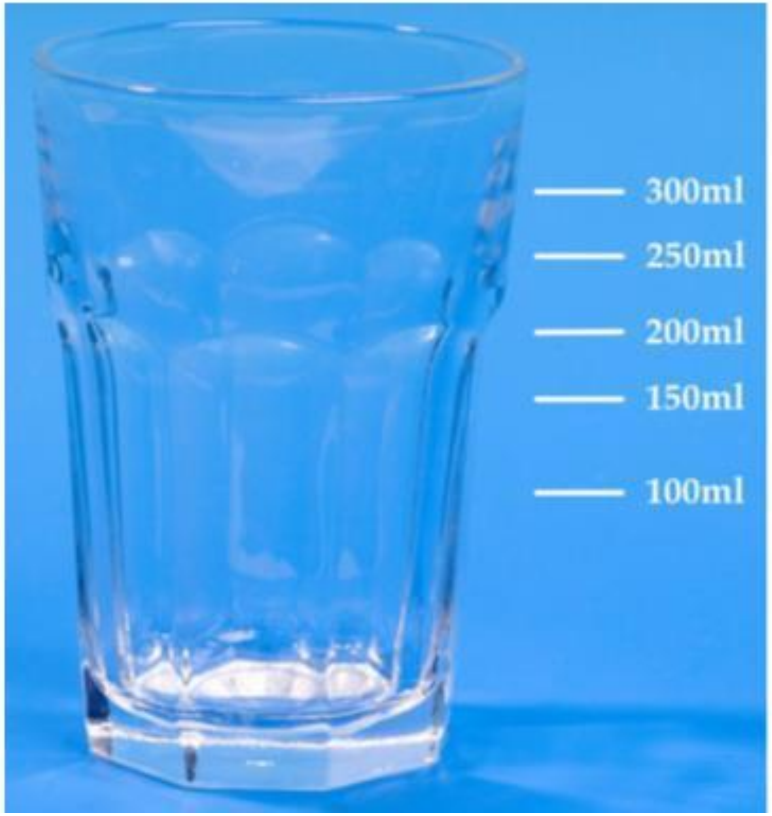
Teaspoon (tsp) Dessertspoon (dsp) Tablespoon (tbsp)

Drink Volume Guidance

Typical quantities of drinks in various containers measured in millimetres (ml)

	Small Glass	Average Glass	Large Glass	Vending Cup	Cup	Mug
Soft Drinks	150	200	300			
Hot Drinks				170	190	260

Here is a life size glass showing what typical quantities look like. You can use this picture a a guide for estimating how much volume of drink the glass holds you are drinking from



Day 1			Day:	Date:
Time	**Where? With whom? TV on? Table?**	**What**	**Brand name**	**Amount eaten**
		6 am to 9am		
		9am to 12 noon		
		12 noon to 2pm		

<table>
<tr><td colspan="3">Day 1</td><td>Day:</td><td>Date:</td></tr>
<tr><th>Time</th><th>Where? With whom?
TV on? Table?</th><th>What</th><th>Brand name</th><th>Amount eaten</th></tr>
<tr><td colspan="5">2pm to 5pm</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">5pm to 8pm</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">8pm to 10pm</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">10pm to 6am</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>

1. Was the amount of **food** that you had today about what you usually have, less than usual, or more than usual?

Usual ☐

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

2. Was the amount you had to **drink** today, including water, tea and coffee and soft drinks, about what you usually have, less than usual, or more than usual?

Usual ☐

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

3. Did you **finish all the food and drink** that you recorded in the diary today?

Usual ☐

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

There are some foods that people often forget

- Coffee, tea, soft drinks, water
- Milk
- Sauce, dressing
- Biscuits, cakes, sweets, chocolate, other confectionary
- Crisps, nuts, other snacks

If you have forgotten to record any food or drink today, please go back and **add them to the diary**

4. Did you take any **vitamins, minerals or other food supplements** today?

Yes ☐ No ☐

If yes **please describe the supplements you took below**

Brand	Name (in full) including strength	Number of pills, capsules, teaspoons

Please record on the next pages details of any recipes or (if not already described) ingredients of made up dishes or take-away dishes

Write in recipes or ingredients of made up dishes or take-away dishes			
Name of dish:		Serves:	
Ingredients	**Amount**	**Ingredients**	**Amount**
Brief description of cooking method:			

Day 2			Day:	Date:
Time	Where? With whom? TV on? Table?	What	Brand name	Amount eaten
6 am to 9am				
9am to 12 noon				
12 noon to 2pm				

Day 2			Day:	Date:
Time	Where? With whom? TV on? Table?	What	Brand name	Amount eaten
		2pm to 5pm		
		5pm to 8pm		
		8pm to 10pm		
		10pm to 6am		

1. Was the amount of **food** that you had today about what you usually have, less than usual, or more than usual?

Usual ☐

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

2. Was the amount you had to **drink** today, including water, tea and coffee and soft drinks, about what you usually have, less than usual, or more than usual?

Usual ☐

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

3. Did you **finish all the food and drink** that you recorded in the diary today?

Usual ☐

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

There are some foods that people often forget

- Coffee, tea, soft drinks, water
- Milk
- Sauce, dressing
- Biscuits, cakes, sweets, chocolate, other confectionary
- Crisps, nuts, other snacks

If you have forgotten to record any food or drink today, please go back and **add them to the diary**

4. Did you take any **vitamins, minerals or other food supplements** today?

Yes ☐ No ☐

If yes **please describe the supplements you took below**

Brand	Name (in full) including strength	Number of pills, capsules, teaspoons

Please record on the next pages details of any recipes or (if not already described) ingredients of made up dishes or take-away dishes

Write in recipes or ingredients of made up dishes or take-away dishes			
Name of dish:		Serves:	
Ingredients	**Amount**	**Ingredients**	**Amount**
Brief description of cooking method:			

Day 3			Day:	Date:
Time	Where? With whom? TV on? Table?	What	Brand name	Amount eaten
6 am to 9am				
9am to 12 noon				
12 noon to 2pm				

Day 3

Day 3			Day:	Date:
Time	Where? With whom? TV on? Table?	What	Brand name	Amount eaten
2pm to 5pm				
5pm to 8pm				
8pm to 10pm				
10pm to 6am				

1. Was the amount of **food** that you had today about what you usually have, less than usual, or more than usual?

Usual ☐

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

2. Was the amount you had to **drink** today, including water, tea and coffee and soft drinks, about what you usually have, less than usual, or more than usual?

Usual ☐

Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

3. Did you **finish all the food and drink** that you recorded in the diary today?

Usual ☐

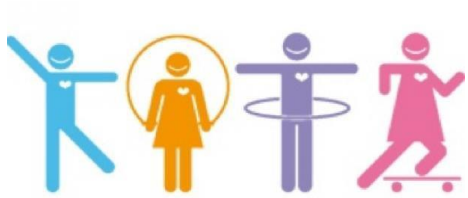
Less than usual ☐ **More** than usual ☐

If your intake was not usual, please explain why:

Write in recipes or ingredients of made up dishes or take-away dishes			
Name of dish:		Serves:	
Ingredients	**Amount**	**Ingredients**	**Amount**
Brief description of cooking method:			

8.5. Appendix E – PAQ-C

Durham University
School of Applied Social Sciences



Children's Physical Activity Questionnaire (PAQ-C)

We are trying to find out about your level of physical activity from *the last 7 days* (in the last week). This includes sports or dance that make you sweat or make your legs feel tired, or games that make you breathe hard, like tag, skipping, running, climbing and others.

Remember:

1. There are no right and wrong answers – this is not a test.
2. Please answer all the questions as honestly and accurately as you can – this is very important.

1. Which of the following PHYSICAL activities did you do in the past 7 days?

		Monday - Friday		Saturday – Sunday	
	No /Yes	How many times in the 4 days?	Total hours/ minutes	How many times over the weekend?	Total hours/minutes
Games/skipping					
Walking for exercise					
Cycling					
Jogging and/or running					
Aerobics					
Football					
Rugby/touch/7's					
Netball or basketball					
Hockey					
Cricket					
Rounders/base-/softball					
Badminton/tennis/squash h					
Rowing/canoeing					
Martial Arts					
Gymnastics					
Dance/cheerleading					
Roller or inline skating					
Skateboarding					
Horse-riding					
Swimming					
Sailing/windsurfing					
Other					
Other					

2. In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing)? (Check one only.)

- I don’t do PE ☐
- Hardly ever ☐
- Sometimes ☐
- Quite often ☐
- Always ☐

3. In the last 7 days, what did you do most of the time during breaktime? (Check one only.)

- Sat down (talking, reading, doing schoolwork) ☐
- Stood around or walked around ☐
- Ran or played a little bit ☐
- Ran or played quite a bit ☐
- Ran and played hard most of the time ☐

4. In the last 7 days, what did you normally do *at lunch* (besides eating lunch)? (Check one only.)

- Sat down (talking, reading, doing schoolwork) ☐
- Stood around or walked around ☐
- Ran or played a little bit ☐
- Ran or played quite a bit ☐
- Ran and played hard most of the time ☐

5. In the last 7 days, on how many days *right after school*, did you do sports, dance, or play games in which you were very active? (Check one only.)

None	☐
1 time last week	☐
2 or 3 times last week	☐
4 or 5 times last week	☐
6 or 7 times last week	☐

6. In the last 7 days, on how many *evenings* did you do sports, dance, or play games in which you were active? (Check one only.)

None	☐
1 time last week	☐
2 or 3 times last week	☐
4 or 5 times last week	☐
6 or 7 times last week	☐

7. *On the last weekend*, how many times did you do sports, dance, or play games in which you were active? (Check one only.)

None	☐
1 time last week	☐
2 or 3 times last week	☐
4 or 5 times last week	☐
6 or 7 times last week	☐

8. Which *one* of the following describes you best for the last 7 days? Read *allfive* statements before deciding one the *one* that describes you.

a) All or most of my free time was spent doing things that involve little physical effort

☐

b) I sometimes (1-2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics)

☐

c) I often (3-4 times last week) did physical things in my free time

☐

d) I quite often (5-6 times last week) did physical things in my free time

☐

e) I very often (7 or more times last week) did physical things in my free time

☐

9. Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week.

	None	Little bit	Medium	Often	Very often
Monday	☐	☐	☐	☐	☐
Tuesday	☐	☐	☐	☐	☐
Wednesday	☐	☐	☐	☐	☐
Thursday	☐	☐	☐	☐	☐
Friday	☐	☐	☐	☐	☐
Saturday	☐	☐	☐	☐	☐
Sunday	☐	☐	☐	☐	☐

10. Were you sick last week, or did anything prevent you from doing your normal physical activities. (Check one.)

Yes ☐

No ☐

If yes, what prevented you?...

Thank you for completing this questionnaire

8.6. Appendix F - GNKQ

GENERAL NUTRITION KNOWLEDGE QUESTIONNAIRE for PARENT/GUARDIAN

This is a survey, not a test. Your answers will help identify which dietary advice people find confusing. It is important that you complete it by yourself. Your answers will remain anonymous. If you don't know the answer, mark "not sure" rather than guess.
Thank you for your time.

Relationship to child:

Section 1: The first few items are about what advice you think experts are giving us.

1. Do health experts recommend that people should be eating more, the same amount, or less of the following foods? (tick one box per food)

	More	Same	Less	Not Sure
Fruit	☐	☐	☐	☐
Food and drinks with added sugar	☐	☐	☐	☐
Vegetables	☐	☐	☐	☐
Fatty foods	☐	☐	☐	☐
Processed red meat	☐	☐	☐	☐
Wholegrains	☐	☐	☐	☐
Salty foods	☐	☐	☐	☐
Water	☐	☐	☐	☐

2. How many servings of fruit and vegetables per day do experts advise people to eat as a minimum? (One serving could be, for example, an apple or a handful of chopped carrots)
(tick one)

2	☐
3	☐
4	☐
5 or more	☐

Not sure	☐

3. Which of these types of fats do experts recommend that people should eat less of? (tick one box per food)

	Eat less	Not eat less	Not sure
Unsaturated fats	☐	☐	☐
Trans fats	☐	☐	☐
Saturated fats	☐	☐	☐

4. Which type of dairy foods do experts say people should drink? (tick one)

Full fat (e.g. full fat milk)	☐
Reduced fat (e.g. skimmed and semi-skimmed milk)	☐
Mixture of full fat and reduced fat	☐
Neither, dairy foods should be avoided	☐
Not sure	☐

5. How many times per week do experts recommend that people eat oily fish (e.g. salmon and mackerel)? (tick one)

1-2 times per week	☐
3-4 times per week	☐
Every day	☐
Not sure	☐

6. How many times per week do experts recommend that people eat breakfast? (tick one)

3 times per week	☐
4 times per week	☐
Every day	☐
Not sure	☐

7. If a person has two glasses of fruit juice in a day, how many of their daily fruit and

vegetable servings would this count as? (tick one)

None	☐
One serving	☐
Two servings	☐
Three servings	☐
Not sure	☐

8. According to the ‘eatwell guide’ (a guideline showing the proportions of food types people should eat to have a balanced and healthy diet), how much of a person’s diet should be made up of starchy foods? (tick one)

Quarter	☐
Third	☐
Half	☐
Not sure	☐

Section 2: Experts classify foods into groups. We are interested to see whether people are aware of food groups and the nutrients they contain.

1. Do you think these foods and drinks are typically high or low in added sugar? (tick one box per food)

	High in added sugar	Low in added sugar	Not sure
Diet cola drinks	☐	☐	☐
Natural yoghurt	☐	☐	☐
Ice cream	☐	☐	☐
Tomato ketchup	☐	☐	☐
Melon	☐	☐	☐

2. Do you think these foods are typically high or low in salt? (tick one box per food)

	High in salt	Low in salt	Not Sure
Breakfast cereals	☐	☐	☐
Frozen vegetables	☐	☐	☐
Bread	☐	☐	☐
Baked beans	☐	☐	☐
Red meat	☐	☐	☐
Canned soup	☐	☐	☐

3. Do you think these foods are typically high or low in fibre? (tick one box per food)

	High in fibre	Low in fibre	Not Sure
Oats	☐	☐	☐
Bananas	☐	☐	☐
White rice	☐	☐	☐
Eggs	☐	☐	☐
Potatoes with skin	☐	☐	☐
Pasta	☐	☐	☐

4. Do you think these foods are a good source of protein? (tick one box per food)

	Good source of protein	Not a good source of protein	Not sure
Poultry	☐	☐	☐
Cheese	☐	☐	☐
Fruit	☐	☐	☐
Baked beans	☐	☐	☐
Butter	☐	☐	☐
Nuts	☐	☐	☐

5. Which of the following foods do experts count as starchy foods? (tick one box per food)

	Starchy food	Not a starchy food	Not sure
Cheese	☐	☐	☐
Pasta	☐	☐	☐
Potatoes	☐	☐	☐
Nuts	☐	☐	☐
Plantains	☐	☐	☐

6. Which is the main type of fat present in each of these foods? (tick one box per food)

	Polyunsaturate d fat	Monouns at-urated fat	Saturated fat	Cholester ol	Not sure
Olive oil	☐	☐	☐	☐	☐
Butter	☐	☐	☐	☐	☐
Sunflower oil	☐	☐	☐	☐	☐
Eggs	☐	☐	☐	☐	☐

7. Which of these foods has the most trans-fat? (tick one)

Biscuits, cakes and pastries ☐

Fish ☐

Rapeseed oil ☐

Eggs ☐

Not sure ☐

8. The amount of calcium in a glass of whole milk compared to a glass of skimmed milk is:
(tick one)

About the same ☐

Much higher ☐

Much lower ☐

Not sure ☐

9. Which one of the following nutrients has the most calories for the same weight of food? (tick one)

Sugar ☐

Starchy ☐

Fibre/roughage ☐

Fat ☐

Not sure ☐

10. Compared to minimally processed foods, processed foods are: (tick one)

Higher in calories ☐

Higher in fibre ☐

Lower in salt ☐

Not sure ☐

Section 3: The next few items are about choosing foods

1. If a person wanted to buy a yogurt at the supermarket, which would have the least sugar/sweetener? (tick one)

0% fat cherry yogurt ☐
Natural yogurt ☐
Creamy fruit yogurt ☐
Not sure ☐

2. If a person wanted soup in a restaurant or cafe, which one would be the lowest fat option? (tick one)

Mushroom risotto soup (field mushrooms, porcini mushrooms, arborio rice, butter, cream, parsley and cracked black pepper) ☐
Carrot butternut and spice soup (carrot , butternut squash, sweet potato, cumin, red chillies, coriander seeds and lemon) ☐
Cream of chicken soup (British chicken, onions, carrots, celery, potatoes, garlic, sage, wheat flour, double cream) ☐
Not sure ☐

3. Which would be the healthiest and most balanced choice for a main meal in a restaurant? (tick one)

Roast turkey, mashed potatoes and vegetables ☐
Beef, Yorkshire pudding and roast potatoes ☐
Fish and chips served with peas and tartar sauce ☐
Not sure ☐

4. Which would be the healthiest and most balanced sandwich lunch? (tick one)

Ham sandwich + fruit + blueberry muffin + fruit juice ☐
Tuna salad sandwich + fruit + low fat yogurt + water ☐
Egg salad sandwich + crisps + low fat yogurt + water ☐
Not sure ☐

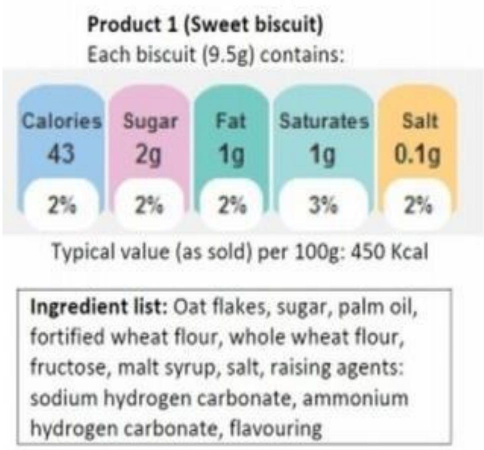
5. Which of these foods would be the healthiest choice for a pudding? (tick one)

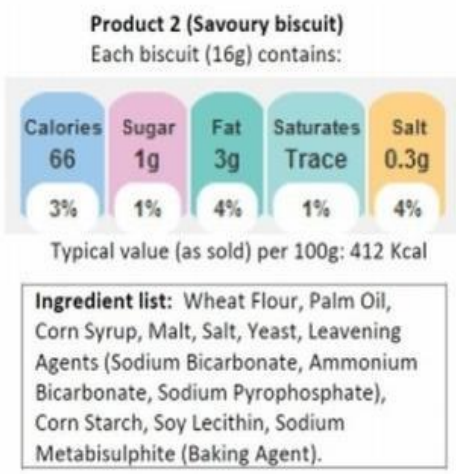
Berry sorbet ☐
Apple and blackberry pie ☐
Lemon cheesecake ☐

Carrot cake with cream cheese topping	☐
Not sure	☐
6. Which of these combinations of vegetables in a salad would give the greatest variety of vitamins and antioxidants? (tick one)	
Lettuce, green peppers and cabbage	☐
Broccoli, carrot and tomatoes	☐
Red peppers, tomatoes and lettuce	☐
Not sure	☐
7. If a person wanted to reduce the amount of fat in their diet, but didn't want to give up chips, which of the following foods would be the best choice? (tick one)	
Thick cut chips	☐
Thin cut chips	☐
Crinkle cut chips	☐
Not sure	☐
8. One healthy way to add flavour to food without adding extra fat or salt is to add: (tick one)	
Coconut milk	☐
Herbs	☐
Soya sauce	☐
Not sure	☐
9. Which of the following cooking methods requires fat to be added? (tick one)	
Grilling	☐
Steaming	☐
Baking	☐
Sautéing	☐
Not sure	☐
10. Traffic lights are often used on nutrition labelling, what would amber mean for the fat content of a food? (tick one)	
Low fat	☐
Medium fat	☐
High in fat	☐
Not sure	☐
11. "Light" foods (or Diet foods) are always good options because they are low in calories. (tick one)	

Agree	☐
Disagree	☐
Not sure	☐

The following questions are related to food labels:





12. Looking at products 1 and 2, which one has the most calories (kcal) per 100 grams (tick one)

Product 1	☐
Product 2	☐
Both have the same quantity	☐
Not sure	☐

13. Looking at product 1, what are the sources of sugar in the ingredient list? (tick one)

Sugar and malt syrup	☐
Sugar, fructose and lecithin	☐
Sugar, fructose and malt syrup	☐
Not sure	☐

Section 4: This section is about health problems or diseases related to diet and weight management	
1. Which of these diseases is related to a low intake of fibre? (tick one)	
Bowel disorders	☐
Anaemia	☐
Tooth decay	☐
Not sure	☐
2. Which of these diseases is related to how much sugar people eat? (tick one)	
High blood pressure	☐
Tooth decay	☐
Anaemia	☐
Not sure	☐

3. Which of these diseases is related to how much salt (or sodium) people eat? (tick one)

Hypothyroidism ☐
Diabetes ☐
High blood pressure ☐
Not sure ☐

4. Which of these options do experts recommend to reduce the chances of getting cancer?
(tick one)

Drinking alcohol regularly ☐
Eating less red meat ☐
Avoiding additives in food ☐
Not sure ☐

5. Which of these options do experts recommend to prevent heart disease? (tick one)

Taking nutritional supplements ☐
Eating less oily fish ☐
Eating less trans-fats ☐
Not sure ☐

6. Which of these options do experts recommend to prevent diabetes? (tick one)

Eating less refined foods ☐
Drinking more fruit juice ☐
Eating more processed meat ☐
Not sure ☐

7. Which one of these foods is more likely to raise people's blood cholesterol? (tick one)

Eggs ☐
Vegetable oils ☐
Animal fat ☐
Not sure ☐

8. Which one of these foods is classified as having a high Glycaemic Index (Glycaemic Index is a measure of the impact of a food on blood sugar levels, thus a high Glycaemic Index means a greater rise in blood sugar after eating)? (tick one)

Wholegrain cereals ☐
White bread ☐
Fruit and vegetables ☐

Not sure ☐

9. To maintain a healthy weight people should cut fat out completely. (tick one)

Agree ☐

Disagree ☐

Not sure ☐

10. To maintain a healthy weight people should eat a high protein diet. (tick one)

Agree ☐

Disagree ☐

Not sure ☐

11. Eating bread always causes weight gain. (tick one)

Agree ☐

Disagree ☐

Not Sure ☐

12. Fibre can decrease the chances of gaining weight. (tick one)

Agree ☐

Disagree ☐

Not sure ☐

13. Which of these options can help people to maintain a healthy weight? (answer each one)

	Yes	No	Not sure
Not eating while watching TV	☐	☐	☐
Reading food labels	☐	☐	☐
Taking nutritional supplements	☐	☐	☐
Monitoring their eating	☐	☐	☐
Monitoring their weight	☐	☐	☐
Grazing throughout the day	☐	☐	☐

14. If someone has a Body Mass Index (BMI) of 23kg/m^2, what would their weight status be?
(tick one)

Underweight	☐
Normal weight	☐
Overweight	☐
Obese	☐
Not sure	☐

15. If someone has a Body Mass Index (BMI) of 31kg/m^2, what would their weight status be?
(tick one)

Underweight	☐
Normal weight	☐
Overweight	☐
Obese	☐
Not sure	☐

Look at the body shapes below:

16. Which of these body shapes increases the risk of cardiovascular disease (Cardiovascular disease is a general term that describes a disease of the heart of blood vessels, for example, angina, heart attack, heart failure, congenital heart disease and stroke)? (tick one)

Apple shape ☐.

Pear shape ☐

Not sure ☐

Section 5: We would like to ask you a few questions about yourself

1. Are you

Male ☐

Female ☐

2. What is your current weight approximately? Please give this in stones and pounds or kilograms.

Stones	
Pounds	
Or Kilograms	

3. What is your current height approximately? Please give this in feet and inches or centimetres.

Feet	
Inches	
Or Centimetres	

4. In general, would you say your health is…

Poor ☐

Fair ☐

Good ☐

Very good ☐

Excellent ☐

5. What best describe your ethnic origin? (tick one)

White British ☐

White Irish ☐

Other White background ☐

Black British ☐

Black Caribbean ☐

Black African	☐
Other Black background	☐
Indian	☐
Pakistani	☐
Bangladeshi	☐
Chinese	☐
Other Asian background	☐
White and Black Caribbean	☐
White and Black African	☐
White and Asian	☐
Other mixed background	☐
Other, please specify:	

Thank you very much for taking part in this survey!

8.7. Appendix G – Follow up letter to participants distributed by GTP staff

Durham & Chester-le-Street SSP
House of Sport
School House
Haworth Building
Leazes Road,
Durham, DH1 1TA
(0191) 334 7209

Durham & Chester-le-Street School Sport Partnership
Working in collaboration with Durham Sixth Form Centre

Dear Parent or Guardian,

I hope your children enjoyed the two Gifted and Talented camp days this term. I enjoyed meeting many of them and was impressed by their ability to pick up new sports. I spoke to many of you at pick-up time about my nutrition survey. Thank you so much to those who agreed to participate, it really helps my research to have as many surveys completed as possible. For those I didn't manage to speak to, I'm running a research project on the Gifted and Talented Group with the aim of learning more about their nutrition. I hope this will benefit not only the G&T program in the future but hopefully, similar children across the country. If you would like to participate and did not receive a survey, please contact me and I can arrange to drop one of at your child's school.

I hope you have managed to complete the survey without any problems, but please contact me if needed at emma.c.wauchope@dur.ac.uk. When you have completed it, you can return it either by taking it to school, notifying me by email that it is ready for collection, or by post. Preferably after July 6th, please return it by post to:

Emma Wauchope

School of Applied Social Sciences

32 Old Elvet

Durham

DH1 3HN

The last date for completion is the 21st July.

Thankyou so much for your participation,

E Wauchope

Post-Graduate Researcher

Durham University

Durham University
School of Applied Social Sciences

Chapter 9. References

ABBASPOUR, N., HURRELL, R. & KELISHADI, R. 2014. Review on iron and its importance for human health. *Journal of Research in Medical Sciences : The Official Journal of Isfahan University of Medical Sciences,* 19, 164-174.

ABRAMS, S. A., GRUSAK, M. A., STUFF, J. & O'BRIEN, K. O. 1997. Calcium and magnesium balance in 9-14-y-old children. *Am J Clin Nutr,* 66, 1172-7.

ABUSABHA, R. & WOELFEL, M. L. 2003. Qualitative vs quantitative methods: two opposites that make a perfect match. *J Am Diet Assoc,* 103, 566-9.

ALSAFFAR, A. A. 2012. Validation of a general nutrition knowledge questionnaire in a Turkish student sample. *Public Health Nutr,* 15, 2074-85.

AMERICAN COLLEGE OF SPORTS MEDICINE, ASSOCIATION, A. D. & CANADA, D. O. 2000. Joint Position Statement: nutrition and athletic performance. *Med Sci Sports Exerc,* 32, 2130-45.

ANDERSEN, R. M. 2008. National health surveys and the behavioral model of health services use. *Med Care,* 46, 647-53.

ANTHONY, P. 2008. Nutrition Screening Tools for Hospitalized Patients. *Nutrition in Clinical Practice,* 23, 373-382.

APPEL, L. J., LICHTENSTEIN, A. H., CALLAHAN, E. A., SINAIKO, A., VAN HORN, L. & WHITSEL, L. 2015. Reducing Sodium Intake in Children: A Public Health Investment. *The Journal of Clinical Hypertension,* 17, 657-662.

ARA, I., VICENTE-RODRIGUEZ, G., PEREZ-GOMEZ, J., JIMENEZ-RAMIREZ, J., SERRANO-SANCHEZ, J. A., DORADO, C. & CALBET, J. A. L. 2006. Influence of extracurricular sport activities on body composition and physical fitness in boys: a 3-year longitudinal study. *International Journal Of Obesity,* 30, 1062.

ATKIN, A. J., SHARP, S. J., HARRISON, F., BRAGE, S. & VAN SLUIJS, E. M. 2016. Seasonal variation in Children's physical activity and sedentary time. *Medicine and science in sports and exercise,* 48, 449.

AUSTRALIAN GOVERNMENT 2014. Move and Play Every Day - National Physical Activity Recommendations for Children 0-5 years. *In:* HEALTH, D. F. (ed.). Online

AXELSON, M. L. & BRINBERG, D. 1992. The measurement and conceptualization of nutrition knowledge. *Journal of Nutrition Education,* 24, 239-246.

BANDURA, A. & WALTERS, R. H. 1977. Social learning theory.

BARANOWSKI, T. & DOMEL, S. B. 1994. A cognitive model of children's reporting of food intake. *The American Journal of Clinical Nutrition,* 59, 212S-217S.

BARANOWSKI, T., DWORKIN, R., HENSKE, J. C., CLEARMAN, D. R., DUNN, J. K., NADER, P. R. & HOOKS, P. C. 1986. The accuracy of children's self-reports of diet: Family Health Project. *J Am Diet Assoc,* 86, 1381-5.

BARBOSA, L. B., VASCONCELOS, S. M., CORREIA, L. O. & FERREIRA, R. C. 2016. Nutrition knowledge assessment studies in adults: a systematic review. *Cien Saude Colet,* 21, 449-62.

BASIOTIS, P.P., WELSH, S.O., CRONIN, F.J., KELSAY, J.L. & MERTZ, W., 1987. Number of days of food intake records required to estimate individual and group nutrient intakes with defined confidence. *The Journal of nutrition*, *117*(9), pp.1638-1641.

BASTERFIELD, L., ADAMSON, A. J., PARKINSON, K. N., MAUTE, U., LI, P. X. & REILLY, J. J. 2008. Surveillance of physical activity in the UK is flawed: validation of the Health Survey for England Physical Activity Questionnaire. *Arch Dis Child,* 93, 1054-8.

BBC NEWS ONLINE 2016. Sugar intake in children 'double recommended level'. *Health.*

BEAGLEHOLE, R., BONITA, R., HORTON, R., ADAMS, C., ALLEYNE, G., ASARIA, P., BAUGH, V.,

BEKEDAM, H., BILLO, N., CASSWELL, S., CECCHINI, M., COLAGIURI, R., COLAGIURI, S., COLLINS, T., EBRAHIM, S., ENGELGAU, M., GALEA, G., GAZIANO, T., GENEAU, R.,

HAINES, A., HOSPEDALES, J., JHA, P., KEELING, A., LEEDER, S., LINCOLN, P., MCKEE, M., MACKAY, J., MAGNUSSON, R., MOODIE, R., MWATSAMA, M., NISHTAR, S., NORRVING, B., PATTERSON, D., PIOT, P., RALSTON, J., RANI, M., REDDY, K. S., SASSI, F., SHERON, N., STUCKLER, D., SUH, I., TORODE, J., VARGHESE, C. & WATT, J. 2011 Priority actions for the non-communicable disease crisis. *The Lancet,* 377, 1438-1447.
BEEK, E. J. V. D. 1991. Vitamin supplementation and physical exercise performance. *Journal of Sports Sciences,* 9.
BELLISLE, F. & ROLLAND-CACHERA, M. F. 2007. Three consecutive (1993, 1995, 1997) surveys of food intake, nutritional attitudes and knowledge, and lifestyle in 1000 French children, aged 9-11 years. *J Hum Nutr Diet,* 20, 241-51.
BENITEZ-PORRES, J., ALVERO-CRUZ, J. R., SARDINHA, L. B., LOPEZ-FERNANDEZ, I. & CARNERO, E. A. 2016. Cut-off values for classifying active children and adolescentes using the Physical Activity Questionnaire: PAQ-C and PAQ-ACut-off values for classifying active children and adolescents using the Physical Activity Questionnaire: PAQ-C and PAQ-A. *Nutr Hosp,* 33, 564.
BENSON, J. E., ENGELBERT-FENTON, K. A. & EISENMAN, P. A. 1996. Nutritional aspects of amenorrhea in the female athlete triad. *International Journal of Sport Nutrition and Exercise Metabolism,* 6, 134-145.
BENTLEY, G. F., JAGO, R. & TURNER, K. M. 2015. Mothers' perceptions of the UK physical activity and sedentary behaviour guidelines for the early years (Start Active, Stay Active): a qualitative study. *BMJ Open,* 5.
BERKEY, C. S., ROCKETT, H. R. H., GILLMAN, M. W. & COLDITZ, G. A. 2003. One-Year Changes in Activity and in Inactivity Among 10- to 15-Year-Old Boys and Girls: Relationship to Change in Body Mass Index. *Pediatrics,* 111, 836-843.
BERVOETS, L., VAN NOTEN, C., VAN ROOSBROECK, S., HANSEN, D., VAN HOORENBEECK, K., VERHEYEN, E., VAN HAL, G. & VANKERCKHOVEN, V. 2014. Reliability and Validity of the Dutch Physical Activity Questionnaires for Children (PAQ-C) and Adolescents (PAQ-A). *Archives of Public Health,* 72, 47.
BILLAH, S. M., FERDOUS, T. E., KARIM, M. A., DIBLEY, M. J., RAIHANA, S., MOINUDDIN, M., CHOUDHURY, N., AHMED, T., HOQUE, D. M. E., MENON, P. & ARIFEEN, S. E. 2017. A community-based cluster randomised controlled trial to evaluate the effectiveness of different bundles of nutrition-specific interventions in improving mean length-for-age z score among children at 24 months of age in rural Bangladesh: study protocol. *BMC Public Health,* 17, 375.
BIRCH, L. L. 1992. Children's Preferences for High-Fat Foods. *Nutrition Reviews,* 50, 249-255.
BRADETTE-LAPLANTE, M., CARBONNEAU, É., PROVENCHER, V., BÉGIN, C., ROBITAILLE, J., DESROCHES, S., VOHL, M.-C., CORNEAU, L. & LEMIEUX, S. 2016. Development and validation of a nutrition knowledge questionnaire for a Canadian population. *Public Health Nutrition,* 20, 1184-1192.
BRENNER, J. S. 2016. Sports Specialization and Intensive Training in Young Athletes. *Pediatrics,* 138.
BRITISH NUTRITION FOUNDATION. 2015a. *Children* [Online]. Available: https://www.nutrition.org.uk/healthyliving/lifestages/children.html?limit=1&start=3 [Accessed].
BRITISH NUTRITION FOUNDATION. 2015b. *Food in Schools - The Curriculum* [Online]. Available: https://www.nutrition.org.uk/foodinschools/curriculum/the-curriculum.html [Accessed].
BRITISH NUTRITION FOUNDATION 2015c. Nutrition Requirements.

BRITISH NUTRITION FOUNDATION. 2016a. *The eatwell guide - A revised healthy eating model* [Online]. Available: https://www.nutrition.org.uk/healthyliving/eatwellguide/eatwell.html [Accessed].
BRITISH NUTRITION FOUNDATION 2016b. Revised Nutrition Requirements. Online **https://www.nutrition.org.uk/healthyliving/resources/nutritionrequirements.html.**
BRITISH SOFT DRINKS ASSOCIATION 2014. The 2014 UK Soft Drinks Report - Creating New Choices.
BROUGHTON, D., FAIRCHILD, R. M. & MORGAN, M. Z. 2016. A survey of sports drinks consumption among adolescents. *Br Dent J,* 220, 639-43.
BRYANT, T. 2002. Role of knowledge in public health and health promotion policy change*. *Health Promotion International,* 17, 89-98.
BUKENYA, R., AHMED, A., ANDRADE, J. M., GRIGSBY-TOUSSAINT, D. S., MUYONGA, J. & ANDRADE, J. E. 2017. Validity and Reliability of General Nutrition Knowledge Questionnaire for Adults in Uganda. *Nutrients,* 9, 172.
BURKE, K. A. E. D. T. T. L. M. 2016. Nutrition and Athletic Performance. Position of Dietitians of Canada, the Academy of Nutrition and Dietetics and the American College of Sports Medicine.
BURKE, L. 2015. Re-Examining High-Fat Diets for Sports Performance: Did We Call the 'Nail in the Coffin' Too Soon? *Journal of Sports Medicine,* 45, 33-49.
BURROWS, T. L., MARTIN, R. J. & COLLINS, C. E. 2010. A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. *J Am Diet Assoc,* 110, 1501-10.
BURROWS, T. L., TRUBY, H., MORGAN, P. J., CALLISTER, R., DAVIES, P. S. W. & COLLINS, C. E. 2013. A comparison and validation of child versus parent reporting of children's energy intake using food frequency questionnaires versus food records: Who's an accurate reporter? *Clinical Nutrition,* 32, 613-618.
BUTTON, K.S., IOANNIDIS, J.P., MOKRYSZ, C., NOSEK, B.A., FLINT, J., ROBINSON, E.S. AND MUNAFÒ, M.R., 2013. Power failure: why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience*, *14*(5), p.365.
BUTTRISS, J. L. 2016. The Eatwell Guide refreshed. *Nutrition Bulletin,* 41, 135-141.
BYTOMSKI, J. R. & SQUIRE, D. L. 2003. Heat illness in children. *Curr Sports Med Rep,* 2, 320-4.
CALFAS, K. J., SALLIS, J. F. & NADER, P. R. 1991. The development of scales to measure knowledge and preference for diet and physical activity behavior in 4- to 8-year-old children. *J Dev Behav Pediatr,* 12, 185-90.
CALFEE, R. & FADALE, P. 2006. Popular Ergogenic Drugs and Supplements in Young Athletes. *Pediatrics,* 117, e577-e589.
CANADIAN SOCIETY FOR EXERCISE PHYSIOLOGY 2016a. The Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour and Sleep.
CANADIAN SOCIETY FOR EXERCISE PHYSIOLOGY 2016b. Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep Guideline Development Report.
CANNELL, J. J., HOLLIS, B. W., SORENSON, M. B., TAFT, T. N. & ANDERSON, J. J. 2009. Athletic performance and vitamin D. *Medicine & Science in Sports & Exercise,* 41, 1102-1110.
CARBON TRUST 2016. Methodology and Results Summary *The Eatwell Guide: A More Sustainable Diet* UK.
CARTER, S. M. & LITTLE, M. 2007. Justifying knowledge, justifying method, taking action: epistemologies, methodologies, and methods in qualitative research. *Qual Health Res,* 17, 1316-28.

CAVADINI, C., DECARLI, B., GRIN, J., NARRING, F., & MICHAUD, P.A. 2000. Food habits and sport activity during adolescence: differences between athletic and non-athletic teenagers in Switzerland. . *European Journal of Clinical Nutrition,* 54, 16-20.

CENTERS FOR DISEASE CONTROL AND PREVENTION 2010. The association between school based physical activity, including physical education, and academic performance. U.S. Department of Health and Human Services.

CHAMBERS, E. T., GODWIN, S. L. & VECCHIO, F. A. 2000. Cognitive strategies for reporting portion sizes using dietary recall procedures. *J Am Diet Assoc,* 100, 891-7.

CHAPUT, J. P., GRAY, C. E., POITRAS, V. J., CARSON, V., GRUBER, R., OLDS, T., WEISS, S. K., CONNOR GORBER, S., KHO, M. E., SAMPSON, M., BELANGER, K., ERYUZLU, S., CALLENDER, L. & TREMBLAY, M. S. 2016. Systematic review of the relationships between sleep duration and health indicators in school-aged children and youth. *Appl Physiol Nutr Metab,* 41, S266-82.

CHEVALLEY, T., BONJOUR, J.-P., AUDET, M.-C., MERMINOD, F., VAN RIETBERGEN, B., RIZZOLI, R. & FERRARI, S. 2017. Prepubertal Impact of Protein Intake and Physical Activity on Weight-Bearing Peak Bone Mass and Strength in Males. *The Journal of Clinical Endocrinology & Metabolism,* 102, 157-166.

CHRISTAKOS, S., DHAWAN, P., VERSTUYF, A., VERLINDEN, L. & CARMELIET, G. 2015. Vitamin D: metabolism, molecular mechanism of action, and pleiotropic effects. *Physiological reviews,* 96, 365-408**.**

CLENIN, G., CORDES, M., HUBER, A., SCHUMACHER, Y. O., NOACK, P., SCALES, J. & KRIEMLER, S. 2015. Iron deficiency in sports - definition, influence on performance and therapy. *Swiss Med Wkly,* 145, w14196**.**

COHEN, J. 1977. CHAPTER 3 - The Significance of a Product Moment rs. *Statistical Power Analysis for the Behavioral Sciences (Revised Edition).* Academic Press.

COMMITTEE ON MEDICAL ASPECTS OF FOOD AND NUTRITION POLICY 1991. Dietary Reference Values for Food and Energy and Nutrients for the United Kingdom *In:* HEALTH, D. O. (ed.).

COOK, A., PRYER, J. & SHETTY, P. 2000. The problem of accuracy in dietary surveys. Analysis of the over 65 UK National Diet and Nutrition Survey. *Journal of Epidemiology and Community Health,* 54, 611-616.

COOMBES, J. S. 2005. Sports drinks and dental erosion. *Am J Dent,* 18, 101-4.

COOMBES, J. S. & HAMILTON, K. L. 2000. The effectiveness of commercially available sports drinks. *Sports Med,* 29, 181-209.

COTUNGA, N., VICKERY, C. E. & MCBEE, S. 2005. Sports nutrition for young athletes. *J Sch Nurs,* 21, 323-8**.**

COUNTY DURHAM SPORT. 2017. *School Games* [Online]. Available: http://www.countydurhamsport.com/2012_legacy/school_games [Accessed 15/03/2018 2018].

COWELL, B. S., ROSENBLOOM, C. A., SKINNER, R. & SUMMERS, S. H. 2003. Policies on screening female athletes for iron deficiency in NCAA division I-A institutions. *Int J Sport Nutr Exerc Metab,* 13, 277-85.

CRAWFORD, D. A. & BAGHURST, K. I. 1990. Diet and health: a national survey of beliefs, behaviours and barriers to change in the community *Australian Journal of Nutrition and Dietics,* 5, 97-104.

CRAWFORD, B., OBARZANEK, E., MORRISON & J. SABRY, Z. (1994). Comparative advantage of 3-day food records over 24-hour recall and 5-day food frequency validated by observation of 9- and 10-year-old girls. Journal of the American Dietetic Association. 94. 626-30. 10.1016/0002-8223(94)90158-9.

CRIBB, V. L., NORTHSTONE, K., HOPKINS, D. & EMMETT, P. M. 2015. Sources of vitamin D and calcium in the diets of preschool children in the UK and the theoretical effect of food fortification. *Journal of Human Nutrition and Dietetics,* 28, 583-592.

CROCKER, P. R., BAILEY, D. A., FAULKNER, R. A., KOWALSKI, K. C. & MCGRATH, R. 1997. Measuring general levels of physical activity: preliminary evidence for the Physical Activity Questionnaire for Older Children. *Med Sci Sports Exerc,* 29, 1344-9.

CROUCH, T. 2015. Sporting Future. *In:* DIGITAL, C., MEDIA AND SPORT (ed.). Online Department for Digital, Culture, Media and Sport.

DARMON, N. & DREWNOWSKI, A. 2008. Does social class predict diet quality? *Am J Clin Nutr,* 87, 1107-17.

DAVIES, P. S., COWARD, W., GREGORY, J., WHITE, A. & MILLS, A. 1994. Total energy expenditure and energy intake in the pre-school child: a comparison. *British Journal of Nutrition,* 72, 13-20.

DAVISON, K. K., MARSHALL, S. J. & BIRCH, L. L. 2006. Cross-sectional and longitudinal associations between TV viewing and girls' body mass index, overweight status, and percentage of body fat. *The Journal of Pediatrics,* 149, 32-37.

DE VAUS, D. 2002. *Surveys in Social Research*, Taylor & Francis.

DEHEEGER, M., ROLLAND-CACHERA, M. F. & FONTVIEILLE, A. M. 1997. Physical activity and body composition in 10 year old French children: linkages with nutritional intake? *International Journal Of Obesity,* 21, 372.

DEHGHAN, M., AKHTAR-DANESH, N. & MERCHANT, A. T. 2005. Childhood obesity, prevalence and prevention. *Nutrition Journal,* 4, 24.

DENZIN, N. K. & LINCOLN, Y. S. 2011. The Discipline and Practice of Qualitative Research. *In:* NORMAN K. DENZIN, Y. S. L. (ed.) *The SAGE Handbook of Qualitative Research.* 4 ed.: SAGE Publications, 2017.

DEPARTMENT FOR EDUCATION AND SKILLS & DEPARTMENT OF CULTURE, M. A. S. 2002. Learning through PE and Sport: A Guide to the Physical education, Schools Sport and Club Links Strategy. *In:* SKILLS, D. F. E. A. (ed.). Nottingham.

DEPARTMENT OF HEALTH, P. A., HEALTH IMPROVEMENT AND PROTECTION. 2011. Start Active, Stay Active: A report on physical activity from the four home countries' Chief Medical Officers *In:* HEALTH, D. O. (ed.).

DEPARTMENT OF NUTRITION AT HARVARD SCHOOL OF PUBLIC HEALTH 2012. Sugary Drinks and Obesity Fact Sheet.

DESHMUKH-TASKAR, P. R., NICKLAS, T. A., O'NEIL, C. E., KEAST, D. R., RADCLIFFE, J. D. & CHO, S. 2010. The Relationship of Breakfast Skipping and Type of Breakfast Consumption with Nutrient Intake and Weight Status in Children and Adolescents: The National Health and Nutrition Examination Survey 1999-2006. *Journal of the American Dietetic Association,* 110, 869-878.

DEVERKA, P. A., LAVALLEE, D. C., DESAI, P. J., ESMAIL, L. C., RAMSEY, S. D., VEENSTRA, D. L. & TUNIS, S. R. 2012. Stakeholder participation in comparative effectiveness research: defining a framework for effective engagement. *Journal of comparative effectiveness research,* 1, 181-194.

HERRMANN, D.C. B., SIOEN, I., KOURIDE, Y., MARILD, S., MOLNÁR, D., MOURATIDOU, T., PITSILADIS, Y., RUSSO, P., VEIDEBAUM, T., AHRENS W. 2015. Impact of physical activity, sedentary behaviour and muscle strength on bone stiffness in 2–10-year-old children-cross-sectional results from the IDEFICS study. *International Journal of Behavioral Nutrition and Physical Activity,* 12.

DICKSON-SPILLMANN, M., SIEGRIST, M. & KELLER, C. 2011. Development and validation of a short, consumer-oriented nutrition knowledge questionnaire. *Appetite,* 56, 617-620.

DIEHL, K., THIEL, A., ZIPFEL, S., MAYER, J., LITAKER, D. G. & SCHNEIDER, S. 2012. How Healthy is the Behavior of Young Athletes? A Systematic Literature Review and Meta-Analyses. *Journal of Sports Science & Medicine,* 11, 201-220.

DIPALMA, J. R. & RITCHIE, D. M. 1977. Vitamin toxicity. *Annu Rev Pharmacol Toxicol,* 17, 133-48.

DOUGLAS, P. D. & DOUGLAS, J. G. 1984. Nutrition knowledge and food practices of high school athletes. *Journal of the American Dietetic Association,* 84, 1198-1202.

DRAPER, A. K. 2007. The principles and application of qualitative research. *Proceedings of the Nutrition Society,* 63, 641-646.

DURHAM AND CHESTER-LE-STREET SCHOOL SPORTS PARTNERSHIP. 2017a. *About Us* [Online]. Online Available: http://www.durhamcityssp.org.uk/?page=67&pm=0 [Accessed 23/08/2017 2017].

DURHAM AND CHESTER-LE-STREET SCHOOL SPORTS PARTNERSHIP. 2017b. *Durham City SSP* [Online]. Available: http://www.durhamcityssp.org.uk/?page=67&pm=0 [Accessed 25/05/2017 2017].

DURRHEIM, K. & PAINTER, D. 2006. Collecting quantitative data: sampling and measuring. *Research in practice: Applied methods for the social sciences.* Juta and Company Ltd.

ECONOMIC & SOCIAL RESEARCH COUNCIL 2015a. Framework for Research Ethics (FRE) *In:* COUNCIL, E. S. R. (ed.). Online Economic & Social research Council

ECONOMIC & SOCIAL RESEARCH COUNCIL. 2015b. *Our principles: researchers and research terms* [Online]. www.esrc.ac.uk Available: http://www.esrc.ac.uk/funding/guidance-for-applicants/research-ethics/our-principles-researchers-and-research-teams/ [Accessed 23/05/2017 2017].

EFSA PANEL ON DIETETIC PRODUCTS, N. & ALLERGIES 2010. Scientific Opinion on Dietary Reference Values for water. *EFSA Journal,* 8, 1459-n/a.

ENGELHARDT, M., NEUMANN, G., BERBALK, A. & REUTER, I. 1998. Creatine supplementation in endurance sports. *Med Sci Sports Exerc,* 30, 1123-9.

ERICKSON, F. 1996. A History of Qualitative Inquiry in Social and Educational Research *In:* FREDERICK ERICKSON DENZIN, N. K. (ed.) *The SAGE Handbook of qualitative research*

ERNST, E. 2002. The risk-benefit profile of commonly used herbal therapies: Ginkgo, St. John's Wort, Ginseng, Echinacea, Saw Palmetto, and Kava. *Ann Intern Med,* 136, 42-53.

EUROPEAN FOOD INFORMATION COUNCIL. 2011. *Special nutritional requirements of the child athlete* [Online]. Available: http://www.eufic.org/article/en/artid/Special-nutritional-requirements-child-athlete/ [Accessed].

FADE, S. 2004. Using interpretative phenomenological analysis for public health nutrition and dietetic research: a practical guide. *Proc Nutr Soc,* 63, 647-53.

FAGGIANO, F., VINEIS, P., CRAVANZOLA, D., PISANI, P., XOMPERO, G., RIBOLI, E. & KAAKS, R. 1992. Validation of a method for the estimation of food portion size. *Epidemiology,* 3, 379-82.

FAROOQ, M. A., PARKINSON, K. N., ADAMSON, A. J., PEARCE, M. S., REILLY, J. K., HUGHES, A. R., JANSSEN, X., BASTERFIELD, L. & REILLY, J. J. 2017. Timing of the decline in physical activity in childhood and adolescence: Gateshead Millennium Cohort Study. *British Journal of Sports Medicine*.

FARROKHYAR, F., TABASINEJAD, R., DAO, D., PETERSON, D., AYENI, O. R., HADIOONZADEH, R. & BHANDARI, M. 2015. Prevalence of Vitamin D Inadequacy in Athletes: A Systematic-Review and Meta-Analysis. *Sports Medicine,* 45, 365-378.

FAT, L. N. 2014. Health Survey for England, 2014 - Children's body mass index, overweight and obesity.

FAUTSCH MACIAS, Y. G., PETER. 2014. Guidelines forassessing nutrition-related Knowledge, Attitudes and Practices. *In:* NATIONS, F. A. A. O. O. T. U. (ed.).

FISHER, A., HILL, C., WEBBER, L., PURSLOW, L. & WARDLE, J. 2011. MVPA Is Associated with Lower Weight Gain in 8–10 Year Old Children: A Prospective Study with 1 Year Follow-Up. *PLoS ONE,* 6, e18576.

FISHER, J. O., JOHNSON, R. K., LINDQUIST, C., BIRCH, L. L. & GORAN, M. I. 2000. Influence of body composition on the accuracy of reported energy intake in children. *Obes Res,* 8, 597-603.

FITZGERALD, A., HEARY, C., NIXON, E. & KELLY, C. 2010. Factors influencing the food choices of Irish children and adolescents: a qualitative investigation. *Health Promotion International,* 25, 289-298.

FLINTOFF, A., FOSTER, R. & WYSTAWNOHA, S. 2011. Promoting and sustaining high quality physical education and school sport through school sport partnerships. *European Physical Education Review,* 17, 341-351.

FOLTA, S. C., GOLDBERG, J. P., ECONOMOS, C., BELL, R. & MELTZER, R. 2006. Food Advertising Targeted at School-Age Children: A Content Analysis. *Journal of Nutrition Education and Behavior,* 38, 244-248.

FOOD STANDARDS AGENCY 2007. FSA Nutrient and Food Based Guidelines for UK Institutions Online

FOOD STANDARDS AUSTRALIA NEW ZEALAND 2010 Consumer research investigating the use of formulated supplementary sports foods.

FOSTER, E. & ADAMSON, A. 2014. Challenges involved in measuring intake in early life: focus on methods. *Proceedings of the Nutrition Society,* 73, 201-209.

IMAMURA, F. R. M., KHATIBZADEH, S., FAHIMI,S., SHI, P., POWLES, J., MOZAFF ARIAN, D., 2015. Dietary quality among men and women in 187 countries in 1990 and 2010: a systematic assessment. *The Lancet,* 3, 132-142.

GALEMORE, C. A. 2011. Sports drinks and energy drinks for children and adolescents--are they appropriate? A summary of the clinical report. *NASN Sch Nurse,* 26, 320-1.

GIBSON, E. L., WARDLE, J. & WATTS, C. J. 1998. Fruit and vegetable consumption, nutritional knowledge and beliefs in mothers and children. *Appetite,* 31, 205-28.

GIBSON, R. S. 2005. *Principles of Nutritional Assessment*, Oxford University Press.

GITLIN, A., SIEGEL, M. & BORU, K. 1989. The politics of method: from leftist ethnography to educative research. *International Journal of Qualitative Studies in Education,* 2, 237-253.

GLEESON, M. 2006. *Immune Function in Sport and Exercise*, Elselvier Health Sciences

GORARD, S. 2003. Combining approaches: a 'compleat' researcher. *Quantitative methods in social science research.* Great Britain A&C Black.

GRIFFITH, R. 2016. What is Gillick competence? *Human Vaccines & Immunotherapeutics,* 12, 244-247.

GRIMES, C. A., BOLHUIS, D. P., HE, F. J. & NOWSON, C. A. 2016. Dietary sodium intake and overweight and obesity in children and adults: a protocol for a systematic review and meta-analysis. *Systematic Reviews,* 5, 7.

GRUNERT, K. G., WILLS, J., CELEMÍN, L. F., LÄHTEENMÄKI, L., SCHOLDERER, J. & STORCKSDIECK GENANNT BONSMANN, S. 2012. Socio-demographic and attitudinal determinants of nutrition knowledge of food shoppers in six European countries. *Food Quality and Preference,* 26, 166-177.

HA, E. & ZEMEL, M. B. 2003. Functional properties of whey, whey components, and essential amino acids: mechanisms underlying health benefits for active people (review). *The Journal of Nutritional Biochemistry,* 14, 251-258.

HADDAD , L. C. H., UDOMKESMALEE, E., ACHADI, E., AG BENDECH, M., AHUJA, A., BHUTTA, Z., FANZO, J., FRACASSI, P., GRUMMER-STRAWN, L.M., KIMANI, E., MARTIN-PRÉVEL, Y., MENON, P., KOUKOUBOU, E.N., NUGENT, R., OENEMA, S., RANDEL, J., REQUEJO, J., SLAYMAKER, T., SWINBURN B., 2016. Global Nutrition Report 2016.

HARCOMBE, Z. 2016. Designed by the food industry for wealth, not health: the 'Eatwell Guide'. *Br J Sports Med*.

HARMER, P. A. 2010. Anabolic-androgenic steroid use among young male and female athletes: is the game to blame? *British Journal of Sports Medicine,* 44, 26-31.

HARRIS, J. E., GLEASON, P. M., SHEEAN, P. M., BOUSHEY, C., BETO, J. A. & BRUEMMER, B. 2009. An Introduction to Qualitative Research for Food and Nutrition Professionals. *Journal of the American Dietetic Association,* 109, 80-90.

HEALTH RESEARCH AUTHORITY. 2017. *Consent and Participant Information Sheet* [Online]. Online [Accessed 23/05/2017 2017].

HEANEY, S., O'CONNOR, H., MICHAEL, S., GIFFORD, J. & NAUGHTON, G. 2011. Nutrition knowledge in athletes: a systematic review. *Int J Sport Nutr Exerc Metab,* 21, 248-61.

HEANEY, S., O'CONNOR, H., NAUGHTON, G. & GIFFORD, J. 2008. Towards an Understanding of the Barriers to Good Nutrition for Elite Athletes. *International Journal of Sports Science & Coaching,* 3, 391-401.

HEINRICHS, N., BERTRAM, H., KUSCHEL, A. & HAHLWEG, K. 2005. Parent recruitment and retention in a universal prevention program for child behavior and emotional problems: Barriers to research and program participation. *Prevention Science,* 6, 275-286.

HENDERSON, L., GREGORY, J. & SWAN, G. 2003. The National Diet and Nutrition Survey: adults aged 19 to 64 years. *Vitamin and mineral intake and urinary analytes,* 3.

HENDRIE, G. A., COVENEY, J. & COX, D. 2008a. Exploring nutrition knowledge and the demographic variation in knowledge levels in an Australian community sample. *Public Health Nutr,* 11, 1365-71.

HENDRIE, G. A., COX, D. N. & COVENEY, J. 2008b. Validation of the General Nutrition Knowledge Questionnaire in an Australian community sample. *Nutrition & Dietetics,* 65, 72-77.

HENRY, P. 2001. Nutrition Knowledge of Athletes. *In:* WOLINSKY., I. & DRISKELL, J. A. (eds.) *Nutritional Applications in Exercise and Sport.* United States of America: CRC Press.

HINTON, P. S., SANFORD, T. C., DAVIDSON, M. M., YAKUSHKO, O. F. & BECK, N. C. 2004. Nutrient intakes and dietary behaviors of male and female collegiate athletes. *International Journal of Sport Nutrition and Exercise Metabolism,* 14, 389-405.

HM GOVERNMENT 2017. Childhood obesity: a plan for action. *In:* HEALTH, D. O. (ed.). https://www.gov.uk/government/publications/childhood-obesity-a-plan-for-action/childhood-obesity-a-plan-for-action#fn:1

HOCH, A. Z., GOOSSEN, K. & KRETSCHMER, T. 2008. Nutritional requirements of the child and teenage athlete. *Phys Med Rehabil Clin N Am,* 19, 373-98, x.

HOLICK, M. F., BINKLEY, N. C., BISCHOFF-FERRARI, H. A., GORDON, C. M., HANLEY, D. A., HEANEY, R. P., MURAD, M. H. & WEAVER, C. M. 2011. Evaluation, Treatment, and Prevention of Vitamin D Deficiency: an Endocrine Society Clinical Practice Guideline. *The Journal of Clinical Endocrinology & Metabolism,* 96, 1911-1930.

INSTITUTE OF MEDICINE 2006. *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements,* Washington, DC, The National Academies Press.

JALAMBO., M. O., SHARIF., R., NASER., I. A. & KARIM., N. A. 2017. Improvement in Knowledge, Attitude and Practice of Iron Deficiency Anaemia among Iron-Deficient Female Adolescents after Nutritional Educational Intervention. *Global Journal of Health Science,* 9.

JANSSEN, I. & LEBLANC, A. G. 2010. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity,* 7, 40.

JANZ, K. F., LETUCHY, E. M., GILMORE, J. M. E., BURNS, T. L., TORNER, J. C., WILLING, M. C. & LEVY, S. M. 2010. Early physical activity provides sustained bone health benefits later in childhood. *Medicine and science in sports and exercise,* 42, 1072.

JANZ, N. K. & BECKER, M. H. 1984. The Health Belief Model: A Decade Later. *Health Education Quarterly,* 11, 1-47.
JENNINGS, A., DAVIES, G. J., COSTARELLI, V. & DETTMAR, P. W. 2009. Dietary fibre, fluids and physical activity in relation to constipation symptoms in pre-adolescent children. *Journal of child health care,* 13, 116-127.
JOHNSON, F., WARDLE, J. & GRIFFITH, J. 2002. The Adolescent Food Habits Checklist: reliability and validity of a measure of healthy eating behaviour in adolescents. *Eur J Clin Nutr,* 56, 644-9.
JOHNSON, H. L., NELSON, R. A. & CONSOLAZIO, C. F. 1988. Effects of electrolyte and nutrient solutions on performance and metabolic balance. *Med Sci Sports Exerc,* 20, 26-33.
JOHNSON, L., MANDER, A. P., JONES, L. R., EMMETT, P. M. & JEBB, S. A. 2008. Energy-dense, low-fiber, high-fat dietary pattern is associated with increased fatness in childhood–. *The American journal of clinical nutrition,* 87, 846-854.
JOHNSON, R. K., APPEL, L. J., BRANDS, M., HOWARD, B. V., LEFEVRE, M., LUSTIG, R. H., SACKS, F., STEFFEN, L. M. & WYLIE-ROSETT, J. 2009. Dietary sugars intake and cardiovascular health: a scientific statement from the American Heart Association. *Circulation,* 120, 1011-20.
JOHNSON, R. K., DRISCOLL, P. & GORAN, M. I. 1996. Comparison of multiple-pass 24-hour recall estimates of energy intake with total energy expenditure determined by the doubly labeled water method in young children. *J Am Diet Assoc,* 96, 1140-4.
JONES, A. M., LAMP, C., NEELON, M., NICHOLSON, Y., SCHNEIDER, C., WOOTEN SWANSON, P. & ZIDENBERG-CHERR, S. 2015. Reliability and Validity of Nutrition Knowledge Questionnaire for Adults. *Journal of Nutrition Education and Behavior,* 47, 69-74.
KARSCH‐VÖLK, M., BARRETT, B., KIEFER, D., BAUER, R., ARDJOMAND‐WOELKART, K. & LINDE, K. 2014. Echinacea for preventing and treating the common cold. *The Cochrane Library*.
KAY, T. 2016. Bodies of knowledge: connecting the evidence bases on physical activity and health inequalities *international Journal of Sport Policy and Politics,* 8, 539-557
KELDER, S. H., PERRY, C. L., KLEPP, K. I. & LYTLE, L. L. 1994. Longitudinal tracking of adolescent smoking, physical activity, and food choice behaviors. *Am J Public Health,* 84, 1121-6.
KIGARU, D. M. D., LOECHL, C., MOLEAH, T., MACHARIA-MUTIE, C. W. & NDUNGU, Z. W. 2015. Nutrition knowledge, attitude and practices among urban primary school children in Nairobi City, Kenya: a KAP study. *BMC Nutrition,* 1, 44.
KIMBER, N. E., ROSS, J. J., MASON, S. L. & SPEEDY, D. B. 2002. Energy balance during an ironman triathlon in male and female triathletes. *Int J Sport Nutr Exerc Metab,* 12, 47-62.
KLIEMANN, N., WARDLE, J., JOHNSON, F. & CROKER, H. 2016. Reliability and validity of a revised version of the General Nutrition Knowledge Questionnaire. *Eur J Clin Nutr,* 70, 1174-1180
KNAPIK, J. J., STEELMAN, R. A., HOEDEBECKE, S. S., AUSTIN, K. G., FARINA, E. K. & LIEBERMAN, H. R. 2016. Prevalence of Dietary Supplement Use by Athletes: Systematic Review and Meta-Analysis. *Sports Med,* 46, 103-23.
KOLAR, A.S., PATTERSON, R.E., WHITE, E., NEUHOUSER, M.L., FRANK, L.L., STANDLEY, J., POTTER, J.D. AND KRISTAL, A.R., 2005. A practical method for collecting 3-day food records in a large cohort. *Epidemiology*, pp.579-583.
KOLETZKO, B., DEMMELMAIR, H., GROTE, V., PRELL, C. & WEBER, M. 2016. High protein intake in young children and increased weight gain and obesity risk1. *The American Journal of Clinical Nutrition,* 103, 303-304.
KOPELMAN, C. A., ROBERTS, L. M. & ADAB, P. 2007. Advertising of food to children: is brand logo recognition related to their food knowledge, eating behaviours and food

preferences? *Journal of Public Health,* 29, 358-367.

KOWALSKI, K. C., CROCKER, P. R. E. & DONEN, R. M. 2004. The physical activity questionnaire for older children (PAQ-C) and adolescents (PAQ-A) manual. *College of Kinesiology, University of Saskatchewan,* 87.

KOWALSKI, K. C., CROCKER, P. R. E. & FAULKNER, R. A. 1997. Validation of the physical activity questionnaire for older children. *Pediatric exercise science,* 9, 174-**186.**

KRANZ, S., BRAUCHLA, M., SLAVIN, J. L. & MILLER, K. B. 2012. What Do We Know about Dietary Fiber Intake in Children and Health? The Effects of Fiber Intake on Constipation, Obesity, and Diabetes in Children. *Advances in Nutrition,* 3, 47-53.

LABOTZ, M. & GRIESEMER, B. A. 2016. Use of Performance-Enhancing Substances. *Pediatrics,* 138.

LANHAM-NEW, S. 2011a. Carbohydrate. *In:* SOCIETY, N. (ed.) *Sport and Exercise Nutrition.* Great Britain: Wiley Blackwell

LANHAM-NEW, S. 2011b. Nutrient Basics *In:* SOCIETY, N. (ed.) *Sport and exercise nutrition* Great Britain Wiley-Blackwell

LANHAM-NEW, S. 2011c. Nutrition for Weight Training, Power and Sprint Training, Middle-Distance and Speed-Endurance Training and Technical and Skill-Based Training. *In:* SOCIETY, T. N. (ed.) *Sport and Exercise Nutrition.* Great Britain Wiley-Blackwell.

LAZAAR, N., AUCOUTURIER, J., RATEL, S., RANCE, M., MEYER, M. & DUCHE, P. 2007. Effect of physical activity intervention on body composition in young children: influence of body mass index status and gender. *Acta Paediatr,* 96.

LEECH, N. & ONWUEGBUZIE, A. J. 2009. A Typology of Mixed-Methods Research Designs. 43, 265-275**.**

LENNOX, A., FITT, E., WHITTON, C., ROBERTS, C. & PRYNNE, C. 2014. Appendix A. Dietary Data Collection and Editing *National Diet and Nutrition Survey. Results from Years 1-4 (combined) of the Rolling Programme (2008/2009 – 2011/12).* Public Health England.

LEVY, A. S., FEIN, S. B. & STEPHENSON, M. 1993. Nutrition knowledge levels about dietary fats and cholesterol: 1983-1988. *Journal of Nutrition Education,* 25, 60-66.

LIEM, D. G. 2017. Infants' and Children's Salt Taste Perception and Liking: A Review. *Nutrients,* 9, 1011.

LIFESTYLES STATISTICS TEAM, H. A. S. C. I. C. 2015. Statistics on Obesity, Physical Activity and Diet. *In:* NIBLETT, P. (ed.).

LINCOLN, Y. S. & GUBA, E. G. 1985. *Naturalistic inquiry*, Sage.

assessment of children and adolescents. *British Journal of Nutrition,* 92, S213-S222**.**

LIVINGSTONE, M. B. & ROBSON, P. J. 2000. Measurement of dietary intake in children. *Proc Nutr Soc,* 59**,** 279-93.

LIVINGSTONE, M. B. E., ROBSON, P. & WALLACE, J. 2004. Issues in dietary intake assessment of children and adolescents. *British Journal of Nutrition,* 92**,** S213-S222.

LIVINGSTONE, M. B. E., ROBSON, P. J. & WALLACE, J. M. W. 2007. Issues in dietary intake assessment of children and adolescents. *British Journal of Nutrition,* 92**,** S213-S222.

LOPEZ, A., CACOUB, P., MACDOUGALL, I. C. & PEYRIN-BIROULET, L. 2016. Iron deficiency anaemia. *The Lancet,* 387, 907-916.

LUFT, F. C., FINEBERG, N. S., SLOAN, R. S. & HUNT, J. N. 1983. The effect of dietary sodium and protein on urine volume and water intake. *J Lab Clin Med,* 101, 605-10.

LUKASKI, H. C. 2004. Vitamin and mineral status: effects on physical performance. *Nutrition,* 20, 632-644.

MANZ, F., KEHRT, R., LAUSEN, B. & MERKEL, A. 1999. Urinary calcium excretion in healthy children and adolescents. *Pediatric Nephrology,* 13, 894-899.

MARISCAL-ARCAS, M., MONTEAGUDO, C., HERNANDEZ-ELIZONDO, J., BENHAMMOU, S., LORENZO, M. & OLEA-SERRANO, F. 2015. Differences in food intake and nutritional

habits between Spanish adolescents who engage in ski activity and those who do not. *Nutricion hospitalaria,* 31.
MARSHALL, K. 2004. Therapeutic applications of whey protein. *Altern Med Rev,* 9, 136-56.
MASON, J. B. & MITCHELL, J. T. 1983. Nutritional surveillance. *Bulletin of the World Health Organization,* 61, 745-755.
MCDEVITT, E.R. 2003. *Ergogenic Drugs in Sports,* Philadelphia WB Saunders
MCDOWALL, J. A. 2007. Supplement use by Young Athletes. *Journal of Sports Science & Medicine,* 6, 337-342.
MCLEAN, R.M., 2014. Measuring population sodium intake: a review of methods. *Nutrients*, *6*(11), pp.4651-4662.
MCPHERSON, R. S., HOELSCHER, D. M., ALEXANDER, M., SCANLON, K. S. & SERDULA, M. K. 2000. Dietary Assessment Methods among School-Aged Children: Validity and Reliability. *Preventive Medicine,* 31, S11-S33.
MEYER, F., BAR-OR, O., MACDOUGALL, D. & HEIGENHAUSER, G. J. 1992. Sweat electrolyte loss during exercise in the heat: effects of gender and maturation. *Med Sci Sports Exerc,* 24, 776-81.
MEYER, F., O'CONNOR, H. & SHIRREFFS, S. M. 2007. Nutrition for the young athlete. *J Sports Sci,* 25 Suppl 1, S73-82.
MILLWARD, D. J. 2004. Protein and amino acid requirements of athletes. *J Sports Sci,* 22, 143-4.
MILNER, J. A. & ALLISON, R. G. 1999. The Role of Dietary Fat in Child Nutrition and Development: Summary of an ASNS Workshop. *The Journal of Nutrition,* 129, 2094-2105.
MILOSEVIC, A., BARDSLEY, P. F. & TAYLOR, S. 2004. Epidemiological studies of tooth wear and dental erosion in 14-year old children in North West England. Part 2: The association of diet and habits. *Br Dent J,* 197, 479-83; discussion 473; quiz 505.
MINGLI LIU, L. W., QINGSEN MING 2015. How Does Physical Activity Intervention Improve Self-Esteem and Self-Concept in Children and Adolescents? Evidence from a Meta-Analysis. *PloS one,* 10.
MINTEL 2014. Sports and Energy Drinks - Executive Summary: UK. *In:* LTD, M. G. (ed.).
MINTEL 2016. Sports and Energy Drinks - UK *In:* LTD, M. G. (ed.).
MISRA, M., PACAUD, D., PETRYK, A., COLLETT-SOLBERG, P. F. & KAPPY, M. 2008. Vitamin D Deficiency in Children and Its Management: Review of Current Knowledge and Recommendations. *Pediatrics,* 122, 398-417.
MOON, G., QUARENDON, G., BARNARD, S., TWIGG, L. & BLYTH, B. 2007. Fat nation: Deciphering the distinctive geographies of obesity in England. *Social Science & Medicine,* 65, 20-31.
MOORE, J. B., HANES JR, J. C., BARBEAU, P., GUTIN, B., TREVIÑO, R. P. & YIN, Z. 2007. Validation of the Physical Activity Questionnaire for Older Children in children of different races. *Pediatric Exercise Science,* 19, 6-19.
MORGAN, G. & SMIRCICH, L. 1980. The Case for Qualitative Research. *The Academy of Management Review,* 5, 491-500.
MUNTNER, P., HE, J., CUTLER, J. A., WILDMAN, R. P. & WHELTON, P. K. 2004. Trends in blood pressure among children and adolescents. *JAMA,* 291, 2107-2113.
NAUGHTON, R. J., DRUST, B., O'BOYLE, A., ABAYOMI, J., MAHON, E., MORTON, J. P. & DAVIES, I. G. 2017. Free-sugar, total-sugar, fibre, and micronutrient intake within elite youth British soccer players: a nutritional transition from schoolboy to fulltime soccer player. *Applied Physiology, Nutrition, and Metabolism,* 42, 517-522.
NEAUM, S. 2010 Children's physical, cognitive, language and emotional and social development *Child Development for Early Childhood Studies.* Great Britain Learning Matters
NEUMAN, W. L. 2014. *Social Research Methods: Qualitative and Quantitative Approaches*,

Pearson Education, Limited.

NEWENS, K. J. & WALTON, J. 2016. A review of sugar consumption from nationally representative dietary surveys across the world. *J Hum Nutr Diet,* 29, 225-40.
NHS CHOICES. 2016. *Eating a Balanced Diet* [Online]. Online Available: http://www.nhs.uk/Livewell/Goodfood/Pages/Healthyeating.aspx [Accessed 31/05/2017].
NHS DIGITAL 2016. National Child Measurement Programme. England, 2015/16 school year. *In:* STATISTICS, O. F. N. (ed.).
NIEPER, A. 2005. Nutritional supplement practices in UK junior national track and field athletes. *Br J Sports Med,* 39, 645-9.
NISEVICH, P. 2008b. Sports Nutrition for Young Athletes: Vital to Victory. *Today's Dietician*
NUTBEAM, D. 2000. Health literacy as a public health goal: a challenge for contemporary health education and communication strategies into the 21st century. *Health Promotion International,* 15, 259-267.
O'CONNOR, J., BALL, E. J., STEINBECK, K. S., DAVIES, P. S., WISHART, C., GASKIN, K. J. & BAUR, L. A. 2001. Comparison of total energy expenditure and energy intake in children aged 6–9 y–. *The American journal of clinical nutrition,* 74, 643-649.
O'DEA, J. A. 2003. Consumption of nutritional supplements among adolescents: usage and perceived benefits. *Health Education Research,* 18, 98-107.
OHMANN, C., BANZI, R., CANHAM, S., BATTAGLIA, S., MATEI, M., ARIYO, C., BECNEL, L., BIERER, B., BOWERS, S., CLIVIO, L. AND DIAS, M., Sharing and reuse of individual participant data from clinical trials: principles and recommendations.. 2017;(12): e018647. *BMJ Open*, *7*. OLIVER, P. 2003. Research and the respondent: Ethical Issues before the research commences. *Student's Guide to Research Ethics.* Second ed. England McGraw Hill
ORTEGA, R. M., PEREZ-RODRIGO, C. & LOPEZ-SOBALER, A. M. 2015. Dietary assessment methods: dietary records. *Nutr Hosp,* 31 Suppl 3, 38-45.
OTTEN JJ, H. J., MEYERS LD 2006. *Dietary reference intakes: The essential guide to nutrient requirements*, National Academies Press.
PADAYATTY, S. J., KATZ, A., WANG, Y., ECK, P., KWON, O., LEE, J.-H., CHEN, S., CORPE, C., DUTTA, A., DUTTA, S. K. & LEVINE, M. 2003. Vitamin C as an Antioxidant: Evaluation of Its Role in Disease Prevention. *Journal of the American College of Nutrition,* 22, 18-35.
PARMENTER, K., WALLER, J. & WARDLE, J. 2000a. Demographic variation in nutrition knowledge in England. *Health Education Research,* 15, 163-174.
PARMENTER, K. & WARDLE, J. 1999. Development of a general nutrition knowledge questionnaire for adults. *Eur J Clin Nutr,* 53, 298-308.
PARMENTER, K. & WARDLE, J. 2000b. Evaluation and Design of Nutrition Knowledge Measures. *Journal of Nutrition Education,* 32, 269-277.
PARNELL, J. A., WIENS, K. P. & ERDMAN, K. A. 2016. Dietary intakes and supplement use in pre-adolescent and adolescent Canadian athletes. *Nutrients,* 8, 526.
PEELING, P. 2010. Exercise as a mediator of hepcidin activity in athletes. *European Journal of Applied Physiology,* 110, 877-883.
PERRON, M. & ENDRES, J. 1985. Knowledge, attitudes, and dietary practices of female athletes. *Journal of the American Dietetic Association,* 85, 573-576.
PETRIE, H. J., STOVER, E. A. & HORSWILL, C. A. 2004. Nutritional concerns for the child and adolescent competitor. *Nutrition,* 20, 620-631.
PETRÓCZI, A. & NAUGHTON, D. P. 2007. Supplement use in sport: is there a potentially dangerous incongruence between rationale and practice? *J Occup Med Toxicol,*
PETR**Ó**CZI, A. & NAUGHTON, D. P. 2008a. The age-gender-status profile of high performing athletes in the UK taking nutritional supplements: Lessons for the future. *Journal of the International Society of Sports Nutrition,* 5, 2.2**.**
PETRÓCZI, A., NAUGHTON, D. P., PEARCE, G., BAILEY, R., BLOODWORTH, A. & MCNAMEE,

M. 2008b. Nutritional supplement use by elite young UK athletes: fallacies of advice regarding efficacy. *Journal of the International Society of Sports Nutrition,* 5, 22-22**.**

PLUDOWSKI, P., HOLICK, M. F., GRANT, W. B., KONSTANTYNOWICZ, J., MASCARENHAS, M. R., HAQ, A., POVOROZNYUK, V., BALATSKA, N., BARBOSA, A. P., KARONOVA, T., RUDENKA, E., MISIOROWSKI, W., ZAKHAROVA, I., RUDENKA, A., ŁUKASZKIEWICZ, J., MARCINOWSKA-SUCHOWIERSKA, E., ŁASZCZ, N., ABRAMOWICZ, P., BHATTOA, H. P. & WIMALAWANSA, S. J. 2018. Vitamin D supplementation guidelines. *The Journal of Steroid Biochemistry and Molecular Biology,* 175, 125-135.

PODSAKOFF, P. M., MACKENZIE, S. B. & PODSAKOFF, N. P. 2011. Sources of Method Bias in Social Science Research and Recommendations on How to Control It. *Annual Review of Psychology,* 63, 539-569.

POITRAS, V. J., GRAY, C. E., BORGHESE, M. M., CARSON, V., CHAPUT, J.-P., JANSSEN, I., KATZMARZYK, P. T., PATE, R. R., CONNOR GORBER, S., KHO, M. E., SAMPSON, M. & TREMBLAY, M. S. 2016. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Applied Physiology, Nutrition, and Metabolism,* 41, S197-S239.

POPKIN, B. M., D'ANCI, K. E. & ROSENBERG, I. H. 2010. Water, Hydration and Health. *Nutrition reviews,* 68, 439-458.

PRYER, J. A., VRIJHEID, M., NICHOLS, R., KIGGINS, M. & ELLIOTT, P. 1997. Who are the 'low energy reporters' in the dietary and nutritional survey of British adults? *Int J Epidemiol,* 26, 146-

PUBLIC HEALTH ENGLAND 2014. National Diet and Nutrition Survey - Results from Years 1, 2, 3 and 4 (combined) of the Rolling Programme (2008/2009 – 2011/2012). *In:* HEALTH, D. F. (ed.).

PUBLIC HEALTH ENGLAND 2016a. The Eatwell Guide Booklet *In:* HEALTH, D. F. (ed.).

PUBLIC HEALTH ENGLAND 2016b. Government recommendations for food energy and nutrients for males and females aged 1 – 18 years and 19+ years.

PUBLIC HEALTH ENGLAND, F. S. A. 2016c. The Eatwell Guide

PUBLIC HEALTH ENGLAND 2016d National Diet and Nutrition Survey. Results from Years 5 and 6 (combined) of the Rolling Programme (2012/2013 – 2013/2014). *In:* HEALTH, D. F. (ed.).

PUNCH, K. 2003. Introduction and Purpose. *In:* PUNCH, K. (ed.) *Survey research: The basics.* London: Sage.

PURCELL, L. K., CANADIAN PAEDIATRIC SOCIETY, P. S. & EXERCISE MEDICINE, S. 2013. Sport nutrition for young athletes. *Paediatrics & Child Health,* 18, 200-202.

RACHELE, J. N., MCPHAIL, S. M., WASHINGTON, T. L. & CUDDIHY, T. F. 2012. Practical physical activity measurement in youth: a review of contemporary approaches. *World J Pediatr,* 8, 207-16.

RANKINEN, T., FOGELHOLM, M., KUJALA, U., RAURAMAA, R. & UUSITUPA, M. 1995. Dietary intake and nutritional status of athletic and nonathletic children in early puberty. *Int J Sport Nutr,* 5, 136-50.

REY-LÓPEZ, J. P., VICENTE-RODRÍGUEZ, G., BIOSCA, M. & MORENO, L. A. 2008. Sedentary behaviour and obesity development in children and adolescents. *Nutrition, Metabolism and Cardiovascular Diseases,* 18, 242-251.

RIDDELL, M. 2008a. The endocrine response and substrate utilization during exercise in children and adolescents. *Journal of Applied Physiology,* 105, 725-733.

RIDDELL, M. C. 2008b. The endocrine response and substrate utilization during exercise in children and adolescents. *Journal of Applied Physiology,* 105, 725-733.

RISSANEN, T.H., VOUTILAINEN, S., VIRTANEN, J.K., VENHO, B., VANHARANTA, M., MURSU, J. AND SALONEN, J.T., 2003. Low intake of fruits, berries and vegetables is associated with excess mortality in men: the Kuopio Ischaemic Heart Disease Risk Factor (KIHD) Study. *The Journal of nutrition*, *133*(1), pp.199-204.

RIVERA-BROWN, A. M., ROWLAND, T. W., RAMIREZ-MARRERO, F. A., SANTACANA, G. & VANN, A. 2006. Exercise tolerance in a hot and humid climate in heat-acclimatized

girls and women. *Int J Sports Med,* 27, 943-50.
ROWLAND, T. 2011. Fluid Replacement Requirements for Child Athletes. *Journal of Sports Medicine,* 41, 279-288.

ROZIN, P. 2006. The Integration of Biological, Social, Cultural and Psychological Influences on Food Choice. *In:* RICHARD SHEPHERD & MONIQUE RAATS (eds.) *The Psychology of Food Choice.* UK.

RUTISHAUSER, I. & BLACK, A. 2013. Introduction to Human Nutrition. *In:* GIBNEY, M. J., LANHAM-NEW, S. A., CASSIDY, A. & VORSTER, H. H. (eds.). Wiley.

RUXTON, C. H. S. 2014. The suitability of caffeinated drinks for children: a systematic review of randomised controlled trials, observational studies and expert panel guidelines. *Journal of Human Nutrition and Dietetics,* 27, 342-357.

SACHECK, J. & SCHULTZ, N. 2016. Optimal Nutrition for Youth Athletes: Food Sources and Fuel Timing. *In:* INSTITUTE, N. Y. S. H. A. S. (ed.). USA American College of Sports Medicine

SAGGESE, G., VIERUCCI, F., BOOT, A. M., CZECH-KOWALSKA, J., WEBER, G., CAMARGO, C. A., MALLET, E., FANOS, M., SHAW, N. J. & HOLICK, M. F. 2015. Vitamin D in childhood and adolescence: an expert position statement. *European Journal of Pediatrics,* 174, 565-576.

SALLIS, J. F., PROCHASKA, J. J. & TAYLOR, W. C. 2000. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc,* 32, 963-75.

SANDERCOCK, G. R. H., VOSS, C. & DYE, L. 2010. Associations between habitual school-day breakfast consumption, body mass index, physical activity and cardiorespiratory fitness in English schoolchildren. *Eur J Clin Nutr,* 64, 1086-1092.

SANDSTROM, G., BORJESSON, M. & RODJER, S. 2012. Iron deficiency in adolescent female athletes - is iron status affected by regular sporting activity? *Clin J Sport Med,* 22, 495-500.

SAPP, S. G. & JENSEN, H. H. 1997. Reliability and Validity of Nutrition Knowledge and Diet-Health Awareness Tests Developed from the 1989–1991 Diet and Health Knowledge Surveys. *Journal of Nutrition Education,* 29, 63-72.

SAVAGE, J. S., FISHER, J. O. & BIRCH, L. L. 2007. Parental influence on eating behavior: conception to adolescence. *The Journal of Law, Medicine & Ethics,* 35, 22-34.

SCAGLIONI, S., SALVIONI, M. & GALIMBERTI, C. 2008. Influence of parental attitudes in the development of children eating behaviour. *Br J Nutr,* 99 Suppl 1, S22-5.

SCARBOROUGH, P., KAUR, A., COBIAC, L., OWENS, P., PARLESAK, A., SWEENEY, K. & RAYNER, M. 2016. Eatwell Guide: modelling the dietary and cost implications of incorporating new sugar and fibre guidelines. *BMJ Open,* 6.

SCHILPZAND, E. J., SCIBERRAS, E., EFRON, D., ANDERSON, V. & NICHOLSON, J. M. 2015. Improving Survey Response Rates from Parents in School-Based Research Using a Multi-Level Approach. *PLoS ONE,* 10, e0126950.

SCHNEIDER, M. B. & BENJAMIN, H. J. 2011. Sports Drinks and Energy Drinks for Children and Adolescents: Are They Appropriate? *Pediatrics,* 127, 1182-1189.

SCHOELLER, D. A. 2009. The energy balance equation: looking back and looking forward are two very different views. *Nutrition Reviews,* 67, 249-254.

SCHUBERT, L., GALLEGOS, D., FOLEY, W. & HARRISON, C. 2011. Re-imagining the 'social' in the nutrition sciences. *Public Health Nutrition,* 15, 352-359.

SCIENTIFIC ADVISORY COMMITTEE ON NUTRITION 2011. Dietary Reference Values for Energy.

SEIFERT, S. M., SCHAECHTER, J. L., HERSHORIN, E. R. & LIPSHULTZ, S. E. 2011. Health Effects of Energy Drinks on Children, Adolescents, and Young Adults. *Pediatrics,* 127, 511-528.

SHEIHAM, A. & JAMES, W. P. T. 2015. Diet and Dental Caries. *Journal of Dental Research,* 94, 1341-1347.

SHIM, J.-S., OH, K. & KIM, H. C. 2014. Dietary assessment methods in epidemiologic studies. *Epidemiology and Health,* 36, e2014009.

SHIN, C. S. & KIM, K. M. 2015. The Risks and Benefits of Calcium Supplementation. *Endocrinol Metab,* 30, 27-34.

SIRARD, J. R. & PATE, R. R. 2001. Physical activity assessment in children and adolescents. *Sports Med,* 31, 439-54.

SJOBERG, A., SLINDE, F., ARVIDSSON, D., ELLEGARD, L., GRAMATKOVSKI, E., HALLBERG, L. & HULTHEN, L. 2003. Energy intake in Swedish adolescents: validation of diet history with doubly labelled water. *Eur J Clin Nutr,* 57, 1643-52.

SMITH, A. 2015b. Primary school physical education and sports coaches: evidence from a study of School Sport Partnerships in north-west England. *Sport, Education and Society,* 20, 872-888.

SMITH, J. J., EATHER, N., MORGAN, P. J., PLOTNIKOFF, R. C., FAIGENBAUM, A. D. & LUBANS, D. R. 2014. The health benefits of muscular fitness for children and adolescents: a systematic review and meta-analysis. *Sports medicine,* 44, 1209-1223.

SNOW, R. C., SCHNEIDER, J. L. & BARBIERI, R. L. 1990. High dietary fiber and low saturated fat intake among oligomenorrheic undergraduates**Supported in part by grant HD-24563 from the National Institutes of Health and by grant GA PS 8806 from the Rockefeller Foundation. *Fertility and Sterility,* 54, 632-637.

SOBAL, J. & MARQUART, L. F. 1994. Vitamin/mineral supplement use among high school athletes. *Adolescence,* 29, 835-43.

SODEXHO 2005. The Sodexho school meals and lifestyle survey 2005. Sodexho WhyteleafeSurrey.

SORIC, M., MISIGOJ-DURAKOVIC, M. & PEDISIC, Z. 2008. Dietary Intake and Body Composition of Prepubescent Female Aesthetic Athletes. *International Journal of Sport Nutrition and Exercise Metabolism,* 18, 343-354.

SOTHERN, M., LOFTIN, M., SUSKIND, R., UDALL, J. & BLECKER, U. 1999. The health benefits of physical activity in children and adolescents: implications for chronic disease prevention. *European journal of pediatrics,* 158, 271-274.

SOTHERN, M. S. & GORDON, S. T. 2003. Prevention of Obesity in Young Children: A Critical Challenge for Medical Professionals. *Clinical Pediatrics,* 42, 101-111.

SPEAR, B. 2005. Sports nutrition. *Guidelines for adolescent nutrition services. Minneapolis, MN*, 199-208**.**

SPRONK, I., KULLEN, C., BURDON, C. & O'CONNOR, H. 2014. Relationship between nutrition knowledge and dietary intake. *British Journal of Nutrition,* 111, 1713-1726.

STEEN, S. N. 1996. Timely statement of The American Dietetic Association: nutrition guidance for child athletes in organized sports. *J Am Diet Assoc,* 96, 610-1.

STEENHUIS, I. H. M., BRUG, J., VAN ASSEMA, P. & IMBOS, T. 1996. The Validation of a Test to Measure Knowledge about the Fat Content of Food Products. *Nutrition and Health,* 10, 331-339.

STORY, M. & KLEIN, L. 2012. Consumption of Sports Drinks by children and Adolescents *In:* FOUNDATION, H. E. R. O. T. R. W. J. (ed.).

SYLVIA, L. G., BERNSTEIN, E. E., HUBBARD, J. L., KEATING, L. & ANDERSON, E. J. 2014. Practical guide to measuring physical activity. *J Acad Nutr Diet,* 114, 199-208.

TALVIA, S., RÄSÄNEN, L., LAGSTRÖM, H., ANGLÈ, S., HAKANEN, M., AROMAA, M., SILLANMÄKI, L., SAARINEN, M. & SIMELL, O. 2011. Parental eating attitudes and indicators of healthy eating in a longitudinal randomized dietary intervention trial (the STRIP study). *Public Health Nutrition,* 14, 2065-2073.

TAYLOR, A. 2012. *Physical Activity and Mental Health* [Online]. The Royal College of Psychiatrists. Available: http://www.rcpsych.ac.uk/healthadvice/treatmentswellbeing/physicalactivity.aspx [Accessed 01/11/16].

TE MORENGA, L., MALLARD, S. & MANN, J. 2013. Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies. *BMJ : British Medical Journal,* 346.

TE MORENGA, L. & MONTEZ, J. M. 2017. Health effects of saturated and trans-fatty acid intake in children and adolescents: Systematic review and meta-analysis. *PLOS ONE,* 12, e0186672.

TE MORENGA, L. A., HOWATSON, A. J., JONES, R. M. & MANN, J. 2014. Dietary sugars and cardiometabolic risk: systematic review and meta-analyses of randomized controlled trials of the effects on blood pressure and lipids. *Am J Clin Nutr,* 100, 65-79.

TEDSTONE, A., TARGETT, V. & ALLEN, R. 2015. Sugar reduction: the evidence for action. *Sugar reduction: the evidence for action.*

TELAMA, R., YANG, X., LESKINEN, E., KANKAANPAA, A., HIRVENSALO, M., TAMMELIN, T., VIIKARI, J. S. & RAITAKARI, O. T. 2014. Tracking of physical activity from early childhood through youth into adulthood. *Med Sci Sports Exerc,* 46, 955-62.

TEMPLE, J. L. 2009. Caffeine use in children: What we know, what we have left to learn, and why we should worry. *Neuroscience & Biobehavioral Reviews,* 33, 793-806.

TENFORDE, A. S., NATTIV, A., ACKERMAN, K., BARRACK, M. T. & FREDERICSON, M. 2017. Optimising bone health in the young male athlete. *British Journal of Sports Medicine,* 51, 148-149.

THE NUREMBERG TRIALS 1949. Trials of War Criminals before the Nuremberg Military Tribunals under Control Council Law No. 10. Washington D.C. : U.S. Governemnt Printing Office

THEIN, L. A., THEIN, J. M. & LANDRY, G. L. 1995. Ergogenic aids. *Phys Ther,* 75, 426-39.

THØGERSEN-NTOUMANI, C., YIN NG, J. Y., NTOUMANIS, N., CHATZISARANTIS, N., VLACHOPOULOS, S., KATARTZI, E. S. & NIKITARAS, N. 2016. 'Mum's the word': Predictors and outcomes of weight concerns in pre-adolescent and early adolescent girls. *Body Image,* 16, 107-112.

THOMAS, D. T., ERDMAN, K. A. & BURKE, L. M. 2016. Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *J Acad Nutr Diet,* 116, 501-528.

THOMSON, B. & SCHIESS, S. 2010. Risk Profile: Caffeine in Energy Drinks and Energy Shots. *In:* AUTHORITY, N. Z. F. S. (ed.).

TILLETT, E. & LOOSEMORE, M. 2009. Setting standards for the prevention and management of travellers' diarrhoea in elite athletes: An audit of one team during the Youth Commonwealth Games in India. *British Journal of Sports Medicine,* 43, 1045-8.

TIMMONS, B. W., LEBLANC, A. G., CARSON, V., CONNOR GORBER, S., DILLMAN, C., JANSSEN, I., KHO, M. E., SPENCE, J. C., STEARNS, J. A. & TREMBLAY, M. S. 2012. Systematic review of physical activity and health in the early years (aged 0–4 years). *Applied Physiology, Nutrition, and Metabolism,* 37, 773-792.

TRAKMAN, G. L., FORSYTH, A., DEVLIN, B. L. & BELSKI, R. 2016. A Systematic Review of Athletes' and Coaches' Nutrition Knowledge and Reflections on the Quality of Current Nutrition Knowledge Measures. *Nutrients,* 8.

TURLEY, K. 2014 Effects of Caffeine on Exercise Responses and Performance in Children and Youth. *American Journal of Lifestyle Medicine* 10.

UAUY, R. & DANGOUR, A. D. 2009. Fat and fatty acid requirements and recommendations for infants of 0-2 years and children of 2-18 years. *Ann Nutr Metab,* 55, 76-96.

ULIN, P. R., ROBINSON, E. T. & TOLLEY, E. E. 2005. The Language and Logic of Qualitative Research *Qualitative methods in public health*

UNIVERSITY OF SALFORD 1999. Microdiet. University of Salford, : Downlee Systems Limited, .

VARIYAM, J. N., BLAYLOCK, J., LIN, B.-H., RALSTON, K. & SMALLWOOD, D. 1999. Mother's Nutrition Knowledge and Children's Dietary Intakes. *American Journal of Agricultural Economics,* 81, 373-384.

VEREECKEN, C. & MAES, L. 2010. Young children's dietary habits and associations with the mothers' nutritional knowledge and attitudes. *Appetite,* 54, 44-51.

VEREECKEN, C. A., KEUKELIER, E. & MAES, L. 2004. Influence of mother's educational level on food parenting practices and food habits of young children. *Appetite,* 43, 93-103.

VISSERS, P. A. J., JONES, A. P., VAN SLUIJS, E. M. F., JENNINGS, A., WELCH, A., CASSIDY, A. & GRIFFIN, S. J. 2013. Association between diet and physical activity and sedentary behaviours in 9–10-year-old British White children. *Public Health,* 127, 231-240**.**

VOORTMAN, T., VITEZOVA, A., BRAMER, W. M., ARS, C. L., BAUTISTA, P. K., BUITRAGO-LOPEZ, A., FELIX, J. F., LEERMAKERS, E. T. M., SAJJAD, A., SEDAGHAT, S., THARNER, A., FRANCO, O. H. & VAN DEN HOOVEN, E. H. 2015. Effects of protein intake on blood pressure, insulin sensitivity and blood lipids in children: a systematic review. *British Journal of Nutrition,* 113, 383-402.

VOSS, C., DEAN, P. H., GARDNER, R. F., DUNCOMBE, S. L. & HARRIS, K. C. 2017. Validity and reliability of the Physical Activity Questionnaire for Children (PAQ-C) and Adolescents (PAQ-A) in individuals with congenital heart disease. *PLOS ONE,* 12, e0175806.

VOSS, C., OGUNLEYE, A. A. & SANDERCOCK, G. R. H. 2013. Physical Activity Questionnaire for children and adolescents: English norms and cut-off points. *Pediatrics International,* 55, 498-507.

WANG, J. J., BARANOWSKI, T., LAU, W. C. P., CHEN, T. A. & PITKETHLY, A. J. 2016. Validation of the Physical Activity Questionnaire for Older Children (PAQ-C) among Chinese Children. *Biomedical and Environmental Sciences,* 29, 177-186.

WARDLE, J., GUTHRIE, C. A., SANDERSON, S. & RAPOPORT, L. 2001. Development of the Children's Eating Behaviour Questionnaire. *J Child Psychol Psychiatry,* 42, 963-70.

WEBSTER, C. A., RUSS, L., VAZOU, S., GOH, T. L. & ERWIN, H. 2015. Integrating movement in academic classrooms: understanding, applying and advancing the knowledge base. *Obes Rev,* 16, 691-701.

WELK, G. 2002. *Physical activity assessments for health-related research*, Human Kinetics.

WELK, G. J., CORBIN, C. B. & DALE, D. 2000. Measurement Issues in the Assessment of Physical Activity in Children. *Research Quarterly for Exercise and Sport,* 71, 59-73.

WHEELOCK, V. J. 1984. “Diet and Cardiovascular Disease”—The COMA Report. *Journal of the Institute of Health Education,* 22, 129-139.

WHITE, J. V., DWYER, J. T., POSNER, B. M., HAM, R. J., LIPSCHITZ, D. A. & WELLMAN, N. S. 1992. Nutrition screening initiative: development and implementation of the public awareness checklist and screening tools. *J Am Diet Assoc,* 92, 163-7.

WHITEHOUSE, G. & LAWLIS, T. 2017. Protein supplements and adolescent athletes: A pilot study investigating the risk knowledge, motivations and prevalence of use. *Nutrition & Dietetics,* 74, 509-515.

WILKINSON, S. 1998. Focus Groups in Health Research. *Journal of Health Psychology,* 3, 329-348.

WILLIAMS, D. P., GOING, S. B., LOHMAN, T. G., HARSHA, D. W., SRINIVASAN, S. R., WEBBER, L. S. & BERENSON, G. S. 1992. Body Fatness and Risk for Elevated Blood-Pressure, Total Cholesterol, and Serum-Lipoprotein Ratios in Children and Adolescents. *American Journal of Public Health,* 82.

WILLIAMS, M. H. 2004. Dietary Supplements and Sports Performance: Introduction and Vitamins. *Journal of the International Society of Sports Nutrition,* 1, 1.

WILLIS, K. S., PETERSON, N. J. & LARSON-MEYER, D. E. 2008. Should we be concerned about the vitamin D status of athletes? *International journal of sport nutrition and exercise metabolism,* 18, 204-224.

WORLD HEALTH ORGANISATION 2010. Global Recommendations on Physical Activity for Health.

WORLD HEALTH ORGANISATION 2015. Guideline: Sugars intake for adults and children. Geneva

WORSLEY, A. 2002. Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour? *Asia Pac J Clin Nutr,* 11 Suppl 3, S579-85.

WRIEDEN, W., PEACE, H., ARMSTRONG, J. & BARTON, K. 2003. A short review of dietary assessment methods used in National and Scottish Research Studies. Scotland

YABANCı, N., KıSAÇ, İ. & KARAKUŞ, S. Ş. 2014. The Effects of Mother's Nutritional Knowledge on Attitudes and Behaviors of Children about Nutrition. *Procedia - Social and Behavioral Sciences,* 116, 4477-4481.

YANG YJ, KIM MK, HWANG SH, AHN Y, SHIM JE, KIM DH. Relative validities of 3-day food records and the food frequency questionnaire. Nutr Res Pract. 2010 Apr;4(2):142-148.

ZARNOWIECKI, D., SINN, N., PETKOV, J. & DOLLMAN, J. 2011. Parental nutrition knowledge and attitudes as predictors of 5–6-year-old children's healthy food knowledge. *Public Health Nutrition,* 15, 1284-1290.

ZEMEL, M. B., SHI, H., GREER, B., DIRIENZO, D. & ZEMEL, P. C. 2000. Regulation of adiposity by dietary calcium. *Faseb j,* 14, 1132-8.