Work-related upper limb disorder:- An investigative study

Jenkinson, Janice

Work-Related Upper Limb Disorder:- An Investigative Study

Janice Jenkinson

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The Abstract

The primary aim of occupational health staff within a manufacturing company is to ensure the health and well being of the employees are safeguarded. The aim may be difficult to achieve as it goes directly against the ethos of business, i.e. making money. It is the researcher's experience that company owners, especially Far Eastern owners, are disinclined to introduce health and safety measures that cost money.

The study is conducted in an electronic company (Company X) in the northeast of England, owned by foreign nationals. Retrospective examination of accident, sickness and absenteeism records reveal that work-related upper limb disorder (WRULD) is apparent and upper limb discomfort is a significant problem in Company X. Research shows that the principle of job rotation tends to reduce fatigue and the incidence of WRULD, consequently sickness and absenteeism and labour turnover will also be reduced.

In Company X physiological stress to the limb is highly relevant to the production line workers, based on case studies of employees with work-related upper limb disorder. This led to conducting a study of two sites building different electrical equipment. 80 employees participated in the study which involved monitoring the employees on six paced production lines in the Personal Computer Monitor factory PCM which included seven teams and employees in five teams on four production lines in the Microwave Oven Factory. A semi paced line, the Bent Tool Machine BTM in MWO were also involved in the job rotation experiment. Discomfort scale measurements were administered to all that took part and an extra objective measurement of grip strength was provided by the employees in the BTM to provide information on fatigue. A comparison between grip strength and discomfort was analysed for any correlation. The main data collection took place between September and December 2000.

There is some evidence that the differences in discomfort is caused by job rotation as where job rotation was taking place the employees in the study had lower levels of discomfort than those on non- rotational duties. In the CDT prep job PCM where job rotation was taking place a comparison between job rotation and the non-rotation group with regard to discomfort in body parts differed (Fisher's exact test, $p=0.05$).

The job action analysis that was designed specifically for the production line environment allowed comparisons of upper limb score for different jobs. It would appear that regular job analysis should be introduced as a matter of practice in Company X in the future. The study demonstrated the importance of prevention and innovation ergonomics and there was evidence to suggest that the occupational health department should adopt an active role in the future for the benefit of the employees and the financial survival of the Company.

University of Durham

Name	Signature	Permanent address	Date

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Declaration

No print of this thesis has been submitted elsewhere for any other degree or qualification and it is all my own work unless referenced to the contrary in the text

Statement of Copyright

Chapter 1: Background of the Study

Introduction

This thesis investigates the cultural issues concerning health and safety, by ethnographic research, and describes the ethnographic techniques, that took place which led to this investigative study of WRULD and discomfort. This thesis addresses the question of how discomfort felt by employees at work may be best alleviated by job rotation and ergonomic intervention. The study was conducted in an electronic company where physiological stress to the limb is highly relevant to the production line work. Examination of accident, sickness and absenteeism records were performed retrospectively and it revealed that work-related upper limb disorder (WRULD) is apparent. Research shows that the principle of job rotation tends to reduce fatigue and the incidence of WRULD, consequently sickness absenteeism and labour turnover is reduced. The study was performed by 80 employees volunteering to participate in a study which involved measuring discomfort scales of individuals. An extra objective measurement of grip strength was provided by the employees in one specific work area to provide information on fatigue. A comparison between grip strength and discomfort was analyzed for any correlation. The results demonstrated that work related upper limb discomfort was found to be a significant problem. To address this problem a job action analysis was designed specifically for the type of repetitive production work and allowed for comparisons of upper limb score for different jobs. It would appear that regular job analysis should be introduced as a matter of practice in Company X in the future. The study demonstrated the importance of prevention and innovation ergonomics.

1.0 Background

The researcher of this study works in an electronic company in the northeast of England. The company produces personal computer monitors and microwave ovens. The number of people currently employed in the firm in mid-summer 2003 is approximately 900 employees. At the time of the research there were approximately around 950 employees. From now on the company will be referred to as Company X. Most tasks in the company are concerned with assembling components by hand. Some jobs require manual lifting although few of these are in the production line areas.

Originally I investigated the cultural aspect of the company in order to acquire information on whether the different cultures represented there had any impact on the health and safety of the individuals within the company. My original concern was that there were difficulties in implementing health and safety changes in an industry financed by another country, owing primarily to cultural differences. My assumption was supported by other work within this field. South Korea's health and safety record is believed to be the worst in the industrialised world (Khang 1999).

A non participant observation technique used by ethnographers was adopted for the initial stage of the research, and was performed in order to attain further insight into the culture of the company. Ethnographic techniques were performed by observing in meetings people's individual behaviour, and the collective actions and outcomes that occurred as a result of those meetings and to ascertain whether the health and safety initiatives were influenced by Far East involvement. Further knowledge was gained by interviewing key personnel, e.g. personnel in management positions directly connected with health and safety, listening to key conversations at all levels in the company, observing people on duties, and using time-sampling techniques when observing the production lines (Cormack1991). The data allowed me to gain an insight into the culture and specific management issues within the company.

Company X is financed by Koreans with its chief executive being a Korean. There are other senior officers who are British accountable to him. Anecdotal evidence suggests that nationals from other countries, particularly from the Far East, are unwilling to implement health and safety recommendations thereby affecting the well being of the employees. Similar to other manufacturing companies in the UK, the prime concern of the company is to thrive financially and sustain its market place. There are differences and similarities in national countries with regards to values systems and beliefs: it is the opinion of (Hofstede 1980; 2003), from his compilation of a survey result collected within a large multinational business organisation within forty countries and comparison between thirty eight other studies. Hofstede (1980) in his study of international differences in work related values believes the battle for recognition of the cultural component in our ideas is worth being fought; the survey revealed differences culturally within behaviour related to values and beliefs and the effects of this within business's and vice versa. He states that if we maintain the naive assumption that because they look like us they think like us then we will not go far. We should not avoid cultures but be able to understand each others culture (Hofstede 1980; 2003). As well as these cultural differences one can see how this can be impacted upon with difficulties in implementing health and safety changes in industry financed by another country, owing to cultural differences (Yee 1998; Kim 1995) by the number of accidents, injuries and the death rate in industry in Korea (Table 2.1 & 2.2) and other eastern countries Chapter 2. There is a tendency for companies to undermine health and safety recommendations even though the penalty for not implementing appropriate health and safety procedures could be high and there is also a danger of being sued by workers (Appleby 2001). However these potential threats do not appear to deter some companies from flouting essential health and safety recommendations. It has been alleged that Company X in which the researcher works could be classified as one of those companies that tend to undermine the work of the health and safety team as the company is too busy concentrating on productivity and trying to make a profit under the constant threat of competition. This may be an unfair comment in that the accident prevention in this company was once only above the Accident Incidence Rate (AIR) in only one factory, Personal Computer Monitor (PCM) in 1998 and from then on it was reduced dramatically (table 5.8). However, the company was not at the forefront when considering possible recommended ergonomic interventions as advised by the health and safety team. Perhaps this may also have some impingement on that these are only recommendations and not necessarily legal requirements. However if approved codes of practice are not followed they are admissible in evidence at court that the firm has not complied with a statutory instrument and companies should seriously consider this (Appleby 2001).

It is alleged by individuals in different positions in the company that there were difficulties in implementing health and safety changes in an industry financed by another country, owing to cultural differences (Yee 1998; Kim 1995). This assumption could not be substantiated through ethnographic research which was difficult to conduct because it was not possible to obtain access to privileged information in the keeping of the company hierarchy, owing to my position of contractual employment.

To what extent racial, individual and cultural attitudes among managers constituted a barrier to my enquires would be difficult to determine. From the ethical point of view information concerning the company and the individual is confidential and can't be used without consent from the company and the people concerned (see Chapter 3 ethics). Where information is obtained that would identify specific individuals within the company it would be unethical to publish that information. The results of the ethnographic research demonstrated how important such research can be, used as a principle of practice since it brought to the forefront the importance of WRULD. The findings of my ethnographic research led me to pursue certain problems, regarding the culture of health and safety generally but especially related to WRULD.

As an occupational health nurse working in Company X responsible for the day to day running of the occupational health department, over the last six years, many employees have sought advice and treatment from the occupational health department. Examination of the accident and injury records reveal a large proportion of employees complained about unsubstantiated discomfort and pain in their upper extremities which could not be adequately diagnosed owing to its diffuse character. However, new ways of testing by biochemical markers of soft tissue injury have been proposed and would allow new ways of testing which could be implemented during occupational health surveillance, or possibly at pre employment, to enable the early warning of impending problems that could lead to WRULD. These markers would provide more insight into the underlying nature of soft tissue disorders (Saxton 2000). Higher exposure of patient handling activities by nurses was associated with higher type 1 collagen synthesis. The results indicated that serum concentration of these biomarkers of type 1 collagen metabolism can reflect the differences between contrasting groups and also varying level of exposure between persons within an occupation (Kuiper et al 2002). However, diffuse symptoms are now recognised and non-specific forearm, wrist or hand pain a soft tissue disorder unspecified are reported under the international classification of disease (ICD 10) as M79.9, and therefore can be limited in a small area of the arm or of a radiating nature (Sluiter et al 2001).

It was noted from the sickness records, sickness and absenteeism are associated with these workers who reported discomfort and pain as in the case studies of Company X (table 5.1) a minimum of 19 hours sick time occurred. The sickness time could have been higher if the cases had not been appropriately managed by the occupational health department. The lack of statistical data on long term sickness absence was apparent. This is a problem that needs to be addressed. It may in this instance have to be managed by the occupational health department although it is usually the remit of Human Resources. Currently we are devising a coding system for the statistical analysis of sick notes with the help of the health and safety consultant.

Work-related upper limb disorders (WRULDs) consist of multiple conditions and syndromes. Signs and symptoms occur such as swelling, erythema, heat, decreased range of movements and crepitation, depending on the type and severity of the condition. Some conditions can become quite acute, such as de Quervains tenosynovitis (Jackson et al 1996). Restricted duties may be required, or job loss may occur. Pain and debilitation may lead to psychological overlay, where perception and reality become indistinguishable to the individual. Chronic pain may lead to psychological and physiological disability. The degree of psychological overlay may be unconsciously increased where there is a claim pending (Leaver 2000).

Work-related upper limb disorders can be prevented by regular occupational health surveillance and planned job rotation. The amount of repetition on the duty, and the amount of force required for the job, the posture applied and the amount of exposure in the job, the time spent on the duty, are all precursors of WRULDs. In 1999/2000 there were 431 new cases assessed for disablement benefit owing to a diagnosed WRULD. 669 cases were reported to *Reporting of Injuries, Diseases and Dangerous Occurrences Regulations* RIDDOR in 2001 making musculoskeletal disorders one of the most commonly reported disease groups (HSE 2001). In 1997 ODIN extended its reporting to include musculoskeletal disorders and this scheme was known as MOSS (Musculoskeletal Occupational Surveillance Scheme) (Cherry et al 2001). During 1997- 2000, 66% of the cases of musculoskeletal problems reported by MOSS were due to hand wrist and arm conditions (Cherry et al 2001). An estimated 7800 new cases of WRULD were examined by Occupational Physicians and Rheumatologists in the year 2000 reporting to the Occupational Disease Intelligence Net (ODIN) surveillance schemes (HSE 2001).

My perceptions that employees were feeling discomfort and not reporting it gave me concern in that there was a possibility that people were working with a WRULD. It concerned me that there might be some employees with discomfort that was non-specific (feeling discomfort but with no obvious signs or symptoms) that could possibly be prevented if reported by allowing preventative measurements to be applied.

Employees appear to accept the discomfort associated with WRULD as part of their working life in spite of the fact that the importance of reporting any discomfort is emphasised in the induction programme. My own observation would seem to support the view that WRULD and discomfort is under-reported. More people were feeling more discomfort than those attended the Occupational Health Department. The following are some quotes on expected discomfort from the employees from the production line: "Everyone expects some discomfort at work", "Of course I have got discomfort. Who hasn't?", "It's all part and parcel of the job".

There is a tendency for employees to accept a certain amount of discomfort at work as the norm. Some employees may report minor symptoms as a as a means of gaining relief from their usual job and adding some diversity to their work. Occupational health should include the mental well-being of the employee (Slaney 1999) and therefore rotation of jobs is important to ensure relief from boredom and lack of job satisfaction (Sullivan 1998).

WRULD may be staged clinically according to its severity:

Stage 1: There is discomfort, aching and tiredness of the limb that is affected during the work shift but settling overnight and on days off. This condition can persist for months and is reversible. There are no physical signs and no reduction in performance at work.

Stage 2: Symptoms do not settle overnight and cause sleep disturbance and when at work there is reduced performance or capacity for repetitive work. Physical signs may be present and this condition usually persists for months.

Stage 3: Symptoms persist at rest and there is a disturbed sleep pattern and pain occurring with non repetitive movements. The employee cannot manage to perform light duties and experiences discomfort with non-occupational tasks. Physical signs are present and the condition may persist for months or even years. There is a variation between individuals and conditions and possibly not all will enter at stage 1. The important factor is at stage one there are no physical signs and therefore the assessment is subjective and led by the employee's symptoms. Workplace assessment could produce any possible link between the symptoms and the duty (Dalton & Hazelton 1987; Sluiter 2001). There are concerns that local muscle fatigue is a precursor to WRULD (Valencia 1986), and is supported by (Ashton-Miller 1999).

Employees tend not to disclose any WRULD discomfort for fear of job loss. There are sometimes delays in reporting symptoms. After the reporting of one incident, a follow-up found 11 minor problems, all of which not detected in time could have become acute medical conditions. When asked why they had not reported the incident the employees stated that it was for concern over redundancy as redundancies where taking place at the time as they feared they would loose their jobs. Therefore it is not possible to report accurately on the level of discomfort of the employees, owing to under-reporting. Job insecurity also has an association with lower health status (Amick et al 1998).

Lengthy delays in reporting make it difficult to confirm WRULD and may arouse suspicion as to whether the injury / symptoms were work–related. Management and supervisors will wonder why the employee had not disclosed that they were feeling discomfort earlier. The delay of reporting also may make it difficult to analyse whether the condition is work-related as all previous risk assessments may not detail any problems identified to WRULD. The specific jobs the employees were performing at the time may not exist anymore and those specific models not built. Therefore to analyse the job and observe the individual performing the job will not be possible. Reporting symptoms early allows a full work place assessment to be performed by the Occupational Health Department at the time of discomfort.

In a joint study Helliwell et al (1992), the employment specific period of prevalence of WRULD at the time of the study was 81%; 47% of those employees affected with WRULD wore wrist splints and 30% of the correspondents at the time of the study complained of pain. It was found that medical advice was seldom sought even though the facilities provided a full time nurse and a doctor one day a week. Although the study discovered there may be psychosocial factors in the reporting of symptoms it did not reveal whether advice on reporting of discomfort was provided by the Occupational Health Department at induction or during employment.

The management of WRULD in prevention is by continuous risk assessment, analysing the problem areas and where necessary applying ergonomic / engineering solutions (Macleod 1993). In Company X the management of WRULD is managed by the use of a discomfort form system. The employee attends the department complaining of discomfort which they allege could be owing to work, or the nurse / physiotherapist considers there could be a work related element then the discomfort form is completed. This form is then passed on to the supervisor with recommendations on the duties that the employee cannot perform (a restriction) or in diffuse conditions job rotation would be advised. An attachment sheet is also provided for the supervisor to view the job itself and see if there could be any improvements. A workplace assessment is carried out by the nurse or physiotherapist or both together to analyse if there any implications with the symptoms being work-related. The employee will stay under the care of the physiotherapist / nurse until recovered. If the recovery is taking longer than expected or the condition is reportable then the employee would be referred to the Occupational Physician.

My own view of Occupational Health is a proactive one, and rather then just dealing with the injuries as they happen, I prefer to prevent accidents happening in the first place. This involves performing what the term 'Occupational Health' means: promoting and maintaining the physical, social and mental well being of employees to the highest degree (Occupational Health March 1999; Verbeek et al 2004). Medical care in companies in the past was first aid dominant and the Occupational Health Nurse was preoccupied with first aid treatment rather than prevention. The intention to provide a proactive occupational health service might be frustrated by the notion that industrial ill health is commonly accepted by both workers and employers. At the 50th Anniversary of the Occupational Health Conference in 1998, Michael Bangs (1999) referred to his previous observation of the Occupational Health Nurses Conference in 1971 that preventable illnesses and health-related problems e.g. pneumoconiosis amongst coal

miners were apparently being accepted in industry by both workers and management. However the general acceptance of preventable industrial diseases has been challenged. Two years ago the coalminers were dominant in the news for making claims for chronic bronchitis and emphysema and for the screening programmes that were in place to confirm the extent of their medical condition (*Evening Gazette 2003)*. Coal miners have a higher incidence of osteo-arthritis in the elbows compared with other occupations (Underwood 2004). With regard to WRULD and mine workers, in the late 1990s, after the success of High Court litigation, a claims handling agreement was negotiated with the Department of Trade and Industry (DTI). The DTI is the government department responsible for meeting the claims of 175,000 claimants who work in the mines for the British Coal Industry and allege they have suffered Vibration White Finger (VWF) as a result of using vibrating tools
(IM group action 2003).

From the commencement of vibration exposure before the first white finger symptoms occur there is a latent period where the person is symptom free. The latent period, the length of time is inversely proportional to the amount of exposure to vibration. This means a shorter latent period leads to a quicker form of VWF (SHE LRC 1991). For those exposed to hand transmitted vibration excess risk was found to be higher for distal sites than more proximal ones, in otherwords, hands and wrists in comparison to the neck (Palmer et al 2001). Those exposed to more than the proposed action level of $2.8m/s^2$ had twice as much wrist hand and neck pain than that of other manual workers that had never used vibrating tools. However confounding effects from other ergonomic risk factors could not be discounted (Palmer et al 2001). Hand arm vibration syndrome (HAVS) and carpal tunnel syndrome (CTS) are amongst the diseases which are most commonly reported under RIDDOR. In 2000/2001 there were 905 cases of HAVS and 119 of CTS; however in comparison with the Department of Wages and Pensions (DWP) figures for VWF and CTS the figures much lower in reporting to RIDDOR and suggests substantial under reporting (HSE 2001).

The Occupational Health Nurse has an image problem in that unenlightened managers wanted them to remain in the medical department and treat casualties. Unenlightened workers regarded the nurses as management stooges, working directly for their employers. The nurses, who had moved into industry to avoid the unsociable hours of the NHS, were content to wait for minor injury casualties to attend the Medical Department for treatment. The nurses at the London 1971 conference campaigned to make it understood as their professional emphasis was on preventative measures and not first aid. Major fatal accidents caused by the barbaric working conditions of the Industrial Revolution created public pressure, which led to the development of industrial safety law (Bangs 1999). Prior to this acts had concentrated more on the preservation of the health and morals of the apprentice. An act passed in 1802 was an attempt to keep the working day for those employed in the mills below 12 hours but was not aimed directly at the safety implications although if less tired it does decrease the risk of accidents. The study of industrial law can be split into three principal areas, industrial safety law, employment law and the law relating to industrial relations. Industrial safety law has a history of statutory invention dating back to the beginning of the last century. The major development for safety has been the Health and Safety at Work Act 1974 (Smith & Wood 1989). It had not been not until 1898 that an injured employee could sue an employer for loss as a result of a breach of statutory duty by the employer (Carter 1999). Sir Thomas Legge sorted out many of the risks and principles of prevention in relation to anthrax as early as 1905 (Carter 1999). In 1950 a joint committee of World Health Organisation (WHO) and the International Labour Organisation (ILO) produced a document which was the first ever to use the term 'Occupational Health'. It stated, "Occupational Health should aim at the promotion and maintenance of the highest degree of physical, social and mental well- being of workers in all occupations" (Slaney 1999).

The lack of pro-activity in Occupational Health in Company X is due to the reactive role perceived by the Company and individual employees. Despite the constant reminders to individuals that the Occupational Health Nurses' role is not to administer first aid, people continue to attend at the Occupational Health Department for first aid rather than to consult the appointed first aider.

The old school of Occupational Health (or Industrial Nursing) has concentrated its efforts on emergency care and is concerned to keep this role, as the nurses seem to deem it necessary in order to prevent loss of their jobs. This narrow vision has led to non-pursuance of the full possibilities of a proactive role for Occupational Health. The traditional practice of Occupational Health does not prevent accidents happening. Pioneers of occupational health, such as Brenda Slaney, recognised the need to be proactive by being out on site observing the processes and interaction of people. Brenda Slaney identified with the importance of cleanliness, good heating, lighting and ventilation, guarding of machinery and safe working practices during the late 1940s (Slaney, 2000 p 18). I feel that the profession has not made enough advancement in this direction, although the responsibility may not lie entirely with the nurses. Their approach may be partly dependent on whether they work directly with the Safety Team or if they are from an agency, contracted or employed direct by the Company and partly dependant on whether there is an occupational health nurse in each manufacturing company.

The occupational health service was felt to offer the second most important means of reducing sickness absence for manual workers in industry, with its emphasis on the importance of return-to-work medicals (CBI 1999). It has been the role of the occupational physician to diagnose and report, rather than of those on the shop floor namely physiotherapists and occupational health advisors / nurses who are more likely to see WRULD in its pure form. "It may be justly claimed and supported that the industrial nurse is the heart of the industrial-medical programme, since as a rule, the industrial nurse is far closer to the industrial worker and his medical difficulties than is the physician" (Fleming 1996). It is those on the shop floor that end up managing and treating the medical condition.

Based on my observations, WRULDs in Company X appear to be associated with the nature of specific tasks in various production lines. There is a question whether changes emanating from the occupational health department in a production company will be listened to. From the occupational health department point of view one needs to identify ways of convincing the team leaders and production managers in the value of injury prevention and the possible benefits to both workers and the company in the long run. There may be difficulties in introducing work pattern changes such as job rotation even if the proposals were based on evidence derived from injury and accident records and sickness and absenteeism records if the ethos of the Company and senior management are not perceptive. There are also concerns that the issue of job rotation should be taken on by management as their own project (Leaver 2000). It is in the company's interest to manage job rotation rather than it is led by Occupational Health. For the management to take responsibility for job rotation provides them control. Management are in a better position to have insight into future changes taking place within production in the company which this information is not always known to Occupational Health and therefore management can consider job rotation into new production areas in advance. To successfully introduce changes in the workplace the intervention programme must be owned and managed by the relevant stakeholders from within the production area (Leaver 2000).

The prevention of injury whether it is caused by an accident or WRULD is important. There is a need to create a culture that matches with my vision of pro-activity to health and safety issues. The reluctance to accept the concept of rotation has been of great concern to me in the prevention of WRULD. I tried to understand the culture and mindset standing in the way of this acceptance of job rotation. Despite a policy being written on Upper Limb Disorder and job rotation it has not been possible to gain the agreement for authorisation of the policy.

Static loading of the upper body or high repetitive movements creates chronic fatigue problems owing to inflammation or reduced blood flow through postural muscles, creating fatigue of smaller muscle groups and biomechanical friction problems which can at least in part be remedied by job rotation (Hagberg 1981: Luopajarvi et al 1979). It is known that lack of rotation of repetitive tasks is a significant factor in the development of WRULD over a period of time. It is thought that the practice of job rotation has the potential to increase productivity (HSE work-related upper limb disorder: A Guide to Prevention 1990) but is not a substitute for improving workstation design. The thesis study is to test the assumption that the practice of job rotation would reveal a reduction in the level of discomfort owing to fatigue and/or WRULD.

The preliminary investigations using ethnographic techniques pinpoints the problem of WRULDs.

- In this project, it is proposed to investigate whether the level of discomfort complained of by workers is associated with specific tasks;
- That the discomfort associated with specific tasks can be alleviated by a job rotation scheme
- To investigate means by which long term changes can be introduced or to investigate the obstacles of introducing long term changes in Company X. Therefore the thesis is about the theory and practice of job rotation.

Summary of Chapter One

From the account of Chapter One the main concerns were that there is an ethos where there is a tendency for employees to accept a certain amount of discomfort at work as the norm, which was discovered via the ethnographic research. Some employees may be reporting minor symptoms as a as a means of gaining relief from their usual job and adding some diversity to their work. It appeared more people were feeling more discomfort than those that attended the Occupational Health Department. Working without discomfort and boredom and having job satisfaction therefore seems a very important issue (Hazzard et al 1992). Therefore what the level of discomfort the employees working on the factory floor were feeling was important and whether it was related to specific duties and if it could be relieved by job rotation needed to be assessed. It was needed to see that if this was the case whether long term changes could be implemented within company X that could address these issues (Leaver 2000). Chapter two therefore leads to the literature search and investigates whether cultural differences have any impact on health and safety issues and the impact of WRULD to acknowledge whether the investigative study of WRULD is feasible.

Chapter 2: Literature Review

Introduction to Chapter Two

One of the purposes of this chapter is to acknowledge whether cultural differences have any impact on health and safety issues hence the Korean health and safety records were perused. This involved a literature search on Korean works accidents, injuries and death rates in comparison with other countries.

The other purpose is to recognise the impact of Work-Related Upper Limb Disorder (WRULD). The literature was searched on WRULD with regards to its different terminologies. WRULD idiopathic nature was explored with regard to psychosocial factors and other intrinsic factors, obstacles such as organisational factors e.g. lack of control over the work and methods of work, high workloads and tight deadlines (HSE 1999). The influence of job demands, complexity, security, the perceived threats of technological advances, interpersonal relationships, lack of knowledge, work incentive schemes, peer pressure and the desire to conform were also discussed (Sleator et al 1998) for awareness of the multifactoral and psychosocial influences on WRULD. The prevalence of WRULD was acknowledged and the physical causes and which types of groups and industries were affected; which symptoms were exacerbated by which occupations. It was investigated whether WRULD could be prevented and effective job rotation and intervention studies were acknowledged. The general costs incurred owing to WRULD especially related to sickness absence and its impact on well-being was explored. The law, legislation, regulation and management practise of WRULD and litigation cases were pursued. This was to provide an overall picture of WRULD, how prevalent it was and how significant a problem.

2.0 Korean health and safety record

The prosecution of responsible people in all of the major accidents shown in Table 2.1 did not contribute to the prevention of similar occurrences. As one accident occurred there was no learning curve from it and other similar accidents kept on occurring. For example, the gas explosion in Map'o Seoul occurred in 1994 and a further gas explosion in Taegu in 1995 (Yee 1998). After the collapse of the Wooam Arcade building in Ch'ungju in 1993 no lessons were learnt and in 1995 in the Sampsoong department store a further building collapsed. Risks to health and safety in these incidents were unacceptable (Yee 1998). Korean accidents are unprecedented. They result from loose co-ordination and communication failure, a risk society, a system failure (Yee 1998). Many observers think that Koreans are now paying for the cost of a delayed maturity bill, and of reckless expansion and rush to growth (Yee 1998). In the 1970s full-scale economic development began at a rapid rate, from an agricultural society to industrial society all within 30 years. "The result of such rush is evident in every social aspect can be summarised as an emerging risk society" (Yee 1998). A risk society is where there is a cultural influence over individualistic behaviour. In the presence of known risks individuals still take risks because of cultural aspects. For example, Yee (1998) in incident 9, Table 2.1, when the contractors were concerned as individuals about the safety of the Sampsoong department they were sacked by the owners. Other contractors were brought in that were prepared to take risks and the inspectors were bribed. A culture was influenced on society that allowed risks to be taken and not consider safety as priority. Either you kept quiet and got the contract or basically you lost it and suffered financially but at the risk to society in general (Yee 1998).

The Sampsoong tragedy is a man-made disaster of criminal magnitude. The root of the problem according to Kim (1995) lies in the mind-set of the Korean people as they had not learnt the lessons from the previous collapse of the Wau apartment and Songsu bridge. Koreans' weakest characteristic is the misdirected aspects of its attitude (Kim 1995).

Table 2.1 Accidents in Korea

Incident	Date	Cause / problems	Fatalities	Casualties
1.Derailment at Kup'o station Pusan	1993	Weakness in organisational co-ordination / blasted ground without subsidence / lack of concern for safety	78	182
2.Airoplane crash at Mokp'o Airport	1993	Poor weather conditions but mainly poor safety measures The airline just hadn't expanded these with the increased airline traffic, and the rescue activity was primitive and delayed	66	46
3.Ferry disaster at Wido	1993	Ferry in operation without a mate/ excessive passengers and cargo. The ferry was carrying 141 People more than its capacity	292	43
4.Collapse of Wooam arcade building in Ch'ungju	1993		28	
5.Boat incident Lake Ch'ungju	1994	No life jackets on the boat	29	
6.Songsu Bridge collapse	1994	Only could weight bear 18 tons, but usually more than 40 tons of constant stress on the bridge	32	
7.The Songsu bridge collapse led to survey of 17 bridges over the Han'gang river	1994	5 bridges were operating at 2 x capacity and 5 bridges 1.5 x capacity- only seven bridges were in safe limits	N/A	
8.Gas explosion at Map'o Seoul	1994		13	
9.Sampsoong department store collapse Seoul	1995	Building owners sacked the contractors who had complained that planned design changes were unsafe, other contractors went ahead without objection / inspectors accepted bribes	502	937
10.Gas explosion in Taegu	1995	Reckless digging in a subway / revealed how poorly the underground pipelines were managed	101	
11.Fire in a summer camp on Hwasung	1999	Electrical short circuit/ poor contingency plans	23	

Source Yee (1998) 1-10; Khang (1999):11

Table 2.2 Injuries and death rate in industry in Korea per calendar year

Year	Employees	Injuries	Accident Rate(number of injured workers x100)	Deaths	Death rate per 10,000 people
1985	4,495,185	141,809	3.15	1,718	3.82
1987	5,356,546	142,596	2.66	1,761	3.29
1989	6,687,821	134,127	2.01	1,925	2.58
1990	7,542,752	132,893	1.76	2,236	2.9
1992	7,058,704	107,435	1.52	2,439	3.44
1993	6,942,527	90,288	1.3	2,210	3.18
1994				2,678	3.68
1997	8,236,641	66,770	0.81	2,742	3.33
1998	7,582,459	51,514	0.68	2,212	2.92
1999	7,441,160	55,405	0.74	2,291	3.08
2000		68,976	0.68	2,528	2.67
2001	No data available on injuries for 2001			2,748	2.60
2002		81,911	0.77	2,605	2.46
2003		94,924	0.90	2,923	2.76

(Ministry of Labour) Analysis of Industrial Accidents 1994/ (Choi 1998) / (Asian Labour Update 2001) (http://agency.osha.eu.int/)

Table 2.2 demonstrates that although minor accidents in Korea are generally declining on information up to 2000, based on the accident rate (number of injured workers x 100). The number of deaths has been steadily increasing since 1998, except for a small drop in 2002, increasing again in 2003. The death rate in industry (per 10,000 people) in Korea demonstrates a steady decrease since 1994, with a rise occurring in 2003. The rate of death per worker is 34 times greater than that of Japan (KCTU 1996). South Korea's safety record is believed to be the worst in the industrialised world (Khang 1999). The number of deaths in Korea by October increased from 1,848 in 1999 to 2,031 in 2000, an increase of 183 deaths (Asian Labour Update 2001). In comparison Great Britain's death rate was 1.2 per 100,000 employees in 1993-1994, 1.0 per 100,000 employees in 1994-1995 and 1995-1996 and 1.1 per 100,000 employees in 2000-2001. In 2000-2001 there were 295 deaths, of which 215 were direct employees and 80 self-employed; figures based on all deaths owing to work accidents/ conditions, not just compensation cases (HSE 2000/2001). Industrial accidents and occupational diseases have emerged as a serious social problem in Korea (KOSHA 2000). In the EU in 1996 the rate of fatal injury average was 3.6 in comparison to Britain 1.9, the highest in the EU was Portugal with 9.6 and lowest Finland with 1.7 (all per 100,000 workers/employees) bearing in mind that Koreas incidents for fatalities was per 10,000 workers (Rates of Workplace Injury 1996).

The Korean Occupational Safety and Health Agency was not established until December 1987 in accordance with the provisions of the Korean Safety Corporation law. At first it was called the Korean Industrial Safety Corporation (KISCO) and in 2000 was renamed (KOSHA) (KOSHA 2000).

Workplaces eligible for industrial accident compensation in Korea were expanded to include any company with one or more employees in July 2000, and at that time the casualty sufferers started to rise. A country's compensation system has a great effect on the reporting of work-related disorders (Armstrong 1996).

In Korea the incidence of cardiovascular and cerebrovascular diseases have increased owing to the utilisation of new chemical items by the manufacturing industry. The construction industry in Korea has the highest fatality rate in 1999. There were 583 fatalities in that industry, a higher level than that of other advanced countries (Choi 1998).

"The largest occupational hazard in South Korea is falling from heights, followed by workers getting caught in machinery, electric shock and getting struck by falling or flying objects" (Choi 1998). Generally British employees having visited Korea were aware of greater risks related to electrics in Korea than in Britain. For example they refer to "water pouring on electrics", and "no barrier dividers between people working on the live electrics", and say "employees learn where not to touch live electric areas" (quotes provided by employees in the ethnographic research). Although these comments have not been verified by the author, they do match with the fact that electric shock is one of the largest occupational hazards in South Korea (Choi 1998). Risk assessment is an important process to be followed whether it is regards to industrial injuries or any other accidents and Korea showed a lack of regard in all not just in industrial environment but also in traffic accidents as Korea is ranked the third worst in traffic respects (Choi 1998). In 2003 from the Korean deaths of 2923 (table 2.2) 1,390 resulted from occupational diseases and 1,533 deaths resulted from occupational accidents. As an illustration of risk we may also note that Korean car accidents involved from the 1,533 of occupational accidents 208 of these fatalities were owing to traffic accidents at work approximately 13.5% due to car accidents (Annual Report 2003).

The Korean accident statistics do not reflect the real situation as the Department of Industrial Safety only deals with medical cases needing medical treatment of over four days and which is compensated according to the Industrial Accident Compensation Insurance Act; it omits accident cases that are treated at the workplace or cases covered by medical insurance. Korea's large number of accidental deaths is attributable to man-made disasters (Ilbo1995)

The Far East generally has a poor health and safety record in comparison with the EU. In China on the 22nd September 2003 a small mine shaft in the Pinggang mining subsidiary of the state owned Jixi mining group in Heilongjjang a gas explosion ripped through the mine killing eight migrant miners. Coal mine accidents are reported almost daily from China this incident initially went unreported and highlights how chaotic and mismanaged China's coal mining industry is with regards to its health and safety (Asian labour bulletin- China 2003). There had been a previous accident with this mining company in June 2002 when 115 miners were killed. The occupational health and safety system in coal mining existed in name only was admitted by the deputy director of the state administration for work safety in China at a conference a month after the incident (Asian Labour bulletin China 2003). 503 miners perished within six weeks in mining accidents. From January to March 2001 55 percent of the official 118 major accidents in mines occurred in township and village enterprises. Government statistics show that 573 miners died in 77 mining accidents in the first quarter of 2001 (Asian Labour Update 2001a). This demonstrated that China the same as Korea had not learnt by its previous incidents. The title of the health and safety bulletin the "Absence of rigor and failure of implementation" demonstrates the concerns over the low levels of workplace safety (China Bulletin 2004).

Injuries and deaths in China in 1997 were 6293 for all work except mining with 11,365 deaths on top of this for mining incidents this is 6 ½ times greater than the figure for deaths in Korea at work (Asian Labour Update 2001b). The death rate in China mines ranks amongst the highest in the world. There is also concern about the lack of occupational health protection as benzene poisoning amongst workers has created widespread public concern. Countries in the Mekong area face the same type of situation as China with weak monitoring, poor law enforcement and inadequate public training (Asian Labour Update 2001b). Taiwan's death rate owing to industrial accidents in 1999 is 602 with 45 deaths owing to industrial disease (Asian labour Update 2001c). In Hong Kong from 1991-2000 workers injured were 665,104 and deaths 2,469 and 6,500 occupational diseases. This means that on average 180 workers were injured each day and one worker died every 1 ½ days (Asian Labour Update 2001). It is not surprising that it has been reported that companies financed and managed by overseas owners have a tendency to disregard health and safety policies (Kim 1995; Khang 1999; Yee 1998).

2.1 Work-related upper limb disorder

Work-related upper limb disorder is not a new condition as it was discovered by Ramazinni in 1700, who made the first historical account of RSI/ WRULD, reporting injuries in clerks and scribes (writers cramp) (McDermott 1986).

There has been a controversy over the definition of stress-related injuries and the recognition by employers of the undefined symptoms. Case related pain was recognised as a major issue for worker health and workplace safety (Hadler 1992). Work-related upper limb disorder (WRULD) is the umbrella term for Work Related Repetitive Movement Injury (WRRMI), Work-Related Musculoskeletal Disorders (WMDs), Occupational Overuse Syndrome (OOS), Upper Extremity Disorders (UEDs), Upper Extremity Musculoskeletal disorders (UEMSDs), Repetitive Strain Injury (RSI), Musculoskeletal Disorders (MSD's), and Cumulative Trauma Disorders (CTDs). Upper Limb Disorder (ULD) is identified as a work condition if there are causative factors related to work (see Appendix 7 work-related medical conditions). Historically Repetitive Strain Injury (RSI) has been the most common terminology but the acronym RSI influences the diagnosis and the medical and organisational management of the condition (Ballard 1993). The British Orthopaedic Associations working party was clear that there was no evidence that repetitive strain injury was a real disease (Bainbridge 1997; Barton et al 1992); and this was postulated by Brooke in 1993). Considering the definition of disease is "a disorder with a specific cause and recognisable signs and symptoms: any bodily abnormality or failure to function properly, except that resulting from a direct physical injury (the latter however, may open the way for disease" it would be difficult to define RSI as a disease (Oxford Medical Dictionary 2002); owing to its idiopathic nature. Hagberg (1996) questioned the existence of RSI. Many clinicians do not accept that repetitive strain injury is a real disease (Abbasi 1998). Physical symptoms without any local signs, or no existence of paraphysiological mechanism are not diseases of occupation but subjective sensory and motor disturbances which manifest themselves when a demand is made on an individual; i.e. they are a psychoneurosis (Lucire1986). Considering repetitive work is only one of the criteria of causative factors leading to WRULD, RSI is an inadequate term. RSI will be defined as WRULD throughout the rest of this thesis. WRULD is a collective term for a group of occupational diseases that consist of musculo-skeletal disorders. A group of healthcare professionals interested in WRULD, the consensus group, identified as a defined condition non-specific diffuse forearm pain (Harrington et al 1998). Palmer et al (1998) added that there can be loss of function, muscle tenderness, weakness and allodynia (pain from stimuli which are not normally painful and occurs in other than the area stimulated but is not referred pain) (Palmer et al 1998).

Sluiter et al (2001) recommends a four pronged approach to establish the probability of work relatedness to upper limb disorder. The first step concerns the temporal relationship between the exposure and development of WRULD which relies on surveillance and the examination of symptomatic patients with signs. The temporal criteria are symptoms present now, or on at least four days during the last seven days, or symptoms present on at least four days during at least one week in the last twelve months including whether the symptoms begin to recur or worsen after the current job was started (Sluiter et al 2001). The second step is risk factors according to the region of the upper extremity affected and these include the physical and non-physical factors. The physical factors are posture, movement, force and vibration. The non physical are the work organisational factors, psychological demands, social support, the type of work and rest ratios (Sluiter et al 2001. The consideration should be if the employee has been exposed to any of these physical and non-physical factors. As research has been very broad and covered many anatomical regions, some collated together, it has been difficult to define specific disorders. In order to acknowledge the functional anatomical landmarks and joints, it is recommended that it is defined as the following seven specific regions, neck, upper back, shoulder, elbow, forearm, wrist and hands (Sluiter et al 2001). The third prong is to check for non-occupational origins of the upper limb disorder such as sports participated in or injuries sustained (Sluiter et al 2001). However, it cannot just be assumed that these are causative and the job the person works on should be analyzed as it may be contributory. The fourth prong is to decide on the level of work relatedness and level of needed action of which Sluiter et al (2001) use the traffic light system green as the safe area (low risk) and red at the danger level (high risk).

WRULD is caused by exposure in the workplace to factors affecting the muscles, tendons, nerves, blood vessels, joints and bursae of the hand, wrist, arm and shoulder etc (appendix 7). These are syndromes associated with characteristic symptoms and physical signs (see appendix 7) (Coid 2003). Force, repetition, posture and duration (exposure) are the important factors in the causation of work-related upper limb disorder, either as stand-alone factor or in combination. Repetition is one of the most cited risk factors of work-related upper limb disorders (Armstrong 1996). Generally WRULD is found to be multifactoral rather than owing to one exposure alone (HSG 60 rev).

WRULD is linked to the physical aspects of work, e.g. loads, poor posture, highly repetitive movements, force application, direct mechanical pressure on body tissues and body vibrations. The work environment and organisational factors leading to WRULD are pace, repetition, time patterns, payment systems, monotonous work, fatigue, cold working environments, and how workers perceive the organisation and psychosocial work factors (HSE 2001b). It is naive to imagine local workplace interventions will be sufficient to address the complex issues surrounding WRULDs, it is important to address the wider organisational and social context in order to have any impact on WRULD reduction (Leaver 2000). Poor economic circumstances, low educational attainment, unsatisfactory leisure time and employment issues are all contributory factors (Buckle & Devereux 1999; Leaver 2000). For any successful health rehabilitation and intervention programme efforts, employers need to be aware of the psychosocial factors and other intrinsic factors, obstacles such as organisational black flags. "Black flags" is the term used for organisational obstacles to recovery; for example policies and procedures that do not aid rehabilitation or intervention (Bartys 2003). Sluiter et al (2001) considers for evaluation of conditions with regard to work-relatedness the physical factors and non–physical; the latter being such items as enough rest ratio, no high psychological demands and no low social support with being satisfactory and in the green area, which is acceptable.

Many work-related upper limb disorders are less well-defined, such as the myalgic conditions that arise with paraesthesiae, discomfort and pain known as diffuse symptoms. Myopathies, muscle disorders that give rise to persistent pain burning sensation, aching and stiffness and can be quite diffuse. Neuropathy includes disorders of the peripheral nervous system typically as a result of nerve entrapment or compression, e.g. carpal tunnel syndrome (Crossman & Neary 2002).

According to the European agency for Safety and Health at work report (Buckle & Devereux 1999), 47% of employees reported working in painful or tiring positions, 60% of employees think work affects their health, and 57% of employees reported repetitive movements and 37% of employees reported the handling of heavy loads.

Work-related upper limb disorder is a highly controversial subject. Expert opinions on the aetiology of work-related upper limb disorders vary from the orthodox medical model of illness where physical tasks are thought to cause tissue damage to an alternative viewpoint where it is ascribed to psychological factors and is seen as a "socio-political phenomenon" (Helliwell 1992).

WRULD has been adopted by the media and the public at large but in medical circles it is widely deprecated (Pheasant 1992). Opinions vary on whether work is causal or just creates an exacerbation of work-related upper limb disorders. Certain conditions may be exacerbated by work, but not caused by it, such as osteo-arthritis of the thumb and carpal tunnel. One third of post-menopausal women have arthritis in the first metacarpal joint in the base of the thumb and in their 20-30s these women had laxity in the thumb joints and by their 50s were arthritic, (Armstrong et al 1994). Pellegrini (1991) suggested those with lax ligaments in youth went on to arthritis later on in life.

Therefore it may be advisable to have more frequent ergonomic assessment on these more susceptible individuals to check for thumb laxity in the early stages on all females.

The reported occurrences of carpal tunnel syndrome, in the workforce, have been steadily increasing over the last two decades (Deivanayagam & Sethi 1993). Repeated application of force whilst the wrist is in a deviated posture is suspected to be one of the major causative factors to carpal tunnel syndrome (Deivanayagam & Sethi 1993), related to turning and gripping and pinching out of neutral; neutral is defined as the position of the wrist being parallel with the forearm. Certain people are more at risk than others as a result of individual characteristics, not all yet fully identified (Pheasant 1992).

Rather than linking upper limb disorder with diagnosed conditions, e.g. tenosynovitis, Pheasant (1992) identifies WRULD as the conditions of unknown pathology. He argues that the inference of what is not known does not exist, lacks scientific grounding. The controversial status of WRULD hinges upon disputes concerning the relative importance of organic and psychological factors in the aetiology of these conditions. They became prominent in the Australian epidemic of WRULD where it was seen as a psychosocial contagion (Pheasant 1992). The symptoms of WRULD result from the hysterical conversion of underlying psychological conflicts (Lucire 1986). It has been discovered by various recent studies that there is a link between WRULD and stress in which situations can arise where injury may be caused owing to the human response to stress. Therefore the physical and psychosocial risk factors in the workplace need to be focused on in a comprehensive ergonomic programme that can minimise both problems (Abbott 2003). Psychosocial factors which may interact with physical factors to produce symptoms of WRULD are listed by Sleator et al (1998) and consist of the job demands, complexity, security, the perceived threats of technological advances, interpersonal relationships, lack of knowledge, work incentive schemes, peer pressure and the desire to conform. Physical and psychosocial work related factors are a major cause of non-specific WRULD however it is more likely to develop in people with neurotic perfectionist traits (Van Eijsden-Besseling et al 2004). Psychosocial factors can lead to WRULD. Examples of these are lack of control over the work and methods of work, high workloads and tight deadlines (HSE 1999). High job demands and low job control was associated with lower vitality, mental health, higher pain and increased risk of both physical and emotional role limitations. High strain and low work-related social support increase the risk (Amick et al 1998).

Systematic studies of the combined effects of physical and psychosocial effects are scarce and available data indicates that the physical environment may have its major effect on the excretion of adrenal hormones through the mediating or moderating effects of psychosocial factors (Gamberale et al 1990). In the Delphi exercise organised via the HSE and the University of Birmingham a consensus set of diagnostic criteria was designed for several of the more common disorders of the upper limb (Palmer et al 1998). The Delphi exercise also recognised the condition of non-specific diffuse forearm pain although this is primarily a diagnosis made by exclusion and recognising it may well be a real entity (Harrington et al 1998). In principle it was found to be no different from characterising a headache or non-specific low back pain (Harrington et al 1998). In non-specific upper limb disorders the evidence for developing valid and reliable case definitions and diagnostic criteria is lacking (Sluiter et al 2001). Information about the nature, location and onset of symptoms of non-specific upper limb disorders will help the clinicians understanding. Two case definitions are prepared for each specific non-specific upper limb disorder one with symptoms only and helpful for those performing work surveillance as a criteria to recognise the probable development of a condition. The second includes both symptoms and signs and is more pertinent for the examination by a physician (Sluiter et al 2001). Sluiter et al (2001) provide a checklist as guidance for registering information on non-specific upper limb disorder in an ability to be able to check for common occurrences and to be able to define if there is any work related element (Sluiter 2001).

2.2 The Prevalence of work-related upper limb disorders

1.2 million people in Great Britain suffer work-related upper limb disorders caused by work (Morris & Ways 2002). 4.2 million working days were lost in 1995 in Great Britain owing to sickness and absenteeism. The TUC estimates 1.7 million people every year suffer from three main work related illnesses: backache, arms conditions and stress-related illness. The estimated prevalence of self-reported WRULDS is 49.25 (IRS conference March 2002).

Seven hundred and fifty thousand people, who had been working in the last twelve months, self reported they were suffering from WRULD (Jones et al 1998). In 423,000 of those cases the back was the most affected part of the anatomy and in 314,000 cases the upper limbs and neck were affected (SWI95 survey- Jones et al 1998). 55% of people who reported a musculo-skeletal disorder caused by work said it affected their back - an estimated prevalence of 642,000 (Jones et al 1998). According to the US National Institute of Occupational Safety and Health (NIOSH 1997) from the Bureau of Labour Statistics (BLS 1994) from a total of 705,800 injuries, 367,424 were due to overexertion in lifting and 65% of these affected the back. 93,325 injuries were owing to overexertion in pushing or pulling objects, which demonstrates the importance of measuring the inertia and a trolley maintenance system; 52% of these injuries affected the back. 68,992 injuries were owing to handling or carrying or turning objects; 58% of these affecting the back. Totalled across the three categories above and included within them i.e. overexertion in pushing, pulling, lifting, handling & carrying objects 47,861 injuries affected the shoulder. 83,483 injuries were the result of other unspecified overexertion events. 92,576 injuries were due to repetition; 55% of these affected the wrist; 7% the shoulder and 6% the back. The average time off work was 18 days. Repetition was a strong factor in relation to WRULD. In a study at an industrial health clinic, 35 cases of lateral epicondylitis (64% of the study sample) were found to be associated with work-related activities (Noteboom 1994).

In Britain WRULD is highest in the craft and related occupations at 5.1% and lowest in the professional occupations at 1.5%. The illness rate of WRULD by sector is highest in the construction industry. The average illness rate of WRULD for the working population is 2.7%. It is estimated that in Britain around 58,000 workers who had worked sometime in the previous year were forced to change jobs owing to WRULD (European Agency for Safety and Health at Work 2001b sheet 9). Approximately 50% of the cases, which present with upper limb symptoms, are classified as non-specific upper limb conditions (Cooper & Baker 1996; Buckle & Devereux 1999). 506,000 workers experienced a self-reported condition that affected the neck or upper limbs in

1995 in Great Britain (Jones et al 1998). Limited range of movement was reported by 86% of survey respondents, whose reported disorders were carpal tunnel syndrome, frozen shoulder, lateral or medical epicondylitis and WRULD (Jones et al 1998). Work Related Musculoskeletal Disorders affects 40 million European workers (Ergonomics Today 2000). In Company X employees are given a pre-employment medical to ascertain if there currently have any WRULD or have had a history of any WRULD. Physical examinations are also performed to define any abnormalities in range of movement or problems with performed resistance on specific body parts relating to their injury and past medical history.

2.3 Symptoms exacerbated by occupations

3.4 % of females are diagnosed with carpal tunnel syndrome and 5.8% of females have non-diagnosed carpal tunnel, and therefore go undetected. This information is known, as a study was performed using a stratified random sample taken from the population register of Maastricht and surrounding villages in the Netherlands. The important question for the study was; Do you wake up at night because of unpleasant sensations in your fingers? All the people that had these symptoms were provided free neurological examination and neurophysiological median nerve motor conduction tests. From the 715 subjects of the stratified random sample there was a 70% response rate. Of these 12 were already diagnosed with carpal tunnel syndrome. The remaining subjects 64 (51 women and 13 men) woke up because of brachialgia paraesethetica nocturna (unpleasant sensations in the fingers at night; among these subjects (1 man and 23 women) were found to have carpal tunnel syndrome (De Krom 1992). This means that out of the 70% response rate of 715 subjects) (minus the 12 people already diagnosed with carpal tunnel syndrome and the male subjects) the 23 women found to have undetected carpal tunnel syndrome was 5.8% (De Krom 1992), and of the cases already diagnosed the adult female prevalence rate was 3.4% (DE Krom 1992).
7.16% of the population have carpal tunnel syndrome (De Krom et al 1992).

70% of patients experience numbness at night and 40% complain of pain radiating into the lower forearm with simultaneous paraesthesiae (Kesson & Atkins 1998). A typical history is of paraesthesiae, numbness and night waking, a desire to shake the hand/

hands to get rid of the numbness or pins and needles, some loss of function and difficulty with dexterity, clumsiness and difficulty holding onto things for a long time (Kesson & Atkins 1998). Mechanical and vasculate factors are believed to be involved with inflammation increasing the size of the structures within the carpal tunnel which causes swelling and compression with scarring which in turn affects the perineural vasculate. By wallerian degeneration and intraneural fibrosis a blockade that is irreversible is eventually produced. Constant symptoms reflect intraneural changes such as that of intraneural oedema or axonal oedema (Rosen et al 2001). Carpal Tunnel diagnosis confirmation is by symptoms currently being present now or on at least four days during the last seven days (Sluiter et al 2001). The symptoms are intermittent paraesthesia or pain in at least two of digits supplied by the median nerve and can occur at night, allowing pain in the palm wrist or radiation proximal to the wrist (Sluiter et al 2001). At least one of the following tests need to be positive to confirm the diagnosis of carpal tunnel, flexion compression, carpal compression, tinel's sign, phalen's test, two point discrimination test, resisted thumb abduction or motor loss with evident wasting of the abductor pollicis brevis muscle/ thenar eminence, Sluiter et al (2001) or abnormal nerve conduction time (Palmer et al 2000). It is suggested that 20,000 work related cases of carpal tunnel syndrome attend the general practitioner every year (Harrington et al 1998). Any diagnostic processes mentioned in this thesis are related to the case studies (Table 5.1) with their evaluation for WRULD as others are not pertinent to this study however a list of reportable WRULDs are in (appendix 7).

Interestingly 93 per 100,000 of employed females have carpal tunnel. 147/100,000 non-working females have carpal tunnel syndrome (De Krom et al 1992). Carpal tunnel syndrome is twice as common in women, especially in the 30-50 year-old group, and often is bilateral and therefore more likely not to be due to work. Carpal tunnel syndrome has been steadily increasing in the workforce in the last two decades (Deivanayagam & Sethi 1993). The Work Loss Data Institute report 1999 demonstrates that the prevalence of carpal tunnel syndrome increases by almost 60% in data entry/ typing positions *(Ergonomics Today, 2001b).* 52% of injuries and illness suffered by females are related to WRULD *(Ergonomics Today, 2001c).* Viikari Juntura et al (1999) conclude that reducing the frequency, duration or intensity of exposure to forceful repetitive work, extreme wrist postures and vibration will likely result in the reduction of Carpal Tunnel Syndrome in the workforce.

Employers, trade unions and employees, employers organisations, health professions and voluntary groups have set several challenging targets as a means of securing health together (a long term strategy for England, Scotland and Wales). It is part of the HSC priority programme for tackling musculoskeletal disorders (Morris & Way 2002 p 12). Battevi (1998) is a study based on returning people to work on low exposure jobs to remain productive.

2.4 The prevalence of work-related upper limb disorders in different industries/ types of groups

Workers in the manufacturing industry have the highest incidence of carpal tunnel syndrome and tendonitis and in the construction industry sprain and strains (Rosecrance et al 1997). There is a close relationship between work-related upper limb disorders and occupational types (see Table 2.3). Armstrong et al (1982) found in a poultry processing plant a plant-wide average incidence rate of 12.8 cases of WRULD per 200,000 hours.

Table 2.3 Types of industries researched or known to have WRULD

Type of industries/ occupations	Medical conditions associated with the types of industries / occupations, and authors
Electrochemical plant UK	Chaterjee (1992) Aaras & Westgaard (1987) 88 cases of WRULD, – 33 of supraspinatus tendonitis, 19 of lateral epicondylitis , 2 of medial epicondylitis, 19 of carpal tunnel, 9 of de Quervains tenosynovitis, 4 of trigger fingers
Carpenters	Atterbury (1996): A medium neuropathy (carpal tunnel syndrome) was found in 78% Of carpenters, who were the subject of the sub study (Stinson & Applegate 1996)
Engineering firms	Batevi (1998): shoulders, elbows, wrists
Forestry Industry	Hagen (1998): neck, shoulder and lower back problems
Biscuit factory packers	HSE (1994): A pain in your workplace
Parquet flooring sorters / furniture manufacturers	Oxenburgh (1991) HSE: Pain in the Workplace / Piergorsh (1993)
Typists	Dalton & Hazelton (1987): Hunters disease of occupations. HSE (1994): wrist and neck injuries
Food packers	HSE HSG 45 (1998) shoulders/hands arms
Medical supply companies / Nurses- backs / cleaning and domestic staff	HSE HSG 45 (1998): 4.3% of employees working on suture products had reported Human factors related problems (WRULD). problems (WRULD). NIOSH (1997): Nurses backs
Visual Display Terminal Users	Hales (1994): VDT users in a telecommunications company
Assembly line workers / plastic moulders / electronic industry	Clegg (1987), Armstrong (2000): manufacturing. (Kilbom et al 1986), (Jonnson et al 1988): electronic industry, neck and shoulders and arms / cervicobrachial
Meat and poultry processors – slaughterhouses	Armstrong (1982) – multiple WRULD Frost et al !9980 Carpal Tunnel
Supermarket cashiers / workers	Mackay (1998), (Ryan 1989) multiple
Garage workers	Kant (1990) – multiple WRULD
Keyboard operators	Sharma (1997) – forearm pain
Sewing machine operators	Schibye (1995) Kaegaared & Anderson (2001): neck and shoulder disorders
Textile workers	Laflamme (1993): multiple WRULD
Automobile Industry	Leaver (2000)- ULD & lower back
Stackers / poultry pluckers / sheep shearers	Punnet (1991), Chung (2001): multiple WRULD
Machine operators/ polishers	Mentioned in (Ballard 1993)- multiple

Types of industries/occupations (continued)	Medical conditions associated with the types of industries / occupations, and authors
Construction workers	Occhipinti and Columbini (1993) hand/forearm
Hairdressers / mushroom pickers	HSE HSG 60 (1990), Oude Vrielink et al (1995): mushroom pickers, neck and shoulders
Wholesale, retail and repairs, hotels /restaurants	Buckle and Devereux (1999), Griffith (1993): multiple WRULD
Postal Workers	Steingrimsdottir et al (2004) : shoulders and wrists
Mining, manufacturing, fisheries, agriculture	NIOSH (1997): mining. Chiang (1993): fisheries. Occhipinti and Columbini (1993):
Quarrymen, aircraft workers, welders, shipyard workers	Quarryman. Herberts et al (1981): welders Bigos et al (1991): aircraft worker

It is important to assess each job and not rely on the crude estimations of occupational risk groups. Gender is an important issue as females are at higher risk from WRULD, possibly because they are more often employed in hand-intensive tasks (Buckle & Devereux 1999). Anthropometrical differences between women and men are to be considered, for example men usually have a higher grip score owing to the larger hand and greater strength of grip. Whereas females may have greater dexterity owing to the smaller hand and digits, therefore females may find light dexterity work easier than males where men may find power grips easier. Women are also susceptible to changes in the hormonal levels when pregnant and in the menopause that can temporarily increase risk (Armstrong 2000). Other influencing factors are personal factors, oral contraceptives, gynaecological surgery, gender, age, obesity, wrist size and shape, acute trauma rheumatoid arthritis, and endocrinological disorders all have an impact on the risk of WRULD (Armstrong 2000). Individuals may have increased vulnerability to injury because of disease, genetic factors and lack of fitness and it is especially important to be aware of these at the pre-placement stage (Hagberg 1996). It is important to recognise that personal characteristics, and environmental and sociocultural factors have a place in WRULD. A person with neck pain may be exposed to an awkward posture at work but also to social stress at home, and therefore both factors contribute to sustained contraction of the trapezius muscle creating pain and stiffness. It may be very difficult to ascertain which is the primary causative factor and which the secondary (Hagberg 1996).

2.5 Work-related upper limb disorder in the electronics industry

The electronics industry mostly consists of mass production lines and fast repetitive work in assembling parts. "People on assembly lines are predicted to exhibit lower job satisfaction, higher absence and worse mental health compared to their counterparts in self-paced and less repetitive jobs" (Clegg et al 1987). Interviews by Clegg et al (1987) revealed that employees working on the assembly line regarded the job simply as a means of earning money. According to Clegg et al (1987) assembly line work is associated with poorer mental health but only when it is combined with high daydreaming and low skill utilisation.

WRULD is found in plants engaged in light manufacturing for example those in the electronics industry (Hymovich & Lindholm 1966). Hymovich & Lindholm (1966) found a rate of 6.6 WRULD cases per 200,000 work hours in an electronics assembly firm (Keyserling 1993). Armstrong et al (1982) found a poultry plant with an average of 12.8 cases per 200,000 work hours and therefore the rate of WRULD in the poultry plant is 6.2 higher than in the electronics industry, therefore the poultry plant is found to have even greater risk than the electronics industry per se. The worst industry for WRULD is manufacturing, where prolonged work with the arms extended can produce soreness in the forearm, for example when the assembly tasks are done with force (as when using a down-driver (if extended to work on the product at a distance) or reaching around the back of computer monitors to adjust controls with the arm extended in a static position for a prolonged time; these body positions do occur in Company X. Company X comes under manufacturing as a company and not all the tasks can be classed as light manufacturing.

2.6 Can WRULD be prevented?

Many of the work-related upper limb disorder problems can be eliminated by re-organising the workplace and ensuring appropriate tools are available for specific purposes or jobs. For example a down-driver should be used for vertical screwing, whereas pistol drivers should be provided for horizontal fixing. A downdriver is used by holding it with a power grip and should be held with the elbow as close in as possible to the body with the wrist in a neutral position. The handgrip for tools is important and should have good cohesion to prevent slipping of the hand which if slipping occurs could reduce grip hold strength. The diameter of the handgrip on hand held tools should not exceed 3cm and have a length of 10cms (Dul & Weerdmeester 2001). The pistol gun should be activated with two to three fingers rather than just the index finger so as to spread the load. Using a downdriver as a pistol gun would bring the wrist out of neutral its natural position. When using a pistol gun as a down driver the wrist will go into ulnar deviation and therefore the risk of de Quervains tenosynovitis occurs. Alternating types of drivers as part of a rotation scheme will help alleviate fatigue. Using the driver out of its application takes the hand out of neutral and is therefore likely to create work-related upper limb disorder problems. Tools weighing 0.4kgs or more are not recommended unless a counter-balance system is used where they are precision work (Freivalds 1999). Driving tools are an important factor in the electronics industry where there is a vast quantity of screwdriving for assembling parts.

New technology which has been developed without due concern for human performance as in the light assembly associated with electronics has led to an increase in work-related upper limb disorder (McDermott 1986). Repetitive motions by industrial assembly workers with circuit board assembly have been associated with the development of de Quervains tenovaginitis, lateral epicondylitis, shoulder tendonitis and problems owing to repetitive power grips (Hagberg 1996). The pinch grip is a common task found in many operations, such as the assembly of small electronic parts and requires four times more effort than the power grip. The pinch grip is using the index finger and thumb in opposition bringing finger and thumb tip in contact (Halpern & Fernandez 1993). Deviated wrist postures (out of neutral) may decrease endurance time for a maximum voluntary pinch exertion by up to 45%. Therefore the pinch grip should be performed with the wrist as near to neutral as possible to allow for maximum pinch strength.

2.7 Sickness absence and general costs owing to work-related upper limb disorders

"Pain in the arm related to work is increasingly recognised as an occupational disorder which may cause significant absenteeism" (Helliwell 1992). The European Agency

report by the Roben's Institute for Health and Ergonomics demonstrates that WRULD problems are significant and on the increase. Work-related upper limb disorder costs Member States up to 2% of Gross National Product (Occupational Health Newsletter 2000 p 3). It is estimated (in Nordic countries and Netherlands where data exists, that the cost of WRULD is between 0.5 – 2 % Gross National Product (GNP) (Buckle & Devereux 1999). HSE estimates £1 billion a year cost to Britain from WRULDs (Leaver 2000). WRULD has become the second most expensive condition after back injuries against which to insure (McDermott 1986). 430,000 people in the UK are receiving various social security benefits primarily for back pain. The CBI estimates that back pain costs £208 for every employee each year (Carter & Birrell 2000).
Work-related accidents and illnesses cost 2.1 to 2.6 percent of gross domestic product each year, equivalent to between 14.5 and 18.1 billion pounds. The total cost to employers in the UK is estimated as between 3.5 billion and 7.3 billion pounds a year; 4-8 percent of all gross company trading profits and averages between £143 and £297 per person employed (Waldron 1990). In the UK the cost to individual companies can be as high as £11,500 per case (European Agency for Health and Safety at Work 2000). Experts from over 20 EU countries have discussed legislative and non-legislative preventative measures such as broader employee involvement and workplace design, in an effort to reduce the incidence of work-related upper limb disorder. Bohlemann (1993b) used a system of predetermined strain, which can give an insight into the physiological cost of work and facilitates the design of new work places.

Salford Royal NHS trust carried out research to identify the obstacles to recovery from musculo-skeletal disorders, owing to the general concern that musculo-skeletal disorders are a major cause of work-related absence in the UK (Project no: R55.086). 20,000 new cases of some form of upper limb disorder occur each year.

"Upper Limb Disorders are a major cause of occupational ill health in Great Britain", the most common form of work-related illness, and have been identified as a priority for action in the Health and Safety Commission HSC Strategic plan for 2001-2004. They have led to a major revision of the Health and Safety Executive Upper Limb Disorder Guidance - Health and Safety Guidance 60 HSG 60 (Morris & Way 2002). In 1995 60% of all individuals suffer work-related ill health, 506,000 suffering upper limb disorders caused by or exacerbated by work and taking an average of 13 days off work. In 1997 one million US workers took time off because of WRULD (Ergonomics 2001). In a Sydney study of 89 process workers the mean deviation of time of suffering symptoms was 67 weeks with a median of 45 weeks. Sickness absence time was 19 weeks mean and 6 weeks median (McDermott 1986).

Sickness absence, reduced productivity, staff replacement and training and compensation claims are estimated at £200 million. The target for (securing health together) by 2010 is a 20% reduction in the incidence of work- related upper limb disorder, and a 30% reduction in the number of working days lost to WRULDs. The estimated costs of upper limb disorders do not include reduced productivity, quality waste and process error losses that inevitably occur when poor ergonomics is accepted in the workplace *(Ergonomics Today May 3 2002.* Eklund (1995) concluded that there is a close relationship between ergonomics and quality, as quality deficiency was three times higher in jobs with poor ergonomics. Upper Limb Disorders cost companies money through sickness absence, high staff turnover, retraining and loss of production. "The average cost of a powerbook may be £2000, but the cost of replacing an experienced worker injured in its use can be as high as £40,000" (RSIQ 2003).

Compensation for claims is increasing and the problem may affect employers' insurance premiums and increase stipulations by the insurers. The highest claim for WRULD against an employer so far has been ¼ million based on future loss of earnings. In California between 1998 to 2001 over 100 citations were given for violating the states' workplace ergonomic rules, and the cost incurred through penalties totalled more than 180,000 dollars *(Ergonomics Today, May 6th 2002).* Reducing health risks at work leads to reduced fatigue, improves staff motivation and increases productivity (HSE 2000). It is estimated that between 1995 and 1996 the cost to employers of musculoskeletal disorders affecting the upper limbs or neck was £208–£221 million (HSE 1995/96). TUC statistics showed that 545,000 people take time off work each year due to upper limb disorders caused or exacerbated by work and these sufferers take about 17 million days of sick leave a year. 43,000 people each year take more than 6 months off sick. The average time off due to a medical condition caused by work is 36 days. Between £315 million and £335 million is the cost to employers of WRULD at 1995/1996 prices (HSE 1995/1996).

It is not impossible to reduce the problem of high turnover if the situation is carefully analyzed. It will in the long term achieve high productivity. For example the situation at the STK telephone plant in Kongsvinger, all the workstations were fixed at a height that resulted in ergonomic problems, which led to neck and arm problems. After workstation redesign the turnover of labour was reduced from 30 percent to 7.5 percent. The cost for design was £30,000 but there was a return of nearly £300,000 from the turnover reduction (Graves 1990). The impact of an ergonomic intervention was that sick leave was reduced from 5.3% to 3.1% and staff turnover from 30.1% to 7.6%. An ergonomic investment (of 350,000NOK) produced total savings of 3,200,000NOK in the Norwegian telephone company (Aaras 1994). The study dealt with the incidence of load related musculo-skeletal illness of female workers exposed to various workloads. Postural load was assessed by the recording of electromyography (EMG) on the upper part of the trapezius muscle, the postural angle of the lower arm and flexion/extension of the head and back. Static trapezius load and the development of musculo-skeletal problems led to sick leave. The length of sick leave was related to the length of employment. By increasing the number of postural and static duration of the trapezius below 1%-2% of maximum voluntary contraction, reducing the magnitude of flexion of the upper arm in the sagittal plane, distributing the work between the flexor and extensors (median <15° flexion and abduction < 10°), and a more dynamic work pattern of the upper arm, this led to improved ergonomics, less neck and arm problems and reduced sickness absence and decreased staff turnover (Aaras 1994).

The study period was lengthy between 1967- 1984 with the intervention taking place early 1975. The study involved 420 subjects with seven hundred man labour years before the intervention and approximately 800 man labour years after the intervention. The tasks performed were cable form and wire joining. Cable form involved laying thin wires between nails on wooden board and then them being sewn together with plastic bands. The main task was wire joining which involved placing the wire into the gun positioned onto the terminal (Aaras 1994). Intervention reduced static load and allowed variation in work position by adjustment of the workstation and sitting and standing position, giving sufficient leg room to avoid the back being bent, and angular adjustments of work table and suspending counterbalance of hand tools lowering the external static loads by supporting the gun.

Where work was carried out above elbow height the load on the shoulder and neck was reduced by the provision of arm supports, limiting vertical dimensions of work operations and work being carried out symmetrically with hands working at same height (Aaras 1994). This means that the factors that may influence WRULD are static load expressed by the magnitude of flexion and extension of the upper arm, static shoulder movement and static trapezius load in percent of maximum voluntary contraction. The dynamic pattern of work is another factor and this relates to the distribution of the muscle load between subgroups of muscles such as flexors or extensors and the number and duration of very low postural load (below 1-2% MVC and an upper arm flexion / extension between +/- 5). The latter, the dynamic pattern, relates to this study X as of its dynamic repetitive nature. The telephone company intervention aimed at reducing the static load and allowing variation in work posture and movements, as postural load clearly influenced the increase of musculoskeletal sick leave (Aaras 1994). Owing to the implementation of various ergonomic interventions in the Redwing Shoe Company in Minnesota, workers' insurance premiums were reduced by 70% between 1989 and 1995 (Hendrick 1996).

2.8 The impact of work- related upper limb disorders on well-being

"Low social support at work and high job insecurity" were independent predictors of restricted activity due to musculoskeletal disorders (Cole 2001). Low social support from supervisors or co-workers appears to be a risk factor for low back pain (Hoogendoorn et al 2001). Bigos et al (1986) showed a positive association between poor social relations at work and episodes of back pain resulting in work absenteeism. Ahlberg-Hulten et al (1995) investigated social support and musculoskeletal pain among female health care workers and found a high frequency of low back pain was significantly related to high psychological demands, low skill utilisation and low authority over decision making.

A two-year population based cohort study was carried out to determine the relative contribution of psychological factors and work-related mechanical factors on the onset of forearm pain (MacFarlane et al 2000). Participants who believed that they could rarely make their own decisions at work have double the risk of forearm pain *(Occupational Health Review, Dec 2000 p2*; MacFarlane et al 2000). Psychosocial factors such as lack of social support at work increases the risk of developing neck and shoulder disorders (Kaergaerd & Anderson 2001). Bigos et al (1986) showed a positive association between poor social relations at work with colleagues and poor employee appraisals. Low-discretion jobs reduce people's ability to deal with problems from more than one perspective (Parker & Wall 1998). Hagen (1998) in a cross-sectional study of the forest industry (654 manual workers, 66 machine operators and 124 administrative workers) concluded that WRULD is associated with both physical and psychosocial work factors. Palmer et al (2001a), in a study of neck pain and its relation to occupational activities, showed a strong association, however, they suggest that psychosocial factors may be more important as they found stronger neck pain associations with frequent headaches, tiredness or stress than with occupational activities.

Glaxo, the spinal research unit of the University of Huddersfield, the HSE and the Department of Behavioural Medicine at Salford University is commissioning a controlled trial of nurse-led psychosocial intervention based study in occupational health units (MacFarlane et al 2000). Its aims are to reduce absence and increase work retention. The sites were matched for work content and organisational culture and the absence rate was an average of 12 days. An experimental intervention with two sites and 1,500 employees and three control sites, it looks to identify psychosocial obstacles to recovery from WRULD and is still ongoing. It completes in the year 2003 (MacFarlane et al 2000). With all work-related upper limb disorders there is a need to consider psychosocial implications and especially so in diffuse conditions where a pure diagnosis is not possible and disorders could arise from secondary aspects of the job. In a cardboard packaging factory a study investigating wide grip pinch applications (Helliwell 1992) and the incidence of arm pain found higher scores for anxiety and depression using the BSI Bradford Somatic Inventory. It also showed the importance of job education and identified a need for a work standard operating instructions to ensure the tasks were done in a particular way.

Psychosocial factors include the individual's subjective perceptions of the work organisation factors (Buckle & Devereux 1999) even though these may not necessarily be a true reflection of the work organisation/culture, and they have important implications for the development and recovery of WRULD. Risk prevention strategies aimed at prevention of work-related upper limb disorders should address both physical and psychosocial work risk factors because these can interact to magnify the risk for some of the musculoskeletal conditions studied. Psychosocial factors may also affect awareness and reporting of musculo-skeletal symptoms and/or perceptions of their cause (Helliwell 1992). Psychosocial aspects of work should be dealt with, in conjunction with workplace design and work organisation (Oude Vrielink et al 1995). Lundburg et al (1989) linked the psychosocial aspects of work with musculoskeletal outcomes via physiological mechanisms and by social or individual differences. The findings about exposure to non biomechanical factors in the work setting affirm that these disorders are complex and multifactoral (Faucett & Werner 1999).

The individual's subjective perceptions (see Table 2.4) of the culture of the company may have some effect on the reporting, development and recovery of WRULD (Buckle & Devereux 1999). If the person's perception of the culture is poor and that perception is well-founded (i.e. a true negative then if injury occurs it only proves to the person that their perception was correct. If the person thought it was a good culture and finds they were wrong (false positive), they are going to be disappointed. Even if the company has a good culture but the person perceives it as a poor culture (false negative) then it can only have a negative impact. Therefore the false negative, false positive and true negative all may have a damaging effect on recovery from WRULD/ injury. The only beneficial outcome is if the perception of the company is a true positive.

Table 2.4 The individual's subjective perception of the health and safety culture

False positive	**True positive**
Own positive perception untrue	Own positive perception true
Poor health and safety culture	Good health and safety culture
False negative	**True negative**
Own negative perception untrue	Own negative perception true
Good health and safety culture	Poor health and safety culture

2.9 Effective job rotation and intervention studies

Very few studies examine the effectiveness of job rotation and WRULDs although a number of studies address the positive impact of variation and pauses during work (Macleod 1993). Some of these studies look at job rotation and its impact on reducing WRULD in the context of such issues as the reduction of boredom, work stress, increased innovation and production, reduced absenteeism and reduced labour turnover (Hazzard et al 1992). Job rotation can give people a broader perspective of the organisations work (Carnall 2003). In applying (McGregor 2003) theory X and Y, X being a negative assumption these people are likely to be anti job rotation; whereas Y people have positive assumptions and are likely to be pro job rotation. Any job rotation plan need to consider converting the employees of theory X assumption. They tend to have an inherent dislike for work they need to be controlled, coerced, punished and directed in order to produce adequate work. They prefer to be directed and have very little ambition and try to avoid responsibility; they are only interested in security. Therefore it is important to direct them into job rotation and acknowledge that this will give them greater job security so that they will take on board the concept of job rotation (McGregor 2003). Apart from books on organisational and behaviour change, research on why workers dislike job rotation and ways of overcoming the obstacles of people not wanting to perform job rotation is almost non existent. The research tends to look at the benefits to the company rather than an individual level. Developing people and becoming more comfortable with change and sharing rewards have been considered as values for individuals associated with multi-skilling (Cross 1990). Very few studies examine directly job rotation programmes where the benefits are shown in the different jobs and in the impact those specific jobs have on the musculo-skeletal system. Little attention has been given to which jobs are most in need of rotation. Smyth & Bennet (2000) have been very specific in this area in relation to the management of WRULD.

Job rotation helps employees understand how their work at one job affects that of other jobs and therefore promotes process innovation and co-operation (Macoby 1997), and allows a wider range of skills and increased flexibility. High employee turnover disrupts team effectiveness and slows production development (Sullivan 1998). Team autonomy increases morale and self-esteem is seen as relevant, because with structured performance based pay the benefits are job satisfaction, quality improvement and productivity. Job rotation helps prevent job boredom and burnout, rewards employees, enhances career development and allows the employee to see the big picture sooner (Sullivan 1998). Job rotation enhances employees' commitment to stay with the company (Sullivan 1998). Exit interview data shows that individuals who feel stalled in their personal growth are less likely to be motivated (Sullivan 1998).

Obstacles to rotation can result from experienced workers not wanting to learn new types of work and machine operators not wanting to lend their machines to others. The practical problems of getting from one job to the next and concerns about lost production time can lead to lack of commitment to job rotation. Difficulty can be faced in finding jobs to rotate to. Inappropriate use of job rotation where similar jobs require equal forces, the same grips and same muscle loading will not prevent work-related upper limb disorder (Hazzard et al 1992). Only variation of the muscle tendon group used alleviates physical fatigue. "Engineering changes should remain the goal of the ergonomics program" (Macleod 1993). In other words job rotation should not be used as a substitute for improvements. Ideally machine robotics should be used in well-structured repetitive tasks requiring considerable force or speed. Although this is not always practical for the company as it is an expensive route that can take them out of the market; not all jobs allow such precision for the use of robotics where more versatility and changeability occur within the job.

Ciriello (2001) examined the incentive bonus and found that the use of incentives are a problem that can exacerbate work-related upper limb disorders because people will work harder and quicker for longer periods to complete the work and therefore tend to keep to one job to gain greater speed and a higher incentive bonus(HSE 2001b). There has been suggestion that shortening of the workdays from seven hours or more to six hours may considerably reduce the prevalence of neck and shoulder pain in those with physically demanding jobs (Wergeland et al 2003).

Table 2.5 provides a few intervention studies that have taken place.There have been many investigative studies of WRULD for example in forestry workers, sewing machinists, carpenters, typists, automobile workers and newspaper personnel. The majority of these were not direct intervention studies but were used as a means to collect research information that could be applied in the future to these occupations.
Job rotation theory and practice are based on medical theory rather than research practice studies e.g. the use of mathematical models (Chadwick & Nichol 2000). The odds of developing a work-related upper limb disorder resulting in lost time were three times greater without an intervention programme (Schneider 1998). Fewer than 30% of general industry employers have effective ergonomics programmes in place today *(Ergonomics Today Nov 99).* The pre-ergonomic assessment prior to build (DFA) Design For Assembly, has long term benefits that far outweigh the costs (Leaver 1999). Bohlemann (1993b) used a system of predetermined strain, which can give an insight into the physiological cost of work and facilitates the design of new work places.

Table 2.5 Intervention studies

Chaterjee, (1992)	Workplace upper limb disorders - a prospective study with intervention Establishing a cause-and- effect relationship and preventative strategy	Ford Motor Company Investigating vibration measurement of tools
Bergamasco, Girola & Columbini (1998)	Guidelines for designing jobs featuring repetitive tasks. *Ergonomics 1998 Vol. 41. No.9. p 1364-1383*	A postural study to lower repetitive tasks in relation to WRULD
Rubenowitz (1997)	Survey and intervention of ergonomic problems at the workplace. *International Journal of Industrial Economics 19:271-275*	Reducing mechanical exposure resulted in the reduction of neck and upper limb disorders

2.10 Counteractive measures for the reduction of WRULD:

Very few intervention studies have evaluated the effect of the intervention on exposure (Cole et al 2003). Between 1987 and 1990 a 21-fold reduction was achieved in WRULD incidence after making engineering modifications in a car parts plant (Chaterjee 1992; Ballard 1994). In the packing operations at one of the Boots chemist sites, six cases of epicondylitis led to concerns of WRULD. Common postures were identified and therefore automation in the factory was increased in an effort to reduce the incidence of epicondylitis. Task rotation, every thirty minutes using a standard colour coded and numbered system was implemented as a preventative strategy from WRULD. To prevent WRULD different ways to close jars were developed. Good commitment and support was given from the top management and this was essential to success (Smyth & Bennet 2000). In a Landrover recovery plan repetitive strain injury practical workplace management led to an 82% reduction in WRULD absence, within six months of providing physiotherapy (Leaver 2000).

It is important to address the cultural, organisational and environmental factors in the incidence of WRULD if an intervention strategy is to be successful (Buckle & Devereux 1999). For manufacturing industries where the production facilities represent a significant level of capital expenditure there is a need to concentrate resources on new products and facilities. In reality the ability to introduce changes to existing company facilities are limited owing to the significant original cost (Wilkinson et al 1998); (Leaver 1999) and any changes would require a plan of future use, as the technological environment is changing fast. In the near future the Cathode Detection Tube (CDT) monitor will be replaced by the Thin Film Transistor (TFT) monitor, known to the media generally as the flat screen monitor. To remain profitable it's critical that the production of TFT monitors is increased and CDT monitors reduced, to stimulate revenue through new technologies. It would not be cost effective to concentrate too much on the existing CDT monitor, as CDT prices are falling and more and more people want to purchase the TFT monitors. It would not be wise to concentrate on the ergonomics and job rotation in relation to the CDT monitors at the expense of the TFT monitors because with new technologies new problems arise.

Sixty percent of sorters developed upper limb musculoskeletal discomfort in the first year of employment in a parquet flooring company (HSE 1991). Rotation took place within the parquet flooring firm, but all the jobs required the same postures and forces and therefore rotation was not effective. The company then went semi-automated, taking out the problem areas of lifting or turning the flooring which were causing WRULD. Thirty percent of the injured persons with sickness absence over one year were able to return in a new situation doing only the visual inspection without the manual handling, thus reducing the risk of exacerbation of WRULD for these employees (HSE 1991).

An investigation in a biscuit factory, in the area where the packing of biscuits took place, showed that the reduction of ergonomic problems in that area led to reduced sickness absence, reduced turnover and a 48 percent decrease in the incidence of work-related upper limb disorder (HSE 1994).

The Japanese Ministry of Labour in 1964 introduced measures to counteract WRULD in keyboard operators, by restricting the hours worked on the keyboard and the amount of keystrokes and by introducing job rotation. This led to the reduction in the incidence of Upper Limb disorders, notably arm and hand repetition injuries (Dalton & Hazelton 1987). Significant measures in reducing WRULD risk include compiling data on company accidents and injuries, personal injury claims, reported discomfort levels, the results of ergonomic assessments, quality and defect levels and the possible benchmarking criteria agreed between companies. Once the compiling of the data is complete, monitoring and evaluation should take place leading to implementation of prevention strategies which should not only decrease the risk of WRULD but that of all injuries.

The evaluation of an ergonomics programme requires an assessment of the before and after levels of sickness injury and absence. It also requires a before and after evaluation of a comparison of employee levels of restrictions, details of employee job satisfaction and employee turnover rate, exit interview data, and quality and productivity levels. For the programmes to be successful they need input from the employees to ensure correct measurement and the experience of the employees is required with regards to understanding the difficulties of the job. For example a fast running production line may create concerns with taking on another job, and therefore interfere in rotation. There should ideally be a training line where speed is not a major priority.

There is a cause for great concern in the present employment situation where agency people are so easily replaced now that there are no "jobs for life" (Steed /Telegraph 2002). Deregulation has led to the loss of jobs for life, and with the introduction of privatisation market forces have led to less concern for workers lives' and health. With pension payouts not having good returns many have to delay their retirement by as much as seven years (Steed /Telegraph 2002) resulting in an ageing workforce. With most agency employees earning just over the minimum wage, a pension is a luxury not easily afforded and the amount of contribution is not going to yield an adequate pension.

A task group was set up to initiate a large study of cost and benefits of job rotation (EU2001). The Scotland section of the European Union International Association of job rotation has funded a programme aimed at tackling the challenges faced by older workers (50+) and will have a large job rotation component (EU 2001b). Chaparro et al (2000) found in old age a reduction in the range of movement especially in men. Comparison of the 25-35 and 60- 69 age groups has shown that wrist flexion would reduced overtime by 12% extension by 41% (dorsi flexion / volar), and ulnar deviation by 22%. This older group may therefore be at greater risk of developing work-related upper limb disorders. "There is an obvious necessity to approach the issue of the ageing European population more proactively" (EU 2001 forum 1 p2). It would seem therefore appropriate to have increased surveillance of those within the 60+ age group. In this research in Company X there were no employees within this age range of 60-69. Since the study older employees are starting to work on the production lines within this age group as this is the only type of work available to them, as they have been made redundant from what was once a long-term job and the only job they had known. Therefore employees that are older are at more risk and also join the production line with no experience of this type of work, and it can be increasingly difficult with a reduced range of movement when their tendons and ligaments are not up to peak fitness.

2.11 Legislation, Regulation and Management Practise

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) and the Labour Force Survey (LFS) have shown major discrepancies. The injury rates reported to the LFS in 1995/96 showed the injury rate at 4,310 and reportable injuries at 1,640; the actual number of injuries reported to RIDDOR was 684. The rates of injury are the number of injuries expressed per 100,000 employed people. The under-reporting of injuries has led to the HSE's commissions review of RIDDOR (HSE 1999 Level and Trends in Workplace Injury). The reporting of WRULD to RIDDOR is not consistent with research; certain conditions are not reportable and other conditions are reported only when there are certain causation factors. For example carpal tunnel syndrome is reportable when associated with the use of hand held vibrating tools, and when pressure is applied with the heel of the hand (known as beat hand) which is deemed to be a one of the causes of carpal tunnel syndrome. Carpal tunnel syndrome is not reportable when work is performed using the wrists out of neutral and with repetitive wrist movement (Weislander 1989). About 1,000 new reported cases of de Quervains are assessed each year and 25 per cent of these cases receive benefit (Harrington et al 1996).

Out of 46 ganglion cases, the highest percentage out of 5 jobs in the study was people engaged in folding/packaging (McCormack 1990). The relation of ganglions to work is under scrutiny and has not been positively established (NIOSH 1997). If in the future ganglions are found to have a work related element then there will be cause for concern as every line on both sites requires folding and packaging at the end of the line where boxing of the product takes place.

The Management of Health and Safety at work regulations require Upper Limb Disorders to be addressed by the following:

1) HSE at work Act 1974 general duty of care. This act imposes duties on all concerned with work activities, on individuals and corporations/companies.

2) HSE Regulations Management of Health and Safety at Work Regulations (1999) Approved Code of Practice and guidance.

3) Workplace (Health, Safety and Welfare) Regulations 1992 Approved Code of Practice.

4) Health and Safety (Display Screen Equipment) DSE Regulations 1992 in relation to VDU users.

5) Provision and Use of Work Equipment Regulations 1998 safe use of work equipment. Approved Code of Practice and Guidance.

6) Personal Protective Equipment at Work Regulations 1992.

7) HSE Manual Handling Operations Regulations 1992.

8) HSE Riddor Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (reporting system) (1995).

9) HSE Working with VDUs INDG36 (1998) Advisory Guidance.

10) HSE HSG 60 (revision) replaces HSG 60 (1990), which replaces beat conditions and tenosynovitis MS10 1997 Advisory Guidance.

11) HSE Upper Limb disorders assessing the risks INDG 171 (1994) Advisory Guidance.

Employers are now obliged to carry out risk assessments and introduce measures to reduce the risk of ill health. This should encourage all employers to take seriously the need for organisational change to tackle WRULD as there is risk of expensive civil action for injuries and financial loss. Although research for sometime has been investigating whether work involving the application of force with the hand in a non neutral position is a causative or contributory in carpal tunnel syndrome (Deivanayagam & Sethi 1993); RIDDOR has not managed to keep-up-to date with current research. Since the recent HSE HSG60 revision (2002) there will be much change to the reporting systems.

2.12 Litigation related to work-related upper limb disorder

Kathleen Harris won a landmark compensation for WRULD (lateral epicondylitis) before her enforced retirement from a London Tax Office in 1995. This case of WRULD was in the public domain and aroused interest for the impact it would have on future claims. Kathleen Harris worked seven and a half hours a day and the only break she had was half an hour for lunch. Her typing averaged four strokes a second. It was deemed that the injuries that had occurred to her arms were attributable as much to the bad working environment (the culture) as to the speed of her work for it was a workplace that cracked whip to improve its productivity (Marland 1997).

The UKs largest ever industrial injury compensation payout has been awarded to the coal miners. The repeated inhalation of coal dust, which contains carbonates which coal miners were exposed to without the necessary precautions led to the possible development of a condition called pneumoconiosis. Around £1.5 billion damages were awarded to 65,000 former miners suffering from pneumoconiosis and up to £50,000 to each former miner depending on age and the severity of the condition. The Department of Trade and Industry is running two major compensation schemes for miners suffering from lung disease and certain vibration related diseases, vibration white finger and carpal tunnel syndrome (www.dti.gov.uk/coalhealth).

The National Union of Miners estimates around 250,000 miners have lodged claims for vibration white finger (BBC News 1999). The typical pay award for each miner with vibration white finger is likely to be between £5000- £10,000 (BBC News 1999). By January 1999, more than 30,000 former miners had been awarded £500 million by the high court (BBC News 1999). Between 2001-2005 more than £1.1 billion has been paid out by the British government to compensate more than 170,000 miners for injuries related to vibration white finger (Aberdare on line 2005). £103 million has been paid to miners and their families in Wales for vibration white finger caused by continuous use of vibrating hand machinery (BBS News 2004); and at this time of nearly 21,000 claims, just over half, had been settled (BBC News 2004). The state of play for claims in January 2005 is, total claims 170,000, live claims 148,000, claims for the deceased 22,000, claims settled 99,000, interim payments 97,000, total compensation 1.1 billion (dti.gov.uk/coalhealth 2005). Eighty five percent of cases reported in 1999-2000 of vibration white finger were miners (HSE 2001). The second most common Department of Health prescribed industrial disease is vibration white finger (VWF). The effects of VWF can range from mild blanching of the fingers to extensive blanching and loss of feeling, therefore interfering with social and work activities (SHE LRC 1991).

Similarly workers in electronic manufacturing can argue that WRULD can cause permanent damage to the hands and there are legal cases to illustrate their claims. In most cases the compensation for WRULD has been rather modest and generally payouts are at average £1,500. Bilateral disabilities with surgery and job loss are compensated at £11,000 to £11,500 (Appleby 2001). In April 2000 Fiona Conaty developed RSI due to a poorly designed work station which meant her wrists was in an awkward position and sued her former employers Barclays bank plc for £243,793 (Sunley 2002). The largest claims of about ¼ million pounds are mainly due to loss of earnings.

Claims for disablement have increased from 1.7% in 1990 to 22.5% in 1996/1997. 62% of all the claims for disablement for 1996-1997 were for WRULD, the number of claims being 4220 (Buckle & Devereux, 1999). Of the claims in Table 2.6, four are related to typing and data inputting (1, 2, 3 & 6). Three claims related to conditions developing as a result of repetitive heavy lifting (4, 8 &10). Gould versus Shell (7) is an interesting case in that the ineffective use of the mouse had led to WRULD. The person had not received training on the use of the mouse and the compensation was based more on lack of training than on the medical condition itself. Interestingly the diffuse case of WRULD (6) was accepted as a claim despite the controversy surrounding the medical acceptance of diffuse WRULD.

Table 2.6 Litigation cases

	Amount	Condition	Job	Claimant v company	Job description	Source
1	£118,000	WRULD	Typists	30 people make claim / Inland Revenue	Typing	Dyer 1994
2	£8000-15000 each (total £61,8000)	WRULD	Data encoders	5 Midland bank workers- 1st successful case in diffuse WRULD	Inputting 15,000 key strokes an hour	Occ Health Review 1998 July August Ossler and others versus Midland Bank
3	£45,000	Tenosynovitis	Typist	Midland Bank	Excessive electronic typewriter work	Appleby 2001
4	£186,281	Lateral epicondylitis	Operator	Scott	Loading and unloading 10kg mandrel on to a toilet paper machine every two minutes 12 hours a day	Occupational Health Review March-April 1997
5	Amount unknown	Trigger Finger		Pepall V Thorn Consumer electronics	Electronics work	Unreported 1984, Appleby 2001
6	£85,000	Diffuse WRULD	Typist	Gallagher V Bond Pearce	Typing	Unreported 9th Feb 2001, Appleby 2001
7	£25,000	WRULD	DSE user	Ms Gould V shell	Ineffective use of mouse	Buckman (2000)
8	£21,000	WRULD Tenosynovitis	Turkey processor	Bernard Matthews PLC V Six Turkey Processors	Lifting 150 tons of turkey a day per person/lack of effective rotation	Ballard 1993/94
9	£6,000 each (total £12,000)	WRULD	Data processor	BT	Poor posture	Ballard 1993
10	£59,617	Osteoarthritis at base of thumb and de Quervains tenosynovitis	Assembly line worker	Vauxhall motors - Jane Inskipp	Loading 500 heavy wheel gears each day onto a machine involving twisting and turning and forceful actions	Ballard 1993

A new web site *www.humanetechnology* has just been developed to contain all the cases of claims for WRULD the job the client was performing and the medical condition it caused, but it currently does not contain the amount of financial settlement. Text messaging is deemed now to be the new cause of WRULD. It has created an upper limb disorder time bomb, which may have a considerable impact on work if economics leads to texting rather than phoning.

For a claim to be made there are four criteria that are required to be present:

1) A foreseeability that the job could cause WRULD

2) No adequate steps, control measures or risk assessments and therefore a breach of duty

3) Evident injury (although with diffuse conditions this can be difficult to determine)

4) Available proof that the condition is work-related

The claimant has three years from the time they became aware the injury was owing to work to bring a claim (Appleby 2001).

The legislation could have a possible latent effect on employment. If electronics companies generally are known to have a higher degree of WRULD than other industries should they be more scrupulous about whom they employ with the result that they might not take on a person that has worked in the construction injury with vibrating tools in case he/she latently developed carpal tunnel syndrome and claim against the company?

RIDDOR is now going to have to match the outcomes of the new HSG60 revision. Further research has identified more conditions and work-related factors that lead to WRULD. The controls have been identified and if not followed by companies they will fail in their duty and will be unable to deny foreseeability. Therefore claims costs could escalate as the claim culture becomes prevalent especially with the no win no fee schemes by solicitors.

2.13 Summary of Chapter 2

The assumption that there may be cultural issues to health and safety can be appreciated in that the literature search revealed that the Far East generally has a poor health and safety record when compared with the EU (Asian Labour update 2001). Table 2.1 revealed the amount of works accidents in Korea and table 2.2 the injuries and death rate in industry in Korea, per calendar year, to be very high in comparison with Britain. The ethnographic research quotes "water pouring on electrics", "no barrier dividers between people working on the live electrics", "employees learn where not to touch live electric areas" and that electric shock is one of the largest occupational hazards in South Korea (Choi 1998), which seems quite believable. That there were difficulties in implementing health and safety changes in an industry financed by another country, owing primarily to cultural differences, supported by Kang (1999) were also supported by the fact that the Far East generally has a poor health and safety record when compared with the European Union (Asian Labour update 2001). Understandably the next chapter investigates the cultural issues concerning health and safety, by ethnographic research in Company X.

The psychosocial factors and other intrinsic factors, as well as the physical factors, were apparent throughout this chapter, HSE (1999) with an awareness of the multifactoral and psychosocial influences on WRULD (Sleator et al 1998). The prevalence of WRULD was widespread affecting many different groups in different industries (table 2.3). It appeared that WRULD can be prevented and effective job rotation and intervention are worthwhile pursuing. The general costs incurred owing to WRULD were significant in relation to sickness absence, labour turnover, litigation claims, etc. The suffering and impact on well-being was apparent. Job rotation helps employees understand how their work at one job affects that of other jobs and therefore promotes process innovation and co-operation (Macoby 1997), and allows a wider range of skills and increased flexibility. Team effectiveness was found to be disruptive when employee turnover is high and slows production development (Sullivan 1998). Job rotation was found to be effective but also helps prevent job boredom and burnout, rewards employees, enhances career development and allows the employee to see the big picture sooner (Sullivan 1998). According to Clegg et al (1987) assembly line work is generally associated with poorer mental health.

Subjective perceptions (see Table 2.4) of the culture of the company may have some effect on the reporting, development and recovery of WRULD (Buckle & Devereux 1999). Therefore it was quite permissible that the initial concern that some employees may be reporting minor symptoms as a as a means of gaining relief from their usual job and adding some diversity to their work was the case. The overall picture of WRULD was that it is a significant problem. Job rotation enhances employees' commitment to stay with the company (Sullivan 1998). Therefore from the company and individual perspective job rotation is well worth serious consideration. It seems logical that level of discomfort was out there in Company X is important and that there was a possibility that more people were feeling discomfort than those that attended the Occupational Health Department. If so whether it was related to specific duties needed to be investigated and if it could be relieved by job rotation. It was essential now to investigate the cultural issues to health and safety by ethnographic research and the research methods to apply to find out which jobs are causing any discomfort and whether job rotation would alleviate any discomfort. How the research methods and how the research was performed is the purpose of Chapter three and a brief overview is provided at the beginning of the chapter.

Chapter 3: Research Methods

Introduction to Chapter three

This chapter investigates the cultural issues concerning health and safety, by ethnographic research, and describes the ethnographic techniques, the semi structured interviews that took place and ethnographic observations in meetings which led to this investigative study of WRULD. This chapter relates to the research methods applied for the case studies (participants of the study) to apply to find out which jobs are causing any discomfort and whether job rotation would alleviate any discomfort. The techniques used for the research are supported by other research i.e. the discomfort questionnaire with the numerical rating scale with combined body picture as in the London Pain Chart (appendix 4 & 5). This questionnaire (appendix 4 & 5) was used to ascertain the amount of discomfort of the participants and the differences of discomfort between those on job rotation and those not doing job rotation. The methods used are compared with other research and with the suitability for this current research in the electronics industry. The instruments used for the research are also compared with other research and support for their use e.g. the dynamometer for grip strength testing, especially with relation to the position of its use.

The Job action analysis developed for the research in this section has a lengthy literature search which allowed the development of this tool to be used to assess the position of workers limbs/body to analyse any concerns with regard to possible development of WRULD and allow for ergonomic intervention. This was essential to be able to find out whether any discomfort that employees were feeling had any work-related element. In this chapter the data collection and how the time sampling was performed, the research design, how the data was analyzed and the sample size used are described. It also discusses the reliability, intra and inter-observer reliability and validity within the study and the limitations of the job rotation study. The ethnographic initial work outside the company took place prior to the commencement of the ethnographic work within the company which took place between January – May 2000. The main investigative study took place September to December 2000. The post analysis and recommendations taking place over 2001. However the time scales are depicted under each individual research heading.

The original research objective was to investigate using approaches employed by ethnographers, to see whether the influence of the different cultures represented in Company X had any impact on the health and safety of the individuals within the company. Following a period of observation the supposition could not easily be proven. The initial investigation gave some indications that the management of health and safety initiatives could be improved especially in the relation to work-related upper limb disorder.

3.0 Preliminary Investigations

Ethnography

Ethnography is social research which bears a close resemblance to the routine ways in which people make sense of the world in every day life (Hammersley & Atkinson 1996). In practical terms ethnography relates to forms of social research that explores the nature of particular social phenomena working with primarily unstructured data that has not been coded at the point of data collection in terms of a closed set of analytical categories (Denzin & Lincoln 2000). Ethnography involves explicit interpretation of meanings and functions of human actions by the analysis of the data, the product of which takes place mainly by verbal descriptions and explanations with "quantification and statistical analysis playing a subordinate role" and has been shaped by its association of the western interest in the character of non-western societies (Denzin & Lincoln 2000).

The ethnographic work started in 1999 which consisted of pilot work outside of the company to practise the principles of ethnography prior to commencing the study of Company X. I was not familiar with the principle and practice of ethnography; hence, the techniques of ethnographic observation were piloted in an up market café in the North of England. I also practised this technique and I performed a pilot study, following the Stephen Lawrence case, then interviewed a volunteer outside of the company to find out how much they knew about the Stephen Lawrence case and how much they felt was racial about the case. The newly acquired ethnographic skills were then applied to investigate my original concern that a company funded by Koreans was less inclined to implement health and safety procedures and that profit takes precedence over employees' welfare. My initial concerns about Korean funded companies were justified following the research of health and safety records in Korea. The research revealed that industrial accidents were more pre-dominant in Korea than in Britain. However I started this project with an open mind by finding out the culture in the company in relation to health and safety. Since I started with no pre conceived ideas or bias about the company the following appropriate approaches were used.

The ethnographic work in the company commenced in January 2000 which took place in an electronics industry in the North East of England. The ethnographic work within this study of company X was used to analyse the following social phenomena. It was assumed that the mismanagement in health and safety in Company X was linked with the company being financed by Korea and that there was some conflict owing to the difference in culture. The initial ethnography involved investigating whether the Korean and British cultural differences had any impact on the health and safety culture.

Whether there was any impact was difficult to determine owing to it not being possible to obtain entry to privileged information or access into the company hierarchy. To what extent the attitudes and barriers I encountered were the result of racial, individual or cultural differences would be difficult to say. The ethnographic approach was appropriate for the objectives of the research, as it enabled me to observe in some cases as a non-participant observer and in other cases as a participant observer and to analyse what was going on in the company. Participant and non-participant observation is a useful means of research and is appropriate where the analysis of data involves explicit interpretation of the meanings and functions of human actions and exploring the nature of particular social phenomena (Denzin & Lincoln 2000). As a participant observer I had the authority to sit in on health and safety meetings and join in but observe at the same time, and was able to interview senior HSE personnel. Minutes of the health and safety meetings were studied to see if there was any conflict between Far East and English workers/ managers.

Ethics

80 out of 81 people that were requested to be participants in the main study of WRULD volunteered to take part in the study and completed their discomfort forms (see appendix 4, 5 & 6) prior to this permission was obtained from the company. Only the

people in the ethnographic research were not approached to seek consent because of methodological reasons and as requiring prior consent would lead to potentially biased results (Dawson 2004). Participant or non-participant observation in experimental research should only be performed where it is impossible to use other methods to obtain essential data and in such studies to safeguard the anonymity of the subjects (BSA 1996). It is applied when an early observation study as part a focused ethnography takes place and no individual can possibly be identified allowing human subject exemption; as observing cultural process rather than individual outcomes and at the same that no one is identifiable through the study (Roper & Shapiro 2000). The ethnography research was aimed at the observation of culture issue rather than individualism. The methods used were semi-structured interviewing, ethnographic observation in meetings and time sampling. How the ethnographic data was collected, notes completed and written are described under the headings of the former methods.

The ethnography research was not completed as although it is alleged by individuals in different positions in the company that there were difficulties in implementing health and safety changes in an industry financed by another country, owing to cultural differences (Yee 1998; Kim 1995), this assumption could not be substantiated through the ethnographic research in Company X. The ethnographic study was difficult to conduct because it was not possible to obtain access to privileged information in the echelons of the company hierarchy, owing to my position of contractual employment. It was difficult to identify to what extent racial, individual and cultural attitudes among managers constituted a barrier to my enquires. From the ethical viewpoint information concerning the company and the individual is confidential and cannot be used without consent from the company and the people concerned. Where information is obtained that would identify specific individuals within the company it would be unethical to publish that information and to have continued to perform the ethnography would eventually have led to identification. To continue would not have been ethical as not only would individuals have been identified but because of not obtaining all access to the echelons the results may have become biased. The study from this point left ethnographic work at a point when no one could be identified or suffer any harm (BSA 1996) and became the main study of WRULD, where all consent to participation in the research took place. However the findings of the ethnographic research that was performed brought forward specific issues that led me to pursue certain problems, regarding the culture of health and safety generally but especially related to WRULD. It demonstrated how important such research can be, used as a principle of practice since it brought to the forefront the importance of WRULD and that all though very few disorders were reported there was significantly more discomfort at work than there appeared. The findings of the ethnographic work is depicted in a separate chapter, Chapter 4. The main study statistical results are in Chapter Five, in order to keep results separate from data collection.

Semi structured interviewing

This ethnographic work incorporated interviewing key personnel. The participants agreed to be interviewed, however, the full reasoning for the interview was not **totally** apparent. The reasoning behind this was that total informed consent would jeopardise methodological rigour (Kannis & Bergmann 1993). However these people remained anonymous (BSA 1996). This ethnographic work took place in early January 2000 within the company. A semi structured interview was performed with open ended questions allowing as much information to be obtained as possible. The advantage of using a semi-structured approach is that they can yield more complex and detailed information than other forms of data collection. The approach allows for an interview guideline using open ended questions to obtain as much information as possible. The interviewer is able to diverge or explore some areas in more depth (Clarke 1999). A Korean senior manager who had an important role in health and safety was interviewed with this semi structured approach. The key to the interview was to find out his interests and commitments to Health and Safety and whether there were any cultural impingements. The interview was performed by considering some open questions that could lead to further conversation to appertain the former (Clarke 1999). The interview was not recorded and therefore key information had to be remembered and written up immediately and then based on exactly what was said a conclusion with regard to commitment to health and safety was analyzed (Edwards & Talbot 1994).

Ethnographic observations in meetings

The ethnographic observations in meetings took place in the first half of the year 2000. The ethnographic observation was an unstructured observation around how the meetings were brought together, how people behaved and reacted, to be able to observe for any cultural influences and to analyse the outcomes (Denzin & Lincoln 2000). From the ethnographic observation it was evident that the Personal Computer Monitor (PCM) health and safety meetings were much more formal and bureaucratic than Microwave Oven (MWO) meetings. The chairman of the former spoke for seventy percent of the meetings, the Health and Safety Chairman approximately twenty five percent and the rest of the committee for the other five percent to address any new issues. People tended to sit in the same chair for every meeting with the same group.

Prior to the meeting there would be general conversation but as soon as the meeting started it was very structured. MWO meetings had a much more relaxed and informal atmosphere, and were therefore more pleasant and people communicated well together. Seating arrangements were different on every occasion and generally there was more banter. There was a main chairperson but every body spoke very freely and the meetings, although following the meeting agenda, were unstructured. Everyone would join in and sometimes there could be several conversations going at the same time. Despite this, at the end everyone was aware of the actions needed to be taken to resolve any Health and Safety issues. However the difference in style from bureaucratic to networking appeared to have no effect on the outcomes or management of outcomes. There tended to be some items on both sites that could be on the agenda for a long period of time, the items are not revealed as it may expose the anonymity of Company X (see Chapter 4 Meeting outcomes).

The whole purpose of this ethnographic observation was to analyse if there were any differences in style relating to culture within the two site health and safety meetings and clearly, although different, there was no effect on outcomes or management of those outcomes. What was cultural and individualistic was difficult to identify. The only notes written were relevant e.g. who the responsible person was and deadline dates for any outcomes. This was written on the copy of the agenda for the meeting which is normal practice. Therefore it was essential as soon as the meeting was over to make an analysis of any other information, relevant to the research, to prevent memory loss of important information owing to time lapse (Hammersley & Atkinson 1996).

Time sampling

Time sampling techniques were performed in the company early 2000 between January and May. They were performed as a continuation of the ethnography to find out if there were any cultural issues affecting health and safety issues, especially in relation to the company being owned and financed by eastern countries. Time sampling techniques were applied to identify industrial issues and to develop the research focus and research questions. Originally two lines on each site MWO & PCM were observed on all the duties to get an idea of the type of movements taking place and also to observe any behaviour. The production line allowed for time to assess the body pattern movements for the particular model running at that time and this was used eventually used to build the job action analysis system (appendix 1) on the production line.

Time sampling techniques were applied as they are appropriate for this type of research (Cormack1991). Since the object of the study was into the cultural and general behaviour relating to health and safety, observation was the best and most objective method of research. Generally if provided a questionnaire people may state they are health and safety conscious but in reality when observed they may be found to be quite the opposite (Hammersley and Atkinson 1996). The initial observation apart from the standard setting of a specific amount of time of 5 minutes for each observation was semi-structured in that there was no specific format used except being aware of observing behaviour and technique. Nothing was written down about the time sampling on the production lines, but this initial time sampling allowed an awareness of the need for clear definitions and a formal observation structure which led to the job action analysis (Cormack 1991). Time sampling of the production line allowed enough time to be able to ascertain the regular body postures ready for the introduction of the job action analysis which incorporated these postures.

Every person in the four highest accident areas was observed doing their job for 5 minutes precisely as unobtrusively as possible (Edwards & Talbot 1994). People tend to behave better when they are being observed, but as the researcher often visits the factory floor, her presence would not cause behaviour change, thus any Hawthorne effects would be eliminated as far as possible. My job itself was to observe the time involved to do tasks, safety aspects, and attitudes and behaviour. The analysis was performed as soon after monitoring as possible for reasons of validity (Edwards & Talbot 1994). The longer the time between the observation and recording of the time sampling, the more difficult it would be to record adequate, concrete and detailed descriptions (Hammersley & Atkinson 1996). In organising the time sampling it was important to sample the routine as well as the extraordinary, the purpose being to ensure as full and representative a range of coverage as possible and not just to single out the "superficially interesting events" (Hammersley and Atkinson 1996 p 49). If this method is adhered to then bias can also not be represented. Two improvements reports were provided to the injection mould shop and the warehouse, based on the analysis of the time sampling (See Chapter 4 reports).

Time sampling techniques were performed in the four main areas that had the highest accident rate at that time. These were the press area, the warehouse, the injection mould shop and the production line B in MWO. In MWO one of the production lines showed a higher accident rate. The production line with the worst accident history was (B line) and the best accident history (A line). These production lines were observed to see if there was anything different occurring on each line; for example different attitudes or different work practices. There was found to be no difference on either production line on these occasions and therefore it was assumed that the accident history was purely incidental as there was nothing to support otherwise. The production lines had an extra element of the observation of physical workload and body postures used for the job action analysis (appendix 1). In PCM the two lines used for the analysis were based on the two production lines that tended not to change models regularly to allow less variance. After this the jobs that were analyzed were as identified in (Table 5.1), the case studies, the jobs that according to the retrospective medical records and sickness absence records were deemed to be problem jobs leading to WRULD. These duties were observed and analyzed with the physiotherapist. In the main study all these specific jobs from the case studies on every production line were analyzed to further refine and focus the research and research questions.

Other methods could have been to introduce a questionnaire for the purpose of identifying body postures, or videoing or using electromyography as in (table 3.2). A questionnaire for the purpose of identifying body postures would not have been effective as the employees do their jobs at such a speed that they never would get chance to analyse it in slow motion. Also they are likely to have no ergonomic experience and therefore unlikely to understand specific terminology or may misinterpret questions.

Videoing the postures or using electromyography would be very difficult in the limited space. Electromyography would only observe the posture and not behaviour. Videoing is more intrusive and if stored could be detrimental to an employee if something inappropriate had been said or done. As long as the employee was working in a way deemed to be safe then the researcher had no issues. In the time sampling observation method nothing was written down on site and everything observed was coded as soon as possible after the observations. Therefore time sampling was the most objective choice. Ethically whilst performing the time sampling if any possible dangerous occurrences were to take place the researcher would need to abandon their research role and deal with the situation. Observing each person for five minutes, allowed a set standard for all observation and ensured no distractions. Five minutes was enough time to observe the process and behaviour of the employee without distraction and to study one whole area and be able to recall the events. Any longer would have led to information overload (Hammersley and Atkinson 1996). The only report writing taking place was for the reports to the warehouse and injection mould shop, as an improvement plan.

The published data cited in Chapter 2 has shown some association between WRULD and types of jobs and provided evidence to support the hypothesis that WRULD could be relieved by job rotation. The hypothesis that planned job rotation reduced discomfort, either diffuse symptoms owing to fatigue and/ or the incidence of work-related upper limb disorder was tested out in the study of Company X by observing selected production lines.

In the study at Company X the 15 case studies (shown in Table 5.1) were observed during Oct 1996-Sept 2000, and these formed the basis for the choice of duties to study on the production lines for they clearly identified which duties were more likely to cause medical conditions. In table 3.1 the time variations of these 15 case studies identify the amount of time people were suffering symptoms before reporting their discomfort.

Table 3.1 Reporting time variations in the case studies of 15 people

(Table 5.1 identifies the case studies)

Time	Number of people reporting symptoms
1-4 weeks	4
4-8 weeks	4
8-12 weeks	4
1 year	1
Information not available	2

I investigated previous cases of work-related upper limb disorder in relation to duties in the study of Company X. A literature search was performed for the job action analysis to base the assessment criteria on, purposeful for the study of Company X. This involved observing employees body posture and creating a score for the jobs with relation to different body movements (see Table 3.3). From the case studies and job action analysis this deemed which duties to observe on the production lines to reveal whether rotation or non-rotation of jobs had any effect on discomfort levels and work-related upper limb disorder. Unfortunately I was not allowed to control which areas employees job rotated and which did not.

The researcher was concerned that the employees could be bored with continually performing the same duties, as in the preliminary work had noted that only a small number of people were on rotating duties. It was essential to investigate whether employees would prefer to rotate their jobs. There was concern about the impact of work-related upper limb disorders on well-being and the costs it incurred. The prevalence of work-related upper limb disorders generally was a concern, and especially in relation to the electronics industry and the high turnover of staff within

Company X (see table 5.7). Prior to the research commencement of the job rotation study, on the two sites, a pilot study was performed via observation in order to obtain some idea of whether job rotation was taking place and if so to what extent. On the computer site, from the four production lines that I observed (out of the six), rotation was taking place on two duties only, where the Occupational Health Department had required it owing to current medical problems. On the Microwave site data collection on rotation was not completed, as at the time changes in the lines' production pattern had been forecast. This meant rotation at this point would be even further decreased owing to training requirements. Data was collected on whether employees preferred to job rotate or not or whether they were indifferent (post the analysis of the discomfort/ grip data).

3.1 Case studies

In a case study of work-related musculo-skeletal complaints in female agricultural workers the observation technique applied was the Ovako Working -posture Analysis System OWAS technique (Oude Vrielink 1995). The observations contradicted the OWAS method and it was decided that it was not the body posture that was the problem but the psycho-social factors, and it was speculated that in the larger firms the personal attention of the employer for their employees was reduced. This is supported by the CBI (1999) survey which shows that employers with fewer than 50 employees had the lowest incident of absence whereas organisations with over 5000 had the highest absence. In the HSE (2000b) analysis it was found that individuals in companies with 2-24 employees had a statistically significant lower prevalence rate of illness caused by work than companies that employed more than 25.

In this study it is proposed to investigate the principle and practice of task rotation on specific production lines, where employees are expected to use the same limb movements for each shift, over a long period of time. The initial part of the study was based on those specific case studies (as previously identified in Table 5.1). Some medical conditions the employees had previously presented with (that related to the case studies) were taking a couple of months to improve. A few cases showed very diffuse and subjective symptoms and were difficult to quantify, medically, owing to the difficulty of diagnosis. This made it difficult to identify the scale of the problem.

The occupational health nurse deals with discomfort and not medical diagnosis. Diagnosing is the remit of the Occupational Physician and the physiotherapist. Fleming (1996) claimed that the industrial nurse is far closer to the industrial worker and his medical difficulties, than is the physician. It is those on the shop floor who manage and treat the medical condition e.g. the nurse and physiotherapist, therefore, it is quite feasible that the nurse plays a part in diagnosis of employees upper limb disorders as she is usually the person that initiates work surveillance from the temporal criteria (Sluiter et al 2001). This will also allow for a greater assistance in reporting to RIDDOR as the occupational physicians are usually part-time and employees symptoms/ signs may have resolved by the time an appointment is made with the occupational physician.

The Southampton examination schedule, Palmer et al (2000), found the new examination protocol repeatable and gives acceptable diagnostic accuracy when tested in a hospital setting. This shows that examination can feasibly be delegated to a trained nurse. The diagnostic criteria needed refining in order to discriminate between discrete pathologies of the shoulder. When there was the presence of shoulder capsulitis the nurse usually also diagnosed shoulder tendonitis and the physician did not. A probable explanation is that subjects with capsulitis also experience pain on resisted movement which is the definition for tendonitis proposed by the HSE workshop (Palmer et al 2000). This study comprised of eighty eight subjects with eight different diagnoses, which was only a small study (Palmer et al 2000).

Employees are encouraged to report symptoms of WRULD early, before there is a defined problem, which makes the symptoms easier to treat. Medical intervention may have prevented the symptoms becoming more defined; if reported earlier. Some studies have been completed by the Department of Environmental Occupational Medicine at the University Medical School of Aberdeen, which published a report in 1997 on the feasibility of developing a prototype decision-aid for initial medical assessments that would help to overcome the difficulties in diagnosing work-related upper limb disorder (Sinclair et al 1996). Which later after development was published as a HSE report as the development and evaluation of diagnostic support aids for upper limb disorders (Graves et al 2000).

Suiter et al (2001) provides a comprehensive criteria for WRULD as mentioned previously in her four pronged approach on research from 1973-2001 from 214 studies, most of them being in the late 1990s. Surveillance case definitions for WRULD have also been defined by Harrington et al (1998) and Palmer et al (1998) and are mentioned within the thesis in areas of diagnosis.

Palmer & Epler (1998) recommend for medical assessment of wrist and hand function the use of objective measurements by goniometry, for wrist flexion, extension and hyperextension, radial and ulnar deviation, proximal and distal interphalangeal joint flexion, extension and hyperextension, thumb carpometacarpal joint flexion, extension and hyperextension and opposition. The measurements of goniometry allow an objective baseline and normal comparator range.

Ergonomic assessment of WRULD

Many studies have used different means of measuring body movements e.g. techniques of posture observation by Electromyography (EMG), Vicon Cameras, videos, computer aided analysis, direct or instrumental techniques, self-reporting assessments, and pen and paper based observation methods. Table 3.2 shows some examples of studies and the measurement facilities and criteria they use. These criteria and facilities vary according to the purpose of the study and the viability.

Table 3.2 Types of studies and measurements and measurement criteria

Author	Measurement facility	Type of Study	Measuring
Deivanayagam & Sethi 1993	Two linear regression model	Experimental study	To measure torque strength one for flexed wrist and one extended
Burdorf 1992	OWAS Ovaka Working posture Analysis System	Cross-sectional of static workload and dynamic workload	To measure trunk posture
Keyserling et al (1993)	computer aided procedure	An investigative study	To measure shoulder posture
Stetson et al (1991)	Videoing		To distinguish grips
Armstrong 1979	cinematography and Electromyography (EMG) & cinematography	Cross sectional – one group carpal tunnel sufferers the other group no carpal tunnel	To observe position and force of hands
Armstrong 1982	EMG	Retrospective study	To measure pulp grasp in the poultry processing plant
Bugajeska 1993	EMG Heart rate and blood pressure	Investigative study	To measure fatigue
Bohlemann 1993	EMG	Prospective study	Time variant of muscle strain
Ashberg 1996	Physiological and psychological questionnaires	Cross sectional study through different types of work	To measure fatigue
Ahlberg- Hulten 1995	Symptom questionnaires	Cross sectional study/ two types of nurses in different hospitals	Association between psychosocial factors and WRULD
Chung 2001	Heart rate and oxygen consumption	Experimental study	Physiological measurement on exertion
Chadwick & Nichol 2000	6 camera vicon/ heart rate and oxygen consumption	Investigative mathematical study	Equations of muscle and joint forces
Cirellio et al 1990 & 1993	Heart rate and oxygen consumption	Experimental investigative studies	Measuring maximum acceptable forces

Author	Measurement facility	Type of Study	Measuring
Hales et al 1994	Questionnaires and clinical examination	Cross sectional study	Association between psychosocial factors and WRULD
Punnet et al 1991	Clinical examinations and interview and video	Case-referent study	Evaluate health effect of trunk postures
Kuzala & Vargo (1992)	Measurement of disability/ pain questionnaires	Investigative study	Measuring grip score
Hagen 1998	Questionnaires (Karasek's and Nordic)	Cross sectional study	Psychosocial job stress
Alsaleh 2001	Body map questionnaires and Discomfort scale 1-10 digital camera and video and Quick Exposure Check (QEC)	Cross sectional design	Working height
Hagberg 1981	EMG & heart rate and Borg Scale The BORG scale is a psychological approach to measuring force, with perceived exertion.	Experimental study	Concentric and eccentric perceived exertion
Hunting et al 1980	Questionnaire on discomfort and health symptoms / dimension of workplace/ anthropometric posture and angle observations	Cross sectional study 119 operators 57 shop girls	To measure for ergonomic improvements

Burdorf (1992) used OWAS, the Ovaka Working-posture Analysis System, with set criteria of trunk posture greater than 20 degrees. More than 30% of time spent with a bent trunk is a prompt for action. OWAS provides a broad view of the relation between force and posture. Burdorf (1992) recommended further research for a gold standard to confirm the best objective measurements of back posture using either observation techniques or direct measurements such as Electromyography (EMG). Stetson et al (1991) used video for distinguishing the pincer grip from other hand-object couplings. This can be more difficult to detect on video than by direct observation. It may be difficult to differentiate between pincer and palmar pinch when using video systems, even on pause, as the required angles can be difficult to obtain owing to the amount of available room and object interference on production lines.

The use of forceful exertions, deviated wrists and pinch hand positions were found to be associated with carpal tunnel syndrome (Armstrong 1979). Chiang et al (1993) demonstrated that fish processing workers were 1.8 times more at risk when exposed to hand wrist forces greater than 3 kg. Exerting hand forces greater than 4 kg less than every 30 seconds increased the risk by a factor of 29 in comparison to no exposure (Silverstien et al 1986). This has implications for the transformer job in Company X, in this study, as the weight of the part is over 4 kgs without force. Tools used repetitively and/or for precision work are recommended to weigh less than 0.4 kgs or to have a counterbalance. If the tool is heavier than 2.25 kgs it is recommended that there should be the provision for the use of two hands (Bergamasco et al 1998).

It was necessary to base the assessment criteria for job action analysis (appendix 1) on current research related to production line work (Table 3.3). This research considered the specific body parts used on the production line (neck, shoulder, back, upper limbs and lower limbs as defined in Table 3.3). This was where observation of the production line by a non–participant was necessary; to unobtrusively observe all the movements of the body that were taking place and the processes of the jobs involved. It can be noted that there has been plenty of research into body movement and associated medical conditions/symptoms, as shown in Table 3.3.

Bugajska (1993) recommended ongoing physiological research into continuous and intermittent isometric exercise as this may advance the understanding of fatigue and repetitive manual work. There has been recognition in ergonomics of a need for an ergonomic tool to provide a more reliable form of assessment. NIOSH (1997) requires detailed information about very specific parameters of the posture to facilitate high precision in the defined indices, but provides no clear indication how this information should be gathered (Waters et al 1993). OWAS the Ovako Working- posture analysis System, Karhu et al (1977) suggests that the results can lack some detail but has a wide range of use. It provides a broad view of the relation between force and posture.

Burdorf et al (1992) argue that direct observation methods, such as OWAS and posture targeting for example (Corlett et al 1979), lack precision and are less reproducible in dynamic work situations as they are not continuous and are liable to intra-and inter-observer variability. Static positions are much easier to observe and therefore more reproducible. Priel's method uses a paper card system called the posturegram, where the observer selects and sketches a posture of interest within a job and uses three reference planes and 14 different upper limb positions. It takes several minutes to complete one posture and is therefore unsuitable for dynamic activities such as in production line work (Li & Buckle 1999). Posture targeting has still remained one of the most popular methods owing to its practicality and its ease of use in the working environment.

RULA (Rapid Upper Limb Assessment) (McAtamney & Corlett 1993) places emphasis on the postural score. This was followed by Rapid Entire Body Assessment (REBA); a postural analysis system sensitive to musculoskeletal risks in a variety of tasks (Hignett & McAtamney 2000) which was designed to evaluate tasks where postures are dynamic, static or rapidly changing. The tool for evaluating change in exposure to risk of musculoskeletal disorders was developed by (Li & Buckle1999). Each has its specific field of practice, and what may be ideal for one assessment may not be found to be so ideal for others - for example RULA is designed for assessing the severity of postural load and is particularly acceptable for sedentary jobs (McAtamney & Corlett 1993). The RULA and OWAS give prime emphasis on methods of observing posture. The assessment should not interfere with the workers' work (Kirwan and Ainsworth 1992) or with the movements being recorded and should be repeatable within the range of movements normally occurring in the duties (Aaras & Stranden 1988). The system developed for use in Company X allowed observation without interference to normal production (Li & Buckle 1999). There was not enough room for cameras and attachments and the purpose was to be as unobtrusive as possible. The design of the job action analysis for Company X was specific to the jobs observed and allowed for unobtrusiveness.

3.2 The Job Action Analysis

Based on the preliminary observations of the production lines a job action analysis was designed specifically for the production line environment, where the Total Actual Cycle Time (TACT) times are very short, to assess the level of risk of WRULD. The tact time is the required time for the assembly of particular components, which includes the working time, waiting time for the product to arrive, and the moving time, i.e. the time in which the conveyor moves. The tact time can be measured by timing from the beginning of one product to the beginning of the next product. The tact time is important for production output, and specifically in relation to WRULD. The shorter the tact time the greater the amount of movements of the upper limb. For example, if a pincer grip (opposition between thumb and index finger) is applied every ten seconds per cycle and then the cycle is reduced to five seconds, the pincer grip action is doubled, therefore increasing the risk of WRULD. The principle of production is to reduce the tact time. The reduction in tact time can be achieved by reducing the working time by having experienced staff. The tact time can be affected by a number of factors such as the speed of the conveyor, inefficiency of the assembly workers producing, and imbalance which may be due to bottlenecks. Or it could be due to the way the jobs are divided up in that one person has more to do than another with persistent time lag in the assembly process. For example if one person takes six seconds to do a job but the next person on the next job takes twelve seconds there is time wastage and imbalance. Defects and breakdowns affect the tact time. The ergonomic assessment was designed with a view to pinpointing problems and providing an effective job rotation system. It does not rule out further ergonomic assessment.

The job action analysis assessment for this study was designed primarily for the production-type environment and for the purpose of analysing job rotation. It is applicable where the tact times are quick (less than one minute per cycle). The job action analysis is a method of analysis which is designed to assess the risk of stresses on certain body parts. Its results enable a rotation scheme to be developed to allow the strain to be taken off specific body parts.

The numeric categorisation in the job action analysis (Appendix 1) measures the angles of posture and the application required for the duties. Repetition and duration of the task are considered. Tact times are low and output is high with averages of 10 ½ seconds' tact time and the production of 2600 monitors in a day. There have been attempts to identify the tolerance of maximal number of repetition exertion per hour or shift but critical levels of repetition are not known. These attempts have related to wrist movements. Luopojarvi et al (1979) found in packers on assembly lines with over 25,000 movements per day high rates of muscle-tendon disorders. Whereas NIOSH found problems that were similar in employees that were exceeding 10,000 movements per day (Freivalds 1999). This means that when each monitor is built using the same movement occurring approximately 10 times per monitor there is greater exposure to risk of muscle-tendon problems (Lupojarvi 1979). Whereas with NIOSH criteria it only needs to be movements occurring 2 ½ times per monitor which is likely this could occur in the packing area on flat pack when creasing the boxes and flaps; and there is a marked difference in the estimations (Freivalds 1999).

The criteria for assessment were readily coded for computer storage and analysis (Columbini et al 1985). The system should be quick, clear, and user-friendly with tick check boxes. It should be easy to learn and create limited paperwork and be specific to the job under consideration. It was designed primarily for production; it was not suitable for warehouse activities. Objectivity is increased by adding other task analysis when required, e.g. biomechanics. The job action analysis is beneficial when there are small numbers of model outputs, and it is ideal as a control for measuring rotation systems and restrictions.

It is preferable that the person completing the job action analysis is sensitive and concerned. It is better to overestimate than underestimate total results, because in attempting to identify potential ergonomic problems it is as well to err on the side of caution (Keyserling et al 1993).

Table 3.3 was designed as a literature search for the job action analysis to base the assessment criteria on for the study of Company X.

The headings below are detailed in table 3.3 with the explicit reasoning behind which criteria were chosen is explained individually under each section labelled and is specific to the production line area:

- Upper limbs
- Wrist
- Shoulders
- Neck
- Back
- Sitting versus standing criteria

- Lifting from the floor
- Lifting from shoulder height
- Pulling and pushing
- The use of Tools

Table 3.3 Literature search for the job action analysis to base the assessment criteria on for the study of Company X.

Accompanying sheet for the job action analysis - Appendix 1	**Based on research of Authors**	**Associations**
Body Part – Neck	**Authors**	
Turning of head 1= occasional -once per cycle or > 2= excessively > once per cycle 3= with twist	Devereux & Buckle, 2000 Li & Buckle 1999	Neck/trapezius problems
Excessive pulling with Arms 1=1/3 task 2= 2/3 task 3= >2/3 task	HSE Manual Handling 1992	Scapulae problems/trapezius/neck
Prolonged looking up and down 1= <30 ° 2=>30 °	Harrington, J.M. et al 1996 Chaffin (1973)<15 °non-significant Ohlson et al 1995 @ 15 °significant	Neck
Repeated looking up and down 1=1/3rd task 2= 2/3rds task 3= >2/3 task	REBA, Hignett & McAtamney 2000	Neck
Body Part – Back		
Stoop 1=>20 °< 40 ° 2=>40 ° 3=with twist	Burdorf et al 1992 Punnet et al 1991 Aaras 1994 <20 °not significant	Back problems
Prolonged standing / sitting 1=50% of time 2=75% 2= 100%	Corlett & Clark 1996	Back problems if over exposed Standing – reduce time spent standing to reduce atherosclerosis (Krause et al 2000)
Lift from floor 1= occasional -once per cycle or < 2= frequent > once per cycle	Manual Handling Guidance on Regs 1992	Back problems if use incorrect technique
Lift from waist 1= occasional -once per cycle or < 2= frequent > once per cycle	Manual Handling Guidance on Regs 1992	Correct position as long as item is not too heavy and is handled well into the body
Lift from shoulder height 1= occasional -once per cycle or < 2= frequent >once per cycle	Manual Handling Guidance on Regs 1992	Concerns especially if static loading and the frequency
Regular twisting of back 1= -45 ° 2 =+45 °	Manual Handling Guidance on Regs 1992	Lumbar pain
Pulling and Pushing 1= occasional -once per cycle or > 2= frequent > once per cycle	Manual Handling Guidance on Regs 1992 (updated 1998 HSE L23)	Strain on scapulae/back strain

Accompanying sheet for the job action analysis - appendix 1	Based on research of Authors	Associations
Body Part – Lower Limbs		
No or little opportunity to sit 1= little opportunity 2=No opportunity	Corlett & Clark 1996	Back and knee problems and varicosity as muscle not pumping whilst still creating stagnancy
Stairs/ uneven surface I= occasional -once per cycle or < 2= frequent > once per cycle	Multiple Authors	Knee problems / back problems from tilting at hip
Kneel / Squat I=occasional –once per cycle or < 2=frequent - > once per cycle	Multiple Authors	Knee conditions
Twisting owing to confined spaces I=occasional –once per cycle or < 2=frequent > once per cycle	HSE	Restricted movements leading to back concerns / unnecessary twisting can also lead to knee problems if twist from the leg.
Body Part – Shoulders		
Pull/push across body 1=Short lever 2=Long lever 3=With force	HSE Work-Related Upper Limb Disorders: Assessing the Risks 1994	Shoulder tendonitis/ capsulitis with force
Reach above shoulder height 1= 60 °-90 ° 2= >90 ° 3=90 °+ with load	HSE Work-Related Upper Limb Disorders: Assessing the Risks 1994	Shoulder tendonitis capsulitis with load
Reaching to full extent 1 = 1x each cycle or less 2=>1x cycle 3 with load	Multiple authors	Multiple shoulder problems but can exacerbate back and neck problems
Body Part – Upper Limbs		
Twist/turn forearm 1=occasional – once per cycle or < 2= frequent > once per cycle 3= with force	HSE Work-Related Upper Limb Disorders: Assessing the Risks 1994	Epicondylitis lateral and medial depending on direction
Wrist out of neutral 1=<20 ° 2=> 20 ° 3= Excessive end of range	Bergamasco et al 1998	Tendonitis/ de Quervains
Gripping/Pressing 1= up to 30% 2= up to 50% 3=>50%	Graves 1990	de Quervains
Hitting palm of hand 1= occasional 2= Frequent every cycle 3= Using excessive force	Cox 1995, Keyserling 1993- hand bashing as tool	Carpal tunnel syndrome (although disputed by some experts that it is work-related)
Claw grip 1=light weight up to 0.4kg 2. Heavier weight > 0.4kg (consider force/ counterbalance) 3. Heavy weight >2.25kg	Bergamasco et al 1998: mostly related to tool weight. Freivalds 1999	Tendon problems

Accompanying sheet for the job action analysis - appendix 1		
Body Part – Upper Limbs	**Based on research of Authors**	**Associations**
Gripping narrow tools 1=Yes 2= Slippery or metal – poor cohesion		
Palmar pinch 1=Yes	HSE Work-Related Upper Limb Disorders A Guide to Prevention p 8. Columbini 1998, Keyserling et al 1983 – poor cohesion/ slippery surfaces	Soft tissue injuries / triggering
Pinch 1=Yes	Bergamasco et al 1998, Freivalds1999, Helliwell et al 1992	
Hook grip 1=Yes	HSE Work-Related Upper Limb Disorders: A Guide to Prevention p 19	Is five more times as stressful as the power grip – de Quervains and tendonitis
Power grip 1=Yes	Bergamasco et al 1998	
Tools vibrate/kick 1=occasional – < once per cycle or 2= each cycle or >	Bergamasco et al 1998, Chao et al 1976	Callus formation /triggering /tendonitis / de Quervains
Trigger tools 1= All fingers (not thumb) 2= single finger	HSE Work-Related Upper Limb Disorders: A Guide to Prevention p 18, Ashton Miller 1999, Columbini 1998	Wrist problems
	HSE 1990 Work-Related Upper Limb Disorders: A Guide to Prevention p 18	Trigger finger

The job action analysis form includes a comment section for any subjective or extra findings. Postures that were not identified in the literature to have any effect on WRULD were rated at zero (appendix 1).

Upper limbs

Chao et al (1976) demonstrates that the pinch grip pinch increases muscle and tendon force owing to the mechanical inefficiency of the pinch posture; increases the magnitude of muscle exertions. At approximately 15% of a person's maximum voluntary contraction (MVC) blood flow starts to be reduced while at 60% of MVC the blood flow is almost completely interrupted. For grip application no weighting score was given to the type of grip applied, e.g. power or claw, but it was kept as 0 if no grip was applied and 1 if the grip was applied. The reasons are that the job action analysis is a quick overview for a quick analysis. The comments section (appendix 1) can be used to highlight any concerns for immediate action. Although this comments section does not add to the scoring system it does highlight qualitative concerns. This could include such items as recommendations to the employee on technique, e.g. not to twist but to turn with his/her feet, or to keep a trolley close enough not to have to stretch to reach but not so close to be obscuring working space; and it could be used to inform the employee of the possible risks in his/her technique. These comments can all be provided to the supervisor with regard to training employees for specific jobs.

Upper Limb Criteria

Wrist

Wrist: REBA criteria used for the scoring system, (except Reba used I for <15° and 2 for >15°). Hignett & McAtamney (2000).
1 if in neutral
2 for <15 degrees of flexion (but not neutral)
3 for 15 degrees or more in either flexion or extension
radial or ulnar deviation add 1
45degrees extension of wrist (Keyserling 1993)

For pronation and supination related to the frequency of movement of the wrist Tichauer (1996) used the following scoring system:
1 if in the mid range of twist
2 if the wrist is at near end of range

Twisting and turning of the arm in the job action analysis are as Tichauer (1996) describe, but for Tichauer it is related to the frequency of movement rather than supination/pronation. The allocation of 3 points (appendix 1) was related to force but this would require a further more in-depth biomechanical analysis, and the need is to identify risk initially. In RULA calculations were also added for excessive static muscle work, repetitive motions and the requirement to exert force or maintain an external load (McAtamney & Corlett 1993).

In this study at Company X, different degrees of flexion were observed rather than just the bend of the wrist, as movements are widely varied on the production lines. 15 degrees radial deviation was marked as the furthest extreme on the range, but radial deviation to such a degree was not taking place. All other wrist positions were measured by observation technique. The criteria (appendix1) for the Company X study were as follows: less than 20 degrees of wrist movement was given a score of one, greater than 20 degrees a score of 2, and at the excessive end of the range a score of 3. Buckle and Devereux (1999) refer to bend rather than specific degrees of flexion as in dynamic motion it may be difficult to be precise. The study does however tie in with the recommendations of Buckle and Devereux (1999), for though the angle in degrees of movement is measured it is kept simple <or> 20 degrees. Some of the motions can be dynamic but the majority of the hand movements are in palmar flexion, and if not, this should be documented as for radial deviation and the excessive end of the range would be 15 degrees. The criteria work on the principle that palmar flexion is being monitored. Any other range should be categorised as appropriate and put into the comments section on the job action analysis form (appendix 1). Keyserling (1993) identified a problem with the extension of the wrist at 45 degrees. The further away from neutral position a joint is moved, the higher the forces on the joint are. Therefore if the handgrip is measured in the neutral wrist position and measured again out of neutral the score for grip will be highest in the neutral position.

Exposure of 20 hours or above with wrist in flexion or extension was defined as a risk (De Krom et al 1990); at 90 degrees extreme extension it increased the intra carpal tunnel pressure (Gelberman et al 1981). Workers with carpal tunnel syndrome used deviated wrist positions more often (Armstrong and Chaffin 1979). Wrist flexion increased median nerve pressure and created medium nerve compression by the flexor tendons (Moore et al 1991) as did wrist extension (Keir & Wells 1992). Wrist flexion allows for a greater grasping effect but then allows a greater application of force (Moore et al 1991). If the wrist is in ulnar deviation greater than 20 degrees it increases pain and pathological findings (Hunting et al 1980). Bergamasco (1998) in a study in an engineering firm, used angles of wrists in observation, but this study of Company X referred to extremes rather than full angles at extreme, and greater than 20 is identified by adding two to the score (Appendix 1 ergonomic breakdown).

Bergamasco (1998) recommends avoiding repetitions using a single finger, e.g. a trigger gun with one finger only, and wrist movements over 50% of its normal range. 30 actions a minute are deemed to be the highest acceptable in frequency with no other risk factors involved. Occupations that require finger flexion with the wrist flexed certainly predispose workers to developing carpal tunnel syndrome (Phalen 1966). Hunting et al (1980) found pain and tenderness in two thirds of clients in medical examination. Classification for degrees of movement of the wrist were 19-39 degrees and 39-56 degrees for their criteria assuming that less than 19 degrees was not a problem for work-related upper limb disorder. These criteria need to have a monitor system that can identify movement with such precision.

Elbows

Elbows were taken into consideration in the study in Company X under the heading of upper limbs within the job action analysis. Turning forearm pronation and supination was a concern for medial and lateral epicondylitis (HSE 1994); (Tichauer 1996). This was covered by a score for

1=occasional – once per cycle or <

2= frequent - > once per cycle

3= with force

Epicondylitis occurs depending on the repetition of the direction, lateral occurring with supination and medial with pronation and an increased risk when the action is forceful (Table 3.3; appendix 1) (HSE Work-Related Upper Limb Disorders: Assessing the Risks 1994)

Elbow discomfort can occur with heavy repetitive lifting but not sufficient evidence was found in relation to posture or repetition of vibration however a score of six was given for application of force for elbow discomfort (NIOSH 1997); and force was acknowledged with a score of 3 in the job action analysis of Company X, which was the maximum value. The end of range of extension of the extensor muscle at the wrist as a result of repeated gripping and twisting and turning of the forearm (pronation/supination) is related to the development of lateral epicondylitis, and excessive loading of normal musculo-skeletal tissue in the arm is related to the onset of epicondylitis. Epicondylitis can occur with the flexion and rotation of the elbow, particularly observed when a static load or forceful pinch grip was involved (Chaterjee 1992).

Friction neuropathy at the elbow through claw-gripping in this study was believed to be work related; the type of grip applied e.g. pinch, claw etc inch grip was considered under the heading of upper limb (appendix 1). Static work was not an issue in the study as the jobs were of a repetitive dynamic nature. Elbow positioning for maximum grip performance was considered (Oxford 2000) and this was represented under the amount of time spent gripping and the weight handled in the claw grip to identify with the relationship between elbow position and grip strength (Kuzala & Vargo 1992; Mathiowetz et al 1985). Elbow and wrist joint contact forces during occupational pick and place activities were measured by in a study by (Chadwick & Nicol 2000), in an ability to produce a mathematical model. The best tool design was found to be right-angled tools used at elbow height, in this study of Company X the tools were mostly downdrivers that were counterbalanced or pistol drivers that were used at elbow height (Ulin et al 1993) which allow the wrist to be kept virtually straight in their anatomical position (Bergamasco 1998).

According to Frievalds (1999) by arranging the workplace within the criteria set in the job action analysis and so as to keep the elbow at 90 degrees, most of the problem can be eliminated. However, in McAtamney & Corlett (1993) a score is given of 1 if the lower arm is held with elbow at 60 to 100 degrees, and a score of 2 if below or above that score. Graveling et al (1990) coded 1. >60°, 2. 60-100°, 3. 100-180°, 4. > 180°and answered yes or no concerning rotational move. Most of the jobs in company X were at around the 90 degree angle and those that were not scored on other indicative factors within the scoring scheme. However, most of the concerns within the studies with regard to elbow position were related to static positions (Chaterjee 1992), whereas company X is related to dynamic. Pulling and pushing across the body and reaching were under consideration of the shoulder region in the job action analysis (appendix 1), and kick back where the worker absorbs the torque known as "kick back" on powered screwdrivers (Ashton-Miller 1999) was considered under body part of upper limbs as is more a risk for wrists (appendix 1). When the assembly tasks are performed with force, as when using a down-driver, employees who were working using an extended arm with the product at a distance, were instructed to bring the product closer in on the production line to prevent extended arm movement.

Local pressure to elbow such as resting elbows e.g. on table, local contact stresses should not be applied and this was not an issue in company X (Wells 2002). The elbow spread was not an issue except in one job of CDT docking and this job was eventually rotated and that action anyway was scored under reaching to full extent with load. Weight was considered under load as weight is a contributory factor to lateral epicondylitis (Sleator et al 1998).

Reaching around the back of computer monitors to adjust controls with the arm extended in a static position for a prolonged time can cause elbow strain but also trapezius/ shoulder problems. Although this was not one of the jobs in the study it was analyzed with the job action analysis and it was recommended to replace the job with the same machine as on the other two lines so that the employee could totally avoid that static position and until this was put in place, rotate the job. The CDT stopped production as it was replaced by the TFT and that job didn't occur anymore. However, whilst it was in place it had still gained a high score under the body position of shoulders.

In hindsight in case of future job changes and this issue being missed it would be pertinent to add a score for elbow position to the criteria, including abduction/adduction and analyse future literature on the topic; since the design of the job action analysis for Company X, Sluiter et al (2001) divided for research and diagnostic purposes the upper body into seven categories one of which is the elbow. The reasoning behind the application of seven categories is that research has been difficult to follow as there are so many different criteria and to apply anatomical functional joints may improve future research with an ability to define less specific conditions (Sluiter 2001). Currently the database is being altered to include the wrist criterion.

However with regard to the summary of evidence (Sluiter et al 2001) Company X performs in the green area (safe area of work for elbows) as acceptable. The only issues were pronation and supination, squeezing and pinching which were marked under upper limb criteria and therefore given a score anyway knowing that these actions cause elbow, hand and arm problems. The psychological demands and social support issues which have implications for WRULD were not covered in this thesis in the study of Company X (Sluiter et al 2001).

Shoulders

Rotator cuff tendonitis is an inflammation of the tendons resulting mainly from impingement, compression and/or reduced circulation. It can be caused by the shape of the acromion impinging on the tendons. Fine et al (1985) have noted that rotator cuff tendonitis or generally supraspinatus was caused by working with a greater than 60 degrees forward flexion/abduction of the shoulder. The condition was found in employees in a study at an assembly plastic automobile part plants. From the anatomical position to abduction/flexion to less than 20 degrees was described as neutral, as this amount of movement was defined as not a problem in the development of WRULD. Lateral rotation when reaching behind with the arm without turning round was not measured in this study, although at 20 degrees of rotation could be deemed a problem. This movement was not in the criteria for the study of Company X as it is not a movement required for the production line at the time of the study. Shoulder pain and neck pain were acute where more than 60 degrees abduction or flexion was applied for more than one hour per day (Bjelle et al 1981). Rapid fatigue occurs at 90 degrees and fatigue at abduction greater than 30 degrees (Chaffin 1973). Abduction greater than 45 degrees of the shoulder creates discomfort (Herberts et al 1980), with rapid fatigue occurring at 90 degrees. Keyserling (1993) found 45 degrees of shoulder elevation to be a concern for WRULD. Forward flexion of the shoulder at 30 degrees may constitute a risk factor in the supraspinatus muscle as the pressure will be greater than 30mmhg, impairing the blood flow to the supraspinatus tendon (Jarvholm et al 1988). Repetitive shoulder flexion brought on acute fatigue (Hagberg 1981) and repetitive shoulder abduction or flexion led to neck and shoulder symptoms (Kilbom et al 1987). Postures invoking static shoulder loads can lead to tendonitis and other shoulder problems (Luopajarvi et al 1979). Upper arm flexion or abduction at 90 degrees, revealed by electromyography, caused local muscle fatigue in less than one minute (Hagberg 1981).

Hands held at or above shoulder height lead to tendonitis and shoulder problems (Herberts et al 1981 and 1984) and (Bjelle et al 1979). Abduction and forward flexion invoking static shoulder loads induce shoulder pain and leads to sick leave owing to musculoskeletal problems (Aaras and Westgaard 1987). NIOSH (1997) discovered that neck and shoulder problems caused by repetition and force could lead to WRULD and as could problems caused by posture. Supraspinatus tendonitis was found to be related to increased elevation of the shoulder.

Lindman et al (1991) found in females with work-related chronic trapezius myalgia changes in muscle morphology. An imbalance between the capillary supply and cross sectional fibres of type 1 and type 2A fibres could be significant in the development of muscle fatigue and pain. Discomfort may indicate that muscle fatigue is under way and preventative measures should be put in place (Valencia 1986). Studies into fatigue and muscle morphology should continue as many studies have found different reasons for localised muscle fatigue (Valencia 1986). Westgaard & Vassljon (1995) aimed to explain why some workers remained healthy whilst others developed musculoskeletal complaints at near identical mechanical exposure. The study demonstrated that perceived general tension is a strong risk factor related to trapezius muscle pain independently of muscular activity. Clinicians have plenty to offer in the field of preventative measures for WRULD. The greater the understanding of fatigue/muscle morphology, the greater the application for prevention in the workplace/community. Postural risk factors for shoulders were evident in work tasks on the production line at Company X. Most of the jobs on the production line for shoulder movement involve dynamic rather than static postures. Therefore the analysis for shoulders was based on regular pulling and pushing across the body (regardless of shoulder height): 1. for a short lever, 2. for a long lever, 3. for force (Appendix 1). The use of the shoulder was incorporated into the regular reaching above shoulder height: 1. 60-90 degrees, 2. > than 90 degrees, 3. 90 degrees with load. Also covered was reaching to full extent: 1. Once a cycle, 2. More than once a cycle, 3. with a load (HSE 1994). If there were any concerns, such as that the action was very repetitive, these could then be added to the comments section for action (Appendix 1).

Lifting from shoulder height

Shoulder/back problems can occur if an incorrect technique or lifting over the weight criteria in the guidelines are used in lifting from shoulder height. Weight guidelines are provided by the HSE with regard to static loading and the frequency of the lift (*Manual Handling Operations* 1992). No lifting from shoulder height currently takes place on the production line except in the decant area. Reaching above shoulder height does take place and this is covered under the shoulder section of (Appendix 1).

Neck

With the neck held in static flexion (Chaffin 1973) at 15 degrees for 6 hrs (chosen as starting point) there were no musculoskeletal problems, at 30 degrees there was a lapse of 300 minutes before severe pain occurred, and at 60 degrees severe pain occurred at 120 minutes. The Landrover study observed neck movements of 30 degrees or more neck posture out of neutral for more than 50% of the overall cycle, or the neck held static for half an hour or more (Wilkinson et al 1998). In the research for Company X prolonged neck flexion/extension defined by degrees less than 30 had a score of 1, greater than 30 was assigned a score of 2. Very few jobs so far have been found with the neck in extension and though this can occur in the camera jobs but usually is more of a dynamic than static position. Static flexions of the neck can quite easily be observed to be more or less than 30 degrees from neutral, and 30 degrees is also the critical point at which neck pains can be caused, according to the research cited above.
A further analysis for the neck was related to turning the head, and was assigned a score of 1 for occasionally, 2 for excessively and 3 for if the neck was in a twisted position as this would apply extra strain.

Neck dynamic flexion between 19 degrees and 39 degrees resulted in low sick leave due to musculoskeletal problems (Aarras & Westguard 1987). In study of Company X this is covered in the job action analysis. The dynamic element is measured by repetitive neck movements when repeatedly looking up and down, if this is performed for a 1/3 of the cycle time it was assigned a score of 1, between a 1/3 to 2/3rds of the time a score of 2 was assigned. More than 2/3rds was assigned a score of 3 (appendix 1). The use of degrees of movement is more difficult where the movement is repeated with many variations therefore time spent with repetitive neck movements within the cycle was applied.

The neck criteria also recognised the strain on the neck when pulling with the arms and when this occurred a 1/3rd of the cycle a score of 1 was assigned, greater than 1/3rd but less than 2/3rds a score of 2, and greater than 2/3rd of the cycle a score of three (appendix 1).

Neck Chaffin's (1973) and Kilbom (1987) criteria for measurement of posture:
1 for 0-10 degrees of flexion
2 for 10 to 20 degrees of flexion
3 for 20 degrees or more of flexion
4 if in extension
twisting or side bending of neck, add 1

Back McAtamney's (1993) criterion for measurement of posture (RULA):
1 when sitting in a position with the hip- trunk at 90 degrees angle or more
2 for 0-20 degrees flexion
3 for 20-60 degrees flexion
4 for 60 degrees flexion

Landrover used over 20 degrees of back flexion as the criterion for their study (Wilkinson et al 1998). Less than 20 degrees seemed not to lead to a higher rate of low back pain (Aaras 1994); (Burdorf 1992).

The criterion from previous research was used for the research at Company X. For flexion of the back the word stoop was used, and this was for flexion from 20 to 40 degrees as a starting point, since 20 degrees was identified as the point when discomfort can arise (Burdorf 1992). Greater than 40 degrees was given a scoring point of 2 and if the person was stooping twisted then the score was 3 (Appendix 1).

Regular twisting of back

Regular twisting of the back causes undesirable stress to the spine. The discs between the vertebrae are stretched and the joints and muscles on each side of the spine are subjected to asymmetric stress (Dul & Weerdmeester 2001). *Manual Handling Operations HSE,* (1992) advocates that back problems can be reduced if the correct technique is used and twisting is avoided. Any lifting taking place from any position that was less than the recommendation of the *Manual Handling Operations* 1992 was assigned a score of zero.

Sitting versus standing criteria

Back and knee problems and varicosity can occur when people are stood still as the muscle is not pumping and creating stagnancy (Corlett and Clark 1996). Back problems can also occur as a result of tilting at the hip when leaning forward in the standing position or not seated correctly. Restricted movements lead to back concerns and unnecessary twisting can also lead to knee problems if twisting from the leg (HSE 2001b).

Sitting / standing:

Up to 50% =1

50%-75% = 2

75%- 100%=3

If someone was standing for 75% of the time the allocation of 1 was not added for the other 25% at the time spent sitting as then the score would be 3, the same as if the person were standing 75%-100% of the time. Generally most of the operators on the line stand 100% of the time, and a few that sit 100% of the time, while others rotate seating to standing positions. At the time of the study no person did either in the 50%-75% range on any of the production lines. The allocation of 0 is for those with freedom to move about and sit and stand as they please. Standing for long periods tires the legs and back. Freedom of choice to be able to move around and sit or stand comfortably is the best option (Dul & Weerdmeester 2001).

Lifting from the floor

Manual Handling Operations HSE, (1992) provides guidelines on the criteria for the lifting of weights. Lifting can lead to back problems if the incorrect technique is used. If lifting from the waist more than twelve times per minute then no more than 4kgs weight tucked into the body should be lifted. Lifting from the floor occasionally was assigned a score of 1 and a score of 2 if frequent where it occurred once or more each cycle (appendix 1).

Lifting from the waist

Manual Handling Operations HSE, (1992) indicates that back problems can occur if the incorrect technique is used e.g. which twisting from the waist, which is one of the criteria in Appendix 1 for the job action analysis. If weights that are being relocated need positioning through a number of positions then it may be necessary to calculate an acceptable weight value. Very few jobs on the production line require any manual lifting. If lifting more than 12 times a minute the part should weigh no more than 2 kgs

(*Manual Handling Operations HSE,* 1992). Lifting from the waist occasionally was assigned a score of 1 and a score of 2 if frequent where it occurred once or more each cycle (appendix 1). The weight was based on the allowance level of the Manual Handling Operation's, therefore if the weight was below the criteria of acceptance level with regard to lifting from the waist (without any twisting) it was allocated a score of zero, as it was deemed not a problem.

Pulling and pushing

Manual Handling operations HSE, (1992) states that back problems can occur if the incorrect technique is used for pulling and pushing trolleys, or the trolleys exceed the guidelines in weight. The weight guidelines are defined by the required inertia. Regular maintenance of the trolleys and monitoring is important to make sure that the inertia required does not exceed the guideline. As a guideline trolleys should not exceed 200N (about 20 kgs) in initial inertia (Dul & Weerdmeester 2001). The HSE (1992) guideline for the starting and stopping of trolleys was 25kgs and whilst in motion 10kgs. However, it was updated and reduced to 20kgs for men and 15kgs for women (HSE 1998). Trolleys weighing more than 700kgs will require inertia above the guidelines and therefore the trolleys should be motorised. Pulling and pushing of trolleys occasionally was assigned a score of 1 and a score of 2 if frequent where it occurred once or more each cycle (appendix 1). Very rarely do the employees on the general production line perform this function, as it tends to be the job of the line feeder.

The use of Tools

Pressure from using scissors or metal tools can lead to digital neuritis. Direct mechanical pressure on the tissues can occur when using badly designed tools and handles (Hagberg et al 1995). The best tool design was found to be right-angled tools used at elbow height (Ulin et al 1993). Chiang et al (1993) demonstrated that fish processing workers were 1.8 times more at risk of upper limb and shoulder problems when exposed to hand wrist forces greater than 3 kg. Exerting hand forces greater than 4 kg less than every 30 seconds increased the risk of developing hand and wrist problems by a factor of 29 in comparison to no exposure (Silverstien et al 1986). Tools used repetitively and/or for precision work are recommended to weigh less than 0.4kgs or will require counterbalance. If the tool is heavier than 2.25 kg it is recommended that there should be the provision for use with two hands (Bergamasco et al 1998). HSG 60 rev HSE's (2002) recommends that the weight of tools should be minimised especially for precision work. Power tools should weigh around 1.5 kgs and no more than 2.3 kgs, and should be suspended or used with counterbalances. The criteria for the study at Company X therefore started with a score of 1 for less than 0.4 kgs of tools or product handling. These weights could have been given an allocation of zero since they are not deemed to be a problem (Bergamasco et al 1998). Tools weighing more than 0.4 kg were allocated 2 points, as they require a counterbalance. The criteria was added and later in the study a third point was added for tools above 2.25 kg which it was deemed should be handled by two hands rather than one (Bergamasco et al 1998), and that tools should weigh no more than 2.3 kgs even if counterbalanced. These requirements have important implications for the transformer job as application of the transformer requires the use of two hands in any recommended ergonomic changes.

Repetition and force and vibration are identified as causative of carpal tunnel syndrome and especially so when found in combination. Carpal tunnel syndrome is caused by vibration from drivers and the posture maintained when using the driver, and the seating and the amount of reach and force required are contributory factors. Supraspinatus tendonitis was associated with increased elevation of the shoulder, especially when using power tools (Hadberg 1996), and epicondylitis with the flexion and rotation of the elbow, particularly observed when a static load or forceful pinch grip was involved (Chaterjee 1992). The type of grip and wrist position was identified in the scoring system in the research at Company X under the heading upper limbs (Bergamasco et al 1998). The ability to grip with regard to cohesion were also considered (Keyserling et al 1993), and the amount of gripping and pressing (Graves 1990). Analysis of shoulder movement, pulling and pushing across the body, using down-drivers and reaching to full extent was also included (HSE 1994). The incidence of carpal tunnel syndrome was associated with the use of vibrating tools and local pressure to the base of the palm. Vibration and kickback (Ashton Miller 1999) and trigger tools (HSE 1990) were also analyzed (see Table 2.8 and Appendix 1).

Torque levels were checked every morning prior to the production lines starting. The current guidelines are that there should be no exposure to vibration greater than 2.5

mm/sec^2 in the dominant plane. The results on the Delvo electrical drivers showed that the Z plane was the dominant plane with a vibration of 1.1 mm/sec^2, which is 1.4 less than the current guidelines, so therefore acceptable. The Y plane measured 0.6 mmsec^2 and the X plane 0.4 mmsec^2. The planes were measured with the driver running permanently and therefore the results of the vibration exposure are likely to be even lower as there is a reduction during normal use. The drivers are maintained regularly by the maintenance department and the rubber sleeves on the drivers are replaced if there is any apparent wear. The rubber sleeve enables facilitation of a better grip, prevents slipping and gives good cohesion, allowing the risk of fatigue to be reduced. Currently three areas where a down-driver is used on one of the sites has been deemed a noise protection area as when the noise levels were recorded in the factory this was found to be at a level where hearing protection is required. Temporary hearing protection is being used but the maintenance department has altered the three drivers and we are awaiting a further test to see if this has reduced the level enough to declare it is no longer a hearing zone protection area.

De Quervains syndrome was associated with excessive ulnar deviation, and trigger finger with the increased movement and local pressure of the terminal phalanges (Chaterjee 1992). Tendonitis was found to be related to repetition, force and posture and particularly when these were in combination; supraspinatus tendonitis related to increased elevation of the shoulder; a posture used especially when working with tools. Two to three finger controls for pistol drivers are better than using just one digit (usually the index finger), for a few fingers spread the load; hence a score of 1 if a few digits are used and 2 if single digit is used (Appendix 1) (Freivalds 1999). Trigger forces should be kept below 10 Newtons (1kg approx) and below 10,000 motions a day. Load score for manual handling was not applicable as very few jobs on the production line had any heavy lifting and these were added to the descriptor as an immediate problem to be dealt with via biomechanics. The Landrover Company, owing to the application of loads in a different type of industry, developed a load score calculation as a means of evaluating risk and risk reduction as more purposeful to that type of environment (Wilkinson1998; Leaver 1999). Kneeling or standing off-balance is not part of the job description in Company X and therefore was omitted from the analysis.

Repetition

Repetitive work is defined as work with the cycle time for the task being less than 90 seconds (Huppes et al 1993). Highly repetitive tasks have been defined as those with a work cycle time of less than 30 seconds or with more than 50% of the cycle time involved in performing the same motion pattern (Silverstein et al 1986). Sustained posture for 50% of the cycle or more than a half hour was deemed to be a problem (Wilkinson et al 1998). It is essential to focus on the real task duration and repetitive tasks and on the existence and distribution of recovery time (Columbini 1998); action frequency is a more accurate estimation factor of risk than cycle times as very short cycles may not necessarily require very frequent gestures and movements (Columbini 1998). Therefore in job rotation schemes, it is important to observe and measure the use of different muscle groups where repetition does take place. When employees rotate to the next job they are in effect getting a rest period as the muscles they have been using are resting whilst other muscle groups are in use.

Static load is a distinct risk element and rest time is an important factor in recovery. Columbini (1998) defines static load as a posture held for more than 4 seconds. For dynamic repetition a ratio of 5 work to 1 rest is recommended and repetitive movements beyond one hour is not acceptable (Columbini 1998). This is why the recommendation of an hourly job rotation is advised. More than 500-2000 manipulations per hour lead to tenosynovitis, 2000 manipulations an hour may lead to de Quervains tenovaginitis (Hammer 1934; Buckle and Devereux 1999). These are important figures for calculating the time of a job cycle. Columbini (1998) places emphasis on recovery time, quoting 10-20 seconds as a significant rest time from repetition and recommending a 5-1 work/rest ratio and an hourly job rotation.

Repetition on the production line is known to be a factor for the development of WRULD. Measurement of repetition was not required in the system as in all cases frequency is high, and the tact time where frequent is not allocated a number. This system is used for numerical analysis and can be checked at a later date for further improvement. It is not a stand-alone risk assessment but a quick and easy scoring system that may require modification. For example regarding loads, biomechanical measurement would be an extra requirement. The purpose is to find where the scores are high and then reduce them first to medium, and then to low if necessary. Risk reduction is paramount. In the comments section any other movements not on the form can be recorded (Appendix 1). If these movements start to occur on a regular basis, they can be added to the analysis and given a score.

This study at Company X, as in the study of Columbini (1998), does not consider psychosocial factors because they are not easy to quantify. It is not as technical as Columbini (1998) or McAtamney & Corlett (1993) as it is meant as a quick guide which will show where full analysis is required once risk has been identified. . For a more overall picture of the company an investigation into the psychosocial factors would be pertinent. Leaver (2000) in an automobile industry assessing the incidence of WRULD when assembling seats in a vehicle, applied in the ergonomics intervention study a musculoskeletal screening tool the Quick Exposure Check (QEC) as in Li & Buckle (1999) and also a subjective discomfort questionnaire. These applications are very similar to Company X in that the job action analysis is a quick exposure check less complex than the QEC as it does not require cross analysis of tables to calculate a score

3.3 The discomfort scale

The Bourbonnais (1981) pain assessment tool consists of the Numerical Rating Scale and a visible observation of the type of pain. This was further expanded by Berker & Hughes (1990) using a tool for pain assessment with body maps. The McGill pain questionnaire has been described as the most adequate and versatile means of measuring the total experience of pain (Melzack 1987; Melzack & Wall 1996; Halligan 1994); but owing to its complexity and length of time required for completion, it was not suitable for this study (McGuire 1984). This study has combined the Numerical Rating Scale (NRS) with body maps developed by Raiman (1986), but only for its use of upper limb (appendix 4 & 5). The study is not measuring the type of pain, only the severity, but all the measurements are recognised in research. The system was chosen to be easy, quick to use, unobtrusive, and allowing a quick return in the field (Edwards & Talbot 1994). If anyone was being treated for acute pain in the medical department then the assessment would be required to be more specific as it would necessitate treatment. It is best to use a multidimensional method in the clinical setting, but for research purposes numerical scale is suitable (Carlsson 1983).

Non-specific pain was measured in this study, even fleeting pain which may have been associated with fatigue and pain that is not related to work. Any employees who had persistent discomfort or discomfort which remained in the same area of the body were referred to Occupational Health. The findings of the observation techniques in the study of Company X matched the areas for fatigue, although much of the discomfort was fleeting and diffuse.

The numerical scale is the second most commonly used form of objective measurements in physiotherapy assessments (Halligan 1994). Its advantages are that it is easy to use, consistent (which improves accuracy) and pain flow charts can be developed from it. The participants quickly learn how to use it. Once they decide on their score for pain they can easily calculate if their pain was worse or improved and therefore move the scale accordingly. It was ideal for the research as numerical data could be analyzed in SPSS. The disadvantage of descriptive words is that they are not easily quantifiable in the research field (Halligan 1994).. The advantage of numerical scales is that they reduce the risk of misinterpretation. Some people may feel that a number is irrelevant to their predicament, but if it is for the purpose of research, not medical assessment, this is not a problem (Halligan 1994). As a research tool the numerical scale was very effective however when used as a medical assessment misinterpretation may adumbrate their assessment.

The discomfort scale used for the research in Company X was the numerical rating scale, and was combined with a body picture, as in the London Pain Chart, on which the affected body area could be coloured (Appendix 4 & 5). The London Pain Chart was used for ease, as it is quicker to colour in an area than to write a description, and also because it allows people to identify an area of discomfort accurately. People may for example describe elbow pain as arm pain, which is not precise enough for research purposes (Alexander et al 1990). Considering the short time employees have available in a production environment, this mixture of measurement analysis was ideal: it was quick and simple, but provided all the necessary details for analysis. Face validity should measure what it purports to measure and the form achieves this. The form was trialled on four clients prior to release at shop floor. The discomfort questionnaire used in Company X study has an advantage over the Nordic Questionnaire as it entailed colouring the body parts affected and therefore there is less room for error. In the Nordic questionnaire there is no mention of the upper or lower arm and discomfort is defined as elbow wrist or hand discomfort (Thomas 1992). If a person was feeling fatigued in the upper arm muscle, the biceps, or had a tendonitis in the lower arm in the Nordic questionnaire this would not have been detected. The colouring system for discomfort allows the employee for him/her to define the exact location of discomfort. However the Nordic Musculoskeletal Questionnaire is suitable for application in a wide diversity of workplaces and covers lower limb problems also (Dickinson et al 1992). A study cannot be justly defined by subjective questionnaires of self-reporting that they are reliable, there needs to be a workplace analysis incorporated with it to be able to ascertain whether the discomfort is due to the workplace ergonomics.

The case study of the female agricultural workers (Oude Vrielink 1995) also applied a questionnaire, the Nordic Questionnaire, which relies on straight forward yes or no answers to discomfort of affected body parts. These methods of observation and questionnaire were also applied in the study of Company X. The observation was by noting the body postures with regard to the criteria for the purpose made job action analysis (appendix one) and the mixed questionnaire form, was a subjective discomfort questionnaire. No discomfort was given a score of zero and maximum discomfort was given a score of 10; if an employee felt his pain was mid range on a Monday he would circle 5 if he felt it was mildly worse on the Friday he would circle 6 (appendix 4). If the pain was in his right palm he would colour in the right palm.

The information from the discomfort forms was then inputted into SPSS with each participant provided a number so that all information could be followed visually, analytically, and anonymously. Visually it was important to observe if any participant was getting pain frequently in one area e.g. right shoulder as they would need to be referred to the Occupational Health Department in case of any WRULD involvement. This could also be visually checked to see how much fleeting discomfort there was in different body parts. In order to ascertain how much discomfort people were feeling and if occurring in similar jobs and in the same body parts, the amount of discomfort from the scale of 1-10 was also observed. Analytically in SPSS individual data could be analyzed but it was effective to check for the amount of discomfort and amount of body parts affected in different people on different jobs, to compare similarities and differences between those that job rotate and those that didn't, between the amount of discomfort and body parts affected (Graphs and Tables Chapter 5).

3.4 Instruments used in the study of Company X

The Dynamometer.

The Jamar dynamometer is an accurate instrument for the measuring of grip strength (Mathiowetz et al 1984), with high inter-rater reliability (r = 97) for both grip and pinch measurements. The reliance of the Dexter system on the Jamar dynamometer was seen as an indication of its reliability since it is used as a strength measuring tool to assess recovery from WRULD (Brown et al 2000). The Jamar dynamometer is the standard for the American Academy of Orthopaedic Surgeons, the American Society for Surgery of the Hand, and the American Society of Hand Therapists (ASHT).). The Jamar is used as the Gold standard (Bellace et al 2000 p 50) and is relied on by (Fishbain et al1999; Niebuhr et al 1987; Crosby 1994). Other studies have used similar microprocessors (Liu et al 2000). Kilpatrick (1956) deemed dynamometers measure force strength rather than pressure. The grip score is only a strength measurement and manual muscle testing does not adequately identify weakness or changes in the small muscles of the hand (Liu et al 2000). Therefore fatigue of these small muscles would not show in the grip score. The strength measurement of the hand grip is at the core of most protocols of functional assessment of the upper limb and patient's occupational ability (Bengalia 1999); and the identification of submaximal effort by isometric strength testing is an important issue, measuring isometric contraction of muscle without joint movement (Fishbain1999).

The Jamar dynamometer would have been used in this study had it not proved too expensive. In the study of Company X on the BTM a digital readout hand-held dynamometer was used to measure hand grip, similar to other microprocessors used in research (Liu et al 2000). However, the study was not measuring grip differences between individuals but only trying to obtain an assessment of the strength in the grip of employees in the study. It was decided to use a simpler but equally reliable tool such as the hand grip isometric test used by other workers in this field of work.

Table 3.4 Types of Dynamometer used in research

Jamar	Solanki et al 2000	*
Jamar	Fishbain et al 1999	
Strain gauge transducer	Chadwick & Nichol 2000	*
Strain gauge transducer	Nevill & Holder 2000	
Jamar dynamometer and Dexter evaluation system	Bellace et al 2000	*
Jamar dynamometer	Crosby 1994	
Jamar dynamometer	Essendrop et al 2001	*

* *Research studies performed after the main data collection in Company X*

Handgrip is often used to measure isometric loading of muscles (Bugajska 1993). Crosby (1994) used the Jamar with the elbow position at 90 degrees which emphasised the need to use more than just level 2 as only 60 percent achieved their maximum at this level. All 5 levels should be applied especially in a clinical setting and where an accurate result is required.

Liu (2000) performed the test with the hand in neutral and the arm flexed at 90 degrees for testing strength. Kuzala and Vargo (1992) found grip score higher when the arm was in full extension. Desrosiers et al (1995) found the grip score was higher with the elbow extended at 90 degrees but found no difference between dominant and non-dominant. Oxford (2000) found the arm in full extension to give the highest results ($p<0.0001$) which is probably because complete elbow extension gives the wrist extensors a mechanical advantage of increased tension.

In the majority of studies before 2000 the test was performed with the elbow flexed at 90 degrees and adducted with the wrist in neutral. This position is the optimum one in studies relating to work and was used for the present study. In isometric testing Liu (2000) used a make test, where the dynamometer is held stationary. Reliability was increased by having the same examiner continuously using the same instrument, the same subjects and testing the same muscles (Liu 2000). The make test has a higher intra-class correlation coefficient (0.95) than break tests (0.87) which rely on the degree of force displacement by the examiner (Stratford & Balsor 1994).Grip strength is greater with the elbow flexed at 90 degrees rather than in full extension (Mathiowetz et al 1985).

3.5 Data Collection

Between September and December 2000 a discomfort scale was completed by the employees (those who volunteered to take part in the research) on the production lines as a measure of the levels of discomfort they were feeling and as an indication of whether those employees job rotating felt less discomfort than those that were not. The discomfort levels of the employees working a five day shift were recorded by the employees on Monday and Friday. The reasoning behind this was to be able to see if there was any deterioration by Friday owing to fatigue. Also to see if after the weekends when initially starting work if any discomfort owing to repetitive work the effect it may have on the tendons, ligaments and muscles which initially had been at rest. The employees that were on four day shifts were asked to complete their discomfort levels every day as each could have a different day off (and where asked to state day off on the form) as it could mask the results as the same needs to be considered as at the weekend (appendix 4 & 5).

Another area was included in the study of Company X, the Bent Tool Machine (BTM); it was proposed to put one of the shifts on rotational duties, as prior to the study rotation was not taking place. This area was chosen as I felt there would be greater controls in the research as the supervisor was a health and safety enthusiast and therefore would allow for planned job rotation v non-rotation comparisons. All the employees on the BTM completed the discomfort form the same as the production lines employees but with an extra objective measurement of grip strength. The grip strength test for the BTM group can be assessed for any correlation for grip levels. The grip strength was measured on a Monday and Friday to see if there is any correlation with the grip level and the results of the discomfort scale measurements and whether any deterioration in grip occurs over the week / over time.

3.6 Research Design

The aim of the study was to investigative work-related upper limb disorder in a case study on two sites building different electrical equipment.

The research design used was a case study. A "case study is a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple areas of evidence" (Robson 1993). Therefore it is a stance or approach rather than a method, it is empirical in that it relies on the collection of evidence about what is going on, using multiple methods of data collection. A case study allows for the researcher's own impressions and perceptions to be brought out into the open. It is an emergent research in that the research design emerges and unfolds from the interactions within the study (Robson 1993).

The multiple methods of case studies usually involve observation, interviewing and analysis of documents as in this study of Company X. Case study allows for the researcher to look at the process and interpretations to dig below the surface of the taken for granted (Edwards & Talbot 1994). An in depth study of a setting allows chronology to be established and interaction with context to be observed (Edwards & Talbot 1994). The advantages of a case study are that it allows an in depth focusing on shifting relationships, it capturises complexities and allows focus of the local understandings. It provides readable data that brings research to life and that is true to the concerns and meanings under scrutiny. The disadvantages are that the appropriate data collection is very time consuming and that it is situation and time bound (Edwards & Talbot 1994). The advantages of progressive focusing is that fresh perspectives are placed on the taken for granted (Edwards & Talbot 1994)

3.7 Main data collection

The main data collection took place between September and December 2000 over 15 weeks in total. For the study 81 people were asked to participate, with one refusal, which left 80 persons in total willing to participate. All participants in the study were male except for two. Because the firm is male dominated it was not possible to divide the sample between males and females for the purpose of testing any differences between them in WRULD and discomfort levels. Since research shows that females are more prone to WRULD it would have been interesting to include a male/female comparison. The study was divided into two parts but was analyzed whole using the statistical package SPSS. Therefore two groups of employees were involved in the study. The aim of this strategy was to prevent deterioration in problems associated with seven specific tasks (work areas as detailed 1.1 to 1.7 inclusive, prior to table 3.5 and 3.6.

The case studies shown in Table 5.1 formed the basis for the choice of duties to study on the production lines for they clearly identified which duties were more likely to cause medical conditions. These tasks were identified to use as the case studies in the research (table 5.1) were having difficulties with these jobs and had developed WRULD in relation to these job (Table 5.1). As is explained in table 3.5 jobs 1.1 – 1.4 (PCM) and table 3.6 jobs 1.5-1.7 (MWO), these jobs are on different sites hence the tasks are completely different although all require some dexterity one can see the difference in the job action analysis scoring in (appendix 10). These specific jobs were highlighted through examination of occupational medical records. Every line was used on both sites for the main data collection; it is possible to compare generally that specific jobs without rotation may cause more discomfort than others. It is not possible to score discomfort against other individuals as discomfort is an individual feeling as different people have different tolerances to discomfort. The study tested the effects of stress on the upper limbs without job rotation (except in areas where job rotation was already taking place) as the researcher was not allowed to introduce a job rotation schedule as permission was not given for this, as there was to be no interference in normal production.

The study involved monitoring the six production lines in the Personal Computer Monitor factory. This involved monitoring seven teams (group one) since one team worked a line on the day the other line teams were off duty. Employees were asked to complete a numerical rating discomfort scale (Halligan 1994), which they completed for the detection of discomfort (see Appendix 4 & 5 for an example). The participants in the study were asked to record the time they had been working on their specific job, the amount of time they had worked at the factory and the time spent in similar type of work. They were asked which their dominant hand was or whether they were ambidextrous.

The models that the employees were working with were noted, as comparison analysis was required. These models are extraneous variables and need to be monitored.

The case studies related to the four following specific tasks:

1.1 Flat pack boxing

1.2 Boxing on the lifter

1.3 Cathode Display Tube Preparation (CDT) Prep

1.4 Earth Wire connection / Printer Board Assembly (PBA) insertion

Table 3.5 Personal Computer Monitor (PCM)

Site	Job	No of people rotating Duties	No of people on non-rotating Duties	Collection method	Total numbers of people
PCM	CDT prep	12	7	Discomfort Form	19
PCM	Earthwire/ PBA Fit	5	5	Discomfort Form	10
PCM	Flat pack	1	6	Discomfort Form	7
PCM	Boxing lifter (in use)	4	1	Discomfort Form	5
PCM	Boxing lifter (not in use)	3	3	Discomfort Form	6
Total		**25**	**22**		**47**

The lifter was not in use for a large amount of the study. Therefore the discomfort score for that specific job could have been different from normal, as in some respect the employees were inadvertently rotating from their usual set pattern within their job (meaning that normally they may use the lifter). When the smaller models are being boxed the lifter is not in use; or if it is waiting for maintenance work to be performed. In this case the employees were all on the smaller model and did not divert from this therefore the measurements were consistent in that the same job was being performed without the lifter, three were rotating duties and three not rotating but within that none of them was using the lifter.

Included with this group were employees in the Microwave Oven Factory, (see Table 3.6) where five teams were monitored. The case studies related to the three following specific tasks:

1.5 Magnetron (part weight 0.86kgs)

1.6 Transformers (part weight 4.7kgs)

1.7 Capacitors (part weight 0.15kgs)

Table 3.6 Microwave Oven (MWO)

Site	Jobs	Rotating	Non-rotating	Collection method	Total number of people
MWO	Magnetron	1 occasional	4	Discomfort Form	5
MWO	Transformer	2 occasional rotation	5	Discomfort Form	7
MWO	Capacitor	0	5	Discomfort Form	5
Total		3 (occasional)	**14**		**17**

Three people did very occasional rotation in MWO but it was deemed ineffective as it was very sporadic. Sometimes days went by without any change in jobs. No-one in the study did an occasional rotation at PCM. The two sites are very similar although they are not building the same products. The culture on each site is very much the same with each site working independently but with similar responsibilities; although PCM did have more job rotation taking place. The data collection process was exactly the same on both sites.

On both sites the employees use down drivers that require being held in a power grip and the jobs require a degree of dexterity but the scores for the job action analysis may differ (see appendix 10). The study is not comparing like for like as there are differences between the jobs. One could analyse the same jobs on each line, for example all the jobs had every line analyzed with the job action analysis but the discomfort levels will differ despite if people are doing the same job as people's tolerances to discomfort are not the same. In the seven jobs in table 3.5 and table 3.6 the CDT prep job in PCM consists of a lot of thumb use in the wire harnessing of CDT prep whereas the docking of CDT requires strength from the arms (the biceps) owing to the CDT weight. The earthwire/ PBA fit requires a lot of pincer grip work which puts stress on the index finger and especially the thumb.

The flat pack job until recently involved flick-turning the box with the arms away from the body twisting the wrist. This manoeuvre can lead to wrist problems, as it also requires movement out of neutral. It could create minor shoulder problems and thoracic problems. The box is not a heavy item but it has to be flicked well away from the body in order to give it enough turning room. Boxing with the lifter involves gripping the double handle into the palm and sustaining the pressure, pulling the lifter across the body with the monitor on, then lowering and releasing the lifter handle to place the monitor in the box; although this was scored as zero for pulling across the body as the lifter does the work. It was however given a score of one for regular reaching 60-90°. Shoulder problems could occur owing to shoulder abduction of up to 90 degrees depending upon the height of the individual and could lead to problems with the wrist extensor problems or tennis elbow or tendonitis.

The magnetron job requires sustained repetitive forceful gripping/flexion of the fingers to use the pistol driver, and this is known to cause triggering of the fingers which if the condition is not managed can require surgical release of the finger tendons. Through holding the magnetron with the hand sustained in a claw grip position in dorsi-flexion pressure can be placed on the carpal tunnel secondary to extreme extension of the wrist and repetitive and forceful sustained finger flexion. Also repetitive forceful sustained flexion and extension of the thumb can place strain on the abductor pollicis longus and the extensor pollicis brevis tendons, leading in turn to de Quervains tenosynovitis. The fingers are also flexed and holding the magnetron in a sustained static grip could lead to trigger finger.

The transformer job can create problems with trigger fingers owing to the sustained grip and weight, and the forceful sustained flexion. Tenosynovitis can occur as the flexor tendons grip tight and wrist extensors maintain a sustained force to keep wrist in neutral, static. The transformer is lifted in a claw grip with the hand pronated (palm facing down) and then the forearm is rotated so that the hand is then supinated (palm facing upwards). The hand goes into dorsi-flexion (extension backover) to support the weight and this position has to be maintained to counteract the down-force created by the down-driver being used in the opposite hand, which further increases the force application in the hand holding the transformer. Some employees may have the strength to control it in neutral but will be taking a large amount of strain; others in backward (dorsi flexion) are out of neutral.

The problems identified are the weight of the transformer, the repetitive claw grip, the turning of the arm supporting the weight, and the weight in one hand in supination and the wrist being out of neutral. The capacitor job is a much lighter part than the handling of the transformer and therefore does not require the same effort to maintain it in position but it also requires a claw grip. The capacitor job appears to have improved over time according to descriptions found in notes, in that it requires less force and dexterity than it used to. This is what led to the development of the discomfort scale to see if employees on these specific jobs had any discomfort and those that job rotated did they benefit from less discomfort.

In the Microwave Oven Factory the Bent Tool Machine (BTM) area was chosen for part of the study, as I felt that the supervisor would be keen, owing to his health and safety interests, to support any health and safety research interventions. The work in this area was shown in the analysis to make use of different muscle groups at different numerical ratings and therefore in theory would benefit from rotation. The purpose was to eliminate the incidence of work-related upper limb disorder by task rotation, a proactive preventive model (Table 3.9 & Appendix 1 & 10). The three shifts of employees completed the discomfort scale, using the same scale as group 1 for consistency. It was not necessary to identify who rotated and who did not. It was planned that jobs with a variety of musculoskeletal stresses should be rotated, in accordance with the job analysis that had been performed in the area. The aim was to prevent loading taking place on one specific area of the body, creating mass stress and fatigue. It was proposed to test the difference between the intervention and control groups by introducing a new scheme for a fixed period. It was proposed to keep the three shift teams on the BTM as usual.

Robson (1993) states that a convenience sample is a “cheap and dirty way” of doing a sample, as it does not produce representative findings. No research is without its problems and one of the duties of the researcher is to be aware of the pitfalls and problems of the methodology. Since the convenience sample covered all the teams on the BTM there were no exclusion criteria. It would not be practical to use another sample as the people were already trained in the job and therefore assessment for the job action analysis to build the matrix was less likely to suffer variation as a result of their inexperience. Some people working on the job may not be used to using their tendons and ligaments and are not up to peak fitness, especially if they have never done this type of work before or recently. They may be more susceptible to fatigue and work-related upper limb disorder and therefore it would be unethical and could be biased if this sample was used to support the hypothesis.

Station 1 on the BTM in MWO involves taking small metal parts from a bucket and welding a metal part for the microwave cavity. To perform this task the wrist comes out of neutral slightly and occasional twisting of the forearm occurs with up to 30% of the job requiring pressing when activating the buttons to move the cavity along a conveyor. The job action analysis score is 13 (appendix 10).

Station 2 involves placing on metal parts ready for welding by the BTM. It also involves the pressing of a button to move the cavity along the conveyor and requires a palmer pinch, there is no twisting of the forearm and the wrist stays in neutral. The job action analysis score is 8 (appendix 10).

Station 3 /4 involves placing metal parts onto the cavity ready for the BTM to weld. To perform this task it involves a palmar pinch and some light pressing of buttons to move the conveyor along, there is also some occasional twisting of the forearm. The job action analysis score is 11 (see appendix 10).

Station 5 involves the same type of activity placing metal parts on the cavity so that the BTM can weld them on. There is no twisting of the forearm but involves a palmar pinch and the wrist is slightly out of neutral and there is also some pressing of buttons. The job action analysis score is 14 (appendix 10).

Station 6 requires some welding of the last parts of the cavity and then the cavities are placed on large trolleys. It requires the wrist to be slightly out of neutral. In all the stations where the wrist was out of neutral it was never more than 20 degrees forward flexion. There is also some pressing of a button to operate the welding machine, anywhere where pressing occurred it was always well less than 30 percent of the job. This job had a high score in comparison to the other jobs as it involved reaching above shoulder height to full extent. The job action analysis score is 18 (see appendix 10).

The employees on the bent tool machine (BTM) in MWO were asked to complete a discomfort scale every day and test their grip strength every Monday and Friday. The initial test was the baseline. All data was to be collected on Monday and Friday combining the results of the three shifts A, B and C.

A group of employees the (intervention group) that did not normally rotate was used for part of the rotation study.16 employees participated 5 were allocated rotating duties (Table 3.7) (although the rotation was not strictly adhered to) and 11 to non rotating duties

Table 3.7 Bent Tool Machine (BTM) in MWO

Site	Job	No of people rotating duties	No of people not rotating duties	Numbers of people in total	Collection method	Extra collection	Sample type
MWO	Station1	1	2	3	Discomfort Form	Grip Strength (1shift in 3)	Convenience
MWO	Station2	1	2	3	Discomfort Form	Grip Strength (1shift in 3)	Convenience
MWO	Station ¾	1	3	4	Discomfort Form	Grip Strength (1shift in 3)	Convenience
MWO	Station 5/6	1	2	3	Discomfort Form	Grip Strength (1shift in 3)	Convenience
MWO	Station 6 weld	1	2	3	Discomfort Form	Grip Strength (1shift in 3)	Convenience
Total		**5**	**11**	**16**			

The Bent Tool Machine groups were subjected to an added measurement, that of grip strength. This was performed using a digital grip measure meter

The reason for not using this grip measure meter on the production lines in the study, is that, owing to the culture in the workplace, it would not be allowed by the supervisors in production time.

For the Bent Tool Machine group the work was not fully line-paced, but semi paced as the employees had some control over the pace. Permission was therefore obtained from the supervisor to perform the tests within the shift as it wouldn't interfere too much in production. If the work had been fully line-paced it would have been necessary to stop the line to do the tests. The discomfort sheet was collected on the Monday and Friday, and whilst collecting the sheets the grip measurement was performed. The information was collected rather than left with the employee where possible, so that the last discomfort score did not influence the employee. Time was allowed for warming up the tendons, muscles, and to allow employees to get back to their usual fitness, on return to work after a shutdown. This is the same principle as athletes warming up after having a break from exercise. This was to prevent employees mistaking discomfort caused by muscles and tendons warming up to peak fitness for the pathological discomfort caused by repetitive work. The time allowed for warming up prevented interference in the research and allowed the new shift patterns to be in full-time operation. The job analysis sheets provided an analysis of the best rotational design.

The grip strength test for the BTM group can be assessed for any correlation with the results of the discomfort scale measurements. The design of the job analysis allows a greater significance in that at a set moment in time the jobs can be analyzed against symptoms/diagnosis. It will be useful for task rotation to use other grips (as in the Bent Tool Machine BTM matrix) or limb tasks. For anyone presenting with musculoskeletal problems the analysis results can immediately identify a job that does not put strain on the affected area and does not exacerbate the medical problem. It speeds up the process of assessment and allows for compensation where different model numbers of the product (i.e. different builds) may change the process.

For the grip test the employees stood with the arms adducted to the side, elbows at 90°, and forearms in neutral with regards to supination and pronation in order to produce reliable results (Talsania & Kosin 1996). The dominant and then the non-dominant hand were measured. It was originally proposed that rotation would take place at four weekly intervals using the risk factors shown in Table 3.9.

A matrix design (Table 3.8) was provided to allow for easy understanding of the proposed rotation. This specific matrix is set out showing times for the night shift. A-E are the letters for specific people.

Table 3.8 The Bent Tool Machine (BTM) matrix

Date	Time	Station1	Station 2	Station ¾	Station 5	St 6 Hinge Weld
12-Nov	1000 – 1145	A	B	C	D	E
12-Nov	1145 – 0130	C	A	E	B	D
12-Nov	0130 – 0200	Break	Break	Break	Break	Break
12-Nov	0200 – 0400	E	C	D	A	B
12-Nov	0400 – 0600	D	E	B	C	A
13-Nov	1000 – 1145	B	D	A	E	C
13-Nov	1145 – 0130	A	B	C	D	E
13-Nov	0130 – 0200	Break	Break	Break	Break	Break
13-Nov	0200 – 0400	C	A	E	B	D
13-Nov	0400 – 0600	E	C	D	A	B
14-Nov	1000 – 1145	D	E	B	C	A
14-Nov	1145 – 0130	B	D	A	E	C
14-Nov	0130 – 0200	Break	Break	Break	Break	Break
14-Nov	0200 – 0400	A	B	C	D	E
14-Nov	0400 – 0600	C	A	E	B	D
15-Nov	1000 – 1145	E	C	D	A	B
15-Nov	1145 – 0130	D	E	B	C	A
15-Nov	0130 – 0200	Break	Break	Break	Break	Break
15-Nov	0200 – 0400	B	D	A	E	C
15-Nov	0400 – 0600	A	B	C	D	E
16-Nov	1000 – 1145	C	A	E	B	D
16-Nov	1145 – 0130	E	C	D	A	B
16-Nov	0130 – 0200	Break	Break	Break	Break	Break
16-Nov	0200 – 0400	D	E	B	C	A
16-Nov	0400 – 0600	B	D	A	E	C

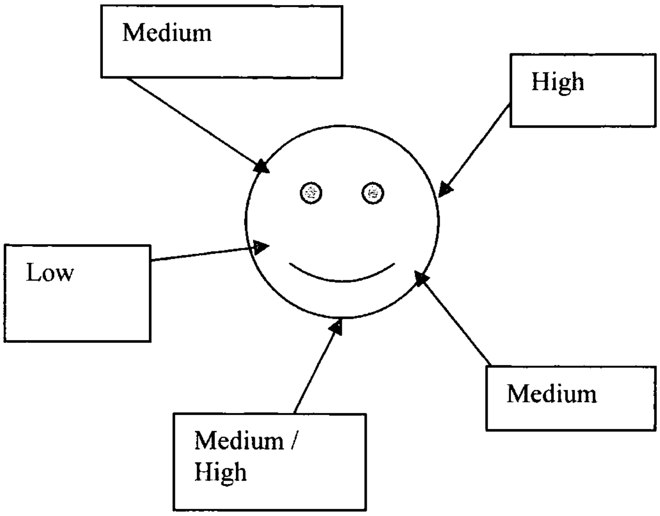
A 5 person rotation scheme (abcde) each letter representing an individual

The matrix Table 3.8 was built from the results of Table 3.9. Station 1 had a high back score for backs and a nil score for shoulders. This was classed as a medium/high result for although its final result of 13 fell in the medium range was allocated medium/high owing to the back score. Station 6 had a total score of 18, and Station 2 a low score of 8. The matrix was built on the risk level as shown in Table 3.10. The task levels were split up, and the person in the A-E matrix (Table 3.8) at whatever point allocated, would rotate reducing risk by entering different score levels.

Table 3.9 BTM Job Action Results (Risk Factors)

Station	Neck	Shoulders	Back	Upper Limbs	Lower Limbs	Totals of risk factors
Station 1	1	0	6	4	2	13
Station 2	0	0	4	2	2	8
Station ¾	1	1	4	3	2	11
Station 5	1	4	4	3	2	14
Station 6 weld	1	6	6	3	2	18

Table 3.10 Job Action Results BTM (Risk Levels)



Risk level	Score
Low	0-8
Medium	9-14
High	15-18

	Risk	Level
St 6 weld	High	Overall
St ¾	Medium	
St 1	High	Back count 6
St 2	Low	
St 5	Medium	

The Proposal for the CDT prep job was to rotate the four duties on an hourly basis (these are four separate duties within the job CDT prep (Table 3.11). Job rotation should be very easy to control as the duties are in very close vicinity to each other, therefore swapping on an hourly basis would not interfere with production. The employees need to work as a team to achieve this process. The current rotation is at least a massive improvement to spending a full day docking every day on CDT prep which did occur on those lines where no rotation of CDT prep took place. The rotation falls down where two hours are spent on wire harness and two hours docking. We have seen earlier in the case studies that docking causes elbow problems and the wire harness duties thumb problems. The proposed job rotation should be effective in reducing the effects of WRULD. At the time of the study rotation was taking place as current rotation (Table 3.11). It was suggested that the proposed rotation should take place but the researcher was not given permission to intervene in the rotation schedule. Since the study I observed one of the lines following the proposed rotation. At this time there is only one CDT line which in due course will change to building TFT monitors.

Proposed rotation

Table 3.11 Rotation current and proposed on CDT prep

Proposed Rotation		Current Rotation	
I hr on	**Peeling the wrapper and docking on to the conveyor**	**1 hr on**	**Peeling the wrapper and docking on to the conveyor**
I hr on	**Wire Harness**	**1hr on**	**Docking onto the line**
1 hr on	**Docking on to the line**	**2hrs on**	**Wire harness**
1 hr on	**Wire Harness**		

Since the research in Company X in PCM this rotation is taking place more but requires auditing.

Rotation in the packing area on PCM was becoming more apparent on each line although it is not consistently applied; some lines rotate hourly and some after every break. Therefore the time lapse between job rotations was unclear, and how often the rotation occurred. Now there is only one CDT line in production. It is not feasible to allow employees to job rotate when they feel like it as those on easy jobs are not necessarily going to volunteer to go on to harder jobs. One of the supervisors commented on another line that "they rotate when they feel tired" meaning when the employees are fatigued. This supervisor is a very good supervisor and a caring individual but he just had not grasped the concept of moving the person before fatigue takes place. The employees taking charge of when to rotate, rather than the jobs being determined by pre-scheduled rotation is an important concept. A research programme could be to repeat the research on two production lines building the same equipment and models. One line would repeat the research with the employees rotating as currently when the employees feel fatigued and the other line using a pre-determined schedule rotation. The employees on both lines would complete the discomfort forms as previously in this study of Company X, then the results of the discomfort would be used to measure the effectiveness of the pre-determined schedule rotation. Which was the most effective in reducing discomfort and WRULD can be evaluated. If the predetermined schedule was found to be the most effective then it could be introduced as part of a new proposed intervention. To further substantiate the findings a cross over design could be applied where the employees in group one start with the pre determined schedule and group two with the rotation as employees feel fatigued and then vice versa.

3.8 Data Analysis

An access database was established to record the results of the various jobs to be analyzed. An entry box was created for each body part potentially impacted upon by the process of the job. Information about the job location, the date of analysis, a job description and the person conducting the analysis were recorded for each job analysis carried out. The name of the person conducting the analysis was removed from the form for the research to maintain anonymity (appendix 10). A sub-total for each body area was included; all the effects to which the body area was subject. The effects on all the body areas were then summed to give a grand total which represented the potential stress factor of the job concerned. An input field for comments was included to note any relevant details that might need to be elaborated upon within the analysis (Appendix 1). The result of each analysis was stored automatically within the database. A system of interrogation is used and the results searched when a particular job analysis profile is required (Appendix 3). The target levels of scoring were entered within the query and any analysis with a result lower than that entered was returned for consideration. This would allow for anyone with an upper limb disorder, whether work related or not, to be able to be provided with a job within their physical capabilities. For example, if they had back pain a score of 20 would be inputted into the query and that would recognise that a job without any back movement that could exacerbate the condition was required (appendix 3) and then a suitable job would be provided as (appendix 2); 20 being the denominator for the programme to understand that the specific body part represented was to be taken out of the analysis.

3.9 Sample Size

For the main study in Company X between September and December 2000, 81 people were asked to participate, with one refusal, which left 80 persons in total willing to participate. The number of employees in the study from PCM was 47 and from MWO was17 (and the BTM MWO 16). The difference in numbers on the sites was owing to the fact that at MWO only three jobs were being observed on all the four lines in MWO whereas in PCM five jobs were being observed on the total of six lines (Table 3.5 and 3.6) with seven shifts over the 6 lines. This means that every job defined as a problem under the case studies Table 5.1 the employees discomfort was analyzed performing those specific jobs. The average age for MWO participants was 29 and a half years and the average age for the Bent Tool Machine BTM (part of the investigative study) at MWO was 32 years and 8 months. The MWO production line staff average age was 25 years and 5 months, ranging from 19 years and 4 months to 47 years. The PCM age range was 17 years and 4 months to 48 years and nine months, the average age being 28 ½ years. Therefore there was a similarity between the sites. The average age inclusive of both sites was 28 years and 9 months. In the PCM group of the 22 people on non-rotational duties and 25 people on rotational duties only a third provided full analysis: nine on non-rotational duties and seven on rotating duties. This low proportion was owing to multiple reasons as follows: 8 people were unreliable sources as they continually did not bring in paperwork; 2 people were unobtainable; 4 people in the study left; 1 moved job; also 3 employees (two employees after non-works accidents and one person for medical reasons) were taken off the study jobs, as it would have been unethical to keep them on the jobs for the study purpose; 13 did not provide enough data for multiple reasons, e.g. these forgot to bring in paperwork on occasions or left it on the line and it was taken away. In MWO 5 people on the paced production line did not provide enough data as 2 left, 1 moved job, and 1 was an unreliable source and 1 employee kept continually forgetting to bring in the paperwork.

The BTM group provided enough data on all accounts. 14 out of 16 employees provided enough data in MWO production. Out of the two who did not one person left the company and the other moved job permanently to one that was not associated with the case studies. This meant that in the short space of the study 7 people left the company.

3.10 Reliability and Repeatability

An access database was established to record the results of the various jobs to be analyzed. The digital handgrip used in this study is a quick and accurate way of measuring and assessing grip strength. It features an easy read-out digital display. It has a measuring capacity of 50 kgs at 1 kg steps. Each individual number is equivalent to a kilogram. For example, a grip of 30 is equivalent to the power of 30 kgs of grip strength. The study was measured with the participants arm by the side of the torso and with the elbow at an angle of 90 degrees. The hand is required to be held with the wrist in neutral as this increases the reliability of the results, because it allows the same position is used in each test. In this neutral position the hand has the greatest chance of applying the maximum force of grip, owing to the muscle force versus length ratio. The muscle is at its most efficient at middle length when the wrist is in neutral. If the hand was in palmar flexion, the length of the muscle is shorter and if in extension, the flexor muscle is lengthened. Although other research states that for a maximum score grip testing is best performed with the arm straight (Oxford 2000), but considering the present study was more concerned with consistency than maximum grip, either method was appropriate. Hobbies have a stronger correlation to maximum grip than occupational demands (Crosby 1994).

Intra and Inter observer reliability

To ensure inter-observer reliability, the analysis forms were all completed with the physiotherapist. Both observers (physiotherapist and researcher) conducted the job action analysis at the same time without consulting for the first 20 forms (which took over four weeks). Scores on all occasions were identical for each section and there was full agreement on the scoring system. Twenty forms without discrepancy were deemed enough for the researcher to continue the rest of the analysis on her own.

Intra-observer reliability was maintained as the criteria applied were the same for each separate event; the same person (the researcher) carried out each job on the same model and the scores tallied identically each time. The job analysis criterion is to provide more objectivity and increase the reliability of the findings.

Validity

All the results are valid, but certain extraneous variables did cause some concern. For instance, in PCM the models of computers built are so variable it was an impossible task to evaluate every model, on every job, without extra staff. The employees felt that generally the models were basically the same except when building the 19 inch model, which was slightly more awkward, but my concern was that it was heavier. Only two of the production lines built 19 inch monitors and it was for a very short span of time. The productivity levels stayed at a reasonably constant level which increases the validity of the assessment, as it shows consistency. There were not many different models in the Microwave Oven factory and the majority were analyzed and found to differ very little in the analysis: apart from showed some differences in an individuals' handling at different times, but not between individuals. One participant it was difficult to decide how much of his discomfort was due to work as he was heavily into DIY. His discomfort levels were not truly of a work nature, as the peak discomfort levels occurred whilst performing DIY. The sport activities were not analyzed in SPSS but checked on a weekly visual basis. Despite the concerns over the complexities and changes in the PCM models and the less relative similarity of the MWO models, it is a fair judgement to say that if the difference had been the other way round where the complexities had been in the MWO factory there may have been more concern that there was possibly effects of the complexities rather than non-rotation of duties creating discomfort. The variability of models in PCM actually helps to validate the study's findings with regard to rotation, for even in spite of this variability the workers at PCM had less discomfort problems, suggesting that rotation had an important effect in reducing them (Graph 4.2).

3.11 Limitations of the job rotation study

A particular methodological problem was the sample size was small in relation to the case studies as selection criteria. A larger study may have allowed for a greater difference in the levels of discomfort and in the BTM employees' grip scores. Ideally the grip score would have been measured on all of the participants in the study (not only the BTM employees) but this was not allowed as it would have interfered with production. The high turnover of staff and people being moved from the job to other areas in the middle of the data collection did not help. Not being allowed to arrange rotation and non-rotation areas as a comparison meant some lack of substantiation.

The limitations to the study are that if the uptake in the BTM study had been the choice of the researcher then two rotational teams would have been elected. The rotational duties shift did not fully follow the matrix design, as a result of management concerns about reduced output when the BTM was down and a requirement to increase productivity. There was limited control over the study as management was not always present owing to the pattern of shifts out of normal hours. At these times the matrix appeared to be less adhered to. There was also a limitation in the study in that the researcher was unable to affect the amount of rotation that took place (unless substantiated on medical grounds), and was not allowed to stop movement of people on the study into areas not connected with the study.

The CDT prep job PCM ideally would have been performed as the proposed rotation of hourly rather then 2 hourly (Table 3.11). The job analysis criterion aims to provide more objectivity and increase the credibility of the findings. Unfortunately permission was not provided to access the attitude survey that had been performed within the company. This would have been a rich source of information. The lack of female employees within the company did not allow for an analysis of discomfort with regard to male/female comparisons.

Summary of Chapter three

The Literature search for the job action analysis to base the assessment criteria on (for the study of Company X) was extensive to cover as many upper limb body strains and movements as possible; thus allowing it to be especially specific to the dynamic repetitive movements of the electronic manufacturing work type of work. Data was collected by obtaining completed discomfort forms from the employees in the study. This data would allow a measure of discomfort and where on the body it was occurring so that it could be analyzed against the employees' job to see if there was any link. Discomfort differences could be analyzed against employees that job rotate and those that don't job rotate. The BTM employees had an extra measurement of grip strength which could be analyzed and observed for correlation between grip strength and discomfort. All the instruments used were well recognised and validated in research. The result of the analysis is available in Chapter 5.

The next Chapter summarises the ethnographic findings from the health and safety meeting outcomes and the implicit reasoning from the interview of the Korean chairman. It also concludes the observations of the press shop and injection mould shop and the report provided for the warehouse and press shop. Also discussed are the concerns of accurate reporting of WRULDs and the importance of these. Prevention strategies from observation of practice on the shop floor are elicited. Considering this is ethnographic work the principles of being an occupational health nurse are to observe practices by health surveillance to be able to understand why people perform duties in specific ways and observe the work environment (Sluiter et al 2001).

Interestingly sixty people in the study claimed they had some discomfort and this was of some concern. Although many people were feeling discomfort, much of it was of a fleeting nature. The ethnographic work provides a means to be able to identify if long term changes can be introduced, investigate the obstacles of introducing long term changes in Company X, as well as trying to identify cultural aspects that have impact on health and safety.

Chapter 4: Summary of Ethnographic Findings

Introduction to Chapter 4

This chapter is a summary of the ethnography detailing the outcome of the reports of the ethnographic observation. Time sampling techniques had been performed in the four main areas that had the highest accident rate at that time: these were the press area, the warehouse, the injection mould and line B. MWO. Two improvement reports were provided to the injection mould shop and the warehouse, based on the analysis of the time sampling. The reports for the warehouse and injection mould were written up as soon as possible on returning to the occupational health department so as not to miss any important issues (Edwards & Talbot 1994). The supervisors were well aware from the reports that observation had taken place on the department. When entering these areas for safety and reasons of politeness the supervisor is always informed that entry to the area is required. However the purpose of the visit is not usually asked about as visits to the site are regular and can sometimes be to see an employee on a personal level and therefore purpose of the visit is not enquired about. The outcome of the reports is designed to be able to be beneficial for the employee and supervisor of the area and therefore access to the area is easy. They are not performed as finger pointing exercises but as useful tools for improving practices. This chapter is a description of what has been found without any interpretation. Further statistical findings are incorporated into Chapter 5 on the benefits of implementing job rotation

4.0 Meeting Outcomes

The meeting outcomes of the health and safety meetings at PCM and MWO are as follows:

There were three items on PCM that took a long time to resolve, one owing to an accident investigation and the other two concerned a proactive measure. The item owing to the accident investigation took one year and three months to resolve and was related to individuals' control of behaviour and bad practice, which if observed earlier, should have been curtailed prior to any accident. In fact, whilst the practice continued, there was risk of further injury, and it should have been dealt with by the disciplinary route, as education was inadequate without other interventions. Another item took two years to resolve as it involved having to research for specific information and building a prototype. A temporary solution was put on place until the build of the prototype. The third item which took one year and three months to resolve, was a maintenance issue and not specifically a health and safety issue, although the changes introduced may have made peoples' jobs slightly easier. Some items were on the agenda for six months at MWO. One of the items needed completing at policy level. Another was a delivery and financial quote problem. Another was a development of a prototype problem and took eight months to resolve, but as it had some general implications for safety a temporary solution had been put in place immediately. Another item was on the agenda for a year on both sites and was owing to an accident follow-up at one of the sites; it concerned both sites as there was the possibility of a reoccurrence of the same accident occurring in the other site. A system was put in place immediately to prevent a further occurrence but a second system was also developed as a foolproof measure, and that took some time as it had to be prototyped till the perfect solution was obtained.

The reasoning behind mentioning the length of time for issues to be addressed was to show that there is similarity between sites and that health and safety issues were dealt with. A system was put in place to reduce the overall length of time that the issues were on the agenda. Since the beginning of this year a coded system has been put in place as a preventative strategy for any problems being left on the agenda for too long. If an issue is on the agenda for two meetings running it is printed in green with the responsible person's name against it. If the issue continues unresolved till the third meeting then it is printed in amber, and at the fourth meeting it is printed in red and is taken to a very senior management level to find out why it has not been resolved and what can be done. The important issue is that the health and safety meetings are important from the point that it is paramount in connecting the two sites as they both work independently. If the health and safety issues were kept separate on each site then these accidents would have been likely to occur on the other site.

4.1 The Reports

The Warehouse

The warehouse was extremely busy owing to the late timing of containers. It was obvious that this was creating too much pressure for the supervisor and employees; and with the rush the risk of injury increased. There was also an unsafe practice at that time of lifting the dock leveller manually as the electronic device was down. It was necessary to intervene to prevent any injury, fortunately at that point the time sampling had just been completed. A report was filed to the supervisor on the findings. The situation was discussed and the supervisor was taking two actions. One was to prevent further occurrences of using the dock leveller when it was broken by introducing a documenting system for the reporting of faulty equipment to prevent any loopholes. If levellers are not repaired quickly and other levellers go out of operation then people would revert to lifting them manually as they would feel that there was no alternative if a container arrived. The other action was to apply a penalty for any late arrival of containers as a proactive measure to ensure the containers were delivered on time. The outcomes of these findings are not included in the job–rotation section as they are of a specific nature not related to job rotation but an incident that was a health and safety issue that required prompt action and that was dealt with immediately. The second issue was taking steps to prevent stress and accidents that could have occurred by the employees having to rush if containers were delayed because it would slow production. Therefore a penalty system was put in place to ensure the arrival of the containers on time and therefore allow adequate time for the employees to do the job safely and efficiently.

Press Shop

In the press shop, no incidents were observed at the time of the time sampling therefore there was nothing to report, so no reports were filed.

Injection Mould

The report for the injection mould shop defined that certain tools being used were not of the correct width as the knives being used were less than 8mm width and therefore new knives were ordered above 8mm but less than 16mm as the recommendation. Longer pliers were recommended and changed in accordance to the recommendation of a 100mm (Dul & Weerdmeester 2001). Advice was given to refrain from packing from the floor level but raise items to a suitable waist level. Advice was also given on stacking lighter boxes on the low level and the heavier boxes at chest height. Job rotation was encouraged particularly in between two specific jobs as both used different types of grips and one required too much static loading and the other too much blunt trauma. It is known that all the tools were replaced but how much of the other improvements took place is unsure as injection moulding was outsourced shortly afterwards. At the time of the report the supervisor was new to the post and inexperienced in ergonomics and health and safety regulations. The supervisor was very responsive and keen to act appropriately and was very supportive.

Discomfort

Out of the 80 people in the study 60 claimed they had discomfort, 5 had no discomfort at all and 15 did not provide data to answer the question. The amount of people claiming discomfort was significantly high which backed up my suspicions from the ethnographic study. One person did have less discomfort on the day he was not on his normal job (identified in the case studies as a problem of non-rotation). Therefore the occasional rotation was not effective rotation. One person did increase his rotation towards the end of the study (instigated by the medical department) and the discomfort slightly improved but not enough to affect the overall scores whilst the study was in progress.

Outside Activities

Information on activities outside of work was recorded. Sport activities did not appear to have any influence on the results. In fact the researcher had some concern over the general lack of exercise levels of the participants. Some investigation and health education may be warranted in this area.

The perspective of Company X

Productivity is the core objective of any commercial enterprise: the number of products available for the consumers is the first priority. The constant threat of internal competition from within the company itself from other sites under the same company name, as well as from other companies in the same type of business diverts attention from the welfare of individual employees. Company X is no different from other companies with the increase concerns of competition. The increased turnover rate of employment also takes its toll.

Interview

From the interview with the health and safety chairman it appeared he had taken the role not from choice, and was not fully committed.

4.2 Prevention strategies: observing practice on the shop floor

Accidents may be prevented within the company by following up previous accidents and applying a strategy that prevents further similar accidents, or by observations on the factory floor and reporting of near misses. In Company X this is the current practice. Education on the reporting of accidents and near misses is emphasised in the induction programme prior to commencing work in the company. Reporting of near misses is dealt with by the supervisor, who supplies the recommendations for prevention which are then approved by the manager. The near miss report is all held on a database; a query in the database allows for following-up near misses to make sure that they have been dealt with by the appropriate persons and are followed up in the same way as the accident reports. It is important to be proactive and prevent injuries and follow up any that do occur in order to reduce the incidence of WRULD.

The second incident recorded in Table 4.1 involving the deflection of a yoke wire which required a repetitive forceful pincer grip owing to faulty parts. The deflection yoke wire connector was too small, and it required resolution to prevent the development of upper limb disorders. The deflection yoke wire connectors that were too small were mixed with the deflection yoke wires that were the correct size. This was to reduce risk by having some connectors easy to apply and some requiring forceful grip rather than all requiring forceful grip. The ideal would have been to return all the deflection yoke wires to the supplier but they had been in stock too long. In an effort to be proactive the deflection yoke wire connectors were mixed (the normal and the ones that were two small) in order that the ratio reduction would prevent problems by decreasing the risk. Through prevention WRULDS can be averted, this particular incidence could have led to many upper limb problems related to forced pincer grip, especially de Quervains tenosynovitis and tendonitis if left with the employees only applying the faulty connectors. The pincer grip is five times more stressful than the power grip and the application of force increases the problem (HSE 1994).

The first incidence in table 4.1 was the result of an accident that led to a preventative strategy being put in place that would prevent further incidences of the same type of accident reoccurring and that is why it is important that any accidents / incidents are followed up as this accident could have had the potential to be serious. The trailer came of the dock leveller too early the risk was that the fork lift truck could have ended completely going off the dock leveller and into the space in between which could cause serious injury and possibly a fatality as well as damage cost implications. The outcome of this accident to prevent further incidences was that a key-collection system from the trailer deliverer was put in place to prevent removal of the trailer. An emergency air line locking device was made. This prevents the airline being attached, which prevents the trailer being moved until the fork lift truck driver has completed the job and come off the dock.

The third incident was an incident reported by myself to the team leader about a damaged footstool whilst out on site on a general observation of the activities on site as a proactive measure. The team leader immediately disposed of the damaged kickstool that had been damaged by the fork lift truck and re-ordered explaining the reasoning behind having to re-order.

The fourth incident was a near miss and this was reported under the near miss accident reporting system. The power press tool had fallen from the crane and if someone had been hit the chances are this could have led to a fatality. An investigation was put straight into place and demonstrates the importance of reporting near misses.

The fifth incident in Table 4.1 demonstrates the importance of the involvement of the engineers as they made an in-house tool that was not commercially available off the shelf, and this long-handled tool prevented injury / WRULD. This problem was that the hand could constantly be getting knocked and was in an awkward position when trying to work on the door latches of a specific model of microwave oven. This in house tool was effective in prevention of this problem.

The sixth incident is that when the new models are observed for any problems that could relate to WRULD the job action risk analysis is monitored and any changes made can have an impact on keeping company insurance payments level or lower as can prove that the necessary analysis are taking place and that risk is being minimised. Various problems owing to individual techniques were monitored and improved.

The seventh incident relates to the follow up of any works discomfort and a discomfort form is completed by the employee and nurse and a prevention strategy put in place to prevent any exacerbation of symptoms and prevention of further cases. The person may be put temporarily on restriction from the specific job and slowly brought back into the job once the problem on the job has been rectified should there be found to be a problem. A workplace assessment is followed up by the physiotherapist or nurse or in most occasions both together to see if there is any element of work – relatedness to the condition. If there are any problems then the risks are notified to management and supervisors either with a solution or the supervisors and management to look at a solution. The second part of the form with the resolution of how to address the problem should be returned to the Occupational Health Department but on most occasions this does not happen at Company X. In most incidences the problems are resolved but the notification does not follow with it which often means the department is having to chase up to see if the issues have been dealt with. A work discomfort system was created to allow for the tracking and identifying of problem areas, and to enable quick resolution of problems. Information is attached to this system for management to resolve the issues.

In incident 8 this is with regard to personal protective equipment (PPE) post a minor accident. Company X appears to have the use of personal protective equipment in very good order with the risk assessments for PPE.

In the study we have seen the development of conditions owing to specific jobs where rotation was not taking place, and preventative actions have been identified (Table 4.1). After incident 1 in Table 4.1 the actions of prevention taken as a result of a minor accident have prevented any more serious injuries. The same applies to incident four, where no accident actually occurred but the report of a near miss prevented what could have been a serious injury. This is still quite a proactive approach in although that some accidents/ incidents did occur within Table 4.1 the strategies put in place prevented further accidents/ incidents and the near miss reporting system prevented serious accidents.

Table 4.1 Examples of prevention of accidents and work-related upper limb disorder in Company X.

Incident	Accident or WRULD	Prevention Strategy
1.Trailer coming off the dock too early - concern that the fork lift truck may enter and go off the dock when the trailer is being moved	Actions from an accident	1) Instigated a key-collection system from trailer deliverer to prevent removal of trailer 2) Made an emergency air line locking device. This prevents the airline being attached, which prevents the trailer being moved until the fork lift truck driver has completed the job and come off the dock.
2. Deflection yoke wire connector too small	Work-Related Upper Limb Disorder prevention	The deflection yoke wire connectors that were too small were mixed with the deflection yoke wires that were the correct size. This was to reduce risk by having some connectors easy to apply and some requiring forceful grip rather than all requiring forceful grip. The ideal would have been to return all the deflection yoke wires to the supplier but they had been in stock too long.
3. Kick stool damaged by forklift truck - noted that it was not stable	Reduction of risk of accident	Defective item disposed of and employees educated in the importance of moving items out of the fork lift truck's way and disposing of and recording of any faulty items
4. Dropping of power press tool from crane	Accident	Near miss reported and Investigated and a prevention strategy put in place; in this case no one was injured and no damage occurred but it could have led to severe injury/ costs
5. Various problems - individual techniques monitored and improved. Long handles made by engineering to apply to tools to prevent knuckle injuries.	WRULD prevention	Work Discomfort System – allows for tracking and identifying problem areas to enable quick resolution to a problem. Information is attached for management to resolve the issues.
6. Introduction of new models / Insurers	WRULD	Job Analysis
7. Prevention strategy for control of exacerbation of symptoms	Accident or WRULD	Restriction system of duties
8. Personal Protection Equipment Schedules	Accident / General Health WRULD consideration	Risk assessments

The accident reporting system in the company of this study is well controlled and is monitored on a monthly basis. The supervisors of the employees are responsible for accident investigation and preventative action: this is audited by the Health and Safety section of the Company.

4.3. Accurate reporting of WRULDs

The new reports from the European Union and the changes in the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) have had some impact on this research. The new ideas in RIDDOR for reporting of work-related upper limb disorder are not yet generally known, but in the past there have been some concerns about under-reporting. RIDDOR is now matching in with the research, whereas before certain causative factors in WRULD that was accepted in research as work-related were not actually reportable under RIDDOR. For example carpal tunnel syndrome was only reportable if using vibrating tools or bashing with the palm of the hand in duties at work. Carpal tunnel syndrome was not reportable under RIDDOR for work carried out with the wrists out of neutral this is where the wrists are not parallel with the forearm but are in dorsi/ volar flexion (extended backwards) or in palmar flexion (bent in towards the palm) in static or dynamic positions, even though this was identified as work-related in the research as caused compression around the carpal tunnel. Since the new Health and Safety Executive Health and Safety Guidance revision 60 (HSE, 2002) is putting more emphasis on risk assessments, the research in Company X has explored the preventative aspect of WRULD in relation to the jobs, and has incorporated an analysis of the benefits of job rotation. The HSG Rev 60 is concerned not only with the physical work, i.e. repetition, force, posture and duration of exposure, but also with the working environment, psychosocial factors and the analysis of individual differences (anthropometric/medical) and this reflects recent research findings from many studies that is now included in the revision. Companies are going to have to follow this guide and perform job action analysis/ risk assessments in order to stay within the law.

Certain conditions previously were also not reportable under RIDDOR until April 1996, such as stenosing tenosynovitis (trigger finger), which is a classic WRULD. However, there have been claims made against this medical condition prior to its recognition under the RIDDOR reporting scheme (Lee v Vauxhall motors) in September 1994 and (Ball v the Post Office in June 1994).

www.humantechnology.co.uk/wruld/sumjudg.htm
Stenosing tenosynovitis is a painful condition, but also can be disabling if not treated or diagnosed correctly.

How changes in reporting of work-related upper limb disorder to RIDDOR will occur is still uncertain and is at present under scrutiny. To implement this within Company X is to keep the company informed of any changes to RIDDOR to allow them informed choice to decide how management will manage it. Presentations are currently taking place on WRULD identifying the problem areas and possible solutions within Company X. These presentations are informing management of the possible changes and how the individual and company may be affected. Out of 3 incidents in the month of July 2003 of possible WRULDs (which is higher than normal) only one case was possibly reportable but in the future there is the possibility that all three will be reported. If this is the case the HSE will be very vigilant and be investigating the increase. This increase also has a detrimental effect on the amount of claims from the company's point of view as this could increase the insurance premiums.
The Management of Health and Safety at Work Regulations, the Manual Handling Operations Regulations 1992, and the Display Screen Equipment Regulations 1992 require employers to assess the risk of work-related upper limb disorder.

4.4 Job analysis

Other work carried out on work-related upper limb disorder has usually been performed by ergonomists and other allied medical professionals. The Occupational Health Advisor/Nurse is a prime person in Occupational Health owing usually, to a full-time post, which makes it possible to carry out much of the work and to be proactive rather than reactive. As previously discussed, there has been under-reporting to RIDDOR. Some companies may have a part-time doctor, so by the time referral to the company doctor takes place, the employees' symptoms have subsided. For example, a condition such as de Quervains, if promptly treated, can settle relatively quickly and therefore by the time the patient is seen by the doctor the signs and symptoms have completely settled and therefore there is no medical condition to report to RIDDOR.

The development of an access database to monitor areas is a unique idea. The job action analysis is based on research criteria from many authors' research (Table 3.3). Its difference to a risk assessment is that it allows for a full job analysis, which can provide a report of improvement at the time, of a job change. Only descriptive information and an analysis of the job's history was available, but the job action analysis will provide greater information on WRULD as comparisons over time become available and previous ergonomic assessments can be checked against the new ones (for the same job). It facilitates backtracking at any point to see the problems/improvements in any specific area, and making an immediate evaluation of jobs where medical restriction for an individual may be required. It also allows for the best possible design in rotation. It is not adequate to rotate jobs where the same significant stresses may occur; this system can ensure a variety of different limb uses, types of grip and posture applications. Not only is the study looking at the anatomy and physiology, the analysis of the jobs, etc. as a whole picture, but it will serve to increase the knowledge base. According to the statistical findings from SPSS, there is more discomfort on the production lines than previously thought, although much of it is diffuse. The solution to this fatigue leading to diffuse discomfort is to implement effective job rotation on all of the production lines.

The employees with work-related upper limb disorder, the case studies (table 5.1) the time varied for the reporting of their symptoms from between 1–12 weeks (table 3.1). One employee waited a year before reporting his medical condition. The minimum recovery time once symptoms were reported was 4 weeks and the majority recovered by 16 weeks; although 2 took 18 months to fully recuperate and these employees had both worked on the transformer job. One employee who worked on the earthwire job took 6 months to recover and another employee on the capacitor job took 5 months to recover (table 5.1). None of these employees was job rotating.

A summary of the job rotation experiment showed that lower levels of discomfort were felt generally amongst the employees that job rotated. The number of body parts of discomfort was also less in employees on rotational duties on the CDT prep job (table 5.4).

Summary of Chapter four

Examples of prevention of accidents and WRULD in Company X have been demonstrated and the importance of prevention highlighted (table 4.1). The reports for the warehouse and injection mould shop were taken seriously and the recommendations taken on board. The work discomfort system that was created to allow for the tracking and identifying of problem areas, and to enable quick resolution of problems was designed by Occupational Health and the Health and Safety Manager. Information is attached to this system for management to resolve the issues. Other issues that were implemented were the issues of using different colour prints to highlight unresolved health and safety meeting issues moving from green meaning a responsible person has been appointed to deal with the issue and it has been on the agenda twice. At the fourth meeting if the problem is not resolved the item is highlighted in red and is taken to a very senior management level to find out why it has not been resolved and what can be done to resolve it. These former issues being taken seriously and acted upon are encouraging and promising when considering possible changes with regards to job rotation as it means there is a chance that the company may seriously look to implementing job rotation.

The new ideas in RIDDOR for the reporting of WRULD are not yet generally known, but may have implications in the future for those that do not risk assess or perform effective job rotation. The job action analysis is based on research criteria from many authors' research (Table 3.3). It's different to a risk assessment in that it allows for a full job analysis, which can provide a report of improvement at the time of a job change. Lower levels of discomfort in the employees in this study of Company X on job rotation was found to be the case. This lower level of discomfort and the researched job rotation analysis are solid proof for the company that they should take the issue of WRULD seriously. If the company acts upon the information from the job action analysis they will be covered under any new information from RIDDOR as they are ahead in progress and can be seen as pioneers in the prevention of WRULD. Therefore the next Chapter looks at the benefits of implementing job rotation.

Chapter 5: The benefits of implementing job rotation

Introduction to Chapter 5

It appears from the literature search, and the ethnographic work and the findings of the research so far on Company X, that there could be benefits from implementing job rotation. If the company acts upon the information from the job action analysis they will be covered under any new information from RIDDOR. There may be implications in the future for those that do not risk assess or perform effective job rotation. In Chapter two it was found that there could be many savings made, financially, from the implementation of job rotation. From an alturistic point of view, it was found to be more beneficial for the employees, hence the first section heading in this chapter Finance and Altruism.

The cases of WRULD reported between October 1996 to Sept 2000 were analyzed in table 5.1. Table 5.6 shows the numbers of people reporting symptoms of discomfort and the time variation of duration of symptoms in the 55 cases between Mar 1997- Sept 1999 concentrating on the issues of under-reporting. The other concern of these 55 employees is that although they could not be provided a diagnosis per se, they do have discomfort of a non-specific diffuse type nature as previously mentioned (Sluiter et al 2001), and could be also latent developers of specific WRULDs. These would be defined under case one as a temporal criteria and therefore their jobs need surveillance to see if there are any links with the development of the discomfort (Sluiter et al 2001). The psychology and advantages of job rotation were explored and the labour turnover and company accidents were analyzed for any insight with regards to job rotation and if there could be any benefits from this. The physiology of WRULD was discussed and the effects of abnormal physiology and how this may impinge further on the development of WRULD.

Job rotation, non-rotation and occasional rotation on PCM and MWO site was documented to see what the current situation was. The grip measurements from the main study are correlated and discomfort and statistical analysis provided which shows benefits from implementing job rotation. The findings in this chapter were that the employees in the study prefer to job rotate. An exhaustive description of medical diagnosis in relation to duties in the study of Company X matched with the physiology and illustrative evidence is provided. The physiology of some of the conditions of WRULD, and the findings of the present research WRULD/ discomfort is found to be preventable where job rotation takes place.

5.0 Finance and altruism

Pressure from financial cutbacks, reduced training and the reduction of employee staff, do nothing to help implement the principle of job rotation. The difficulty of training people on the production lines owing to the high staff turnover rate and sickness absence increases the problem further. External pressure from outside agencies and headquarters also has an impact. Prevailing attitudes and impinging circumstances do not make the task easy. Reducing sickness absence, accidents, and the turnover rate and ensuring the employment of capable persons are important in the business world for financial reasons and for increased productivity and competitiveness. This is the reason why this research is important to businesses. The factories should benefit from job rotation, as it should reduce absenteeism and turnover. Less time will be spent off the production line for medical treatment, therefore increasing productivity. The cost of possible claims from Upper Limb Disorder should also be reduced. Table 5.1 defines the need for a job rotation system as these jobs were found to be work-related upper limb disorders with pure diagnosis not just of a fleeting fatigued nature. Even so the results from the discomfort forms alone shows that the fleeting and diffuse symptoms the employees are feeling are still a concern even if they do not lead to WRULD as stated earlier the need under health and safety is to consider the employees well being.

Unnecessary costs are also incurred; sickness absence (CBI 1999) is rated at £542.00 per person average cost per year. This would produce a cost of nearly 13 billion to the UK business if applied to the whole UK workforce. According to the latest figures the average time lost through sickness absence is 3.2% in the UK between 1984-and 1999 (HSE Labour Market Trends August 1999). In Company X the short term casual sickness in November 2000 accounted for a 2.16% loss of time and long term sickness absence 1.6 % loss, giving a total of 3.32%. Since the national average of 3.2% is for long term sickness only, the company's sickness rate is only half of this figure, yet these are still unnecessary costs.

The data was collected for table 5.1 based on retrospective examination of accident and injury records carried out in the preliminary investigation and analysis of the medical records. These specific jobs as identified were selected for the study and all the production lines where these jobs occurred as in table 5.1. The case studies shown in Table 5.1 formed the basis for the choice of duties to study on the production lines for they clearly identified which duties were more likely to cause medical conditions.

Analysis of the jobs remains difficult as the models change so regularly, and as new technology arrives, processes change. Originally the earth wire job (ID5 duties), Table 5.1) required many more wire attachments and required a stronger pincer grip than it does today. Therefore Printed Board Assembly (PBA) / video board fit was used as a substitute for the pilot study. This job required increased pincer grip in force and repetition and had a higher upper limb score than the current earth wire job does today. Although the Printed Board Assembly (PBA) did not require quite as much pincer grip as the original earth wire duty it was the nearest to it in similarity and therefore was the optimum choice.

The information in the following case studies (table 5.1) was of people known to me personally. Some of these employees had medical conditions, prior to my position in the company and information was retrieved from notes to ascertain any WRULD involvement. Other employees medical conditions were diagnosed post my involvement and these conditions tracked. The progress was assessed by documentation of range of movement, inspection, palpation, and specific tests e.g. grip strength, tinel's test for median nerve compression in the carpal tunnel and phalen's test which applies compression to the median nerve in the carpal tunnel by maintaining maximum wrist flexion and if positive produces symptoms of pins and needles etc depending on what signs and symptoms the employee was presenting with, all to provide any measurement of improvement.

The employees' symptoms were documented on how much discomfort they were feeling if there was less or more discomfort; if they felt improvement and if there were any exacerbating or relieving factors and if discomfort occurred at any specific times. Some tests are rather objective and some subjective. Range of movement and grip strength and personal feeling of discomfort can be described as subjective whereas inspection, palpation and specific tests e.g. tinel's test for median nerve compression in the carpal tunnel, may be seen as more objective (Kesson & Atkins 1998). However even objective tests are not fool proof as sensitivity for tinel's range from 25-75% and estimates of specificity fall between 70%-90% (Sluiter et al 2001). However, the information on how progress by the employees was assessed is not available as an individual per se.

5.1 The Case Studies of Company X

Table 5.1 Work-related upper limb medical diagnoses in relation to duties in the study of Company X. (The cases below were observed during Oct 1996-Sept 2000.

Case ID	Job / Duties	Diagnosis / and citations – based on work relatedness	Causes	Treatment time	Sick Time	Management	Resolved or significantly improved (post referral)
1	Packing with the Lifter	Golfers elbow (early) Medial epicondylitis / (HSE Work-Related Upper Limb Disorders – Assessing the Risks 1994; Tichauer 1996)	Turning forearm into pronation whilst gripping lifter handle	2 hrs	Nil	Rotation	4 weeks
2	Packing with the Lifter	Tendonitis (Niosh 1997 / repetition and weight)	Exacerbation post non – work related accident (See 1 above)	5hrs	2 weeks	Restriction / Rotation	8 weeks
3	Transformer	Soft tissue injury-callus and triggering of fingers (Bergamasco et al 1998; Chao et al 1976)	Repetitive sustained forceful gripping/ claw grip	3hrs	Nil	Rotation	10 weeks
4	Flat pack boxing	De Quervains / (Graves 1990)	Turning and flicking box over out of neutral / ulnar deviation	1 ½ hrs	Unknown	Restriction	Unknown
5	Earth wires	Thumb discomfort with hypermobility (Quanbeck 2000)	Repetitive sometimes sustained forceful pincer grip	3 hrs	None	Moved from job Restriction from repetitive gripping especially pincer	6 months
6	Transformer	Soft tissue injury - callus (Bergamasco et al 1998; Chao et al 1976)	See 3 above	2 hrs	None	Job with less gripping use of fatter handles and job rotation	4 weeks
7	Transformer	Elbow / hand discomfort (Columbini 1998; Keyserling et al 1983)	See 3 above	5 hrs	1 week	Rotational duties / torque advice to management	4 months
8	Capacitor	Friction neuropathy - nerve irritation in elbow	Wide palmar grip (light part) – and repetitive forceful gripping of down-driver	7 ½ hrs	None	Rotational duties	5 months
9	Magnetron	Trigger finger (HSE work-related upper limb disorders a guide to prevention)	Repetitive forceful gripping of driver (usually pistol driver)	7 ½ hrs	None	Restriction from repetitive, forceful and sustained gripping	4 months
10	CDT prep	Elbow discomfort (Niosh 1997 / repetition and weight)	Heavy repetitive lifting	4 hrs	6 weeks	Restriction from repetitive heavy lifting	12 weeks
11	Transformer	Discomfort in arms – left numbness and tingling sensation (early carpal tunnel syndrome)–Right hand callus and mild triggering	Lt hand out of neutral in claw grip – creating compression on carpal tunnel. Rt hand repetitive forceful gripping – leading to callus build up by gripping and friction triggered by sustained repetitive forceful gripping.	2 hrs	None	Rotating two jobs, one without driver	4 weeks

Case ID	Job / Duties	Diagnosis	Involves	Treatment time	Sick Time	Management	Resolved or significantly improved (post referral)
12	Transformer	Trigger finger (Bergamasco et al 1998)	Mass increase in production job involved capacitor and magnetron which at one time was one job – causative factor-repetitive forceful sustained gripping	Approximately 13hrs	Unknown (information not provided)	Restricted from sustained repetitive forceful gripping	18months
13	Transformer	Callus formation top of metacarpal heads / (Bergamasco et al 1998; Chao et al 1976)	Owing to repetitive forceful sustained gripping and friction of down driver	1 ½ hrs	None	Job rotation	6 weeks
14	Transformer	Trigger finger (Bergamasco et al 1998)	Same as 12 above	Approximately 9 hrs	Unknown	Same as 12	18months
15	CDT prep	Bilateral epicondylitis (Niosh 1997 / repetition and weight)	Owing to heavy repetitive lifting	2 hrs	10 weeks	Re-deployed	11 weeks
Totals	**7 specific jobs**			**66 hrs**			

Seven other cases of limb discomfort were reported, with jobs entailing repetitive, forceful, sustained gripping of drivers. A further case showed de Quervains tenosynovitis owing to forced pincer movements (on a job not in the study). This condition developed when the employee returned to work, after the shutdown, to a new job, the medical condition developing within two weeks. The employee was redeployed and his symptoms took four weeks to resolve, with seven lost production hours.

Sickness absence occurred, within the case studies, causing lost production hours (as in above Table 5.1). Some employees were forced to go on sick leave because they were only allowed to use one hand, (e.g. ID 4) having been diagnosed with de Quervains tenosynovitis. About 1,000 new reported cases of de Quervains are assessed each year and 25 percent of these cases receive benefit (Harrington et al 1996). ID 1 developed medial epicondylitis through operating the lifter; ID 2 developed tendonitis performing the same job. ID 3 developed callus and trigger finger through gripping the transformer; ID 6 also developed a callus from this operation. ID 7 had elbow and hand discomfort as a result of heavy repetitive sustained gripping of the transformer, and ID 8 suffered friction neuropathy at the elbow through claw-gripping the capacitor and repetitive, forceful gripping of the down-driver (Table 5.1). Friction neuropathy is defined as a WRULD (appendix 7). Descartha et al (2004) suggest that the incidence of ulnar nerve entrapment at the elbow is associated with biomechanical risk such as holding a tool in position repetitively. Medial epicondylitis and other nerve entrapments, cervicobrachial neuralgia, carpal and radial tunnel syndromes are at risk of ulnar nerve entrapment and there was also an association with obesity (Descartha et al 2004). Ulnar neuropathy can be confirmed if the patient demonstrates a positive combined pressure and flexion test within one minute (Sluiter et al 2001). The patients elbow is in maximum flexion and the ulnar nerve is compressed and if the test is positive paraesthesiae occurs in the ulnar distribution distal to the elbow (Sluiter et al 2001).

There is a 16% incidence in the population of subluxation of the ulnar nerve anterior to the medial epicondyle as the elbow moves from extension to flexion and these people are more likely to develop WRULD ulnar neuropathy in jobs where holding tools in position is a risk in itself (Jobe et al 1997; Descartha et al 2004). When these employees were put onto rotating duties, the medical problem was straight away found to improve, in that the stress was taken off the affected area for a period of time allowing some respite. Clinical assessment showed improvement after rotation of duties; for example, patients showed increased range of movement, decreased swelling, reduction of heat and pain, and resolved crepitation. Employees who had originally been rotating and were then taken off rotational duties by their supervisors found that, having been returned to rotation by the Occupational Health Department, their problems were resolved. The reasoning behind starting the study a few weeks after the return from the shutdown was to allow time for a warming up period for the tendons, muscles, etc to get back to their usual fitness peak.

The ID numbers follow on each injury and duty and this is analyzed from table 5.1 stating what injury occurs owing to which specific job and on what specific part of the upper limbs.

ID1, an employee diagnosed with early medial epicondylitis (golfers elbow), had developed his injury by continually turning the arm, pulling across the body and turning the hand into pronation whilst operating the lifter. The symptoms were known to the employee two months before referral, despite education in induction to report symptoms immediately. The medical condition resolved in one month after intervention, owing to the return to rotational duties. Increased productivity is identified as a causal factor in work-related upper limb disorder and the employees symptoms of medial epicondylitis had come on at a time of increased productivity.

ID3, had a soft tissue injury and callus formation on the hands as a result of repeated heavy gripping whilst using a gun on the transformer job. The soft tissue injury improved once the employee was placed on rotational duties and the relief from repetitive gripping allowed the soft tissue underneath the callus to heal.

ID4, developed de Quervains tenovaginitis and suffered temporary job loss and pursued a job elsewhere. Time for recovery is unknown and it is quite possible that treatment was provided outside the company.

ID5, an employee who suffered thumb discomfort, had been a floater (an employee rotating through many jobs) without any problems and was then placed solely onto earth wire connection duty. The job involved a repetitive pincer grip movement, which caused mild hypermobility of the thumbs when in extension. This could have been prevented if he had remained on rotating duties, as previously he had not had any discomfort problems. He was temporarily moved to another job (without referral to the Occupational Health Department) where it appeared to settle but once he returned to a job with the same movements the medical problem soon returned. The medical problem took six months to resolve.

The transformer job can create problems with trigger fingers owing to the sustained grip and weight, and the forceful sustained flexion. Tenosynovitis can occur as the flexor tendons grip tight and wrist extensors maintain a sustained force to keep wrist in neutral static. The transformer is lifted in a claw grip with the hand pronated (palm facing down). Then the transformer, weighing approximately 4.7 kgs, is lifted and the forearm rotated so that the hand is then supinated (palm facing upwards). The hand goes into dorsi flexion/ palmar extension (backover) to support the weight and this position has to be maintained to counteract the down-force created by the down-driver being used in the opposite hand, which further increases the force application in the hand holding the transformer. Some employees may have the strength to control it in neutral but will be taking a large amount of strain; others in backward (dorsi flexion) are out of neutral, which can lead to WRULD problems. The problems identified at this stage are the weight of the transformer, the repetitive claw grip, the turning of the arm supporting the weight, and the weight in one hand in supination. The hand has to counteract the down force and this means it may come out of neutral, its natural position, and go into palmar extension.

ID11 held the transformer with the left hand out of neutral in claw grip, apposition which created compression on the carpal tunnel. The repetitive forceful gripping of the driver with the right hand led to callus build up. Discomfort in the arms occurred on the left with numbness and a tingling sensation (early carpal tunnel syndrome).

The transformer job involves using a down-driver to secure the transformer (see Illustration 5.1). The transformer converts and isolates AC voltage from (230 to 1100) for the microwave. The down driver torque is a one-stop clutch; when the torque is reached the driver automatically stops rotating. If over-torqued it takes off the threads of the screw and stresses the wrist at the end of the movement. The capacitor works in conjunction with the high voltage diode to double and rectify the voltage to 2400 volts DC to drive the magnetron. The magnetron uses the voltage to generate microwave energy. The transformer part is very heavy (4.7 kgs) to support with one hand, especially considering the manoeuvres.

Illustration 5.1. The transformer being screwed into place by a down driver

Note the repetitive forceful sustained gripping, utilising the finger and wrist flexor tendons as evident in the picture. The hand is in slight radial deviation creating further stress on the wrist.

The transformer is made of steel and sufficient steel is required to get magnetic coupling between the primary and secondary windings (coils) and this is the reason for its heavy weight. 4 kgs of force is high for hand/wrist exposure; with low force at 1 kg (Silverstein et al 1986). The transformer job requires the support of weight of 4.7kgs before the consideration of force.

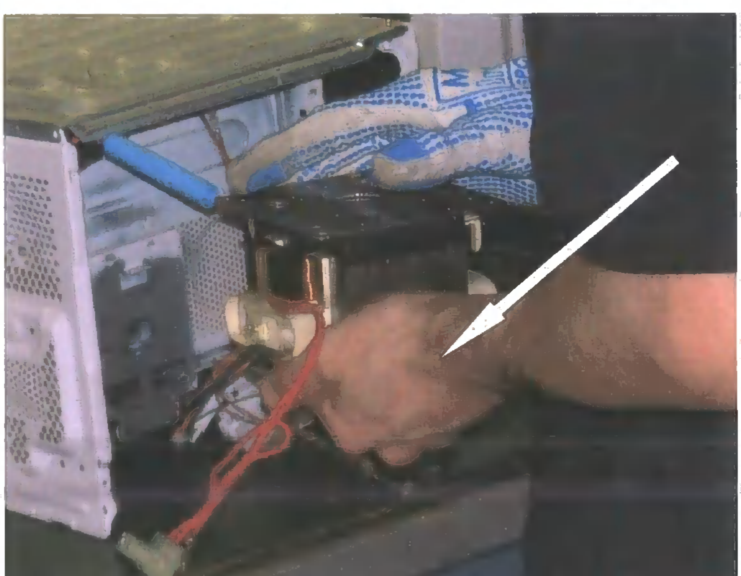
Medical problems associated with the job are as follows:

ID3, was where a soft tissue injury and callus formation occurred, to hands, owing to heavy gripping repeatedly whilst using a gun on the transformers. The soft tissue injury improved once placed on rotational duties as not repetitively gripping it allows the soft tissue underneath the callus to heal.

ID6, was an employee on the same job as ID3, who suffered soft tissue injury callus build up owing to excessive gripping.

ID7, had elbow and hand discomfort on transformer duties owing to repetitive gripping in a claw grip, to rotating the forearm arm and supporting the weight of the transformer, and to kick-back from the down-driver. Eccentric contractions are recognised as having a high potential for muscle damage and rapid eccentric muscle contractions may be seen when the worker absorbs the torque known as "kick back" on powered screwdrivers (Ashton-Miller 1999).

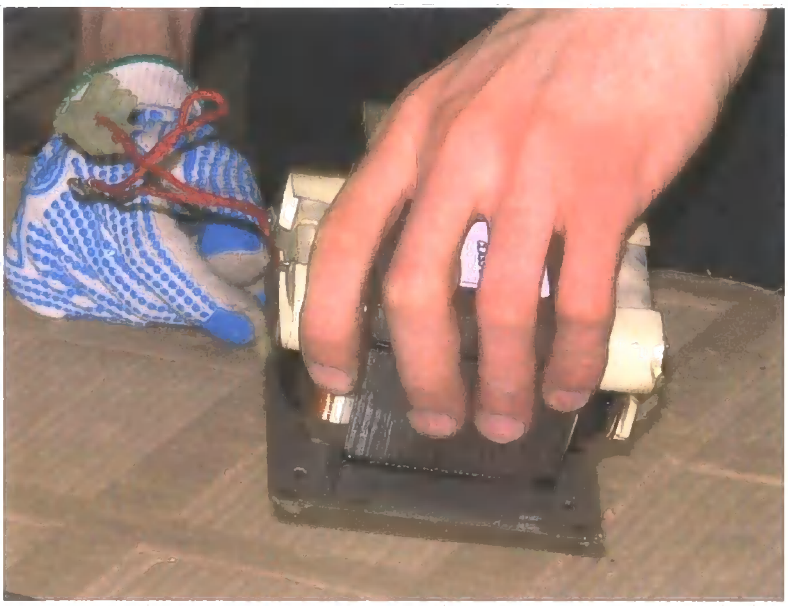
Illustration 5.2. Supporting the transformer with the hand



The hand supporting the transformer is supinated and in palmar extension. The hand in this position has to counteract the down force created by the down driver. This creates extra stress on both the extensor and flexor tendons.

The transformer is required to be lifted in a claw grip with hand pronated (as in Illustration 5.3) then to be lifted with the hand rotating into supination, (as in Illustration 5.2). The task is made more difficult by the fact that it is often performed with the non-dominant left hand.

Illustration 5.3 Preparing to lift the transformer



Note the claw grip in the left hand preparing to lift the heavy transformer.

The non-dominant hand can have 10 percent less grip power than the dominant hand (Crosby 1994) and therefore is more at risk of injury than the dominant hand. There is a further 10-20 percent decrease in grip when gloves are worn (Bergamasco et al 1998) but gloves are a requirement for the job to prevent lacerations to hands from sharp steel. The dominant hand grips a down-driver and powerfully tries to apply four screws to the transformer, which is also being held with force. Gripping the transformer requires a sustained load on both the finger flexor tendons and the wrist extensors to keep the wrist in neutral; this action can lead to work-related upper limb disorders.

The capacitor job (Illustration 5.4) is a much lighter part at only 0.15 kg, and therefore does not require the same effort to maintain it in position but it also requires a claw grip. This job appears to have improved over time according to descriptions found in notes, in that it requires less force and dexterity than it used to.

Illustration 5.4. The capacitor being clipped into place

Note the wide palmar pinch being applied ready to secure the capacitor (Illustration 5.5). The repetitive nature of the job with the wide palmar pinch creates stress on the thenar muscles, which could create discomfort in the thumb. The force applied is minimal but can vary if certain parts are a tighter fit. The repetition rate is a significant cause for these types of injuries to the thumb.

ID8's symptoms were caused by repetitive gripping in a wide palmar grip on the capacitor job (a much lighter part than the transformer) and from twisting of the forearm.

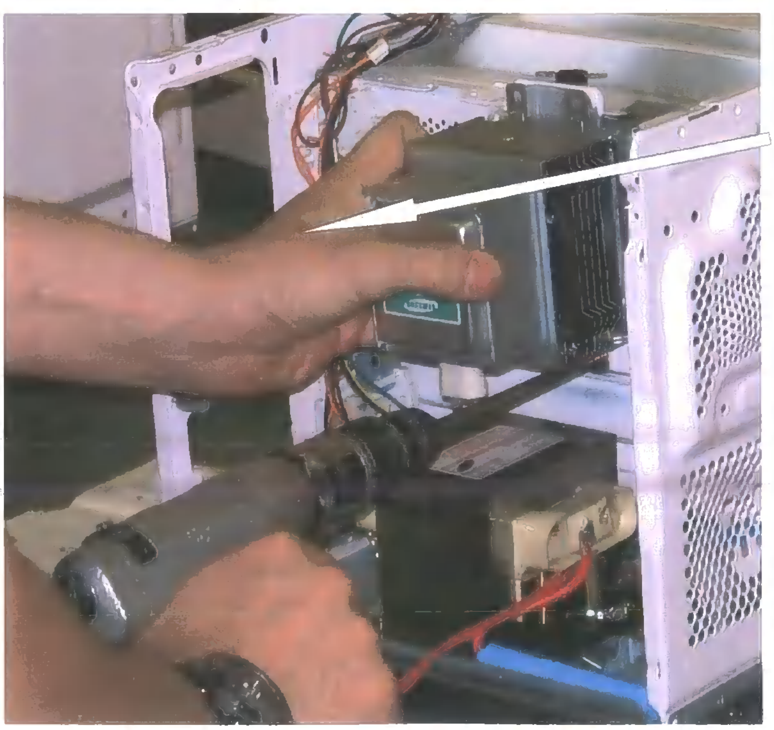
Illustration 5.5. Securing the capacitor

This operation creates the same problems as using the down-driver in the transformer job but does not require such force.

Illustration 5.6. Using the down-driver to secure the clip on the capacitor

The magnetron job requires the use of a pistol gun (see Illustration 5.7). It goes into the microwave from the side rather than the top, unlike the downdriver in the capacitor job and transformer. The magnetron job requires sustained repetitive forceful gripping/flexion of the fingers to use the pistol driver, and this is known to cause triggering of the fingers which if the condition is not managed can require surgical release of the finger tendons.

Illustration 5.7. Pistol gun use in the magnetron job

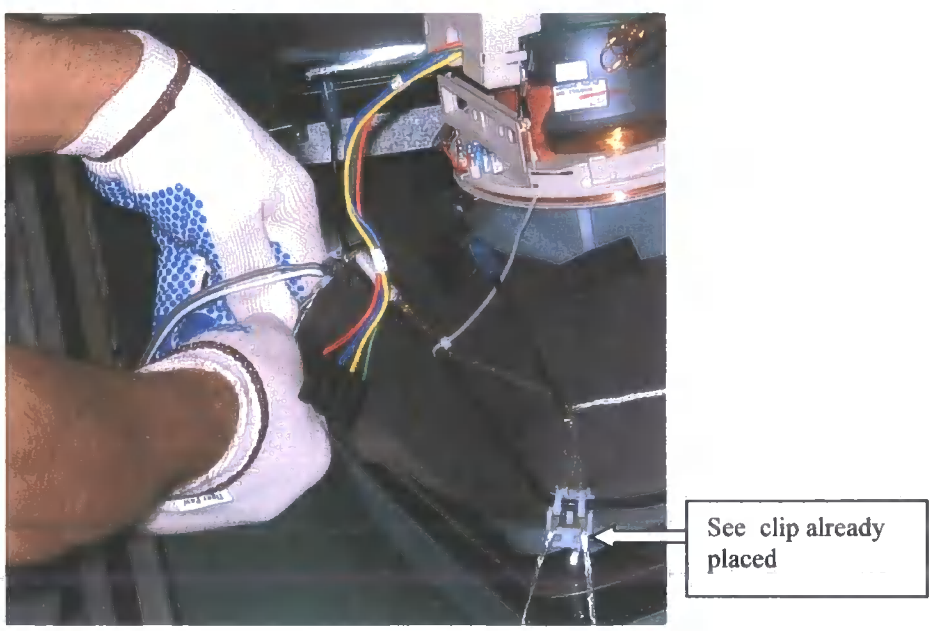


Note the left hand in a claw grip and in dorsi flexion. Use of the pistol gun creates flexion of the fingers and can lead to the development of trigger finger (stenosing tenosynovitis), due to the repetitive overuse of two fingers to activate the trigger of the gun.

Illustration 5.8. Peeling the wrapper from the monitor front ready to lift the monitor – CDT prep

Cathode Display Tube Preparation (CDT prep) is a three-part job, split into four, on the rotating lines. Those employees that rotate spend one hour on the job of peeling the wrapper (Illustration 3.8) and lifting the CDT on to the small conveyor. The next two hours are spent in two positions doing the wire harness (Illustration 5.9). This involves using the thumbs to clip the harness over the casing to hold the CDT in place. The last part involves one hour on docking the CDT on to the line (Illustration 5.10).

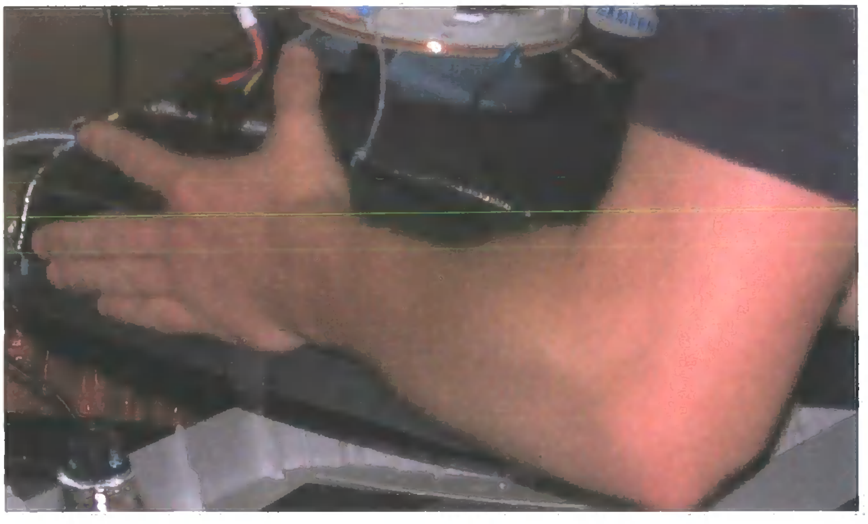
Illustration 5.9. Wireharness



Since the research on the case studies, it is suspected that two people have thumb problems, possibly hypermobility of the thumb, which may be causing thumb instability. The employees' thumb problems arose whilst working on the wire harness (part of CDT prep), and they were required to be restricted from the job. In theory hypermobility increases susceptibility to injury owing to the instability in the cartilage as the tendons have to work harder to stabilise the thumb. As this condition is not identified in a research area then restriction from this job (prior to employment) cannot be placed on a person with hypermobile thumbs. It would be pertinent to rule out osteoarthritis if someone is complaining of thumb discomfort without any other specific diagnosis (Harrington et al 1996).

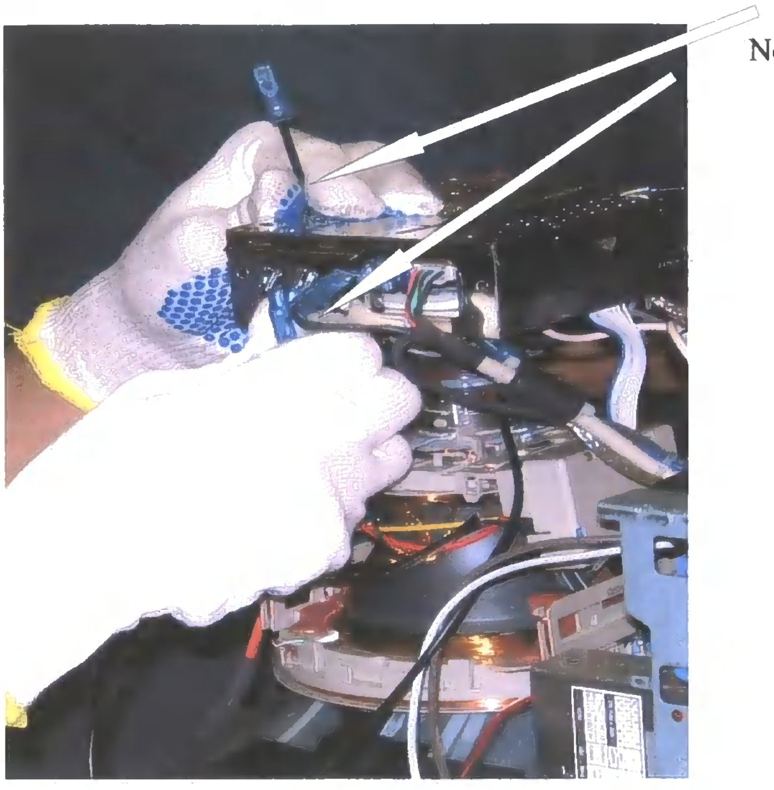
CDT prep docking can create elbow problems from the spread, the weight of the CDT and reaching to dock the CDT. Neck problems are a possibility if the employee comes too far forward when settling the weight.

Illustration 5.10. Docking the CDT



In Illustration 5.11 the person is applying a pincer grip to attach the wires. If too much force is required, or if the action is very repetitive, it can lead to conditions such as De Quervains tenosynovitis or trigger finger (stenosing tenosynovitis).

Illustration 5.11. Printed Board Assembly PBA Fit / Earthwires

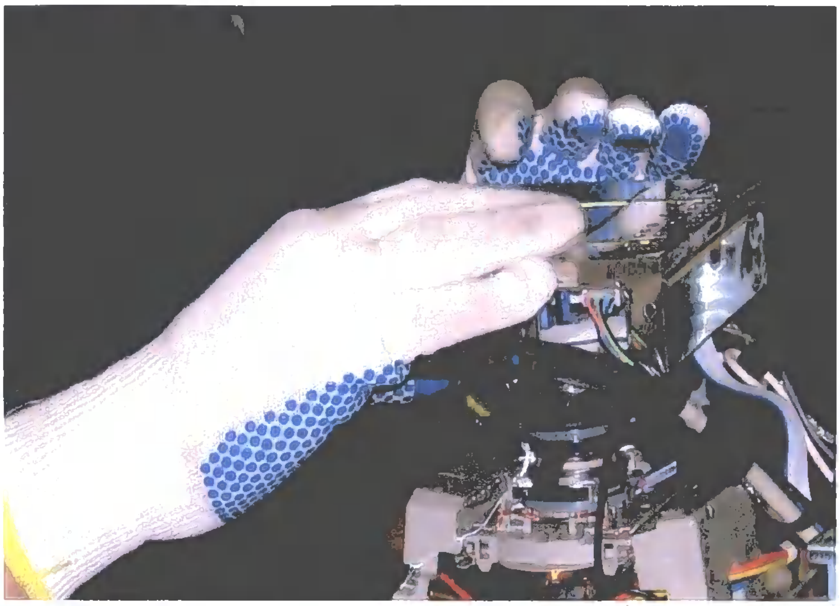


Note the pincer grips

ID5, developed a thumb problem. This was an employee who had been a floater (the employee rotating through many jobs without any problems), the employee was then placed solely onto earth wire connection duty. The job involved repetitive pincer grip movement, which was secondary to mild hypermobility of the thumbs. This could have been prevented if he had remained on rotating duties, as previously he had not had any discomfort problems when rotating. He was temporarily moved to another job where it appeared to settle but once returned to a job with the same movements the medical problem soon returned. The medical problem took six months to resolve.

Clicking in the video box (Illustration 5.12), if it is a tight fit, can lead to wrist and finger flexor problems. However no employee performing this job has reported medical problems.

Illustration 5.12. Clicking in the video box



In view of the weight of the box (Illustration 5.13) the turning of the box could lead to tennis elbow (lateral epicondylitis) or to shoulder tendonitis as a result of the rotation movement in passing the box across the body, if the employee did not turn the box in stages. All the employees were noted to turn the box in stages in neutral.

Illustration 5.13. Boxing up without the lifter

Applying force when preparing to box up (Illustration 5.14) can lead to tendon problems or de Quervains if the box is too thick or the crease is too thick.

Illustration 5.14. Preparing the box prior to boxing

ID4, developed de Quervains tenosynovitis owing to his technique of turning and flicking the box with the wrist out of neutral. The employee suffered temporary job loss and pursued a job elsewhere. Time for recovery is unknown and it is quite possible that treatment was provided outside the company.

The flat pack job (Illustration 5.15) of applying a sticky label does not pose any problems. Until recently it involved flick-turning the box with the arms away from the body twisting the wrist. This manoeuvre can lead to wrist problems, as it also requires movement out of neutral. It could create minor shoulder problems and thoracic problems. Although the box is not a heavy item it has to be flicked well away from the body in order to give it enough turning room.

Illustration 5.15. The flat pack job

Boxing with the lifter (Illustration 5.16) could lead to shoulder problems or wrist extensor problems or tennis elbow or tendonitis. It involves gripping the double handle into the palm and sustaining the pressure, pulling the lifter across the body with the monitor on, then lowering and releasing the lifter handle to place the box. Shoulder problems could occur owing to shoulder abduction of up to 90 degrees depending upon the height of the individual.

Illustration 5.16. Operating the lifter (boxing up with the lifter)

Note the grip in the right hand. The fingers are flexed and the thumb is flexed under the second bar of the control. For the lifter this requires a squeeze and clench action.

Note that the angle of the shoulder is at 30 degrees. This posture was not included in the criteria of static postures as it lasts only seconds; (Jarvholm et al 1988) only found this to be a problem when static.

As a dynamic posture it falls in the criteria for shoulders when the arm crosses the body (Appendix 1 and 10) The major concern was the application of the grip as the fingers and thumb are flexed and then squeezed in a clench and with repetitively turning the arm whilst pulling the lifter across the body and pronating the arm there is the risk of developing medial epicondylitis.

ID1, Was an employee who was diagnosed with early medial epicondylitis (golfers elbow), (symptoms were known to the employee two months before referral). He had developed his injury by continually turning the arm, pulling across the body and turning the hand into pronation whilst operating the lifter. The medical condition resolved in one month after intervention, owing to the return to rotational duties. Increased productivity is identified as a causal factor in work-related upper limb disorder.

ID2, was diagnosed with tendonitis, originally owing to trauma that was not work-related. This demonstrated the importance of referral to return-to-work medicals, as if pre–screened this particular person would not have been placed on the job of operating the packing lifter where he was sent without referral to the Occupational Health Department. His condition was exacerbated by increased production and through stopping rotation. The employee returned to the above situation after a shutdown rest period. He was then placed on restriction followed by rotation, taking two months to fully resolve the medical problem. Tendonitis

5.2 Physiology of WRULD

Based on the physiology of some of the conditions of WRULD and the findings of the present research WRULD is preventable.

Abnormal physiology

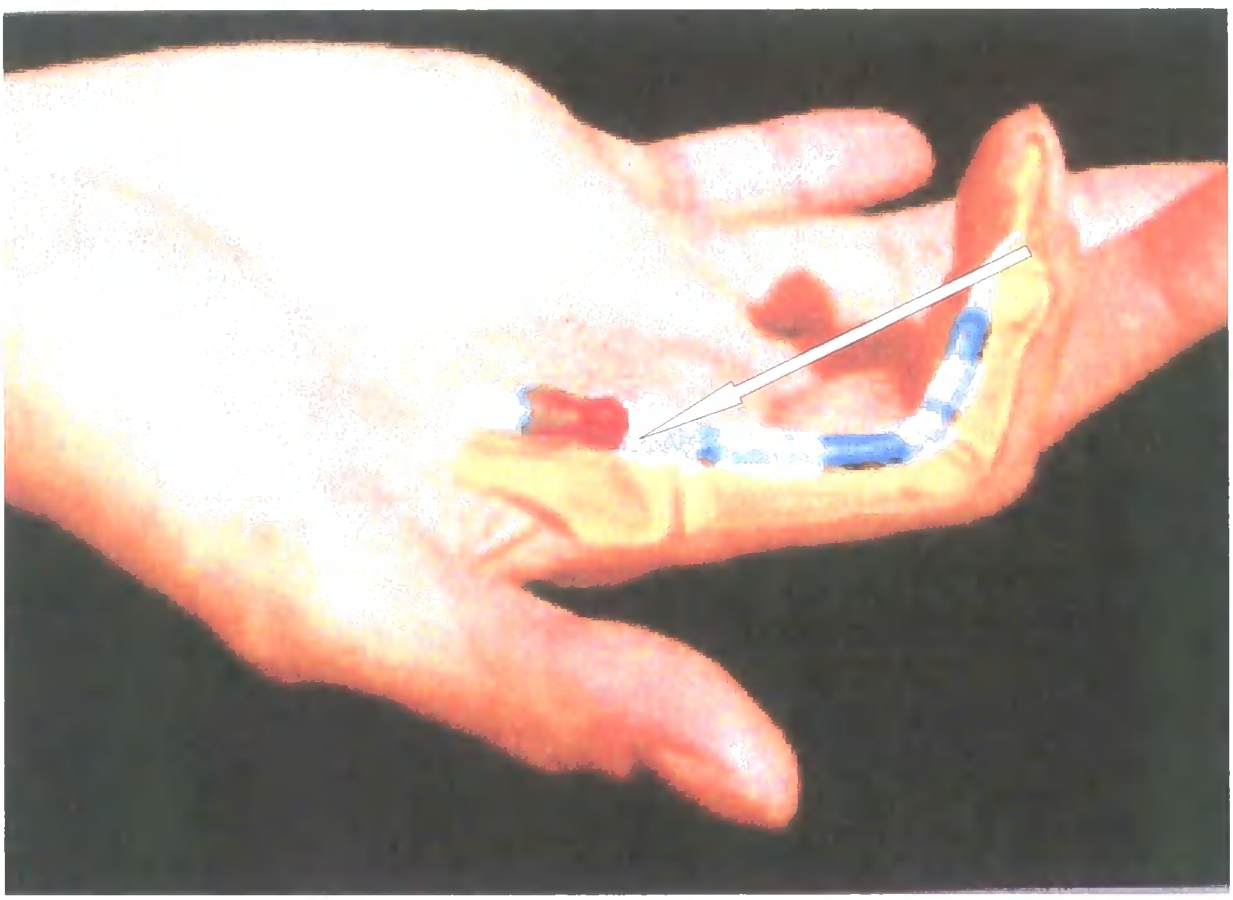
73% of people presenting with de Quervains tenosynovitis have some abnormal anatomy and are therefore more susceptible owing to degenerative changes (Jackson et al 1986). From 300 cadavera wrists studied, in 75% of them it was noted the number of tendons within the compartment differed from what is considered standard. There was a complete or partial septation in 40% of the wrists. The first extensor compartment was divided by a septum and two tendons or more were present in the major subcompartment in about a third of the cadavera specimens; only 77 specimens were found to be so called text book arrangement, where the abducter pollicis longus is inserted uniformly into the base of the metacarpal of the thumb (Jackson et al 1986). In the prospective study of forty patients with de Quervains septation was found in 27 patients 67.5%. The finding was that septation of the first extensor compartment is more common in patients with de Quervains disease than the general population and suggests that this anatomical variation is involved in the aetiology of de Quervains disease. Obviously this can not be detected at pre employment medical and therefore is an unknown factor on pre-placement. Certain individuals may be predisposed to repeated tenosynovitis that have HLA (Human Leucocytlocus A) antigens (Sluiter et al 2001).

A narrow carpal canal and a squarer shape of the wrist and a smaller size hand have all been associated with a high prevalence of carpal tunnel syndrome (Faucett & Werner 1999). Considering at pre employment the carpal canal is an internal structure that cannot be observed and one cannot refuse to employ someone based on the anthropmetric measures of the hand because they are at increased risk of developing carpal tunnel syndrome (Faucett & Werner 1999). These facts make it even more expedient to apply job rotation as a means of risk reduction. However if at pre-employment the individual has the square hand of osteoarthritis Epstein et al (2003) and diagnosis is proven it may not be pertinent to employ in repetitive hand tasks.

A trigger finger is caused by the thickening or swelling of the lining of the flexor tendon; this pinches the tendon and prevents normal smooth gliding and once the tendon is too swollen to fit back into the tunnel (the arrow point Illustration 5.17) the tendons get stuck and locking or clicking occurs. The condition may be secondary to systemic disease such as rheumatoid arthritis or diabetes mellitus (Kesson & Atkins 1998).

Sluiter et al (2001) in the criteria for the evaluation of work relatedness does not mention trigger finger as one of the eleven main disorders, however it would be recognised under the demise of a non-specific disorder requiring work place assessment. Harrington et al (1996) confirms that trigger finger is the result of tenosynovitis and that fibrosis and constriction lead to obstruction of the tendon motion at the first annular pulley (see illustration 5.17). Harrington et al (1996) confirm that the commonest cause is overuse and repetitive gripping activities. It is usually diagnosed by the snapping phenomenon as the flexor tendon is caught at the thickened pulley of the sheath when the finger is in flexion and released on extension (Kesson & Atkins 1998). Usually a palpable nodule is felt which makes the diagnosis easier if this is present ((Kesson & Atkins 1998). Treatment is by corticosteroid injection, Kesson & Atkins (1998) however, if it doesn't resolve it may require surgical release. It is important to rule out diabetes mellitus or rheumatoid disease as trigger finger can be secondary to these systemic diseases (Kesson & Atkins 1998).

Illustration 5.17 Trigger finger

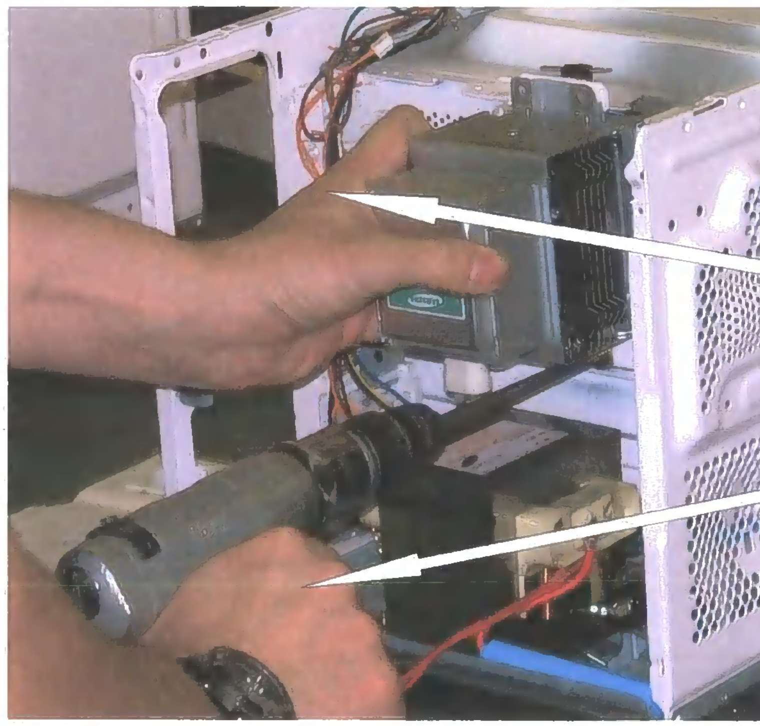


www.medicalmultimedia.com

It was felt that Id3, 12 and 14 developed trigger finger as a result of working on the transformer job which required a repetitive sustained forceful power grip for the down-driver.

It was noted in the case studies (table 5.1) that ID9 developed trigger finger which was thought to be associated with forceful repetitive gripping of a pistol driver on the magnetron job (Illustration 5.18).

Illustration 5.18 Pistol gun use in the magnetron job



Note the left hand in a claw grip and in dorsi flexion.

Note the right hand is forcefully gripping the trigger on the gun with the fingers

Use of the pistol gun requires flexion of the fingers which may lead to the development of trigger finger (stenosing tenosynovitis), secondary to the repetitive overuse of two fingers to activate the trigger of the gun.

Through holding the magnetron as in (Illustration 5.18) with the hand sustained in a claw grip position in dorsi flexion pressure can be placed on the carpal tunnel secondary to extreme extension of the wrist and repetitive and forceful sustained finger flexion. Also repetitive forceful sustained flexion and extension of the thumb can place strain on the abductor pollicis longus and the extensor pollicis brevis tendons, leading in turn to de Quervains tenosynovitis. The fingers are also flexed and holding the magnetron in a sustained static grip which could lead to trigger finger.

After the data analysis seven other employees reported discomfort which had occurred owing to jobs entailing repetitive forceful sustained gripping of drivers. These people did not develop stenosing tenosynovitis but had suffered unnecessary discomfort. These people were then placed on rotating duties by the occupational health department and the discomfort soon resolved. This could have been avoided if effective job rotation had taken place that allowed relief from the repetitive forceful sustained gripping and allowing the smaller muscles and the tendons / ligaments to relax and recover from fatigue.

Illustration 5.19 De Quervains

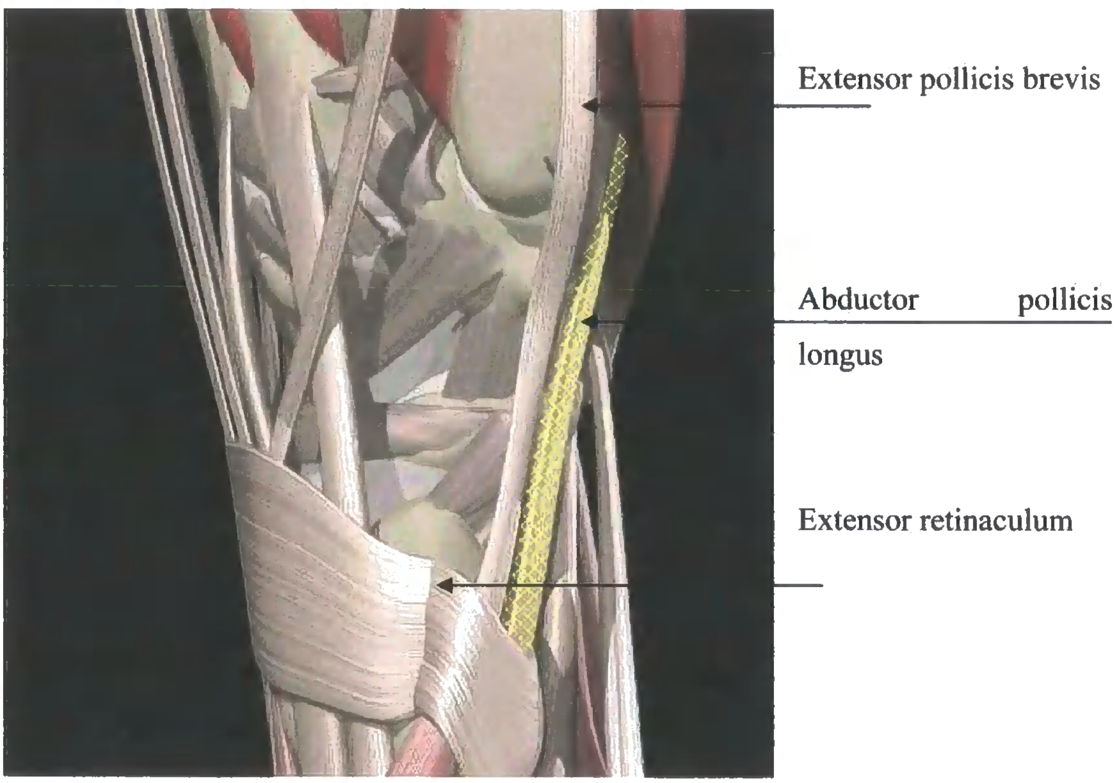


Illustration- www.anatomy.tv

The extensor pollicis brevis and the abductor pollicis longus are the affected tendons in De Quervains tenosynovitis (also known as stenosing tenosynovitis). The two tendons lie in close proximity running through a channel over the radial styloid process which lies just above the level on the top of the wrist on the internal aspect. The extensor pollicis brevis allows extension of the thumb and the abductor pollicis longus allows its abduction. Owing to its opposite directional flow the tendons are impaired by friction, stenosing in a tight area and creating swelling owing to the accumulation of fluid build up or thickening of the vascular sheath. In Company X any jobs that require a forceful pincer grip can exacerbate this condition; the tasks that could cause this are earth wires/PBA fit. The scenario with the faulty connectors where the deflection yoke wire connector was too small, if the issue had not been rectified it could have led to de Quervains tenosynovitis (Table 4.1). De Quervains tenosynovitis is more often related to a blow injury but 73% of people presenting with this condition have some abnormal anatomy and are therefore more susceptible owing to degenerative changes. It is named de Quervains tenovaginitis although sometimes is called de Quervains tenosynovitis, although it is not truly an 'itis' (the ending for all medical words that mean inflammation) as there is no inflammation in the synovium (Jackson et al 1986). The discrepancy between clinicians and surgeons over the diagnostic term used may be because clinicians are more likely to see de Quervains tenosynovitis when it's in its acute stage, whereas once the condition requires surgery it is in a chronic state and therefore vascular thickening may have occurred leading to tenovaginitis. These symptoms may be exacerbated by activities requiring thumb adduction and flexion and wrist ulnar deviation (Almekinders 1998).

Signs and symptoms of de Quervains are swelling, redness, heat and pain and in the acute phase crepitation can be felt over the radial side of the wrist. The pain may radiate up the forearm or into the thumb. The test for de Quervains is known as Finklestein's test (Kesson & Atkins 1998). The thumb is fully flexed and then the fingers wrapped round the thumb. The hand is then moved by the client into ulnar deviation. If the test is positive if it provokes pain around the tendons at the styloid process as the tendons are being stretched (Harrington et al 1998). There will also be reduced pincer grip owing to the pain. Crepitations are likely to be felt by placing the hand over the affected area (the styloid process) when the wrist is in ulnar deviation. It is important to distinguish between de Quervains and other conditions such as extensor tendonitis of the forearm, lateral epicondylitis and radial tunnel syndrome (Sluiter et al

2001). Sluiter et al (2001) diagnoses de Quervains based on symptoms and physical examination signs when the patient, at the present time, or on at least four days during the last seven days, has intermittent pain or tenderness localised over the radial aspect of the wrist radiating either proximally to the forearm or distally to the thumb and includes one of the following tests being positive. The tests are a positive Finklestein's test, resisted thumb extension or resisted thumb abduction (Sluiter et al 2001). Sluiter et al (2001) had added resisted thumb abduction as an extra criterion since the Delphi exercise (Harrington et al 1998).

Causes of de Quervains tenosynovitis are repetitive and sustained forceful gripping or load on the affected tendons. The long-term complications are that if not treated and handled correctly in the acute stage it can lead to a chronic problem that requires surgical treatment. De Quervains tenosynovitis can develop into the chronic condition tenovaginitis (there is no occurrence of '–itis' inflammation in the synovium) as a result of a thickened vascular sheath (Jackson et al 1996).

If the medical condition is managed well by keeping the person off the job which has been the causative factor, and then returning the person very slowly to the original job allowing for effective job rotation once the medical condition has resolved, it helps to prevent reoccurrence (Dalton & Hazelman 1987). Initial treatment for de Quervains tenosynovitis is rest, and damp wrapped ice therapy, however, ice as a therapy has been used for soft tissue/ sport injuries as one of the oldest therapeutic modalities (Bleakley et al 2004). Bleakley et al (2004) asks why do we use ice at all when systematic reviews show no real evidence of benefit? If there is no 'itis' inflammation in the condition of de Quervains then the use of ice is even less pertinent as a treatment (Jackson et al 1996). Applying a wrist brace, especially at night, and ultrasound therapy, are methods of treatment. If unsuccessful then an injection of corticosteroid is required and should be administered between, and parallel to, the two tendons (abductor pollicis longus extensor pollicis brevis) or alternatively apply deep transverse friction massage (Kesson & Atkins 1998).

ID4 developed de Quervains by turning and flicking the box over with the wrist out of neutral, particularly into ulnar deviation. A further case of de Quervains tenosynovitis developed owing to forced pincer movements (on a job not in the study). This condition developed within two weeks when the employee returned to a new job after a shutdown. The employee was redeployed and his symptoms took four weeks to resolve, with seven lost production hours.

Golfers' elbow, known as medial epicondylitis, affects the flexor compartment in the forearm. Lateral epicondylitis (known as tennis elbow) affects any of the extensors attaching to the origin of the common extensor on the lateral epicondyle. They can arise spontaneously, or by trauma or by upper limb disorder owing to work. Non-related work activities such as hobbies and sports or a combination of the activities can give rise to lateral epicondylitis. Lateral epicondylitis is the more common of the two (Almekinders 1998).

Lateral epicondylitis can be caused by twisting at the wrist, e.g. using screwdrivers, operating a lifter, or using torque wrenches or drivers. Inflammation occurs between the junction of the common extensor tendon and the bone, and tenderness occurs around the lateral epicondyle, and typically involves the extensor carpi radialis brevis and less commonly the anterior edge of the extensor digitorum communis aponeurosis or the extensor carpi radialis longus (Jobe et al 1997). The diagnostic tests are to use a passive stretch, in which the client with the arm straight curls up the fingers into a fist and stretches down into palmar flexion. This stretches the fingers and wrist extensors and will create an active stretch of the extensor tendons in the arm (Kesson & Atkins 1998). The client will feel pain either along the specific extensor or at the lateral epicondyle where the common extensor attaches. To apply a further test the client rests the palm on the table, and then the examiner applies light pressure to the mid three fingers and asks the client to move the hand backwards into dorsi flexion whilst applying resistance (active stretch), this will cause discomfort. In the early stages any activity that aggravates the condition should be avoided (Kesson & Atkins 1998). This avoidance then makes it easier to assign a causative factor for if avoiding what is believed to be the causative factor the symptoms should resolve. Mainly it is the extensor carpi radialis brevis that is affected in lateral epicondylitis (Jobe et al 1997).

Sluiter et al (2001) for the case definition to diagnose epicondylitis, based on symptoms only, uses at least intermittent activity dependant pain directly located around the lateral or medial epicondyle. One must use the time rule to see whether the symptoms are present now, or on at least 4 days during the last seven days, or symptoms present on at least four days during at least one week in the last twelve months. This is the temporal criteria used for all the cases of WRULD in (Sluiter et al 2001); based on symptoms only to be able to apply workplace prevention so that surveillance can take place and intervention strategies be implemented in a timely manner (Sluiter et al 2001). If the patient has clinical signs of epicondylitis then the time rule is symptoms present now or on at least four days during the last seven days and at least intermittent activity- dependant pain directly located over the specific epicondyle. The signs being local pain on resisted wrist extension (lateral) or on resisted wrist flexion (medial) (Sluiter et al 2001) which is the same signs used for diagnosis as (Harrington et al 1998).

Lateral epicondylitis is common between the ages of 40 and 50 (Almekinders 1998). It occurs 75 percent of the time in the dominant hand and can occur spontaneously, therefore it is not always easy to determine whether work was causative or the problem came on spontaneously (Almerkinders 1998). Company X currently pre-screens all employees via a pre employment /pre placement medical.

Regardless of whether there are work factors that can be identified it has to be assumed there are and preventative measures put in place to prevent further exacerbations of the medical condition. Illustration 5.20 identifies the attachments around the epicondyles and the difference of the site for Lateral Epicondylitis (Tennis Elbow) and Medial Epicondylitis (Golfers Elbow).

Illustration 5.20 Epicondylitis

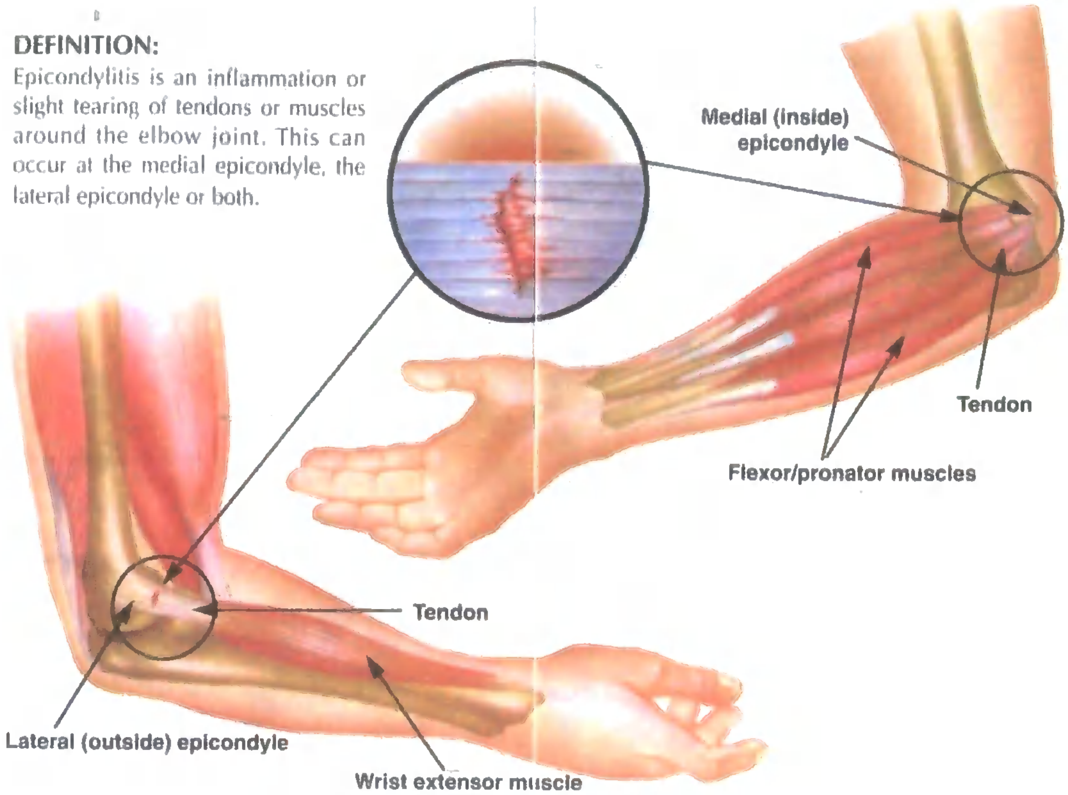


Illustration from EpiSport Clasp Information Applications and Instructions FLA Orthopaedics inc.

There are specific tests for the diagnosis of lateral epicondylitis. The results of the test if positive reveal that there is inflammation or slight tearing of tendons or muscles around the lateral epicondyle. Kesser and Atkins (1998) enumerate the tests used for the diagnosis of lateral epicondylitis as follows:

1) Palpation of the lateral epicondyle – instils discomfort.
2) Stretch of the extensor muscles (passively) is positive if produces discomfort.
3) Resisted extension of wrist- is positive if painful and difficult.
4) Resisted middle finger extension (relates to extensor carpi radialis)-produces discomfort and is difficult to perform.

Only 2/4 positive diagnosis = Tennis Elbow

Grip strength FGS (full grip strength and PFGS (pain free grip strength) are good objective measures of improvement or deterioration.

We have noted in the study of Company X that in the Cathode Detection Tube(CDT) prep job bilateral epicondylitis and elbow discomfort were related to repetitive heavy lifting in the docking of the CDT when rotation of duties did not take place. This led to restriction of duties and redeployment. We have also noted that packing with the lifter was associated with the development of early medial epicondylitis, owing to the repetitive turning of the forearm whilst gripping the lifter handle with the arm into a pronated position. The medical condition resolved significantly within four weeks with the introduction of job rotation (Table 5.1).

This chapter is about which WRULDS are preventable and therefore the importance of job rotation is demonstrated by the fact that these people have developed specific conditions related to specific jobs and that when job rotation was introduced the symptoms started resolving.

Many of the jobs in Company X could actually cause WRULD but fortunately those in table 5.1 are those only at the time of the study identified as a problem. Sometimes a temporary job may exist on the line such as using pliers all day or gauges and this is quite concerning because though the job might only be happening for one day, the same employee tends to get left on the job. This person is particularly liable to develop a WRULD as they are unfamiliar with the pliers and are brought straight into the job at speed without warming up and their tendons, muscles and ligaments may not be up to peak fitness as their usual job may be the one that has the least physical stress. In PCM and MWO the work contributes to the development of WRULDs and exacerbation of existing conditions of those not on rotational duties as all of the employees that developed WRULD in table 5.1 were not on rotating duties. These employees were put on restriction for their medical conditions and were not even able to go just onto rotational duties until their condition improved. In total these employees spent a minimum of 209 weeks where they were not able to do their normal duties. This is very frustrating for the employee whom is not only suffering but also has the extra concern how long the company will keep them employed when they are on enforced restrictions. These employees are often victims of their own success in that they are so good at their jobs that they usually get kept on the same job with detriment to themselves. In the meantime someone will have needed to have been trained up to perform that job and this will have meant loss of production and quality issues possibly occurring. The employee training up on the new job is likely not to be put onto rotational duties and therefore is at increased risk of WRULD. According to Hakkanen et al (2001) newly employed workers in hand-intensive tasks have a high risk of upper limb and neck-shoulder disorders. As mentioned previously some workers are more prone to WRULD and certain people would be well advised not to undertake such work if they have previously suffered a trigger finger or a tendonitis as these conditions can easily reoccur if subjected to factors that can exacerbate the condition.

It begs the question that should pre employment screening occur, from a personal viewpoint I would agree with pre-employment medicals, however, some people may see it as an impingement on their rights. It is not a legal requirement except in areas where there is possible danger not to perform medical clearance e.g. HGV drivers/ divers etc (Cox 1995). It is pertinent that under the relevant regulations statutory medical examination take place, via health surveillance, of lead, ionising radiation and asbestos workers. If the risk to the person of WRULD is forseeable as they have had previous exacerbations should the individual or the company take that risk? However it is possible for workers with a reduced working capacity to remain productive, albeit in jobs featuring a lower exposure potential than the acceptable threshold for healthy workers (Battevi et al 1998). However, in pre-employment medicals it is necessary to abide by the Disability Discrimination Act (DDA 1995).

Other influencing factors to WRULD are personal factors, oral contraceptives, gynaecological surgery, gender, age, obesity, wrist size and shape, acute trauma, rheumatoid arthritis, and endocrinological disorders and that females are more susceptible to WRULD. It may be permissible for a doctor to declare a person unfit for production work based on medical grounds if they have for example rheumatoid arthritis. It would not be acceptable to declare someone unfit that is female as that would be seen as prejudice or sexist, or because some one is obese and more at risk, therefore it means that job rotation is pertinent as a preventative measure. The wire harness job can cause thumb problems; another job redesigned was relocation as it had the potential to cause back problems as the lifting of the monitor relied significantly on the use of the scapulae region when tilt lifting the CDT monitor. It is necessary to look at potential risk and not rely on reported cases only. There is a risk of carpal tunnel syndrome on the CDT adjustment job on PCM as it involves reaching behind the computer monitor to make adjustments; this takes the hand out of neutral into palmar flexion. In the camera job on the CDT in PCM there is a risk of neck problems owing to static extension of the neck. Production changes very quickly in electronics manufacturing where you get rid of one problem, for example the weight of the CDT as it is being replaced by the TFT another problem occurs as the TFT requires a grip application that is greater than the CDT and there are more jobs of finer and greater dexterity. There is also a concern about the grip postures on the TFT and this is covered in chapter 7.

Currently a new posture has been identified and this may require adding to the job action analysis as it has been found on the TFT there is occasional lateral rotation on the shoulder when collecting parts from the trolley. First of all it needs to be decided if this action can be eliminated and needs a workplace assessment for alternatives and whether avoidance of this action can be built into the employees' work instruction. The job action analysis is original and certainly innovative as there has been no other observation methods so simplistic with maximum information. As some medical conditions can take a while to develop it is probably by good luck rather than good management that people on the other jobs just mentioned have not developed a problem as they have not been job rotating. When one relates the physiology the jobs and the work demands as discussed earlier there is a potential for WRULDs to develop and this could be minimised by job rotation.

5.3 Rotation versus non-rotation

The number of people rotating in the different jobs was as indicated in Table 5.2. The number of people rotating at Personal Computer Monitor factory was 53.2% of the total and number at the Micro-Wave Oven factory was nil except for eight people on occasional rotation, as can be seen in Graph 5.1.

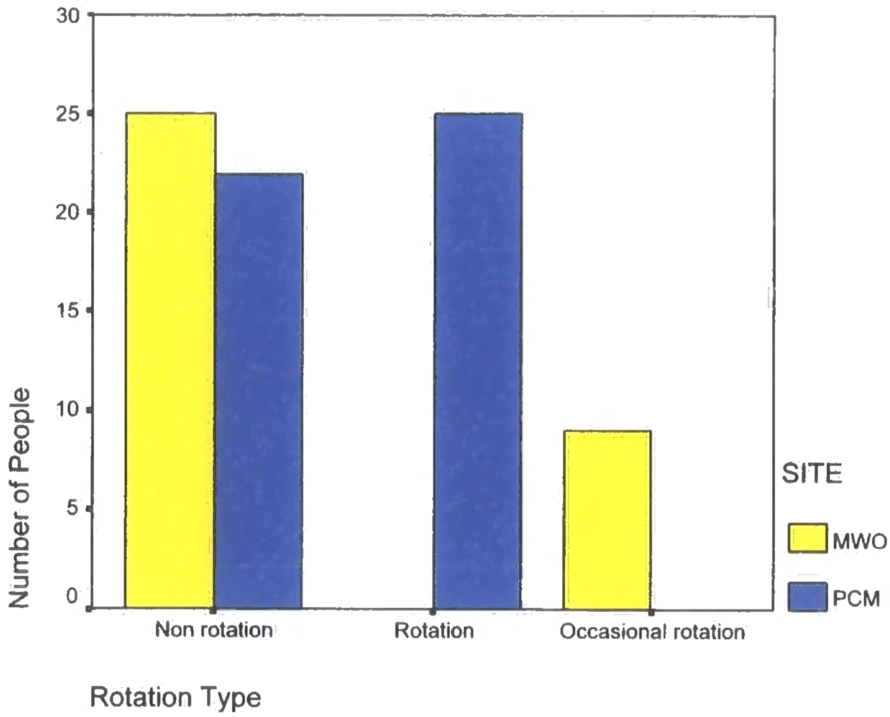
It is postulated that job rotation could be applied in the electronic factory and reduce the probability of employees developing WRULD. In this study of Company X, a small number of employees were recruited for this exercise. Table 5.2 shows the number of employees involved in Personal Computer Monitor were 47 and Microwave Oven factory 33. The rotation that took place at MWO was basically non-existent as days could go by without any form of rotation and therefore the comparisons between the sites are straightforward. Site comparison shows that MWO employees had more discomfort than the PCM employees (Graph 5.2).

Table 5.2 Jobs/ Rotation / non-rotation/ occasional rotation between PCM and MWO site

SITE	PCM	PCM	PCM	PCM	PCM	PCM	PCM	MWO	MWO	MWO	MWO	MWO	MWO	MWO	MWO	MWO	MWO
JOBS	CDT Prep	Earth Wire	Flat Pack	Lifter in use	Lifter not in use	**Total**	**Total PCM %**	Capacitors	Magnetron	Transformer	St 1	St 2	St ¾	St 5	St 6 weld	**Total**	**Total MWO %**
Non-rotation group	7	5	6	1	3	22	46.8	5	4	5	2	2	3	2	2	25	75.7
Rotation group	12	5	1	4	3	25	53.2	0	0	0	0	0	0	0	0	0	0
Occasional Rotation group	0	0	0	0	0	0	0	0	1	2	1	1	1	1	1	8	24.3
Total	19	10	7	5	6	47	100	5	5	7	3	3	4	3	3	33	100

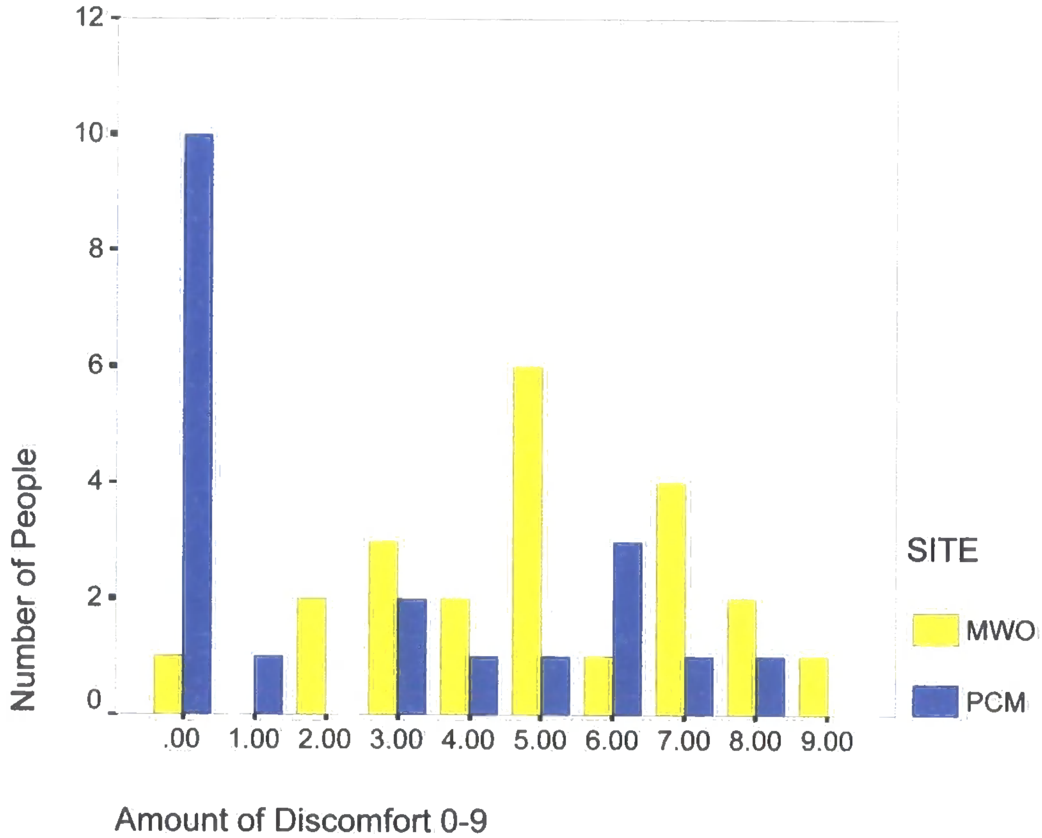
The nature of the tasks in each site is different as they are building different electronic equipment; all the jobs require some degree of dexterity, some more than others. The jobs are not particularly heavy on either site. The heaviest job in the study of Company X in PCM is the docking of the CDT and in MWO the fixing of the transformers. It is impossible to compare different jobs as the muscle groups used vary in each job and the job action analysis varies between them (appendix 10). One could argue that irrespective of the differences in the tasks in these two factories the employees are subjected to repeat stress on their hands and upper limbs without job rotation. However, the stress on each body part is present as calculated (appendix 10).

Graph 5.1. The number of people on job rotation in the Microwave Oven and Personal Computer Monitor sites



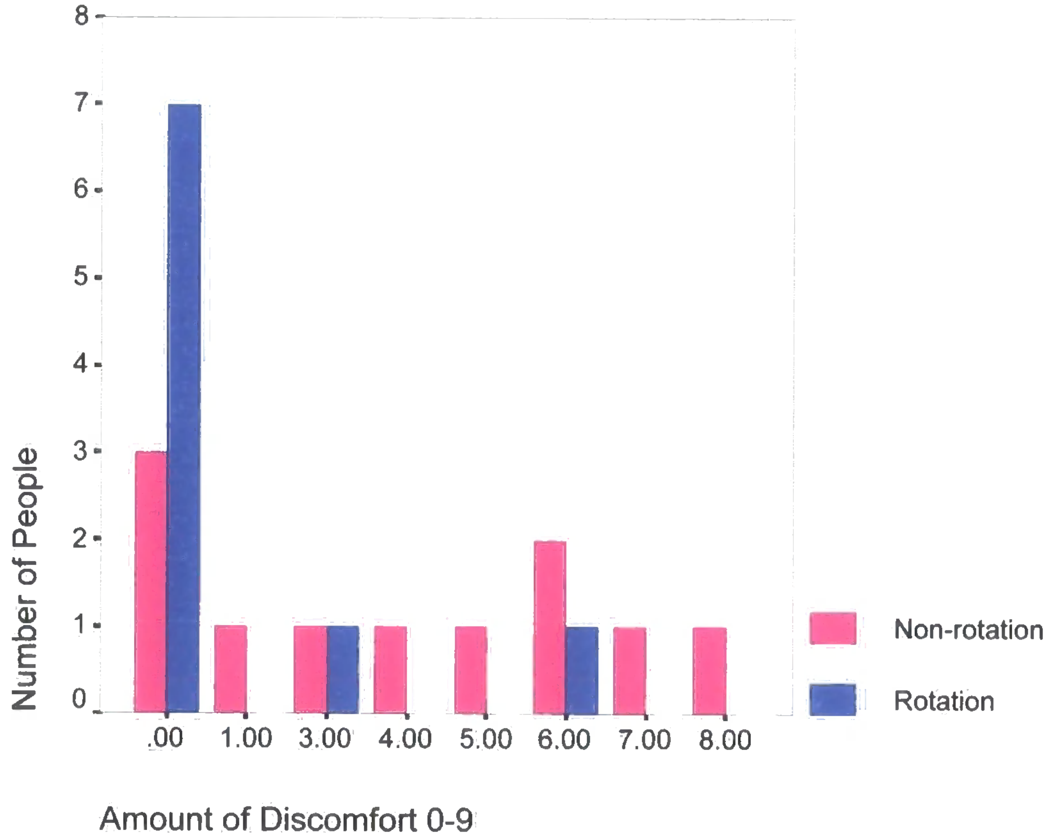
It is evident in Graph 5.1 that only occasional rotation takes place at MWO whereas at PCM 25 people practice job rotation permanently. The occasional rotation at MWO is discounted as it was so infrequent and often days went by without any rotation.

Graph 5.2 The amount of discomfort on a Friday in week 5 at each site



Graph 5.2 provides the figures for employees' discomfort in week 5 on the two sites. In PCM 53 percent rotated while there was no effective rotation taking place at MWO (Table 5.2). Ten employees out of 20 in PCM had no discomfort whereas only one employee out of 22 in MWO had no discomfort. In MWO the highest band for discomfort was in the medium level a discomfort level of 5. The data show that discomfort is less present in people at the PCM site, where rotation was taking place. To examine whether this difference could be due to rotation or whether it is just the different types of jobs at the two sites, the PCM site alone was analyzed by comparing discomfort in people with rotational duties and non-rotational duties.

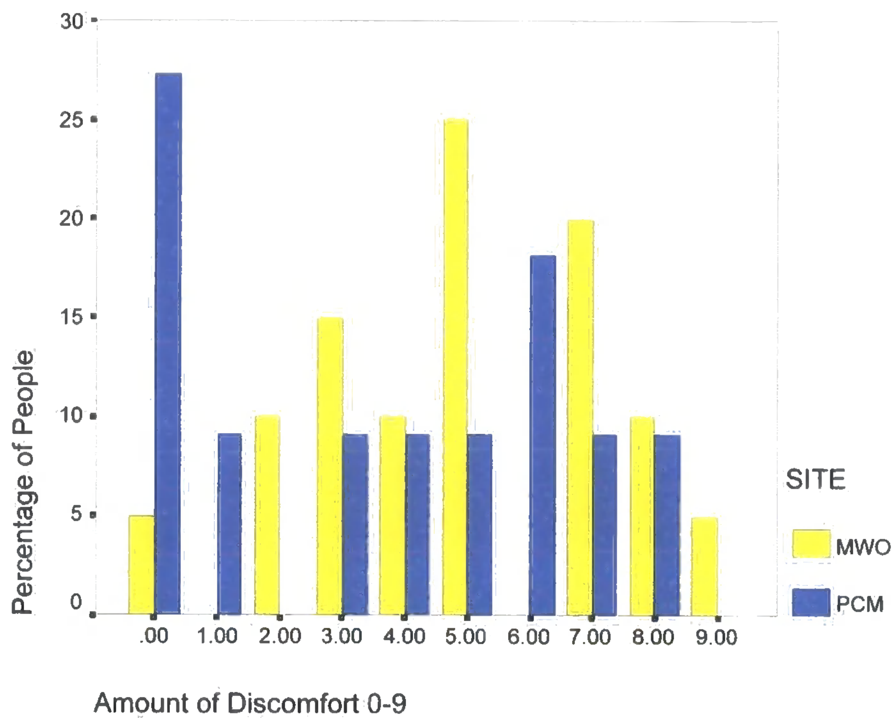
Graph 5.3. Amount of discomfort of people job rotating and non-rotating in week 5 on PCM (week with the most data)



Although the sample is too small to be statistically significant there is some indication that discomfort is lower for people on job rotation. In week 5 where most data was available, 7 out of 9 job rotating people had no discomfort while in the non-rotating group only 3 out of 11 had no discomfort, while 5 had a fairly high discomfort level of at least 5 (on a scale of 0-10).

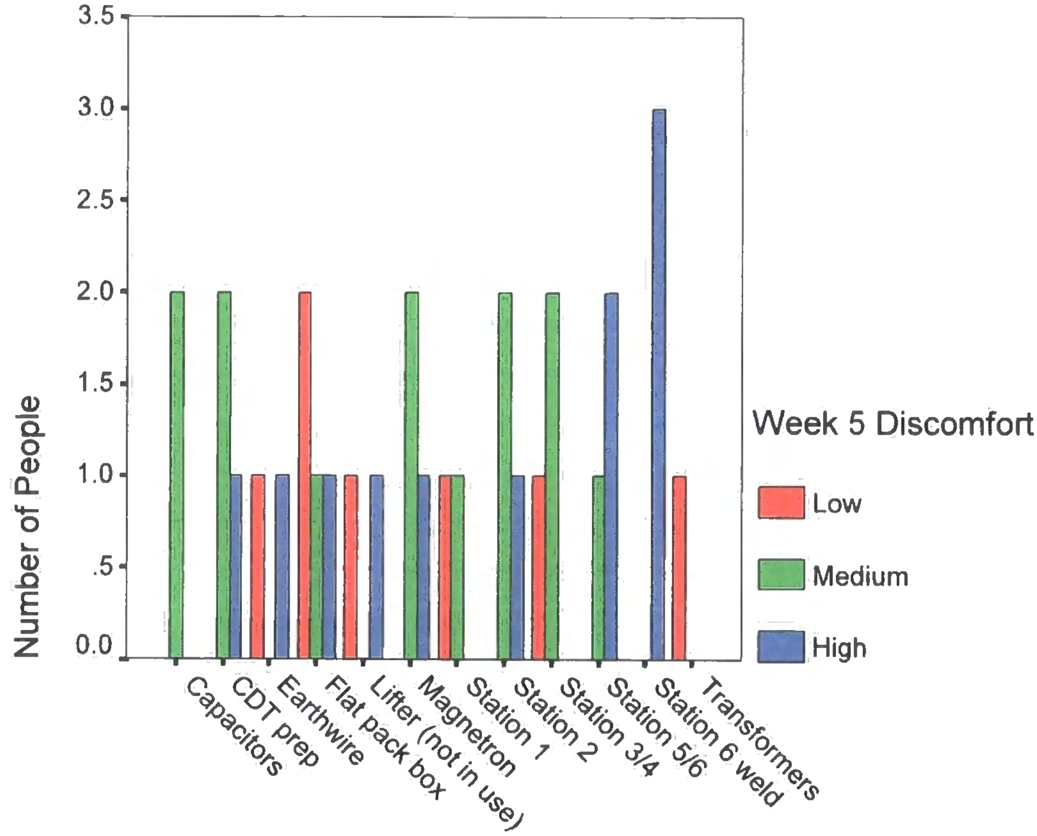
In addition, for all individuals not on permanent rotation the discomfort levels were analyzed, to see if the level of discomfort was similar for the two sites (Graph 5.4). Graph 5.4 shows that generally similar discomforts indeed occur over the two sites except that 27% of employees at PCM show no discomfort and only 5% at MWO show no discomfort. Hence the difference in discomfort levels between PCM and MWO as observed in Graph 5.2, may be caused by both permanent rotation taking place in PCM only and by differences in the sites due to other circumstances, for example the types of job. Whether the different discomfort levels could indeed be caused by the differences in jobs was something that required clarifying (Graph 5.5). For the purpose of analysis in graph 5.5 the discomfort scales were aggregated into 3 groups, i.e. low =0-2, medium = 3-5, high= 6-10.

Graph 5.4 Amount of discomfort among non-rotation people only in the Personal Computer Monitor and Microwave Oven factories measurement of discomfort in week 5.



In Graph 5.5 analysing the different jobs for discomfort levels it shows for example that discomfort is seriously present in station 6 weld (all three individuals having high discomfort) if compared to the flat pack box duties (only two out of four medium or high discomfort). This result was not surprising as station 6 weld had the highest job action analysis score for the whole of the BTM (appendix 10). The reason for this is that this job involves stacking cavities on to a trolley, and although the recommendations were to stack only five high, sometimes owing to shortage of space they stack six high until the stock is reduced. Robotics is not really the answer to the problem as the precision on stacking is a safety aspect and if the machine were to run a fraction out the microwave cavities would topple and possibly injure someone. It would appear that job rotation could help reduce the level of discomfort experienced by employees. Both rotation as planned in the BTM matrix (Table 4.2) and stacking at the recommended height of five cavities high should alleviate the discomfort.

Graph 5.5 Discomfort in week 5 on specific jobs (non rotation)



There appears to be some association between the level of discomfort experienced by the employees and the types of jobs carried out, which is a possible explanation of the difference in discomfort levels between PCM and MWO To find out whether job rotation can reduce the amount of discomfort in a particular job, Cathode Display Tube preparation (CDT prep), was analyzed. Only the weeks with data of at least 8 employees were used as anything less would be too small for any objective analysis. CDT was the only job fully analyzed, as it was the only duty for which rotation was taking place on an hourly- 2 hourly rotation permanently for a fairly large number of people.

Analysis of rotation versus non-rotation on the specific job of CDT prep shows that people on job rotation have lower discomfort levels (Table 5.3) and have discomfort in fewer body parts (Table 5.4).The weeks where at least four people were rotating duties and no less than 8 people including the employees on non- rotation in total, their discomfort scores were analyzed for discomfort levels and discomfort in number of body parts. Number of body parts of discomfort can be seen in table 5.4 to be less in employees on rotational duties on the CDT prep job. For instance in week 6: 3 out of 5 employees on rotational duties did not feel any discomfort in any part of the body and only two people on rotational duties had discomfort, in one body part only. On the other hand, employees on non rotational duties all felt discomfort; one employee with only one body part feeling discomfort, and two employees feeling discomfort in two parts of the body. In week 7: 2 out of 4 employees in the rotation group had discomfort in one body part whereas the 4 employees in the non-rotation group all suffered discomfort two had discomfort in one body part and two had discomfort in two body parts. The effects of rotation seem more significant in week 5: 8 people reported no discomfort in the job rotation group whereas three out of four people in the non-rotation group complained of discomfort in two body parts. In those employed on job rotation in weeks 5 & 6 & 7 totaled together 13 people suffered no discomfort in any body parts whereas all except one worker in the non-rotation group suffered discomfort in body parts. In other words (in week 5 & 6 & 7) only 5 out of 18 had discomfort in body parts that were rotating their jobs and 13 out of 18 did not have any discomfort at all. In comparison the non- rotation group 10 out of 11 people had discomfort, which means 90.9% suffered discomfort in this group.

Only the number of body parts for which employees felt discomfort in week 5 differed significantly between the rotation and the non-rotation group in the CDT prep job PCM (Fisher's exact test, $p=0.05$) (table 5.4). Hence, there is some evidence that the differences in discomfort is caused by the rotation.

The finding of this small-scale study appears to suggest that rotation can be effective in lowering discomfort levels generally. However to be fully conclusive a larger study would be needed to test the hypothesis that organized job rotation is effective in reducing discomfort levels. This would also provide an opportunity of investigating whether the discomfort improves over time while people are rotating duties.

Table 5.3 The number of people rotating or not rotating in different categories of discomfort on CDT prep PCM

In week 5	Non-rotation	Rotation	Total
Low	0	4	4
Medium	2	0	2
High	1	1	2
In week 6			
Low	0	3	3
Medium	1	2	3
High	2	0	2
In week 7			
Low	2	4	6
Medium	2	0	2
High	0	0	0

The number of people was not sufficient to provide statistical evidence in table 5.3 for those rotating and non-rotating on CDT prep.

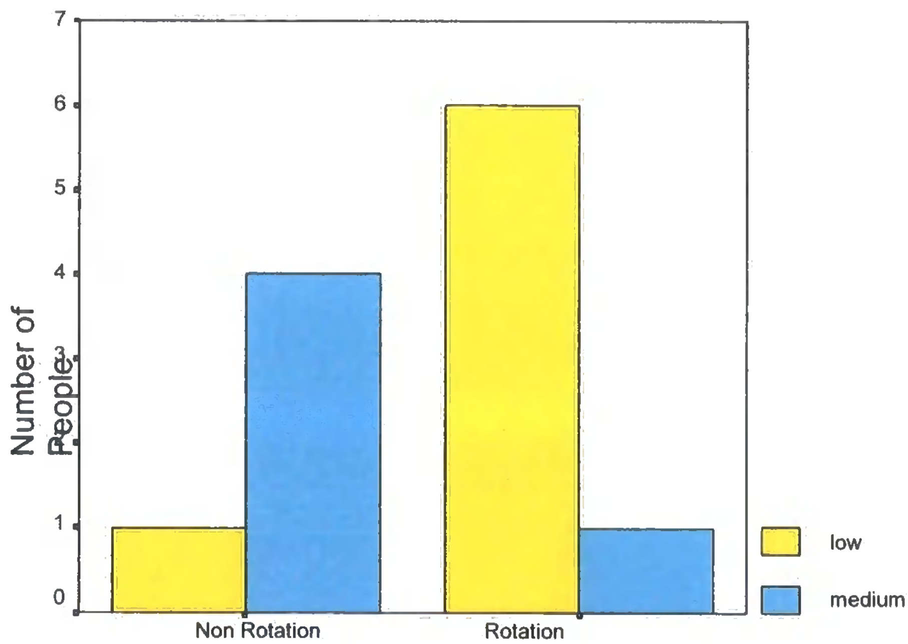
Effects of rotation on body parts

Table 5.4 Number of body parts suffering from discomfort in rotational and non rotational duties

Week 5	Non rotation	Rotation	Total
No body parts	1	8	9
One body part	0	0	0
Two body parts	3	1	4
Week 6			
No body parts	0	3	3
One body part	1	2	3
Two body parts	2	0	2
Week 7			
No body parts	0	2	2
One body part	2	2	4
Two body parts	2	0	2

The information in Graph 5.6 was collated by calculating the average discomfort of people on CDT prep Fridays, and creating three categories of discomfort. The first category is 0-3, the second category is 3-6 and the third is 6-10 (no-one was in the third category). As shown in Graph 5.6 six people from the rotating group had an average discomfort between 0 and 3. There is some evidence that the average discomfort on a Friday differs for rotating and non-rotating people as (Fisher's exact test gives a P-value of 0.07). The evidence is not fully conclusive as the number of people tested is rather small (only 12 people).

Graph 5.6 Average discomfort among people on Cathode Display Tube (CDT) preparation in the Personal Computer Monitor factory (PCM), on a Friday in job rotation and non-rotation.



Discomfort was analyzed on a Friday as fatigue would be expected to be at its highest after a week at work, rather than on a Monday when the employee has had a rest period. Fatigue would be expected to be especially high for those that had remained on the same job, as the stress levels to the same areas of the body would theoretically be significant.

Table 5.5 Pearson's Correlation - Grip / Discomfort based on data from week 1. (Variables are made up of three components, right or left hand (R or L), 1st or 2nd Measurement (1 or 2) and Monday or Friday (M or F).)

	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F	Discom-fort Monday	Discom-fort Friday
R1M	1.000	.991*	.871*	.885*	.785*	.786*	.660	.799*	.137	.756*
R2M	.991*	1.000	.913*	.926*	.801*	.784*	.702*	.830*	.178	.789*
L1M	.871*	.913*	1.000	.996*	.829*	.828*	.865*	.907*	.278	.825*
L2M	.885*	.926*	.996*	1.000	.828*	.824*	.865*	.905*	.231	.796*
R1 F	.785*	.801*	.829*	.828*	1.000	.928*	.617	.883*	.025	.684
R2 F	.786*	.784*	.828*	.824*	.928*	1.000	.705*	.908*	-.096	.711
L1 F	.660	.702*	.865*	.865*	.617	.705*	1.000	.873*	.281	.681
L2 F	.799*	.830*	.907*	.905*	.883*	.908*	.873*	1.000	.120	.744
Discomfort Monday	.137	.178	.278	.231	.025	-0.96	.281	.120	1.000	.614*
Discomfort Friday	.756*	.789*	.825*	.796*	.684	.711	.681	.744	.614*	1.000

** Correlation is significant at the 0.01 level (2 tailed)

*Correlation is significant at the 0.05 level (2 tailed)

Table 5.5 shows that the grip measurements are repeatable, as the correlations between two measurements made on the same hand on the same day are very high. For example, the correlation between the first and the second measurement on the right hand on Monday (R1M and R2M) is 0.99. It was noted that the correlation between the first and second measurement was also high (over 0.87) if the measurement was made on the left hand and/or on the Friday. This assessment entailed two grip measurements on the same hand under the same conditions, and therefore it was expected that the correlation would be high.

The correlation between measurements on different hands but on the same day is also fairly high, but lower than correlation between measurements on the same hand, this was to be expected as different factors may play a role in affecting left and right hand grip measurements. Correlations between measurements on different hands but on the same day (for example between R1M and L1M) vary from 0.62 to 0.93. Surprisingly, discomfort on Friday correlated with the measurements made on Monday, while it did not correlate with measurements made on Friday. This is probably co-incidental, as for similar data of the rest of the weeks this was not found to be the case.

The correlations between measurements on the same hand on Monday and Friday were also fairly high and significant, varying from 0.78 (between R2M and R2F) to 0.91 (between L2M and L2F). There was no significant correlation between discomfort on a Monday and grip measurement ($p > 0.05$). The small study size may be the cause for not finding a significant effect and this may have affected the overall result. From a statistical analysis point of view, the sample is very small and a more powerful analysis could have been performed in a larger study with more participants. The importance of the grip score is that it provides a baseline by which to detect whether there is any later improvement or deterioration. One person had a low grip score, which was partially attributed to anthropometrical differences where the hand and digit size were small for the build of the individual and therefore allowed less application of grip (see appendix 9). All the grip scores of all the employees in the BTM study in MWO are in appendix 9, these scores were analyzed against appendix 8, which contains the normal grip score levels for males, as only males were in the BTM study.

It has been found since the research that MWO has increased its job rotation but not on all production lines. All the employees in the case study (table 5.1), it appears by observing the jobs and the physiology of WRULD based on diagnosis and citations based on work relatedness and the results of the study in Company X that by job rotation it is highly likely that these WRULDs could have been prevented by job rotation. Since the research, presentations have been given to the senior management in an effort to encourage job rotation. These presentations have been based on the findings of medical problems matched with the physical duties and the physiology backed up with research; and also considers the new problem of the increased grips within the TFT at PCM. There has also been emphasis at these presentations on the HSG 60 revision and RIDDOR catching up with the research and how this will affect the company if they are not job rotating. Three people not on job rotation in one month alone in this year had WRULD that eventually may be reportable under the new regulations and research. The law was also emphasized in these presentations and the effects of compensation on the company. Since the research, improvements are going ahead with the ergonomics of the transformer job at MWO. In Chapter 6 ergonomic changes that are occurring with the transformer job are discussed.

Based on the findings of this information from table 5.1 and the illustrations demonstrating the postures required on the jobs and the physiology, this led to Chapters 6 and 7 which defines the job rotation choices based on Chapter 5. Table 7.1, the PCM rotation scheme, demonstrates the use of different grips to alleviate fatigue. There is an alternation from a pincer grip, to a power grip when using downdrivers, to a visual job which require no use of grip to allow muscle/ tendon group rest. Table 7.2, the MWO rotation scheme, also uses the principles of alternating grip and scores but does not include the capacitor job as this has now been outsourced.
The findings of the results of the statistics on discomfort further acknowledge that job rotation will be effective in reducing WRULD and discomfort.

5.4 Site determination for job-rotation

In order to eliminate any bias, the employees were not made aware of the full aim of my studies. It was not asked whether the employees would prefer to rotate duties or not until the main data collection was completed. I was concerned that upper limb discomfort might be being reported; under the disguise that some employees may report minor symptoms (with no detected signs) as a means of being allowed a restriction from their usual job. If not addressed, such discomfort or boredom with their job could lead to psychosomatic problems.
The study did bring forward two pronounced cases of WRULD. The findings from the initial ethnographic research and the study revealed that discomfort was significant. A person came forward with elbow problems related to docking of the CDT and a further person came forward with a medical condition possibly related to their previous employment.

Under-reporting

In Company X, 55 cases reported discomfort from March 1997 to September 1999. All could be suffering from WRULDs, and were registered on the database, although not all were confirmed as sufferers of WRULDs owing to diffuse symptoms with lack of concrete evidence. The time taken to report symptoms varied considerably (see Table 5.6).

Table 5.6 Numbers of people reporting symptoms and the time variation of duration of symptoms in the 55 cases between Mar 1997- Sept 1999 in Company X

Duration of symptoms in weeks	The Number of people reporting symptoms
<one week	16
1-4 weeks	16
4-8 weeks	7
8-12 weeks	5
6-18 months	6
Information not available	5
Total	55

Lengthy delays in reporting make it difficult to confirm WRULD and may arouse suspicion as to whether the injury / symptoms were work–related. Management and supervisors will wonder why the employee had not disclosed that they were feeling discomfort earlier. The delay of reporting also may make it difficult to analyse whether the condition is work-related as all previous risk assessments may not detail any problems identified to work-related upper limb disorder. The spontaneous action of certain medical conditions for example lateral epicondylitis make the causative factor sceptical as whether work related or has not just occurred spontaneously, especially in the 40-50 age group where this is common (Almerkinders 1998). The specific jobs the employees were performing at the time may not exist anymore and those specific models not built. Therefore to analyse the job and observe the individual performing the job will not be possible. Reporting symptoms early allows a full work place assessment to be performed by the Occupational Health Department at the time of discomfort.

The only information that was available on work-related upper limb problems in Company X was based on claims and positive diagnosis data, apart from a discomfort reporting procedure. The claims for musculoskeletal problems allegedly caused by work-related upper limb disorder within the Company by January 2000 were 25 percent of all claims. The other 75 percent of the claims were related to accidents. Claims over the following year for work-related upper limb disorder, January 2000 – 2001, was at 14 percent of the total accident claims for that year, with fourteen claims for accidents and two for WRULD. There is a possible overlap between accidents and work-related upper limb disorder where the latter is the result of post-traumatic injury, (where a physical injury occurs leading to a WRULD as the original injury has not settled enough before returning to work and exacerbation the injury (ID2 Table 5.1). Like work-related upper limb disorder, post-traumatic injury causes lack of concentration or fatigue, increasing the risk of further accidents.

An interesting observation is that claims that have been pending tend to be made by employees that are not satisfied with the way they are treated at work by their seniors, or the employees claim because they feel that the company has not taken them seriously and there has not been enough done post prevention. It is doubtful that some of these employees will actually receive a claim based on their diffuse symptoms. However it emphasises the importance of the well being of the employee in regard to how he perceives he is treated at work. Employees who feel they are regarded and respected by their managers tend not to make a claim despite being likely to be successful in receiving a claim. These employees may have a positive perception that the company meant them no harm (Table 2.4). It is estimated that in 1995 over one million people in Great Britain were suffering from a work-related musculoskeletal disorder (Jones et al 1998 -SW195 survey 1995).

5.5 The psychology and advantages of job rotation

Owing to the high turnover rate within the company, I had concerns that boredom might be one of the criteria for leaving the company. If so, it had significance for the well-being of the employee, and implications for training and rotation (Broadbent 1986). I was unable to obtain data on exit interviews as these tended to be performed by the Human Resources personnel and data was only in personal files and not generated as statistics. Therefore any attempt to access data was denied. In view of previous research on the lack of job satisfaction as a result of repetitive boring work (Broadbent, 1986), job rotation should be seen as one answer to the company's high level of staff turnover.

Table 5.7 **Turnover in Company X**

Monthly Turnover				
Year	Month	Employed	Leavers	Turnover %
2000	Jan	1069	1	0.1
2000	Feb	1151	6	0.5
2000	Mar	1152	42	3.6
2000	Apr	1222	170	13.9
2000	May	955	177	18.5
2000	Jun	970	91	9.4
2000	Jul	927	10	1.1
2000	Aug	984	105	10.7
2000	Sep	952	120	12.6
2000	Oct	939	111	11.8
2000	Nov	960	63	6.6
2000	Dec	902	112	12.4
2001	Jan	882	50	5.7
2001	Feb	888	77	8.7
2001	Mar	875	70	8.0
2001	Apr	904	70	7.7
2001	May	867	68	7.8

Yearly Turnover				
2000	All	1015	1008	99.3
2001	To May	886	447	50.4

$$\textbf{Turnover rate} = \frac{\textbf{number of leavers}}{\textbf{average number employed}} \textbf{ X 100} \quad \textbf{(CBI 1999)}$$

If the turnover is 50.4% as shown in table 5.7 from January – May in 2001 the new employees are more likely to be accident prone and the lack of warm up time would contribute possibly to higher incidence of WRULDS. There is paucity of researched data that improving muscle strength and flexibility will prevent WRULDs. However, there are indications that exercise programmes are useful in improving circulation of those in hand intensive jobs. Further benefits are, improved joint flexibility, muscle extensibility, improved posture, muscle tone with reduced stress and improved morale (Childre & Winzeler 1995). Exercise programmes need to be managed well to prevent embarrassment (Lee et al 1992). This evaluation paper provides a substantive breakdown of useful and non useful exercises mainly aimed at video display terminal users (Lee et al 1992). Proper et al (2002), found that exercise showed that it reduced absenteeism, although limited. They felt the scientific evidence on the physical activity programs at worksites is still limited owing to insufficient high quality controlled trials and that future randomized control trials are necessary, paying special attention to the description of randomization, inclusion criteria, compliance and analysis, according to intention to treat, as currently trials failed to be explicit in these areas (Proper et al 2002).

In Company X an exercise programme was developed by the physiotherapist and Occupational Health Advisor but, owing to the fact that the company wanted little disruption time to productivity, they would only release one line. Eventually the employees on the one production line felt embarrassed and were not keen to continue unless other lines were involved (Lee et al 1992). The manager would not give permission to involve the other lines therefore the exercise was disbandoned, despite the improvement in productivity, which obviously was not accepted to be in relation to the exercise programme.

There might be a link between a high turnover rate and WRULD: the more frequently people leave, the more training is required and the longer people stay in the job they are training for before they can move onto another job and then rotate. Non-rotation increases the risk of WRULD, leads to boredom and increases people's desire to leave. The turn-over rate in Company X is very high, and in January to May 2001 as stated it was 50.4, percent already over half the workforce. The recruitment and training costs of this turnover must be phenomenal. The ratio of agency to direct staff keeps increasing and although this keeps down costs of sickness absence and redundancy pay outs, overall it is quite costly. Probably very little of the staff turnover in Company X has anything directly to do with WRULD or discomfort but indirectly it does have an impact on the current employees with regards to training and rotation. The turnover rate in 2002 was 18.1 percent for direct staff and 271.3 percent for agency staff. The agency employees, in 2002 were 38 percent of the total workforce. The agency staff is used for flexibility of employment as they make it easy to increase and decrease the number of employees at a week's notice but the cost of the high percentage turnover is felt in training for different jobs and fulfilling effective job rotation. As new employees start work they need time to train up on specific jobs before they can rotate effectively. If the turnover is high, it means that existing employees are continuously waiting for new employees to train up and become proficient enough to be able to rotate jobs. Ideally a production line should primarily be running to include training.

The annual turnover rates for labour in 1999 in the Northern region were 16.2 percent and 17.2 percent in companies with between 499 and 4,999 employees, and 17.7 percent for manufacturing companies (CBI 1999). Company X of the study between January and May is thus almost three times the annual expected turnover rate. It is a pity that that the CBI statistics are not broken down into types of manufacturing, as car manufacturing has a lot more problems, with heavy parts to move, and more manual handling, working in very awkward postures and labour- intensive tasks. The electronics manufacturing industry possibly has a lower annual turnover (Chung 2001).

The Human Resource (HR) function is undermanned and requires extra staff to provide full statistics on sickness absence, with a breakdown of reasons for absence, exit interviews information and proactive action to prevent the high-turnover rate. The long-term benefit would far outweigh the cost implication of another HR employee. Currently the turnover in HR is 25% and this needs to be reduced, as these people are core communicators and provide much of the information to encourage effective management principles within the company.

In 1998 PCM had three more reportable accidents than MWO, but between 1999 and 2000 MWO had a higher level of reportable accidents than PCM (Table 5.8). MWO halved its total number of reportable accidents from 4 to 2 in 2000.

Table 5.8 Accidents in the Microwave Oven (MWO) and Personal Computer Monitor (PCM) factories- in the study of Company X

Site	Year	Work -ing Days in the year	Total Accidents	Report-able Accidents	Total Staff	AIR= Number of reportable accidents X 100000/ No of Employ-ees in one year	ASR The Accident Severity Rate (ASR) = Total lost time owing to accidents x 100,000/ working time in hrs	AFR The Accident Frequency Rate (AFR) = Total number of Accidents X 100,000 / Total of Working Time	SIC code The Standard Industry Classifi-cation A classified code for different types of industries	Industry Standard Accident Incident Rate (AIR) reported that year for the SIC code (reportable actual level for all industries under this code – see below table
MWO	1998	226	168	4	338	1184	43	27.5	31	1356
MWO	1999	231	130	4	336	1190.5	41.9	20.9	31	1318
MWO	2000	230	94	2	383	522.3	21.5	13.7	31	1337.07
PCM	1998	226	177	7	518	1351	35.9	18.9	32	972
PCM	1999	231	116	3	448	670.3	22.6	14	32	973.07
PCM	2000	230	107	1	483	206.9	5.6	12.3	32	957.40

SIC 31= Manufacturing of electrical equipment (microwaves)

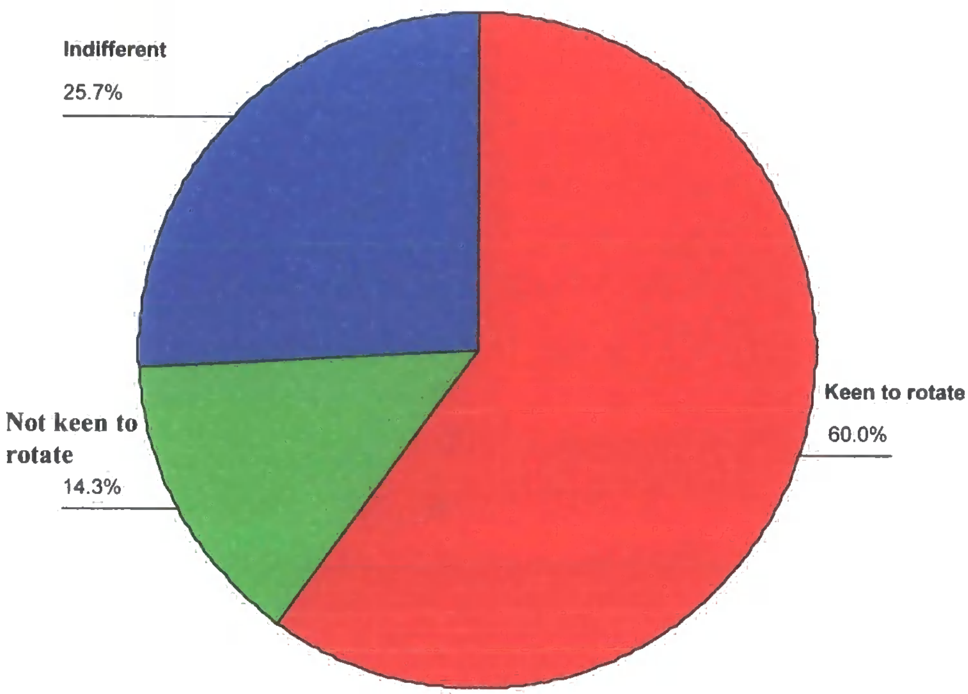
SIC 32= Manufacturing of Communication equipment e.g. computers

An acceptable level is a rate below the Industry Standard Accident Incident Rate. In Company X the Accident Incident Rate (AIR) at the Personal Computer Monitor factory in 1998 was above the British Safety Council level but it fell to almost a sixth of its 1998 level by 2000 and is currently at only 21 percent of the British Safety Council standard. Microwave Oven factory has never had its accident incident rate as high as the level of the British Safety Council AIR standard (Table 5.8) and reduced its own by almost 49 percent from the year 1999 – 2000.

The 1997 statistics in Company X for Microwave Oven saw a 21 percent reduction in accidents over the year; for Personal Computer Monitor a 14 percent reduction. The target for 1998 was for a further 10 percent over the whole site. Every month the statistics are reviewed and brought to the Safety Committee on each site. A summary is provided for each supervisory area with an anonymous accident history for each individual accident. Every year at the Board of Directors meeting, a new target is set for improvement.

Graph 5.7 represents the preference of employees with regards to job rotation. This information was collected after the main data collection rather than prior to the study to ensure it would not influence the outcome by making employees aware of the objectives of the study.

GRAPH 5.7 Preference of the employees in the study to rotate, non-rotate or indifferent.



Of those participants available to approach with regard to their choice for or against job rotation 42 were keen to job rotate, 10 were not keen to rotate and 18 were indifferent. Out of the 10 of those not keen to rotate two had medical conditions (not work-related) and felt that to rotate to other jobs might exacerbate their symptoms. Other employees felt they were good at their job, and didn't mind it, and were concerned about the time it would take to retrain for another job. An employee said about rotation, "Any employer with any sense could not fail to recognise the clear advantages of making a more monotonous job more interesting, creating some variety for their employees". Originally there were 81 participants in the study. Only 70 were asked about their preference for job rotation as because out of 81, 1 had refused to participate in the beginning, 1 had moved his job to a totally different area, 4 were unreliable sources as they continually forgot to bring in paperwork and 5 employees had left the production line in that short space of time.

Traditionally the Occupational Health Advisor / Nurse is expected to react to what the company perceives as its main concerns. There are many times when there may be a political agenda for pursuing certain issues or it may be that management does not want to believe they have any problems or are misled as to their main problems. In Company X work-related upper limb disorder could have been foreseen, as it is known to be apparent in the electronics industry (RIDDOR 1995: Reporting of Injuries, Diseases and Dangerous Occurrences Regulations). The low number of people reporting work-related upper limb disorder and discomfort in Company X did not appear that the problem was significant. However the findings from the initial ethnographic research and the study in Company X revealed many more employees in fact suffer from discomfort even though much of it is diffuse. It seems the majority of employees have discomfort even if it is only fleeting as two thirds of the employees in the study self–reported discomfort of different varying degrees.

A Brief Summary of Chapter Five

This chapter has discussed which WRULDS in Company X are preventable and the importance of job rotation is demonstrated by the fact that these people in the case studies have developed specific conditions related to specific jobs and that when job rotation was introduced the symptoms started resolving. The differences were examined as the decreased discomfort in PCM in comparison to MWO may have related to rotation taking place in PCM only or by differences in the sites due to other circumstances, for example the types of job. Whether the different discomfort levels could indeed be caused by the differences in jobs was something that needed clarifying. There appeared to be some association between the level of discomfort experienced by the employees and the types of jobs carried out, which is a possible explanation of the difference in discomfort levels between PCM and MWO. To find out whether job rotation could reduce the amount of discomfort in a particular job, a specific job in PCM, Cathode Display Tube preparation (CDT prep), was analyzed. It was found that those who partook in job rotation suffered less discomfort. The extensive description of the medical diagnosis in relation to the duties in the study of Company X matched with the physiology and body postures applied. Based on the physiology of some of the conditions of WRULD and the findings of the present research WRULD/ discomfort, is found to be preventable where job rotation takes place. Therefore, it was pertinent to define which jobs should rotate with which to provide effective job rotation. Hence the next chapter implementing innovations in Company X.

Chapter 6 Implementing innovations in Company X

Introduction to Chapter six

The findings from the last chapter demonstrated that implementation of job rotation would be beneficial for the employee and company. In this chapter job rotation was analyzed and a rotation programme for the boxing end of PCM was recommended. However, since this recommendation, the process changed and the CDTs were replaced by TFTs monitors. The risk level of the jobs was considered with regards to the result of the job action analysis and low medium and high risk jobs were intermingled. The object is to continue to try to keep lowering the risk level score itself. Ergonomic solutions were a major concern especially with the transformer job and three solutions were recommended to resolve the problem.

6.0 Management of WRULD in relation to research

In 1995, in a company where packing operations were performed to pack the end product, there were concerns that the job process may be causing lateral epicondylitis. A consultant ergonomist was contracted in to the company to identify if there were any work related elements to the upper limb disorders of employees that were working in the packaging area. The ergonomist concluded that "many of the postures and activities observed could be categorised as contributing to general wear and tear rather than generating an acute risk" (Smyth & Bennet 2000). Management response was very supportive, and automation was added to the process; ergonomic changes and job rotation was introduced every 30 minutes on all workstations to reduce the risks of WRULD and help in rehabilitation. By 1996 all the cases of epicondylitis were successfully rehabilitated. In this case it is difficult to identify how much of the recovery was due to workplace redesign and how much due to the job rotation. This is the problem with research in that where there is more than one element imposed it is not possible to say which factor was the successful one; it could be either or an element of both or possibly but unlikely by pure chance.

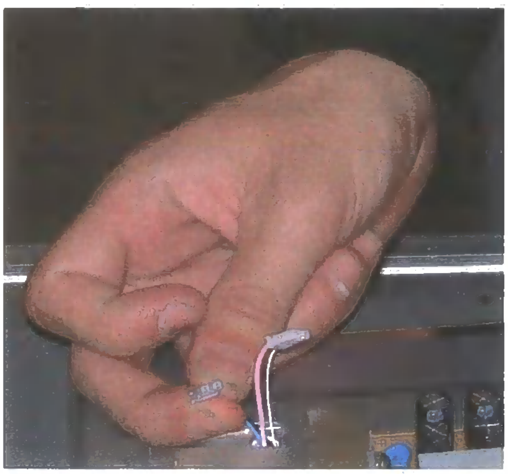
There is confliction in research especially if the methodology is not clearly defined. Flexed wrist and extended wrist are a risk factor for carpal tunnel (De Krom et al

1990). Pinch grasp has been noted in Armstrong and Chaffin (1979) to be associated with carpal tunnel syndrome but this was not found to be the case in another study (De Krom et al 1990). This may be because in Armstrong and Chaffin's (1979) study that the pincer grip was performed with the wrist out of neutral whereas in De Krom et al (1990) the wrist may have been in neutral when applying a pincer grip (although not stated) therefore causative factors are more likely to be related to the deviated wrist position or exerted forces within the pincer grip as a combination of the wrist deviated position. De Krom et al (1990) do not define whether the pincer grip was static and repetitive or dynamic, it only provides the hours of exposure in the week. Armstrong and Chaffin (1979) identify that the grip was used when tugging on heavy fabric to align it as it went through the sewing machine. This job is repetitive and requires a great amount of force which will soon give fatigue. The grip would be more described as a palmar pinch or grasp rather than a pincer grip. The job will be forceful and the wrist would need to come out of neutral and as fatigue occurs the wrist is liable to come further out of neutral still flexing the wrist further as the smaller hand muscles fatigue. The conflicting research therefore does not clarify enough in the plan of job rotation. Despite this it is well known that the pincer grip and deviated wrist positions are precursors to WRULD, the former de Quervains tenosynovitis and the latter carpal tunnel syndrome, and as a preventative strategy jobs involving these activities should be job rotated.

The pinch grip is an important posture as calculations indicate that the use of the pinch grip can result in 20% to 50% more force in the tendons adjacent to the median nerve than occurs in the power grip. Therefore it is suggested the pinch grip is more liable to lead to carpal tunnel syndrome than if the power grip is applied (Armstrong & Chaffin 1979).

In the illustration 6.1 the person is using a pinch grip with the thumb and mid finger in opposition bringing mid finger and thumb tip in contact. Sometimes this application is used as an alternative but it can be noted that the wrist is in neutral.

Illustration 6.1 pinch grip using mid finger in opposition



Also gripping with the palm down and in clockwise rotation is a risk factor for lateral epicondylitis and anticlockwise for medial epicondylitis and increased risk with an extended wrist for lateral and flexed wrist for medial epicondylitis.

6.1 Rotation programmes

Diagram 6.1 Rotation programmes

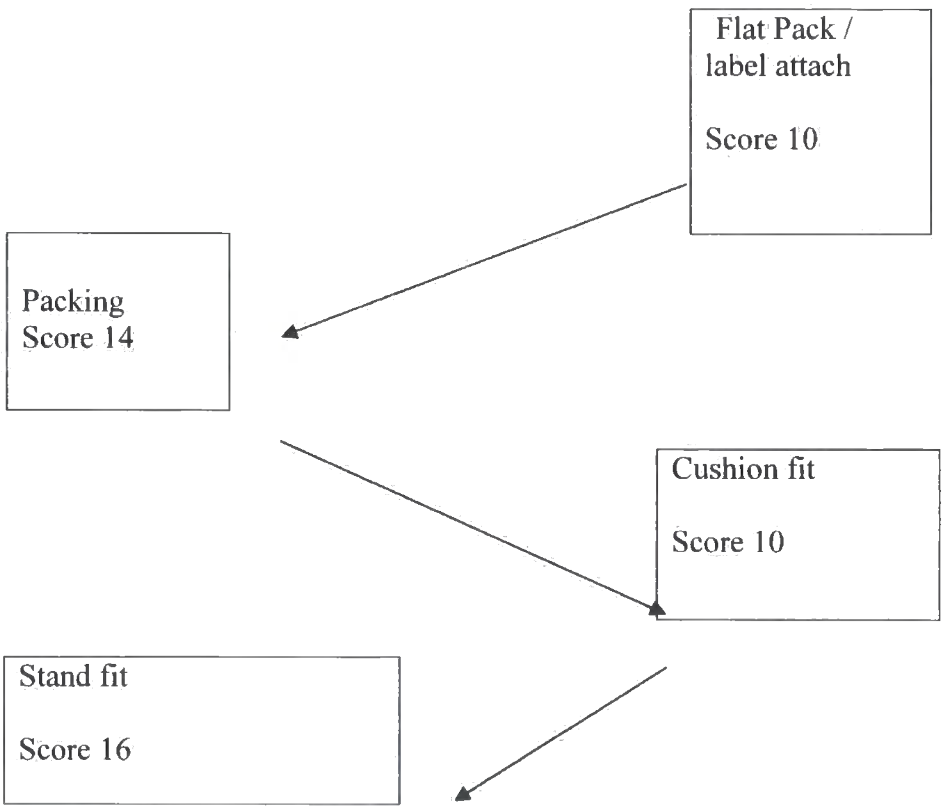


Diagram 6.1 is a rotational programme that was suggested to the supervisors / team leaders. Diagram 6.1 is the designed hourly job rotational scheme for packing. Up till

very recently there became only one CDT line, prior to this when four lines were operational the four lines were rotating as follows: Two of the lines were job rotating the packing and flat pack jobs but no rotation of duties was taking place on cushion fit or stand fit duties. One of the lines was rotating the packing job with stand fit, but not rotating cushion fit or the flat pack job. The rotation here was not significant as employees were moving between jobs with almost the same score of 14/16 and therefore it was not effective rotation.

The packing job entails lifting the monitor and placing it in the box. In view of the weight of the box (illustration 5.13) the turning of the box could lead to tennis elbow (lateral epicondylitis) or to shoulder tendonitis as a result of the rotation movement in passing the box across the body.

The flat pack job involves turning under the bottom flaps and turning out the top flaps of the box, erecting the box ready for packing and applying a sticker onto the box. Until recently the flat pack job involved, with certain individuals flick-turning the box with the arms away from the body twisting the wrist. This manoeuvre can lead to wrist problems, as it also requires movement out of neutral. It could create minor shoulder problems and thoracic problems. Although the box is not a heavy item it has to be flicked well away from the body in order to give it enough turning room if not performed whilst on the conveyor. Note that in appendix 10 this specific job has a score of 14. Once all the employees turned the box on the conveyor this prevented the flicking of the wrist (which had been certain individual's bad practice). The delivery of the boxes to the employee reduced the regular lifting at the waist therefore reducing the overall score to 10.

Stand fit involves erecting the stand for the monitor ready for packing.
Cushion fit is the outer packing for the monitor to keep it safe in the box. The employee picks up two polystyrene cushions and bashes the cushions together with each hand around two sides of the monitor with the elbows almost at 90 degrees. The results of each job can be seen in diagram 6.1 and a further breakdown of the job action analysis (appendix 10). One line was allowing rotation however the employees saw fit. The jobs included packing, cushion-fit and stand fit, but not the flat pack job. No monitoring of

the rotation activities was taking place and for any prevention strategy it is important that all rotation is monitored. I believe that the company will generally buy the idea of job rotation if it does not interfere with production. Currently quite a few areas are rotating on a two hourly basis every break. If this was monitored against those not rotating the company may then decide if this has been effective to rotate all employees every break. Even more significantly the company can then monitor how effectively the job rotation is working when all employees are performing job rotation every break. As discussed earlier we do tend to advise hourly rotation based on research (Bergamasco et al 1998). The occupational health department staff does send people back to work after employees injuries have settled, onto hourly job rotation. However there has never been a report of anyone suffering WRULD that has been on two hourly job rotation.

Owing to their close proximity to each other in these four jobs in diagram 6.1 employees can swap with minimal disruption to production. The jobs are immediately adjacent to each other and therefore timing for change over can easily be organised between the four employees as they are within speaking distance from each other. It would be possible to arrange rotation from the opposite end of the line but confirming time changeover would be difficult owing to the distance apart and could have a detrimental effect on the production levels owing to delay time. For ease and greater awareness of the full job within this process it is best to rotate those adjacent to each other where they are observing the full process and have greater understanding of the whole job; where possible if this fits with improving the overall scores and allows for rest periods of different muscle groups.

Ideally rotation would take place in the order shown in diagram 6.1 as this way the two jobs with a score of 14/16 which require a different application of grip would not be consecutive and would allow for medium scores of 10 in between. In the BTM earlier we noted the scoring level (Table 3.10) (Table 6.1). Medium (9-14) flat pack is within this criterion at 10 and cushion fit is also medium at 10. Packing is 14 and therefore medium although this drops to 10 (a low medium) if using the lifter. Stand fit have a score of 16 and therefore is high as it is between 15-18. This means that the employee starting on flat pack spends an hour on the medium risk level then an hour on each other medium level and an hour high. This means that between the level of 14 and 16 there is a lower level medium of 10 on each occasion. It is necessary to keep looking at ergonomics to consider if the scores can be further lowered.

Table 6.1 risk level

Risk level	Score
Low	0-8
Medium	9-14
High	15-18

Currently these duties are under review and the company is now only running one CDT line as the company moves further towards all the production lines building the stand Thin Film Transistor (TFT) monitors and the possible total phasing out of the CDT monitors. If new jobs are coming into the company they should be job rotated from the beginning. Ideally they would have an ergonomic assessment prior to starting the process. In reality this is not always the case in companies and where critical safety such as electric shock or accidents may occur this may be top priority; but ergonomics appears to be low on the profile. Most of the medical conditions in fairness do take some time to develop and there may be some short leeway till an assessment is arranged; however this amount of time is unknown. We are aware such conditions as de Quervains tenosynovitis can develop quite quickly and therefore any company working in this way leaves themselves open to conjecture. In Company X there is a close relationship between health and safety and occupational health and this may have had some impact in the reduction of WRULD as both teams see it as still a major problem if not managed and prevented.

6.2 Ergonomic solutions

Solutions to the problem of the weight with regard to the transformer job in MWO are as follows:

The transformer currently weighs 4.7 kgs and under stress of the sustained hold whilst supporting the transformer whilst it is being fixed into position this weight is further increased. The production line output is approximately 180 microwaves an hour and the employee on the transformer job performs this action for every microwave, the output has not changed since the study. Divided up this means that every 20 seconds the employee performs this action, in reality the tact time will often be quicker as these figures include down time for quality problems etc.

Solution (1) would be to use a more efficient lighter torroidal transformer. This uses a smaller size core allowing a continuous flux flow of energy. The problem is that the extra cost of £20 for a torroidal (AGW electronics) as against £12.00 for the current transformer would take it out of the market. Buying in bulk would bring down the initial price but the ratio difference would stay the same. Moreover it would not solve the technical problem as the core would require 4-5 windings of insulation owing to resistance, and therefore the overall weight of the transformer would probably not be significantly reduced. The maximum reduction of the overall weight of the transformer would be approximately thirty percent which is 1.4kgs which means that the transformer will weigh 3.29 kgs. This means that the torroidal transformer is still above the weight for use with one hand, as application for the use of two hands is any weight over 2.25kgs. Therefore use of this more expensive torroidal transformer which is highly likely to take the microwave out of the market price it does not appear is an option as handling the device will still require the use of two hands with possible financial detriment to the company. There still also may be increased fixing problems that may not be apparent till a prototype is made and it could create more problems with regards to WRULD than anticipated.

Diagram 6.2 demonstrates the workings of a high voltage transformer. The alternating potential (mains 230 V) applied to the primary winding induces an alternating magnetic flux within the core of the transformer. This magnetic flux in turn produces an alternating voltage across the secondary windings. The induced voltage is proportional to the number of turns of each winding.

Diagram 6.2 High Voltage Transformers

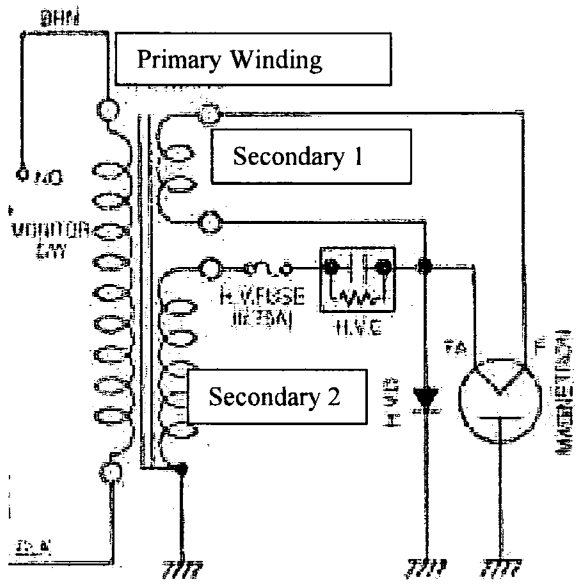


Table 6.2 demonstrates the type of winding required and the voltage output that occurs, the amount of turns required to produce that voltage, and the effect this has on the diameter

Table 6.2 Data for the transformer (diagram 6.2)

Winding	Voltage	Turns	Diameter
Primary	230 V 50 Hz	210	1.15 mmsq
Secondary 1	3.12 V	3	1.0 mmsq
Secondary 2	2230 +- 30	2170	0.36 mmsq

Core Size 105 X 87.5 X 69 millimetres.

Solution (2) would be to obtain a tool for the BTM that would cut out a lip on the cavity into which the transformer could be slotted. This would take some of the weight while the transformer is being screwed in. The tools can be quite expensive. This still would not solve the problem of the claw grip with rotation of the hand, which could only be overcome by arranging for shipping it in the opposite way up. In otherwords currently the transformer arrives from abroad with the smooth plate edge down over it then needs to be turned so that it is fixed at the top of the microwave (Illustration 5.1 to 5.3). This unnecessary turning of the arm in preparation to fix in place the transformer can lead to the development of epicondylitis either lateral or medial depending upon the directional turn and it can also put the employee at risk of tenosynovitis. The claw grip can lead to trigger finger and if performed with the hand out of neutral is identified as a risk factor for carpal tunnel syndrome (De Krom 1990). Therefore the transformer should arrive the right way up (not required to be turned) and be fixed via the use of the jig meaning that the employee is not having to maintain a claw static grip and instead the transformer will be lifted with two hands straight onto the jig and the use of the jig will prevent the strenuous effort from the employee having to support the transformer. The employee will then be in an easy position just to down-drive in the screws with the dominant hand. The employee should still be job rotated as the transformer job still requires a power grip when driving

Solution (3) would be to build a jig and arrange for the transformer to arrive the other way up. This option is the one that has been chosen as a solution to the problem and is currently in its second build as a prototype.

Innovations and economics

I doubt that the transformer job could be automated owing to the precision required to do the job, and after speaking with the engineers this appears to be the case. The expense of automation, even if possible, would be astronomical and may not be thought to outweigh the human costs incurred through sickness. Although sickness time was low in the case studies it is not clear financially the costs incurred in Company X with regard to sickness owing to WRULD or to the individual. Currently there is no ongoing litigation related to this job. Even so, the concern in production is that already it is dearer to build in this country compared to cheaper labour abroad. It is the quality, efficiency, productivity and the adaptability to change that keeps the company in business and we need to increase production each year to keep our place in the market without increasing costs. Solution (3) combined with effective job rotation would reduce the risk of WRULD. Currently the jig is being reworked ready to use for the new models coming in and should be in place by the end of 2003.

Summary of Chapter 6.

It appears that certain innovations were accepted and the willingness to build the jig for the transformer job at least shows some commitment. The overall idea is to limit the score in the job action analysis by looking at possible ergonomic interventions and then consider job rotation. For example job rotation in the transformer job is fine but without the changes in the ergonomics the job still remains high risk, until the running of the build of the microwave with the jig in place. The rotation programme for the boxing end of PCM was recommended and there was some improvement in the amount of rotation taking place. However, with the process changing and the CDTs being replaced by TFTs monitors it was not possible to monitor whether the recommendation would have stayed permanently in place.

Chapter 7: Work Ergonomics -

Introduction to Chapter seven

Now that the innovations in Chapter 6 had been somewhat accepted it was time to consider the work ergonomics. A rotation scheme was designed for PCM and MWO after the analysis of many of the jobs (tables 7.1 & 7.2). There was a necessity to make sure that management really understood the issues and legal aspects and therefore the reasoning for introducing presentations by the occupational health department was so that management was fully informed in order to make choices and take responsibility. The team leaders are probably the best people to monitor ergonomics since they have most recent line experience, and were specifically invited to the presentations. The occupational health nurse has had to take on a preventative role to increase senior management awareness of the issues of ergonomic assessments and job rotation and keep up to date with legislation of the HSE and RIDDOR in order to inform management.

7.0 In the light of the research

In the light of the research findings and the experience of conducting this MPhil research in Company X, it may be possible to introduce innovations and changes in the company resulting in improved productivity, reduced costs due to sickness and absenteeism and rapid turnover of work force. The health of the employees will also be better looked after. The previous chapters have detailed the need for job rotation within Company X as there has been defined WRULD cases as in table 5.1. The physiology of the conditions and the job action analysis and discomfort associated with these case studies have been found to match the conditions. The discomfort levels from the research revealed more discomfort was felt by employees that do not rotate and this further backs the case for job rotation. Not only have the case studies found to have problem with the specific jobs (Table 5.1), but other jobs have been defined as possible causes of WRULD based on the job action analysis.

7.1 The possibilities

The jobs could be more ergonomically designed and unnecessary movements should be eliminated such as unnecessary reaching behind a monitor with the wrist in a non neutral position such as the adjustment job mentioned earlier in PCM. Also the lateral rotation of shoulder taking place when collecting from trolleys at PCM this should be avoided where possible. The overall idea is to limit the score in the job action analysis by looking at possible ergonomic interventions and then consider job rotation. For example job rotation in the transformer job is fine but without the changes in the ergonomics the job still remains high risk

The PCM rotation scheme (Table 7.1) was analyzed using the job action analysis form (appendix 1). The risk score is required to move from a higher to a lower score and at the same time the type of grip applied should be varied as a preventative measure for the reduction of WRULD.

Table 7.1 PCM rotation scheme

Job	Neck	Back	Lower limb	Shoulder	Upper limb	Risk score	Grip Type
Wire dressing	0	3	2	0	3	8	Pincer grip
Chassis inspection	0	4	0	1	2	7	Visual / no grip
PBA fit	0	6	2	2	5	15	Uses down-driver
Video fit	0	3	2	0	4	9	Pincer grip
Tilt	0	3	2	0	3	8	Uses down-driver
DY wire	0	3	2	1	4	10	Pincer grip
Relocation	1	4	2	1	5	13	Lifting/ down-driver

There are many possibilities, but the company could start by rotating the top three duties (listed in Table 7.1) the wire dressing job, chasis inspection and PBA fit and the bottom four duties in table 7.1 with another group. Once the employees have been trained rotation should realistically be hourly. If the turnover rate was addressed by resolving the issues identified in the exit interview data and therefore retain staff, then it may be possible to rotate all seven jobs on an hourly basis. Currently this would be very difficult with the high turnover rate and the ratio of agency workers to direct. The agency turnover is currently higher than the direct staff and this greatly interferes with training and job rotation.

Printed Board Assembly (PBA) fit has a higher score for back movements as it involves obtaining boards from trolleys at different levels. Using the correct technique is very important to prevent injury, i.e. the person should squat to collect boards from the lower level rather than bend the back. Relocation can have a higher score depending on the size of the model build. Technique is also crucial on this job, and it takes some time to train employees for it.

On the chassis inspection job, the back score is lower. On some lines there is a machine to attach the sticker and this prevents the employee having to reach. It was recommended that all the lines purchase a machine to reduce the risk of injury, but this is highly unlikely to go ahead now as the company is moving towards building TFT monitors rather than this CDT model.

7.2 Policy of monitoring ergonomics

The team leaders are probably the best people to monitor ergonomics since they have most recent line experience, but because they have different education levels and experience in ergonomics the job action analysis needs to be reasonably easy to comprehend. Moreover if the analysis is time-consuming they may not to be able to allocate the necessary time to it. If team leaders take an interest in ergonomics the employees see that they are concerned about their health and well-being, which itself has a positive effect on the health and safety culture (Table 2.4).

The scores for the different jobs in the MWO rotation scheme (Table 7.2) were analyzed using the job action analysis form (Appendix 1). The total risk score was rotated by the results, (Magnetron 14, Fuse – 10, and Panels-12), which ensured risk reduction in total and also allowed for a change in grip type; all the jobs were in the medium risk range (9-14).

Table 7.2 MWO rotation scheme

JOB	GRIP TYPES	NECK	BACK	LOWER LIMBS	SHOULDERS	UPPER LIMBS	TOTAL RISK SCORE
Magnetron	Pinch & pistol driver	4	4	2	0	8	14
Panels	No drivers but pinch	0	4	2	1	5	12
Fuse	Pliers palmer	1	3	2	0	4	10

The capacitor job is now completed outside of the company and therefore is not in the matrix of Table 7.2 (appendix 10). The transformer job is quite likely to be included in the matrix in the correct position once the ergonomic changes and observation and calculation of the process has taken place. There is great emphasis on employees' technique and a requirement for an operating procedure to prevent the total score increasing. There are difficulties in rotation in MWO owing to the number of jobs requiring "driver" use, and therefore, where possible, pistol and down-driver use should be rotated at least hourly. The lines should not be split, e.g. into quality control and production, as what may be suitably divided for job rotation cannot be managed if they are ran as separate concerns. The lines originally were split but now that the quality jobs are all part of the general production this allows for a greater variation in job rotation.

Research into job rotation should lead to a reduced rate of sickness absence and staff turnover by providing relief from discomfort, boredom and lack of job satisfaction. Increased job variety and job satisfaction will have a positive impact on production. A company willing to take on such research will have recognition as a proactive leader in the field of research, which may also have a positive effect on the corporate image of the company. Claims for work-related upper limb disorder should decrease as with job rotation the amount of discomfort felt by the employees and the symptoms of Upper Limb Disorder will decrease. The job action analysis system measuring the level of physical workload can be used in the long term to update and record ergonomic job activity. An additional benefit of the system is that it can be built into an Access programme and thereby save the costs of pre-designed computer packages.

The feasibility of introducing changes within the factory are not impossible but at the same time difficult to persuade production to take on board further responsibilities and this is the reasoning behind the presentations being performed by the occupational health department so that management are fully informed to make choices.

Now all complex problems related to the possible development of WRULD are photographed using a digital camera and the pictures are incorporated into a powerpoint presentation. This presentation is given to the senior management in production maintenance, engineering, team leaders, and a member of the human resource team, so that all parties are aware of the issues to address.

The presentations for Company X and other companies with similar problems need to consider and include the following problem areas:

- 1) Habit / traditional methods
- 2) Production pressures
- 3) Perception of new methods as difficult
- 4) Identify poor understanding of WRULDs and increase that understanding.
- 5) Consider psychosocial factors

The whole of the occupational health team has an important part to play as the occupational health advisor / nurse, physiotherapist and doctor's ethos is to prevent illness/injury rather than cure. The role of the occupational health nurse in introducing innovative practice has been to observe and give informed choices to the production management. The occupational health nurse is the only full time health professional and has had to take on a preventative role to increase awareness to the senior managers on the issues of ergonomic assessments and job rotation and keeping up to date with legislation of the HSE and RIDDOR.

Summary of Chapter 7.

The case study employees have had medical problems with the specific job actions but since the development of the job action analysis other jobs have been defined as possible causes of WRULD, which is a very important issue for the employees, company and occupational health. Without the job action analysis these may have gone unnoticed as the qualitative measure of the job doesn't always match the quantitative. What can seem a relatively easy simplistic job can produce different results when quantitatively analyzed especially with a sensitive specific analysis for the type of work. The observation method HARBO (hands relative to the body) is rather a simplistic tool aided by a computer but only measures five postures; it does not measure if a person is in a twisted position. It is ideal for measuring long cycles such as movements over the day to get a full calculation, especially if comparing people in totally different occupations, but is not suitable for where there is short cycle time analysis and it is not clear how static postures are defined (Wiktorin et al 1995). Through the study it has been identified that observation methods need to be suitable for the environment where analysis is to take place and this is why the job action analysis in the study of Company X was designed. The job action analysis system measuring the level of physical workload can be used in the long term to update and record ergonomic job activity.

The system can be built into an Access programme and thereby create a saving of huge costs of pre-designed computer packages, which are likely not to be applicable, or financially viable to the company. Considering the researcher analyzed all the information and inputted it and the health and safety manager built most of the database the costs were very minimal. Now that all complex problems related to the possible development of WRULD are photographed, using a digital camera, the evidence is more apparent for the management etc, to see when they have been incorporated into the powerpoint presentation with the physiology demonstrated and the problems associated with the dynamic repetitive movements. For success these presentations need to cover the problems of habit and traditional methods, express the understanding of production pressures but be able to give some measure of time saving once job rotation or ergonomic intervention is in place. Here is a necessity to be aware of any perception of new methods as being difficult and be supportive and explanatory, encouraging more forward thinking people to encourage others. It is important to identify poor understanding of WRULDs and increase that understanding, as without that job rotation will not be accepted. It is necessary for the company to consider psychosocial factors and measure these with participation from employees. Its necessary to create a culture that is open and subject to any change that is for the better.

Chapter 8: Planning for a proactive service in Company X

Introduction to Chapter 8

Now that implementing innovations and work ergonomics had been reasonably achieved in Company X it was time to think about the planning of a proactive service in Company X. Work standard operations are mentioned and the need to take account of the ergonomics of the job and not just the general safety aspects; as previously mentioned individual techniques can be causative to WRULD and standard operations need to be finely adjusted to incorporate all risk factors. The percentage of people wanting to job rotate is discussed and that production should take the onus of job rotation rather than the occupational health department and this is probably best managed by the team leaders. The Occupational Advisor and physiotherapist can then assume a more preventative role in assisting the team leaders in any further ergonomic considerations. Some training in ergonomics should also be a priority to increase understanding of WRULD, so that when building equipment for the lines they consider ergonomics from the outset. The employees should be aware of the interest taken by the company in the prevention of injury and this would increase the health and safety culture which in turn may improve psychosocial factors. Many ideas were brought forward for recommendation on the collection of data etc. to improve staff turnover, monitoring sickness time, especially in relation to WRULD, and selecting candidates of the right calibre for a specific job. Recommendation is that all the return to work medicals and all pre-placement medicals be referred to occupational health by human resources.

8.0 Work standards

Cross sectional studies can only demonstrate an association between exposure and outcome. A full prospective cohort study with greater controls, more objective measurements and less extraneous variables within a company that is more open to research should serve to increase the knowledge base. This may succeed in providing research that promotes the implementation of job rotation. The aim of further study would be to investigate the effectiveness of job rotation in a factory where employees are required to use specific parts of the body repetitively for prolonged periods. The project would either confirm or refute the hypothesis that planned job rotation reduces work-related upper limb disorders and discomfort levels with long term economic benefits for the employer resulting from decreased turnover rates and less sickness absence.

Job rotation in order to aid recovery of an upper limb disorder is usually recommended to take place hourly. There has been one case of an employee who rotated from break to break roughly every two hours but was slow to recover, and whose recovery was much quicker once he changed to an hourly job rotation. The recommendations generally for employees without any upper limb problems has been hourly however is a maximum of break to break job rotation the company has had no problems currently with anyone working within this criteria. If break to break job rotation was implemented on all production lines and found not to cause WRULD or discomfort then the company may opt to stay with the means of break to break job rotation. If this is not found to be the case then the hourly job rotation should be implemented and reassessed. At PCM with the new TFT owing to the applications of grips it may be that hourly job rotation is necessary. The study has found that work standard operations need to take account of the ergonomics of the job and not just the general safety aspects; as previously mentioned individual techniques can be causative to WRULD and the old adage of 'I have always done it like this' dies hard. Where employees are taught by previous workers on the specifics of the job if taught a bad technique it can carry on continuously (such as the flicking of the wrist in the flat pack job). The work standard operations need to be finely adjusted to incorporate all risk factors right down to exactly how a driver should be held in a power grip with the hand as near to neutral as possible before the driver is ever handled by an employee.

Sickness time occurred in the case studies in Company X (Table 5.1), of a total of nineteen hours and possibly much more, thereby costing the company for lost time, replacement of staff and health care costs and treatment. As far as I am aware there has only been one claim made by the case study employees, though they have up to three years to make a claim as long as the criteria are met (Appleby 2001). The increased cost of litigation and in most cases the compensation for WRULD has been rather modest and payouts average £1,500 (Appleby 2001). If all the 15 cases claimed compensation it would amount to £22,500. Bearing in mind there has been successful claims for loss of earnings (not in Company X) that could increase costs; a proactive role for occupational health would prevent some of these unnecessary costs and prevent unnecessary discomfort in employees.

In Company X auditing and monitoring the statistics may have prevented some of these medical conditions arising. Job rotation would have benefited the employees in the case studies as some of the medical conditions were found to have come on after stopping rotation. Considering that in this study of Company X, 60 percent of people wanted to rotate and 25 percent of people were happy either way it left very few not keen to rotate a statistic that needs to be addressed.

8.1 The grip applications in the TFT at PCM

All the illustrations 8.1–8.4 are different types of grips' three of these grips are very common postures when building the Thin Film Transistor (TFT) monitor, the power, pinch and hook. The power and the pincer are the most common of the hand postures. All the illustrations (8.1-8.4) are grip application on parts being built on the TFT, apart from the palmar pinch which is for demonstration purposes of the grip only but may possibly occur on some models of the TFT. The TFT is very complex to analyse as the variations in how often power pincer grip etc is used as it changes dramatically with every model built. It has been impossible to design a job rotation system for each individual monitor build, time wise and lack of occupational health resource and that the monitors can be obsolete for others quite quickly. Therefore a generic system was advised which was to alternate all the grips below on an hourly basis at the same time considering any one decanting product at different levels onto trolleys to give them some relief from that job also. It is pertinent that production takes onus of this rather than the occupational health department. It has been left with senior management to see how they are going to handle the job rotation.

Illustration 8.1 Pincer Grip

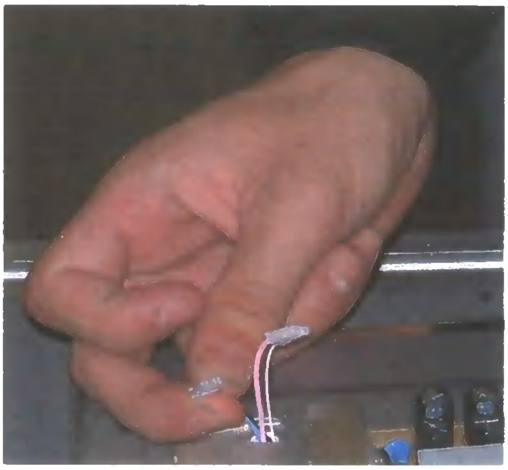


Illustration 8.2Hook Grip

Illustration 8.3 Power Grip

Illustration 8.4 Wide Palmar Pinch

8.2 The role of the team leaders and HR in occupational health management

According to the literature search, the psychosocial factors within the company require investigation. The team leaders are in a prime position to monitor the ergonomics, as they have the most recent line experience and oversee the line under the supervision of the supervisor. This would involve the team leaders training in job action analysis and organising and monitoring rotation. Although initially this may be time-consuming the long term benefits should pay off as the turnover and sickness absence would decline and their own line becomes increasingly better balanced. The employees would be aware of interests in the prevention of injury and this would increase the health and safety culture which in turn may improve psychosocial factors. The Occupational Advisor and physiotherapist can then assume a more preventative role in assisting the team leaders in any further ergonomic considerations. Engineering staff should also be trained, so that when building equipment for the lines they consider ergonomics from the beginning, preventing expensive changes at a later date.

The importance of the selection process cannot be denied as it is a waste of time and money to employ someone for a job that is not suited to his/her personality and abilities. The Human Resource Department therefore has a responsibility to select candidates of the right calibre (McDermott 1986). Pre-placement medicals are important; for research has shown that some people are more susceptible to WRULD and therefore require pre-screening. The importance of the return-to-work medical assessment has also been demonstrated by people in the case studies returning to the production line with injuries without referral to the Occupational Health Department.

8.3 A breakdown of the recommendations:
(For Company X and all other companies where risk of WRULD is present).

The answer based on this research is for production to implement effective job rotation. For human resources to consider the staff turnover and collect and evaluate all exit interview data in an effort to retain future staff and to select candidates of the right calibre for the specific job so that they are more likely to stay with the company. Human resources should monitor any sickness time occurring especially in relation to WRULD and use any data that could be useful such as analysing any attitude survey, which may if evaluated and acted upon assist in the retention of staff. All the return to work medicals and all pre-placement medicals should be referred to occupational health by human resources.

A multi disciplinary team (human resources, production and occupational health) should monitor the culture/ psychosocial factors within the production area to strive to improve morale and the health and well being of the employees. Health and safety should from the claims analyse how much of the claims are related to accidents and WRULD rather than as one entity as this will provide a better picture of the incidence and claims culture and analyse the costs for insurance.

Production should improve the work standard operations to include prevention of WRULD. Engineering staff and all team leaders should be trained in ergonomics

The key is to always be proactive rather than reactive especially as the research has further emphasised the requirement for job rotation in the level of discomfort which was found to be higher in people that do not job rotate. The study has an objective job action analysis researched for use in the production line environment and has been found to be effective in analysing jobs against discomfort felt by the employees and WRULDs. It has also been beneficial in identifying other jobs that have a potential for

WRULD and identifying ways to rotate around specific jobs. The study of Company X has been pertinent in that it has covered all the aspects of physiology with the physical movements and identified these with specific jobs. It has also identified the psychology of job rotation from boredom of performing the same job to the elements of the constrictions such as high turnover and absence and the legalities. For production to succeed and for the welfare of the employee all these constrictions and the psychology needs to be considered by applying the recommendations and taking on the whole concept of job rotation.

Research Conclusion

This thesis investigated the cultural issues concerning health and safety, by ethnographic research. A rich source of information that would have been beneficial to this study was the attitude survey within Company X, but, unfortunately, permission was not granted to access it. This would have given insight into more of the psychosocial issues and the level of social support within the company and possibly support for any cultural concerns. This attitude survey, performed at pre and post study, would have been very beneficial for the company and employees to ascertain which levels of support were needed in the company. The ethnographic techniques that took place in Company X, led to this investigative study of WRULD and discomfort. The study addressed the question of how discomfort felt by employees at work may be best alleviated by job rotation and ergonomic intervention. The investigative study showed that there were a few cases of WRULD (table 5.2) and that discomfort was present for the employees on the production lines, although often fleeting. The number of body parts affected for which employees felt discomfort in (week 5) differed significantly between the rotation and the non-rotation group in the CDT prep job PCM (Fisher's exact test, $p=0.05$) (table 5.4). Hence, there is some evidence that the difference in discomfort is caused by the rotation and that job rotation reduces discomfort.

The results demonstrated that job rotation and ergonomic intervention could alleviate discomfort and the job action analysis was very effective to allow analysis for job rotation and has been beneficial in identifying other jobs that have a potential for WRULD. However there was no correlation on the BTM (MWO) between grip strength and discomfort but a larger study may have shown a correlation and it was unfortunate that permission was not obtained to perform grip strength measurement on the production lines. WRULDS in Company X have been found to be preventable and the importance of job rotation is demonstrated by the fact that these people in the case studies have developed specific conditions related to specific jobs and that when job rotation was introduced the symptoms started resolving. The study also showed that the employees of the study preferred to job rotate (Graph 5.7). A follow up study, post the introduction of job rotation and ergonomic intervention, would have been beneficial to evaluate pre and post differences of discomfort levels; including post staff turnover and sickness absence levels.

The differences between levels of discomfort in PCM in comparison with MWO may have related to rotation taking place in PCM only, or by differences in the sites due to other circumstances, for example the types of job. There appeared to be some association between the level of discomfort experienced by the employees and the types of jobs carried out, which was a possible explanation of the difference in discomfort levels between PCM and MWO. A specific job in PCM, Cathode Display Tube preparation (CDT prep), was analyzed. It was found that those employees in this job that did job rotate suffered less discomfort. Based on the physiology of some of the conditions of WRULD and the findings of the present research WRULD is found to be preventable and discomfort reduced where job rotation takes place. The study demonstrated the importance of prevention and innovation ergonomics.

A rotation programme for the boxing end of PCM was recommended. However since this recommendation the process changed and the CDTs were replaced by TFTs monitors. The risk level of the jobs was considered with regards to the result of the job action analysis and low medium and high risk jobs were intermingled. Ergonomic solutions were a major concern especially with the transformer job and a prototype jig was built in an order to solve the problem. A rotation scheme was designed for PCM and MWO after the analysis of many of the jobs (table 7.1 & table 7.2). There was a necessity to make sure that management really understood the issues and legal aspects and therefore the reasoning for introducing presentations by the occupational health department so that management are fully informed to make choices and take responsibility. The team leaders are probably the best people to monitor ergonomics since they have most recent line experience. The occupational health nurse has had to take on a preventative role to increase awareness to the senior managers on the issues of ergonomic assessments and job rotation and keep up to date with legislation of the HSE and RIDDOR in order to inform management.

Not only have the case studies found to have problems with the specific jobs but since the development of the job action analysis other jobs have been defined as possible causes of WRULD, which is a very important issue for the employees, company and occupational health.

In fairness the company has taken on board many of the issues with regards to job rotation and ergonomic innovation, however, it has not been fully implemented on all production lines with regard to job rotation. There have been difficulties in that the recent changes in production now mean certain jobs are extinct and new jobs need reassessing especially in the PCM site. It has been found since the research that MWO has increased its job rotation but not on all production lines. All the employees in the case study (table 5.1), it appears by observing the jobs and the physiology of WRULD based on diagnosis and citations based on work relatedness and the results of the study in Company X that by job rotation it is highly likely that these WRULDs could have been prevented by job rotation.

The company should follow the recommendations on job rotation and those depicted in the heading 8.3. The job action analysis needs to be kept up to date with current research. If the company acts upon the information from the job action analysis they will be covered under any new information from RIDDOR as they are ahead in progress and can then be seen as pioneers in the prevention of WRULD. The final commitment would be to sign the policy written on Upper Limb Disorder and job rotation by the health and safety manager and occupational health nurse, it has not been possible so far to gain the agreement for authorisation of the policy.

Appendix 1: Job action analysis form, test results and the ergonomic breakdown for the job action analysis.

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
2			

Division	Department	Area

NECK

Repeated Turning of the Head	0
Excessesive Pulling with Arms	0
Prolonged Looking Up and Down	1
Repeated Looking Up and Down	0

BACK

Regular Bending or Stooping Repetitive or Sustained	1
Prolonged Standing	2
Prolonged Sitting	0
Regular Lifting from Floor	1
Regular Lifting from Waist	1
Regular Lifting Shoulder Height or Above	0
Regular Twisting of Back	0
Pulling and Pushing	0

LOWER LIMBS

No or Little Opportunity to Sit	1
Regular use of Stairs or Uneven Surfaces	0
Regular Kneeling or Squatting	0
Regular Twisting due to Confined Space	0

SHOULDERS

Regular Pulling / Pushing Across the body	1
Regular Reaching Above shoulder Height	0
Reaching to Full Extent	0

UPPER LIMBS

Regular Twisting or Turning	0
Regular Activities with Wrist out of Neutral	0
Excessive Gripping or Pressing	1
Repeated Hitting with Palm of Hand	0
Regular Wide Claw Grip	0
Regular Gripping of Narrow Items	1
Palmar Pinch	0
Pinch Grip	1
Hook Grip	0
Power Grip	0
Tools Regularly Vibrating or Kickback	0
Regular use of Trigger Tools	0

Comments

TOTAL NECK	TOTAL SHOULDERS	TOTAL BACK	TOTAL UPPER LIMB	TOTAL LOWER LIMB	GRAND TOTAL
1	1	5	3	1	11

Appendix1. Ergonomic breakdown for the job action analysis

<u>NECK</u>

Turning of head:	**1. Occasional - once per cycle or <** **2. Excessively > once per cycle** **3. With twist**
Ex pulling i/c arms	**1. =1/3** **2. = 2/3** **3. Majority of task = >2/3**
Prolonged looking Up or Down	**1. <30°** **2. >30°**
Repeated looking Up and down	**1. = 1/3** **2. = 2/3** **3. Majority of task = > 2/3**

<u>BACK</u>

Stoop	**1=> 20°<40°** **2= >40°** **3= with twist**
Prolonged standing/ sitting	**1 = 50%** **2 = 75%** **3 = 100%**
Lift from floor	**1= Occasional - once per cycle or <** **2= Frequent > once per cycle**
Lift from waist	**1= Occasional - once per cycle or <** **2= Frequent > once per cycle**
Lift from Shoulder height	**1= Occasional -once per cycle or <** **2= Frequent > once per cycle**

Regular twisting of back	1 = <45° 2 = +45°
Pulling and pushing	1. Occasional - once per cycle or < 2. Frequent > once per cycle

LOWER LIMBS

No or little opportunity to sit	1. Little opportunity to sit 2. No opportunity to sit
Stairs/uneven surface	1 Occasional - once per cycle or < 2 Frequent > once per cycle
Kneel/squat	1. Occasional - once per cycle or < 2. Frequent > once per cycle
Twisting owing to confined space	1. Occasional - once per cycle or < 2. Frequent > once per cycle

SHOULDERS

Pull/push across body	1. Short lever 2. Long lever 3. With force
Reach above shoulder height	1. 60- 90° 2. > 90° 3. 90 + with load
Reaching to full extent	1. 1x cycle or < 2. >1 x cycle 3 with load

UPPER LIMB

Twist/turn forearm	1. Occasional - once per cycle or < 2. Frequent > once per cycle 3. Force
Wrist out of neutral	1. <20°

	2. > 20° 3. Excessive end of range
Gripping/pressing	**1. Up to 30%** **2. Up to 50%** **3. >50%**
Hitting palm of hand	**1. Occasional - every cycle or <** **2. Frequent – every cycle** **3. Using excessive force**
Claw grip	**1. Light weight < 0.4kg** **2. Heavier weight > 0.4kg** **(consider force / counterbalance)** **3. Heavy weight >2.25kgs**
Gripping narrow tools	**1. Yes** **2. Slippery or metal - poor cohesion**
Palmar pinch	**1. Yes**
Pinch	**1. Yes**
Hook	**1. Yes**
Power	**1. Yes**
Tools vibrate/ kick	**1. Occasional - < once per cycle** **2. Each cycle or >**
Trigger tools	**1. All fingers (not thumb)** **2. Single finger**

Appendix 2

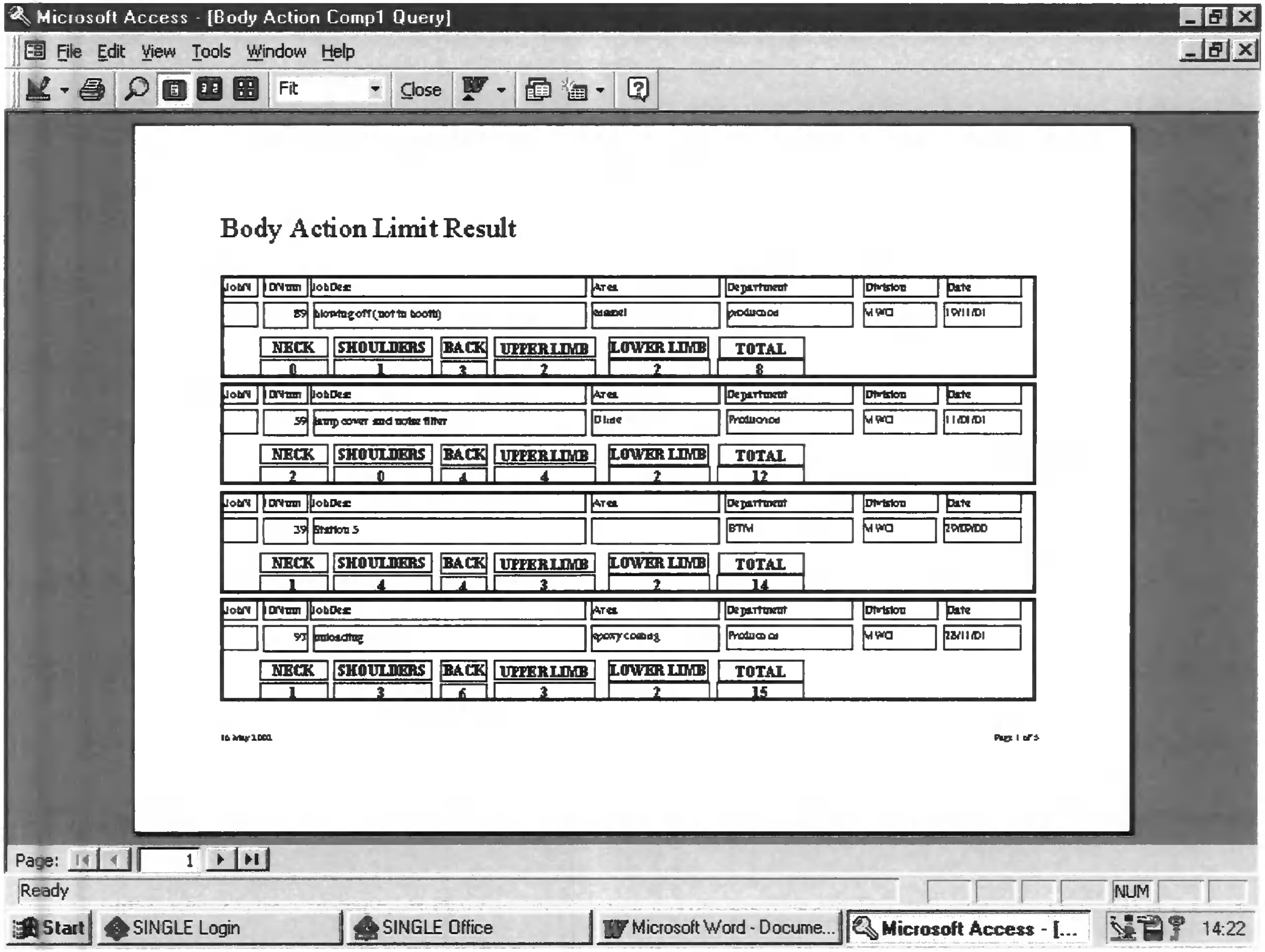
Body Action limit results

Appendix 3

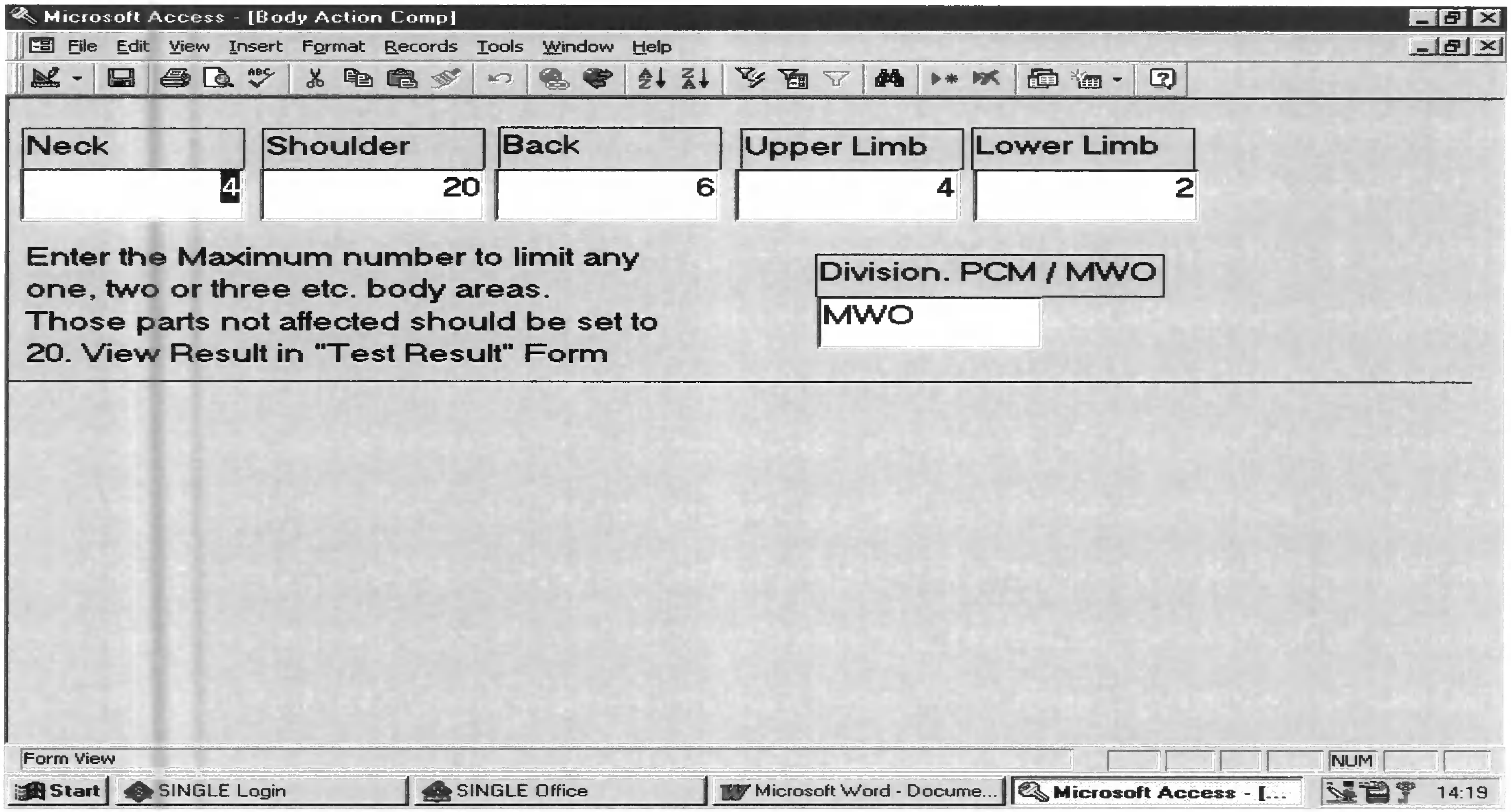
Body action limit results total

Appendix 2

Body Action Limit Result



Appendix 3 Body Action limit total results



Appendix 4 Employee self administered discomfort scale questionnaire (5 day shift)

Full time 5 day shift
Work Area:
Models worked on over the week on a daily basis:

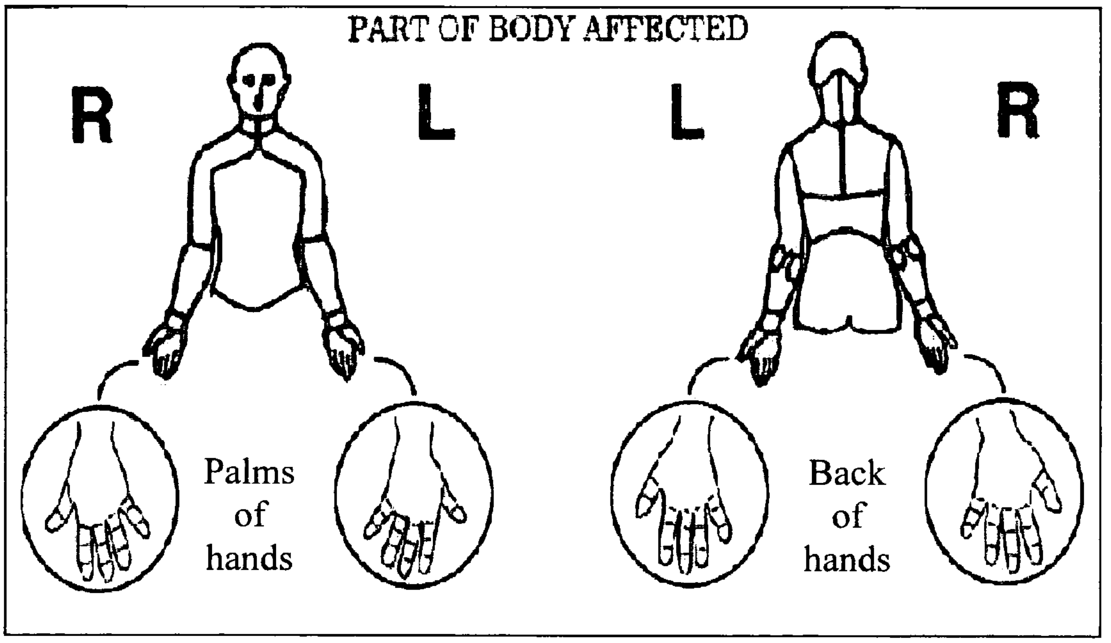
Please mark on diagram any discomfort felt on Monday and Friday on the scale 0-10

0= No discomfort **10 = Extreme discomfort**

Monday 0- 1- 2- 3- 4- 5- 6- 7- 8- 9 - 10

Friday 0- 1- 2- 3- 4- 5- 6- 7- 8- 9 - 10

Please colour in the area where you are feeling discomfort (if any)
Please complete even if you do not have any discomfort and mark at 0
If you have more than one area of discomfort then mark it on the body and number it, then apply another scale to that second area below the diagram. (Please see attached examples).



Monday 0- 1- 2- 3- 4- 5- 6- 7- 8- 9 - 10

Friday 0- 1- 2- 3- 4- 5- 6- 7- 8- 9 - 10
Please state activities on days off (e.g. tennis, painting and wallpapering)

Appendix 5. Employee self administered discomfort scale questionnaire (4 day shift)

<u>Full time 4 day shift</u>

Work Area:

Models worked on over the week on a daily basis:

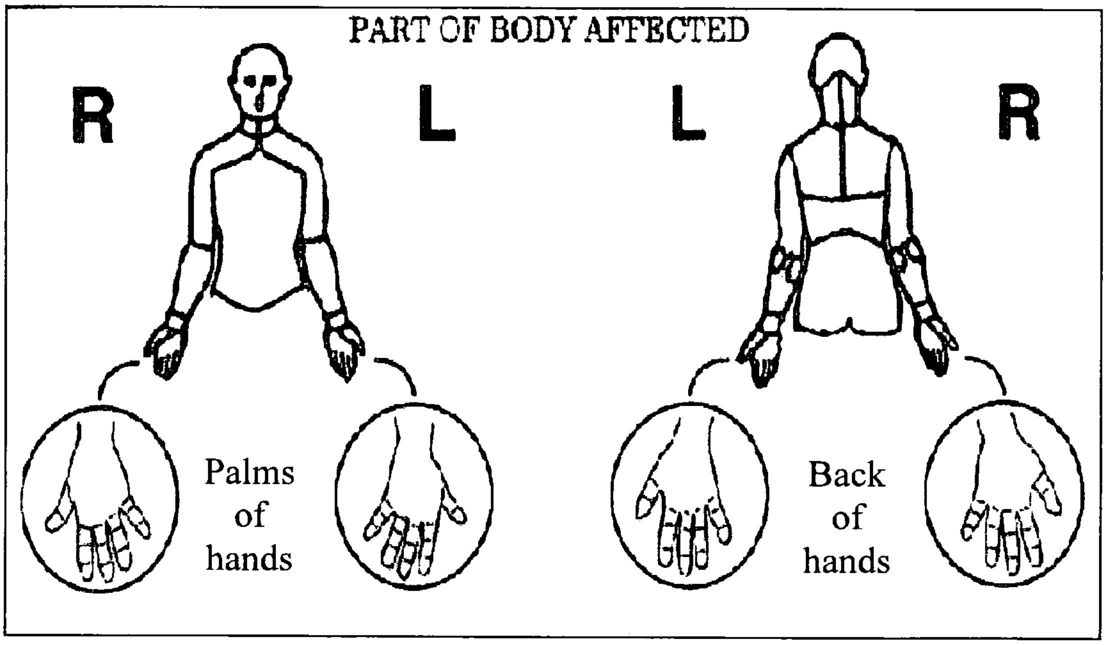
Please state days off over the week:

Please mark on diagram any discomfort felt on a daily basis on the scale 0-10

Monday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10
Tuesday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10
Wednesday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10
Thursday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10
Friday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10

0= no discomfort **10 = Extreme discomfort**

Please colour in the area where you are feeling discomfort (if any)
Please complete even if you do not have any discomfort mark at 0
If you have more than one area of discomfort then mark it on the body and number it, then apply another scale to that area below the diagram. (Please see examples).



Monday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10
Tuesday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10
Wednesday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10
Thursday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10
Friday	0-	1-	2-	3-	4-	5-	6-	7-	8-	9 -	10

Please state activities on days off e.g. (Ten-pin bowling, gardening) -----------------

Appendix 6

Information explained for consent from the employee

Please do you mind filling in this form as we are performing research, comparing what discomfort, if any, employees are feeling, and comparing it to the job analysis the physiotherapists and I have performed.
There are three examples to help you understand how to fill in the form. These examples are not based on real problems they are just for example purposes only to help you to interpret how to complete the form and I will leave you these examples once I have explained how to complete the form. It will take up less than one minute of your time each day. Please complete it daily as to fill it in afterwards you may not be able to remember what you were feeling specifically at the time.

Next Step: Explained the three example sheets, (explaining 0= no discomfort) (10= Extreme discomfort) therefore five is medium discomfort. Between 0-5 is nil to medium discomfort. Between 5-10 is medium to extreme discomfort, then explained with reference to the examples.

If you have more than one area of discomfort then you also need to fill in the bottom part of the form with the numbers of discomfort associated to that discomfort and draw it on the body and label it no 2 (as in the example). Please also fill in the form on your day off (for 4-day shift workers). Please right down what you did on your days off e.g. played golf

This study is to run for several weeks as this allows enough time to come up with a good enough picture to analyse.

Points for employees

1) Don't be to concerned about the numbers of the models as this information I can obtain from the supervisor
2) Have you had any recent injuries that may have influence on your discomfort scale
3) If you do more than one job please write down the days you did the other jobs
4) Are you already receiving medical intervention
5) If you have any concerns please attend the medical department

Appendix 7

Diagnosis of the specific conditions classed as Work-related upper limb disorders - The associated medical conditions - Specific soft tissue disorders

1. De Quervains Tenosynovitis
2. Tendonitis e.g. shoulder (supraspinatus)
3. Tenosynovitis
4. Lateral Epicondylitis
5. Medial Epicondylitis
6. Ulnar nerve irritation
7. Thoracic Outlet Syndrome
8. Trigger Finger (Stenosing Tenosynovitis)
9. Shoulder Capsulitis (frozen shoulder) no generally accepted associations
10. Carpal tunnel syndrome
11. Tension Neck Syndrome
12. Cervical Syndrome
13. Cubital Tunnel syndrome
14. Hypothenar hammer syndrome
15. Vibration White Finger
16. Pronator teres syndrome
17. Anterior interosseous Syndrome
18. Posterior interosseous syndrome
19. Upper Thoracic Back and Shoulder conditions
20. Digital Neuritis
21. Hammer Syndrome
22. Bursitis
23. Ganglion cyst – no generally accepted associations

Grip strength performance on all subjects (males) in Kgs **Appendix 8**

Age	Hand	Mean	SD	low-high
20-24	Dominant	55	9.4	41-75
	Non Dominant	47.5	9.9	32-68
25-29	Dominant	54.9	10.5	35-71
	Non Dominant	50.2	7.4	35-63
30-34	Dominant	55.4	10.2	31-77
	Non Dominant	50.2	9.9	29-65
35-39	Dominant	54.4	10.9	34-80
	Non Dominant	51.3	9.9	33-71
40-44	Dominant	53.1	9.4	38-75
	Non Dominant	51.3	8.5	33-74
45-49	Dominant	50	10.5	29-70
	Non Dominant	45.8	10.4	26-72
50-54	Dominant	51.6	8.2	35-68
	Non Dominant	46.3	7.7	31-65
55-59	Dominant	46	12.1	26-70
	Non Dominant	37.8	10.6	19-58
60-64	Dominant	40.8	9.3	23-62
	Non Dominant	34.9	9.2	12-52
65-69	Dominant	41.4	9.4	25-59
	Non Dominant	34.9	9	19-53
70-75	Dominant	34.2	9.8	14-49
	Non Dominant	29.5	8.2	14-42
75+	Dominant	29.9	9.6	18-61
	Non Dominant	25	7.7	14-54
All	Dominant	47.4	12.9	14-80
	Non Dominant	42.3	12.5	12-72

Dominant and non-dominant normal grip score related to age, as provided with the hand held dynamometer.

APPENDIX 9

THE BTM GRIP STRENGTH RESULTS OF ALL THE PARTICIPANTS IN THE BTM STUDY

Appendix 9 BTM employees grip strength measurement scores

*NR= Non rotation (R@4rotation starting at 4th week) P=proposed rotation N=night shift U= Unnobtainable T= Time Owing L= left

No	Site	Job	R / NR	Week1	R1m	R2m	L1m	L2m	R1f	R2f	L1f	L2f	Week2	R1m	R2m	L1m	L2m	R1f	R2f	L1F	L2F
16	MWO	Station 1	NR-R@4	Week1	30	28	24	24	34	34	24	28	Week2	N	N	N	N	N	N	N	N
17	MWO	Station 2	NR-R@4	Week1	off	off	off	off	off	off	off	off	Week2	N	N	N	N	N	N	N	N
18	MWO	Station 3/4	NR-R@4	Week1	37	37	32	32	31	29	30	31	Week2	N	N	N	N	N	N	N	N
19	MWO	Station 5/6	NR-R@4	Week1	24	24	28	28	27	28	33	29	Week2	N	N	N	N	N	N	N	N
20	MWO	Station 6 weld	NR-R@4	Week1	40	40	41	41	42	38	36	36	Week2	N	N	N	N	N	N	N	N
21	MWO	Station 1	NR	Week1	27	25	25	24	33	31	30	31	Week2	33	33	28	28	35	34	27	27
22	MWO	Station 2	NR	Week1	38	38	35	35	38	34	32	33	Week2	23	26	29	29	23	27	31	35
23	MWO	Station 3/4	NR	Week1	29	26	22	22	22	26	28	23	Week2	27	27	27	27	25	23	22	22
24	MWO	Station 5/6	NR	Week1	44	44	43	43	42	43	42	43	Week2	45	45	44	44	45	45	45	47
25	MWO	Station 6 weld	NR	Week1	37	37	40	38	37	37	35	35	Week2	40	40	41	41	35	36	33	34
26	MWO	Station 1	NR / P	Week1	N	N	N	N	N	N	N	N	Week2	37	36	30	31	43	40	35	34
27	MWO	Station 2	NR / P	Week1	N	N	N	N	N	N	N	N	Week2	41	43	39	37	35	35	38	32
28	MWO	Station 3/4	NR / P	Week1	N	N	N	N	N	N	N	N	Week2	34	37	40	40	33	33	43	38
29	MWO	Station 5/6	NR / P	Week1	N	N	N	N	N	N	N	N	Week2	40	40	42	42	39	42	38	41
30	MWO	Station 6 weld	NR / P	Week1	N	N	N	N	N	N	N	N	Week2	42	42	38	39	43	42	27	35
76	MWO		NR	Week1									Week2								
No	**Site**	**Job**	**R / NR**	**Week3**	**R1M**	**R2M**	**L1M**	**L2M**	**R1F**	**R2F**	**L1F**	**L2F**	**Week4**	**R1M**	**R2M**	**L1M**	**L2M**	**R1F**	**R2F**	**L1F**	**L2F**
16	MWO	Station 1	NR-R@4	Week3	31	29	25	25	28	30	23	21	Week4	0	0	0	0	34	38	25	24
17	MWO	Station 2	NR-R@4	Week3	37	36	35	35	37	37	34	35	Week4	38	35	33	35	38	36	34	35
18	MWO	Station 3/4	NR-R@4	Week3	30	28	31	31	28	28	30	28	Week4	33	31	32	31	28	29	30	27
19	MWO	Station 5/6	NR-R@4	Week3	28	28	29	29	31	32	34	32	Week4	33	31	32	31	33	34	31	31
20	MWO	Station 6 weld	NR-R@4	Week3	off	off	off	off	off	off	off	off	Week4	42	41	40	37	41	42	40	33
21	MWO	Station 1	NR	Week3	N	N	N	N	N	N	N	N	Week4	31	25	30	22	36	34	23	27
22	MWO	Station 2	NR	Week3	N	N	N	N	N	N	N	N	Week4	26	21	25	27	26	23	19	24
23	MWO	Station 3/4	NR	Week3	N	N	N	N	N	N	N	N	Week4	20	23	26	22	29	25	21	20
24	MWO	Station 5/6	NR	Week3	43	43	47	45	N	N	N	N	Week4	45	46	44	45	46	45	46	45
25	MWO	Station 6 weld	NR	Week3	N	N	N	N	N	N	N	N	Week4	40	41	41	39	24	24	31	32
26	MWO	Station 1	NR / P	Week3	39	39	38	36	43	40	30	37	Week4	N	N	N	N	N	N	N	N
27	MWO	Station 2	NR / P	Week3	34	36	36	34	35	35	37	39	Week4	N	N	N	N	N	N	N	N
28	MWO	Station 3/4	NR / P	Week3	37	34	40	39	39	33	41	35	Week4	N	N	N	N	N	N	N	N
29	MWO	Station 5/6	NR / P	Week3	39	42	36	38	44	43	38	38	Week4	N	N	N	N	N	N	N	N
30	MWO	Station 6 weld	NR / P	Week3	42	42	40	38	44	43	43	43	Week4	N	N	N	N	N	N	N	N
76	MWO		NR	Week3									Week4								

No	Site	Job	R / NR	Week5	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F	Week6	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F
16	MWO	Station 1	NR-R@4	Week5	N	N	N	N	N	N	N	N	Week6	31	32	27	27	29	32	31	32
17	MWO	Station 2	NR-R@4	Week5	N	N	N	N	N	N	N	N	Week6	32	32	34	35	38	38	38	36
18	MWO	Station 3/4	NR-R@4	Week5	N	N	N	N	N	N	N	N	Week6	30	31	30	30	31	31	32	31
19	MWO	Station 5/6	NR-R@4	Week5	N	N	N	N	N	N	N	N	Week6	30	29	33	34	31	31	28	30
20	MWO	Station 6 weld	NR-R@4	Week5	N	N	N	N	N	N	N	N	Week6	43	43	39	35	44	42	37	37
21	MWO	Station 1	NR	Week5	31	31	21	25	33	31	22	26	Week6	N	N	N	N	N	N	N	N
22	MWO	Station 2	NR	Week5	24	22	28	33	26	36	31	28	Week6	N	N	N	N	N	N	N	N
23	MWO	Station 3/4	NR	Week5	21	23	29	28	31	26	21	27	Week6	N	N	N	N	N	N	N	N
24	MWO	Station 5/6	NR	Week5	45	44	44	45	L				Week6	N	N	N	N	N	N	N	N
25	MWO	Station 6 weld	NR	Week5	39	40	40	38	33	32	32	37	Week6	N	N	N	N	N	N	N	N
26	MWO	Station 1	NR / P	Week5	39	31	40	26	41	39	41	39	Week6	37	37	32	33	37	41	35	37
27	MWO	Station 2	NR / P	Week5	40	36	37	34	39	43	41	43	Week6	41	34	38	37	39	33	40	39
28	MWO	Station 3/4	NR / P	Week5	T	T	T	T	31	36	37	37	Week6	33	37	34	38	29	39	31	31
29	MWO	Station 5/6	NR / P	Week5	39	41	43	42	U	U	U	U	Week6	40	40	38	38	41	41	39	44
30	MWO	Station 6 weld	NR / P	Week5	44	45	39	41	44	45	41	39	Week6	45	43	37	37	44	43	39	40
76	MWO		NR	Week5									Week6								
No	Site	Job	R / NR	Week7	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F	Week8	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F
16	MWO	Station 1	NR-R@4	Week7	32	32	28	28	33	33	30	31	Week8	N	N	N	N	N	N	N	N
17	MWO	Station 2	NR-R@4	Week7	30	37	36	35	37	34	34	34	Week8	N	N	N	N	N	N	N	N
18	MWO	Station 3/4	NR-R@4	Week7	31	29	31	29	35	35	32	33	Week8	N	N	N	N	N	N	N	N
19	MWO	Station 5/6	NR-R@4	Week7	28	30	32	32	27	30	32	32	Week8	N	N	N	N	N	N	N	N
20	MWO	Station 6 weld	NR-R@4	Week7	41	43	38	33	44	42	36	37	Week8	N	N	N	N	N	N	N	N
21	MWO	Station 1	NR	Week7	31	29	24	26	28	32	23	23	Week8	30	31	32	24	36	32	24	27
22	MWO	Station 2	NR	Week7	23	27	34	33	25	24	30	31	Week8	24	25	26	22	27	28	24	30
23	MWO	Station 3/4	NR	Week7	19	16	26	26	U	U	27	24	Week8	U	U	U	25	27	27	24	26
24	MWO	Station 5/6	NR	Week7									Week8								
25	MWO	Station 6 weld	NR	Week7	25	41	34	36	40	37	40	37	Week8	38	39	40	42	39	39	36	36
26	MWO	Station 1	NR / P	Week7	N	N	N	N	N	N	N	N	Week8	39	40	41	35	42	43	40	39
27	MWO	Station 2	NR / P	Week7	N	N	N	N	N	N	N	N	Week8	33	34	35	31	38	30	37	34
28	MWO	Station 3/4	NR / P	Week7	N	N	N	N	N	N	N	N	Week8	Off	Off	Off	Off	37	40	37	39
29	MWO	Station 5/6	NR / P	Week7	N	N	N	N	N	N	N	N	Week8	42	43	44	32	42	42	41	41
30	MWO	Station 6 weld	NR / P	Week7	N	N	N	N	N	N	N	N	Week8	43	44	45	37	44	44	42	41
76	MWO		NR	Week7	44	44	44	44	44	44	44	44	Week8	44	43	42	42	42	44	43	42

No	Site	Job	R / NR	Week9	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F	Week10	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F
16	MWO	Station 1	NR-R@4	Week9	33	29	30	26	34	34	33	32	Week10	34	33	34	31	35	34	30	31
17	MWO	Station 2	NR-R@4	Week9	off	off	off	off	off	off	off	off	Week10	37	37	38	36	33	35	32	33
18	MWO	Station 3/4	NR-R@4	Week9	32	30	32	34	31	36	34	34	Week10	32	32	31	31	34	32	33	32
19	MWO	Station 5/6	NR-R@4	Week9	29	31	31	32	32	30	30	29	Week10	34	31	33	29	31	29	33	30
20	MWO	Station 6 weld	NR-R@4	Week9	44	37	43	35	42	44	35	38	Week10	42	44	38	39	43	43	35	34
21	MWO	Station 1	NR	Week9	N	N	N	N	N	N	N	N	Week10	33	34	28	27	32	33	28	28
22	MWO	Station 2	NR	Week9	N	N	N	N	N	N	N	N	Week10	24	31	18	29	25	24	28	25
23	MWO	Station 3/4	NR	Week9	N	N	N	N	N	N	N	N	Week10	27	27	27	25	27	30	25	26
24	MWO	Station 5/6	NR	Week9									Week10								
25	MWO	Station 6 weld	NR	Week9	N	N	N	N	N	N	N	N	Week10	37	39	39	38	35	38	41	41
26	MWO	Station 1	NR / P	Week9	42	41	41	40	39	40	38	37	Week10	N	N	N	N	N	N	N	N
27	MWO	Station 2	NR / P	Week9	38	36	40	38	38	38	37	35	Week10	N	N	N	N	N	N	N	N
28	MWO	Station 3/4	NR / P	Week9	30	32	41	38	39	33	37	33	Week10	N	N	N	N	N	N	N	N
29	MWO	Station 5/6	NR / P	Week9	41	44	42	37	43	42	46	47	Week10	N	N	N	N	N	N	N	N
30	MWO	Station 6 weld	NR / P	Week9	off	off	off	off	off	off	off	off	Week10	N	N	N	N	N	N	N	N
76	MWO		NR	Week9	N	N	N	N	N	N	N	N	Week10	42	42	44	42	45	43	40	39
No	Site	Job	R / NR	Week11	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F	Week 12	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F
16	MWO	Station 1	NR-R@4	Week11	N	N	N	N	N	N	N	N	Week 12	34	31	29	31	39	38	31	31
17	MWO	Station 2	NR-R@4	Week11	N	N	N	N	N	N	N	N	Week 12	37	37	35	34	37	39	36	36
18	MWO	Station 3/4	NR-R@4	Week11	N	N	N	N	N	N	N	N	Week 12	32	30	32	30	31	31	33	28
19	MWO	Station 5/6	NR-R@4	Week11	N	N	N	N	N	N	N	N	Week 12	31	32	33	31	31	26	32	28
20	MWO	Station 6 weld	NR-R@4	Week11	N	N	N	N	N	N	N	N	Week 12	40	41	36	30	41	43	35	32
21	MWO	Station 1	NR	Week11	33	30	25	26	32	32	27	24	Week 12	N	N	N	N	N	N	N	N
22	MWO	Station 2	NR	Week11	20	21	26	27	19	24	19	26	Week 12	N	N	N	N	N	N	N	N
23	MWO	Station 3/4	NR	Week11	31	28	29	30	29	30	29	27	Week 12	N	N	N	N	N	N	N	N
24	MWO	Station 5/6	NR	Week11									Week 12								
25	MWO	Station 6 weld	NR	Week11	43	39	41	42	38	41	41	39	Week 12	N	N	N	N	N	N	N	N
26	MWO	Station 1	NR / P	Week11	41	43	39	38	42	43	40	39	Week 12	40	43	38	38	off	off	off	off
27	MWO	Station 2	NR / P	Week11	35	33	34	35	38	Off	Off	Off	Week 12	34	31	34	33	36	32	22	37
28	MWO	Station 3/4	NR / P	Week11	32	31	37	33	36	38	33	36	Week 12	38	42	33	32	39	41	33	31
29	MWO	Station 5/6	NR / P	Week11	45	43	37	39	41	42	42	44	Week 12	41	42	37	41	44	44	42	43
30	MWO	Station 6 weld	NR / P	Week11	40	40	41	42	44	43	38	35	Week 12	44	43	37	39	42	43	42	37
76	MWO		NR	Week11	U	42	42	42	40	39	39	37	Week 12	N	N	N	N	N	N	N	N

No	Site	Job	R / NR	Week13	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F	Week14	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F
16	MWO	Station 1	NR-R@4	Week13	34	33	29	26	32	29	30	23	Week14	N	N	N	N	N	N	N	N
17	MWO	Station 2	NR-R@4	Week13	off	off	off	off	29	38	34	33	Week14	N	N	N	N	N	N	N	N
18	MWO	Station 3/4	NR-R@4	Week13	32	31	33	29	34	31	32	31	Week14	N	N	N	N	N	N	N	N
19	MWO	Station 5/6	NR-R@4	Week13	29	31	33	33	25	31	31	29	Week14	N	N	N	N	N	N	N	N
20	MWO	Station 6 weld	NR-R@4	Week13	43	43	38	35	44	41	39	38	Week14	N	N	N	N	N	N	N	N
21	MWO	Station 1	NR	Week13	off	off	off	off	32	32	22	22	Week14	33	33	23	24	33	32	27	26
22	MWO	Station 2	NR	Week13	23	21	25	25	26	31	31	29	Week14	26	24	22	22	25	22	27	28
23	MWO	Station 3/4	NR	Week13	28	27	28	27	23	28	29	27	Week14	30	30	28	28	NR	U	U	U
24	MWO	Station 5/6	NR	Week13									Week14								
25	MWO	Station 6 weld	NR	Week13	42	41	42	41	42	40	42	41	Week14	42	40	42	43	40	42	43	43
26	MWO	Station 1	NR / P	Week13	N	N	N	N	N	N	N	N	Week14	44	40	37	37	43	43	40	37
27	MWO	Station 2	NR / P	Week13	N	N	N	N	N	N	N	N	Week14	U	U	U	U	33	32	31	35
28	MWO	Station 3/4	NR / P	Week13	N	N	N	N	N	N	N	N	Week14	35	39	36	34	34	39	34	32
29	MWO	Station 5/6	NR / P	Week13	N	N	N	N	N	N	N	N	Week14	41	42	35	41	40	41	41	41
30	MWO	Station 6 weld	NR / P	Week13	N	N	N	N	N	N	N	N	Week14	44	44	35	36	44	45	35	35
76	MWO		NR	Week13	42	43	42	41	44	41	42	40	Week14	41	40	40	38	40	42	42	39
No	Site	Job	R / NR	Week15	R1M	R2M	L1M	L2M	R1F	R2F	L1F	L2F									
16	MWO	Station 1	NR-R@4	Week15	32	30	21	21	32	35	28	29									
17	MWO	Station 2	NR-R@4	Week15	37	36	35	32	37	37	32	35									
18	MWO	Station 3/4	NR-R@4	Week15	33	32	31	29	35	32	34	32									
19	MWO	Station 5/6	NR-R@4	Week15	32	31	30	31	30	31	28	27									
20	MWO	Station 6 weld	NR-R@4	Week15	45	45	36	39	43	42	35	35									
21	MWO	Station 1	NR	Week15	N	N	N	N	N	N	N	N									
22	MWO	Station 2	NR	Week15	N	N	N	N	N	N	N	N									
23	MWO	Station 3/4	NR	Week15	N	N	N	N	N	N	N	N									
24	MWO	Station 5/6	NR	Week15																	
25	MWO	Station 6 weld	NR	Week15	39	39	39	36	U	U	U	U									
26	MWO	Station 1	NR / P	Week15	32	36	32	31	41	41	38	37									
27	MWO	Station 2	NR / P	Week15	38	37	34	31	37	34	37	34									
28	MWO	Station 3/4	NR / P	Week15	41	38	40	35	39	44	42	32									
29	MWO	Station 5/6	NR / P	Week15	44	43	37	36	43	42	40	41									
30	MWO	Station 6 weld	NR / P	Week15	off	off	off	off	44	45	34	37									
76	MWO		NR	Week15	N	N	N	N	N	N	N	N									

APPENDIX 10

THE RESULTS OF THE JOB ACTION ANALYSIS

FOR THE FOLLOWING JOBS

MAGNETRON

CAPACITORS

TRANSFORMERS

LIFTER

LIFTER / NOT IN USE ON BOXING

FLAT PACK

BTM Station1

BTM Station 2

BTM Station ¾

BTM Station 5

BTM Station 6 weld

The 1999 HSE 251 Report indicated that practitioners preferred to use rather descriptive words, which is rather subjective. An approach that defined specific angles in posture assessment would be more objective. The job analysis criterion in this study is to provide the objectivity and reliability to the findings of the assessments (Appendices 1, 2 & 3).

Job Action Analysis (Test Results

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
M1638	Magnetron		14/09/00

Division	Department	Area
MWO	Production	A Line

NECK

Repeated Turning of the Head: 0

Excessesive Pulling with Arms: 0

Prolonged Looking Up and Down: 0

Repeated Looking Up and Down: 0

BACK

Regular Bending or Stooping Repetitive or Sustained: 1

Prolonged Standing: 3

Prolonged Sitting: 0

Regular Lifting from Floor: 0

Regular Lifting from Waist: 0

Regular Lifting Shoulder Height or Above: 0

Regular Twisting of Back: 0

Pulling and Pushing: 0

LOWER LIMBS

No or Little Opportunity to Sit: 2

Regular use of Stairs or Uneven Surfaces: 0

Regular Kneeling or Squatting: 0

Regular Twisting due to Confined Space: 0

SHOULDERS

Regular Pulling / Pushing Across the body: 0

Regular Reaching Above shoulder Height: 0

Reaching to Full Extent: 0

UPPER LIMB

Regular Twisting or Turning: 1

Regular Activities with Wrist out of Neutral: 1

Excessive Gripping or Pressing: 1

Repeated Hitting with Palm of Hand: 0

Regular Wide Claw Grip: 1

Regular Gripping of Narrow Items: 0

Palmar Pinch: 0

Pinch Grip: 1

Hook Grip: 0

Power Grip: 0

Tools Regularly Vibrating or Kickback: 1

Regular use of Trigger Tools: 2

Comments:

TOTAL NECK	TOTAL SHOULDERS	TOTAL BACK	TOTAL UPPER LIMB
0	0	4	8

TOTAL LOWER LIMB	GRAND TOTAL
2	14

Job Action Analysis (Test Results

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
m1638	Capacitors		14/09/00

Division	Department	Area
MWO	Production	A Line

NECK

Repeated Turning of the Head: 0

Excessesive Pulling with Arms: 0

Prolonged Looking Up and Down: 2

Repeated Looking Up and Down: 0

BACK

Regular Bending or Stooping Repetitive or Sustained: 1

Prolonged Standing: 3

Prolonged Sitting: 0

Regular Lifting from Floor: 1

Regular Lifting from Waist: 0

Regular Lifting Shoulder Height or Above: 0

Regular Twisting of Back: 0

Pulling and Pushing: 0

LOWER LIMBS

No or Little Opportunity to Sit: 2

Regular use of Stairs or Uneven Surfaces: 0

Regular Kneeling or Squatting: 0

Regular Twisting due to Confined Space: 0

SHOULDERS

Regular Pulling / Pushing Across the body: 0

Regular Reaching Above shoulder Height: 1

Reaching to Full Extent: 1

UPPER LIMB

Regular Twisting or Turning: 1

Regular Activities with Wrist out of Neutral: 1

Excessive Gripping or Pressing: 2

Repeated Hitting with Palm of Hand: 0

Regular Wide Claw Grip: 1

Regular Gripping of Narrow Items: 1

Palmar Pinch: 1

Pinch Grip: 1

Hook Grip: 0

Power Grip: 1

Tools Regularly Vibrating or Kickback: 1

Regular use of Trigger Tools: 0

Comments:

TOTAL NECK	2	TOTAL SHOULDERS	2	TOTAL BACK	5	TOTAL UPPER LIMB	10
TOTAL LOWER LIMB	2	GRAND TOTAL	21				

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
1716	Transformers		31/08/00

Division	Department	Area
MWO	Production	B line

NECK

Repeated Turning of the Head	0
Excesseeive Pulling with Arms	0
Prolonged Looking Up and Down	2
Repeated Looking Up and Down	1

BACK

Regular Bending or Stooping Repetitive or Sustained	1
Prolonged Standing	3
Prolonged Sitting	0
Regular Lifting from Floor	0
Regular Lifting from Waist	0
Regular Lifting Shoulder Height or Above	0
Regular Twisting of Back	0
Pulling and Pushing	0

LOWER LIMBS

No or Little Opportunity to Sit	2
Regular use of Stairs or Uneven Surfaces	0
Regular Kneeling or Squatting	0
Regular Twisting due to Confined Space	0

SHOULDERS

Regular Pulling / Pushing Across the body	1
Regular Reaching Above shoulder Height	0
Reaching to Full Extent	0

UPPER LIMB

Regular Twisting or Turning	3
Regular Activities with Wrist out of Neutral	2
Excessive Gripping or Pressing	2
Repeated Hitting with Palm of Hand	0
Regular Wide Claw Grip	2
Regular Gripping of Narrow Items	2
Palmar Pinch	0
Pinch Grip	1
Hook Grip	0
Power Grip	1
Tools Regularly Vibrating or Kickback	0
Regular use of Trigger Tools	0

Comments

TOTAL NECK	TOTAL SHOULDERS	TOTAL BACK	TOTAL UPPER LIMB	TOTAL LOWER LIMB	GRAND TOTAL
3	1	4	13	2	23

Job Action Analysis (Test Results

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
65E	Lifter		21/09/00

Division	Department	Area
PCM	Production	E line

NECK

Repeated Turning of the Head
0

Excessesive Pulling with Arms
0

Prolonged Looking Up and Down
0

Repeated Looking Up and Down
0

BACK

Regular Bending or Stooping Repetitive or Sustained
0

Prolonged Standing
3

Prolonged Sitting
0

Regular Lifting from Floor
0

Regular Lifting from Waist
0

Regular Lifting Shoulder Height or Above
0

Regular Twisting of Back
0

Pulling and Pushing
0

LOWER LIMBS

No or Little Opportunity to Sit
2

Regular use of Stairs or Uneven Surfaces
0

Regular Kneeling or Squatting
0

Regular Twisting due to Confined Space
0

SHOULDERS

Regular Pulling / Pushing Across the body
0

Regular Reaching Above shoulder Height
2

Reaching to Full Extent
1

UPPER LIMB

Regular Twisting or Turning
0

Regular Activities with Wrist out of Neutral
1

Excessive Gripping or Pressing
0

Repeated Hitting with Palm of Hand
0

Regular Wide Claw Grip
0

Regular Gripping of Narrow Items
0

Palmar Pinch
0

Pinch Grip
1

Hook Grip
0

Power Grip
0

Tools Regularly Vibrating or Kickback
0

Regular use of Trigger Tools
0

Comments
1@ each cycle puts plastic bag on extra

TOTAL NECK	0	TOTAL SHOULDERS	3	TOTAL BACK	3	TOTAL UPPER LIMB	2
TOTAL LOWER LIMB	2	GRAND TOTAL	10				

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
15" Tulip 3	packer (lifter not in use)		30/11/00

Division	Department	Area
PCM	Production	B line

NECK

Repeated Turning of the Head: 3

Excessesive Pulling with Arms: 1

Prolonged Looking Up and Down: 0

Repeated Looking Up and Down: 1

BACK

Regular Bending or Stooping Repetitive or Sustained: 0

Prolonged Standing: 3

Prolonged Sitting: 0

Regular Lifting from Floor: 0

Regular Lifting from Waist: 2

Regular Lifting Shoulder Height or Above: 0

Regular Twisting of Back: 0

Pulling and Pushing: 0

LOWER LIMBS

No or Little Opportunity to Sit: 2

Regular use of Stairs or Uneven Surfaces: 0

Regular Kneeling or Squatting: 0

Regular Twisting due to Confined Space: 0

SHOULDERS

Regular Pulling / Pushing Across the body: 1

Regular Reaching Above shoulder Height: 0

Reaching to Full Extent: 0

UPPER LIMB

Regular Twisting or Turning: 0

Regular Activities with Wrist out of Neutral: 0

Excessive Gripping or Pressing: 0

Repeated Hitting with Palm of Hand: 0

Regular Wide Claw Grip: 0

Regular Gripping of Narrow Items: 0

Palmar Pinch: 1

Pinch Grip: 0

Hook Grip: 0

Power Grip: 0

Tools Regularly Vibrating or Kickback: 0

Regular use of Trigger Tools: 0

Comments: every 1/2 h one cushion will fall off and collapses

TOTAL NECK	TOTAL SHOULDERS	TOTAL BACK	TOTAL UPPER LIMB	TOTAL LOWER LIMB	GRAND TOTAL
5	1	5	1	2	14

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
PD73M9L3	Flat box assembly		02/11/00

Division	Department	Area
PCM	Producrion	E Line

NECK

Repeated Turning of the Head: 0

Excessesive Pulling with Arms: 0

Prolonged Looking Up and Down: 0

Repeated Looking Up and Down: 0

BACK

Regular Bending or Stooping Repetitive or Sustained: 0

Prolonged Standing: 3

Prolonged Sitting: 0

Regular Lifting from Floor: 0

Regular Lifting from Waist: 2

Regular Lifting Shoulder Height or Above: 0

Regular Twisting of Back: 1

Pulling and Pushing: 0

LOWER LIMBS

No or Little Opportunity to Sit: 2

Regular use of Stairs or Uneven Surfaces: 0

Regular Kneeling or Squatting: 0

Regular Twisting due to Confined Space: 1

SHOULDERS

Regular Pulling / Pushing Across the body: 0

Regular Reaching Above shoulder Height: 1

Reaching to Full Extent: 0

UPPER LIMB

Regular Twisting or Turning: 0

Regular Activities with Wrist out of Neutral: 2

Excessive Gripping or Pressing: 1

Repeated Hitting with Palm of Hand: 0

Regular Wide Claw Grip: 0

Regular Gripping of Narrow Items: 0

Palmar Pinch: 1

Pinch Grip: 0

Hook Grip: 0

Power Grip: 0

Tools Regularly Vibrating or Kickback: 0

Regular use of Trigger Tools: 0

Comments:

TOTAL NECK	TOTAL SHOULDERS	TOTAL BACK	TOTAL UPPER LIMB	TOTAL LOWER LIMB	GRAND TOTAL
0	1	6	4	3	14

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
	station 1		28/09/00

Division	Department	Area
MWO	BTM	

NECK

Repeated Turning of the Head: 0

Excessesive Pulling with Arms: 0

Prolonged Looking Up and Down: 0

Repeated Looking Up and Down: 1

BACK

Regular Bending or Stooping Repetitive or Sustained: 0

Prolonged Standing: 3

Prolonged Sitting: 0

Regular Lifting from Floor: 1

Regular Lifting from Waist: 1

Regular Lifting Shoulder Height or Above: 0

Regular Twisting of Back: 1

Pulling and Pushing: 0

LOWER LIMBS

No or Little Opportunity to Sit: 2

Regular use of Stairs or Uneven Surfaces: 0

Regular Kneeling or Squatting: 0

Regular Twisting due to Confined Space: 0

SHOULDERS

Regular Pulling / Pushing Across the body: 0

Regular Reaching Above shoulder Height: 0

Reaching to Full Extent: 0

UPPER LIMB

Regular Twisting or Turning: 1

Regular Activities with Wrist out of Neutral: 1

Excessive Gripping or Pressing: 1

Repeated Hitting with Palm of Hand: 0

Regular Wide Claw Grip: 0

Regular Gripping of Narrow Items: 0

Palmar Pinch: 1

Pinch Grip: 0

Hook Grip: 0

Power Grip: 0

Tools Regularly Vibrating or Kickback: 0

Regular use of Trigger Tools: 0

Comments:

TOTAL NECK	1	TOTAL SHOULDERS	0	TOTAL BACK	6	TOTAL UPPER LIMB	4
TOTAL LOWER LIMB	2	GRAND TOTAL	13				

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
	station 2		29/09/00

Division	Department	Area
MWO	BTM	BTM

NECK

Repeated Turning of the Head: 0

Excessesive Puling with Arms: 0

Prolonged Looking Up and Down: 0

Repeated Looking Up and Down: 0

BACK

Regular Bending or Stooping Repetitive or Sustained: 0

Prolonged Standing: 3

Prolonged Sitting: 0

Regular Lifting from Floor: 1

Regular Lifting from Waist: 0

Regular Lifting Shoulder Height or Above: 0

Regular Twisting of Back: 0

Pulling and Pushing: 0

LOWER LIMBS

No or Little Opportunity to Sit: 2

Regular use of Stairs or Uneven Surfaces: 0

Regular Kneeling or Squatting: 0

Regular Twisting due to Confined Space: 0

SHOULDERS

Regular Pulling / Pushing Across the body: 0

Regular Reaching Above shoulder Height: 0

Reaching to Full Extent: 0

UPPER LIMB

Regular Twisting or Turning: 0

Regular Activities with Wrist out of Neutral: 0

Excessive Gripping or Pressing: 1

Repeated Hitting with Palm of Hand: 0

Regular Wide Claw Grip: 0

Regular Gripping of Narrow Items: 0

Palmar Pinch: 1

Pinch Grip: 0

Hook Grip: 0

Power Grip: 0

Tools Regularly Vibrating or Kickback: 0

Regular use of Trigger Tools: 0

Comments: from floor every 8 cycles / press button each cycle

TOTAL NECK: 0 | TOTAL SHOULDERS: 0 | TOTAL BACK: 4 | TOTAL UPPER LIMB: 2

TOTAL LOWER LIMB: 2 | GRAND TOTAL: 8

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
	Station 3 & 4		28/09/00

Division	Department	Area
MWO	BTM	

NECK

Repeated Turning of the Head	1
Excesseaive Pulling with Arms	0
Prolonged Looking Up and Down	0
Repeated Looking Up and Down	0

BACK

Regular Bending or Stooping Repetitive or Sustained	0
Prolonged Standing	3
Prolonged Sitting	0
Regular Lifting from Floor	0
Regular Lifting from Waist	1
Regular Lifting Shoulder Height or Above	0
Regular Twisting of Back	0
Pulling and Pushing	0

LOWER LIMBS

No or Little Opportunity to Sit	2
Regular use of Stairs or Uneven Surfaces	0
Regular Kneeling or Squatting	0
Regular Twisting due to Confined Space	0

SHOULDERS

Regular Pulling / Pushing Across the body	0
Regular Reaching Above shoulder Height	1
Reaching to Full Extent	0

UPPER LIMB

Regular Twisting or Turning	1
Regular Activities with Wrist out of Neutral	0
Excessive Gripping or Pressing	1
Repeated Hitting with Palm of Hand	0
Regular Wide Claw Grip	0
Regular Gripping of Narrow Items	0
Palmar Pinch	1
Pinch Grip	0
Hook Grip	0
Power Grip	0
Tools Regularly Vibrating or Kickback	0
Regular use of Trigger Tools	0

Comments

TOTAL NECK	1	TOTAL SHOULDERS	1	TOTAL BACK	4	TOTAL UPPER LIMB	3
TOTAL LOWER LIMB	2	GRAND TOTAL	11				

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
	Station 5	J.Jenkinson	29/09/00

Division	Department	Area
MWO	BTM	

NECK

Repeated Turning of the Head	0
Excessesive Pulling with Arms	0
Prolonged Looking Up and Down	1
Repeated Looking Up and Down	0

BACK

Regular Bending or Stooping Repetitive or Sustained	0
Prolonged Standing	3
Prolonged Sitting	0
Regular Lifting from Floor	0
Regular Lifting from Waist	1
Regular Lifting Shoulder Height or Above	0
Regular Twisting of Back	0
Pulling and Pushing	0

LOWER LIMBS

No or Little Opportunity to Sit	2
Regular use of Stairs or Uneven Surfaces	0
Regular Kneeling or Squatting	0
Regular Twisting due to Confined Space	0

SHOULDERS

Regular Pulling / Pushing Across the body	0
Regular Reaching Above shoulder Height	1
Reaching to Full Extent	3

UPPER LIMB

Regular Twisting or Turning	0
Regular Activities with Wrist out of Neutral	1
Excessive Gripping or Pressing	1
Repeated Hitting with Palm of Hand	0
Regular Wide Claw Grip	0
Regular Gripping of Narrow Items	0
Palmar Pinch	1
Pinch Grip	0
Hook Grip	0
Power Grip	0
Tools Regularly Vibrating or Kickback	0
Regular use of Trigger Tools	0

Comments

reaches to full extent to left/ press related to

TOTAL NECK	1	TOTAL SHOULDERS	4	TOTAL BACK	4	TOTAL UPPER LIMB	3
TOTAL LOWER LIMB	2	GRAND TOTAL	14				

Job Action Analysis (Test Results)

Job ID	JobDesc	Person Conducting Analysis	Date of Analysis
	Station 6 weld		28/09/00

Division	Department	Area
MWO	BTM	

NECK

Repeated Turning of the Head	0
Excessesive Pulling with Arms	0
Prolonged Looking Up and Down	1
Repeated Looking Up and Down	0

BACK

Regular Bending or Stooping Repetitive or Sustained	2
Prolonged Standing	3
Prolonged Sitting	0
Regular Lifting from Floor	0
Regular Lifting from Waist	0
Regular Lifting Shoulder Height or Above	0
Regular Twisting of Back	1
Pulling and Pushing	0

LOWER LIMBS

No or Little Opportunity to Sit	2
Regular use of Stairs or Uneven Surfaces	0
Regular Kneeling or Squatting	0
Regular Twisting due to Confined Space	0

SHOULDERS

Regular Pulling / Pushing Across the body	0
Regular Reaching Above shoulder Height	3
Reaching to Full Extent	3

UPPER LIMB

Regular Twisting or Turning	0
Regular Activities with Wrist out of Neutral	1
Excessive Gripping or Pressing	1
Repeated Hitting with Palm of Hand	0
Regular Wide Claw Grip	0
Regular Gripping of Narrow Items	0
Palmar Pinch	0
Pinch Grip	0
Hook Grip	0
Power Grip	1
Tools Regularly Vibrating or Kickback	0
Regular use of Trigger Tools	0

Comments

TOTAL NECK	TOTAL SHOULDERS	TOTAL BACK	TOTAL UPPER LIMB	TOTAL LOWER LIMB	GRAND TOTAL
1	6	6	3	2	18

References

Aaras, A. (1994) The impact of ergonomic intervention on individual health and corporate prosperity in a telecommunications environment. *Ergonomics* 37(10):1679-1696

Aaras, A. & Stranden, E. (1988) Measurement of postural angles during work. *Ergonomics* 31: 935-944

Aaras, A. & Westguard, R.H. (1987) Further studies of postural load and musculoskeletal injuries of workers at an electro-mechanical assembly plant. *Applied Ergonomics* 18:211-219

Abbasi, K. (1998) Repetitive strain injury patients have vibration loss. *British Medical Journal.* 316 (21 Feb): 571

Abbott, D. (2003) Stress and strain. *The Health and Safety Practitioner*. Feb: 34-36

Aberdare Online.htm (2005) 400,000 miners still await compensation. Jan. 27.

Alexander, M., Fawcett, J.N. & Runchman, P.A. (1990) Nursing Practice: *Hospital and Home and Adult*. Chuchill Livingstone.

Ahlberg-Hulten, G., Theorell, T. & Sigala, F. (1995) Social support, job strain and musculoskeletal pain among female health care personnel. *Scandinavian Journal of Environmental Health.* 21: 435-439

Almekinders, L.C. (1998) *Soft tissue injuries in sports medicine*. Oxford: Blackwell Science.

Alsaleh, K., Leaver, R. & O'Crawford, J. (2001) Cumulative trauma disorders in manual assembly. The University of Birmingham and Occupational Health Department Landrover.

Amick, B.C., Kawach, I., Coakley, E.H., Lerner, D., Levine, S. & Colditz, G.A. (1998) Relationship of job strain and iso-strain to health status in a cohort of women in the United States. *Scandinavian Journal of Work Environment and Health*. 24 (1) 54-61

Annual Report (2003) Statistics of Industrial Accidents and Occupational diseases www.kosha.net/english/annual/2003/0202.htm

Appleby (2001) RSI Conference. Case Law Update. Charring Cross. London. October

Armstrong, T.J. & Chaffin, B.D. (1979) Carpal tunnel syndrome and selected personal attributes. Journal of Occupational Medicine 21 (7): 481-486

Armstrong, T.J., Foulke, J.A., Bradley, S. J. & Goldstein, S.A. (1982) Investigation of cumulative trauma disorders in a poultry processing plant. *American Industrial Hygiene Association Journal* 43:103 -116

Armstrong, A.L., Hunter, J.B. & Davis, T.R.C. (1994) The prevalence of degenerative arthritis in the base of the thumb in post menopausal women. *Journal of Hand Surgery* 19b 340-341

Armstrong, T., Foulke, J.A., Latko, W., Rabourn, R. & Ulin, S. (1996) Work-related musculoskeletal disorders of the upper limb: Exposure evaluation. *Advances in Occupational Ergonomics and Safety* 1 (2)

Armstrong, T.J. (2000) Work-related upper limb disorders: Background, CTD morbidity patterns, regulatory issues, risk factors and programmes. Lecture Notes 1-19. University of Michigan.

Ashberg, E., Gamberale, F.& Kjellberg, A. (1996) Perceived quality of fatigue during different occupational tasks. *Advances in Occupational Ergonomics and Safety* 1 (2)

Asian Labour Update (2001) Safety and health in South Korea. (June)
The Korean Association of Industrial Injured Workers. ALU 39

Asian Labour Update (2001a) Striking is illegal: 54 miners feared dead
http://www. Asian%20labour%20update%20regional%20roundup%20china.htm

Asian Labour Update (2001b) Occupational Safety and Health in China. April-June ALU 39

Asian Labour Update (2001c) Taiwan's Occupational Health and Safety Situation. April – June ALU 39

Ashton-Miller, J.A. (1999) Response of muscle and tendon injury to overuse. Work related musculoskeletal disorders. National Research Council. Washington D.C: National Academy Press. 19:73-97

Atterbury, M.R., Limke, J.C., Lemasters, G.K., Li, Y., Forrester, C., Stinson, R.& Applegate, H. (1996) nested case- control study of hand and wrist work-related musculoskeletal disorders in carpenters *American Journal Industrial Medicine* 30 (6): 695-701

Baillie, L. (1993) A review of pain assessment tools. *Nursing Standard.* 7 (23) (Feb 24) 25-29

Bainbridge, L.C. (1997) Repetitive strain injury is an unhelpful term. *British Medical Journal* 1044 (7086) (Apr 5).

Ballard J. (1993) Work-related upper limb disorders: Part 1 *Occupational Health Review* 9:20-25

Ballard, J. (1994) Work-related upper limb disorders : Part 2 *Occupational Health Review* 14: 26-28

Bangs, M. (1999) On the write track. *Occupational Health*: 21 March: 21-22

Barton, N.J., Hooper, G. Noble, J. & Steel, W.M. (1992) Review of report of British Orthopaedic Association working party on occupational causes of upper limb disorders. *British Medical Journal* 6822 (304): 309-331

Bartys, S. (2003) Organisational obstacles to recovery form MSDs *Occupational Health Review* 103 May/June: 30.

Battevi, N., Bergamasco, R. & Girola, C. (1998) Criteria for the reintegration in the workforce of workers with musculoskeletal disorders of the upper limbs, based on preliminary practical experience. *Ergonomics* (9): 1384-1397

BBC News Online UK (1999) Record payment for sick miners. Fri. 26 March. http://www.bbc.co.uk/2/low/uk_news/304198.stm

BBC News (1999) Injured miners share five hundred million payout.htm BBC News Fri. Jan. 22

BBC News (2004) UK payout for miners claim rise.htm BBC News. Jan. 12.

Bellace, J.V., Healy, D., Besser, M.P., Byron, T. & Hohman, L. (2000) Validity of the dexter evaluations system's Jamar dynamometer attachment for the assessment of hand grip in a normal population *Journal of Hand Therapy* 13: 46-51

Benaglia, P.G., Franchignoni, F., Ferriero, G., Zebellin, G. & Sartorio, F. (1999) Reliability and validity of the analysis of hand grip and pinch force in isometric and isokinetic conditions *Italian Med Lav Ergonomics* 1: 20-24

Bergamasco, R., Girola, C. & Columbi, D. (1998). Guidelines for designing jobs featuring repetitive tasks. *Ergonomics* 41 (9):1364-1383

Berker, M. & Hughes, B. (1990) Using a tool for pain assessment. *Nursing Times*. 86 (24): 50-52

Bigos, S.J., Spengler, D.M., Martin, N.A., Zen, J. & Nachemson, A. (1986) Back injuries in industry: A retrospective study of 3 employee related factors *Spine* 11: 252-261

Bigos, S.J., Spengler, D.M., Fisher, L.D., Fordyce, W.E., Hannson, T.H., Nachemson, A.L. & Wortley, M.D. (1991) A prospective study of work perceptions and psychosocial factors affecting the reporting of back injury *Spine* 16:1-6

Bjelle, A., Hagberg, M. & Michaelsson, G. (1979) Clinical and ergonomic factors in prolonged shoulder pain among industrial workers. *Scandinavian Journal of Work Environment and Health.* 5:205-210

Bjelle, A., Hagberg, M. & Michaelsson, G. (1981) Occupational and individual factors in acute shoulder-neck disorders among industrial workers. *British Journal of Industrial Medicine* 38: 356-363

Bleakley, C., McDonough, S & MacAuley, D (2004) The use of ice in the treatment of acute soft tissue injury. A systematic review of randomised controlled trials. The *American Journal of Sports Medicine* 32: 251-261

Bohlemann, J., Kluth, K. & Strasser, H. (1993) A system for the analysis of stress and strain in repetitive manual work. London: Taylor and Francis: *Ergonomics of manual work*. 345-352

Bohlemann, J., Kluth, K., Kotzbauer, K. & Strasser, H. (1993b) Electromyographic investigations into different handles of electrical hedge-clippers. London: Taylor and Francis..: *Ergonomics of manual work*.167-170

Bourbannais, F. (1981) Pain assessment development of a tool for the nurse and patient. *Journal of Advanced Nursing*. 6 :272-282

Broadbent, D. & Gath, D. (1981) Symptom levels in assembly line workers Impact of machine paced work on stress. London: Taylor and Francis. Eds Salvendy, G. & Smith, M.J. 243- 253

Broadbent, D.E. (1986) The clinical impact of job design. *British Journal of Clinical Psychology*. 24: 33

Brooke, P. (1993) repetitive strain injury *British Medical Journal* 307:1298

Brown, A., Cramer, C., Eckhaus, D., Schmidt, J., Ware, L. & MacKenzie, E. (2000) Validity and reliability of the dexter hand evaluation and therapy system in hand-injured patients. *Journal of Hand Therapy* (Jan-March): 37-45

BSA British Sociological Association (1996) Statement of ethical practice: 1-4

Buckle, P. & Devereux, J. (1999) Work–related neck and upper limb musculoskeletal disorders. Luxemburg: European agency for safety and health at work. ISBN 9282881741

Buckman, A. (2000) Employer liable for failing to correct wrong use of mouse. *Occupational Health Review* 35: 4-5

Bugajska, J., Roman, D. & Koradecka, D. (1993) Analysis of fatigue during repetitive manual work (hand-grip) London: Taylor & Francis *Ergonomics of manual work* 375-377

Burdorf, A., Derksen, J., Naaktgeboren, B. & Van Riel, M. (1992) Measurement of trunk bending during work by direct observation and continuous measurement *Applied Ergonomics* 23 (4): 263-267

Carlsson, A.M. (1983) Assessment of chronic pain, I: Aspects of the reliability and validity of the visual analogue scale. *Pain* 16: 87-100

Carnall, C. (2003) Managing change in organizations. Essex. Prentice Hall Financial Times 0273657356

Carter, T. (1999) An inspector calls. *Occupational Health* March 21: 16-17

Carter, J.T. & Birell, L.N. (Eds) (2000) *Occupational health guidelines for the management of low back pain at work*: principal recommendations. Faculty of Occupational Medicine, London.

CBI Confederation of British Industry (1999) Focus on absence, absence and labour turnover survey.

Chadwick, E.K. & Nicol, A.C. (2000) Elbow and wrist joint contact forces during occupational pick and place activities. *Journal of Biomechanics* 33 (5) May: 591-600

Chaffin, D.B. (1973) Localised muscle fatigue definition and measurement *Journal of Occupational Medicine* 15: 346-354

Chao, E., Opgrande, J. & Axmear, F. (1976) Three dimensional force analysis of finger joints in selected isometric hand functions. *Journal of Biomechanics* 7 :387-396

Chapparo, A., Rogers, M., Fernandez, J., Bohan, M., Choi, S.D. & Stumpfhauser, L. (2000) Range of motion of the wrist: implications for designing computer input devices for the elderly. *Disability Rehabilitation* September 10-20. 22 (13-14):633-637

Chatterjee, D.S. (1992) Workplace upper limb disorders: A Prospective study with intervention. *Occupational Medicine* 42 (3) August: 129-136

Cheery, N.M., Meyer, J.D., Holt, D.L. & McDonald, J.C. (2001) The reported incidence of work-related musculoskeletal disease in the UK MOSS. Occupational Medicine 51 (7):450-455

Chiang, H.C., Yin-Ching, K., Chen, S. S., Hsin-Su, Y., Trong-Neng, W. & Chang, P. Y. (1993) Prevalence of shoulder and upper limb disorders in the fish processing industry. *Scandinavian Journal of Work Environment and Health* 19:126-131

Childre, F., & Winzeler, A. (1995) Cumulative Trauma Disorder: A primary care provider's guide to upper extremity diagnosis and treatment. Nurse Practitioner Forum 6 (2):106-119

China Labour Bulletin (2004) The absence of Rigor and the failure of implementation: Occupational Health and Safety in China (Note 1)

Choi, S. (1998) Trends in Industrial Safety and Health in South Korea American Red Cross. *Occupational Health and Safety*: 1-3

Chung, M.K., Lee, I. & Yeo, Y.S. (2001) Physiological workload evaluation of screw driving tasks in automobile assembly jobs. *International Journal of Industrial Ergonomics* 28: 181-188

Ciriello, V.M., Snook, S.H., Blick, A.C. & Wilkinson, P.L. (1990) The effects of task duration on psychophysically determined maximum acceptable weights and forces. *Ergonomics* 2: 187-200

Ciriello, V.M., Snook, S.H. & Hughes, G.J. (1993) Further studies of psychophysically determined maximum acceptable weights and forces. *Human Factors* 35 (1): 175-86

Ciriello, V.M., Snook, S.H., Webster, B.S. & Dempsey.P. (2001) Psychophysical study of six hand movements. *Ergonomics* 44 (10) August: 922-36

Clarke, A (1999) Data collection: the research interview. Research in practice. *Professional Nurse* 14: (7): 246-248

Clegg, C., Wall, T. & Kemp, N. (1987) Women on the assembly line: A comparison of main and interactive explanations of job satisfaction, absence and mental health. *Journal of Occupational Psychology.* 60: 273-287

COID (1993) Compensation for Occupational and Disease Act COID – Act for WRULD. www.physioa.org.za/news/newsreview.asp?id=33

Cole, D.C., Ibrahim, S. A., Shannon, H.S., Scott, F. & Eyles, J. (2001) Work correlates of back problems and activity restriction due to musculoskeletal disorders in the Canadian national population survey. *Occupational Environmental Medicine* 58: 728-734

Cole, D. C., Wells, R.P., Frazer, M.B., Kerr, M.S., Neumann, W.P. & Laing, A.C. (2003) Methodological issues in evaluating workplace interventions to reduce work-related musculoskeletal disorders through mechanical exposure reduction. *Scandinavian Journal of Work Environment and Health.* 29 (5): 396-405

Columbini, D., Occhipinti, E. & Malteni, G. (1985) Posture analysis. *Ergonomics* 28: 275-284

Columbini, D. (1998) An observational method for classifying exposure to repetitive movements of upper limbs *Ergonomics* 41. (9): 1261-1289

Cooper, C. & Baker, P.D. (1996) Upper limb disorders. *Occupational Medicine* 46:435-437

Corlett, E.N. & Clark, T.S. (1995) *The ergonomics of workspaces and machines* 2nd Edn. London: Taylor and Francis.

Corlett, E.N., Madeley, S.J. & Manenica, I. (1979) Posture targeting: a technique for recording working postures 22 (3): 357-366

Cormack, D.F.S. Eds (1991) The research process in nursing. Blackwell scientific publications London ISBN 0632028912

Cox, R.A.F. (1995). Fitness for Work: The medical aspects. Oxford: Oxford University Press

Crosby, C.A., Marwan, A., Wehbe, M.D. & Mawr, B. (1994) Hand strength: Normative values. *Journal of Hand Surgery* 19 (4): 665-670

Cross, M. (1990) Changing job structures. Oxford. Heineman News. (ISBN0434902845).

Crossman, A., R. & Neary., D. (2002) Neuroanatomy an illustrated colour text. Churchill Livingstone . London. (ISBN 0443062161)

Dalton, S. & Hazelton, B.L. (1987) Repeated movements and repeated trauma. In Raffle, P.A.B., Lee, W.R., McCallum, R.I., Murray, R. *Hunters diseases of occupations* 6th Edn. London (Eds) Edward Arnold: 622-633

Dawson, A.J (2004) Methodological reasons for not gaining prior consent are sometimes justified. *British Medical Journal*. 329:87

DDA (1995) Disability Discrimination Act. Chapter 50. HMSO.

Deivanayagam, S. & Sethi, N. (1993) Effects of wrist deviation on hand torque strength and the potential for CTS. London: Taylor and Francis *Ergonomics of manual work* 265-268

De Krom M.C.T.F.M., Knipshield, P.G., Kester A.D.M. & Spaans, F. (1990) Risk factors for carpal tunnel syndrome. *American Journal of Epidemiology* 132: 1102-1110

De Krom M.C.T.F.M., Knipshield, P.G., Kester A.D.M., Thijs, C.T., Spaans, F. & Boekkooi, P.F. (1992) Carpal tunnel prevalence in the general population. *Journal of Clinical Epidemiology* 45 (4): 273-376

Denzin, N.K. & Lincoln, Y.S. (2000) Handbook of qualitative research. In Atkinson, P. & Hammersley, M. Ethnography and participant observation 2nd ed Ch 15: 248-261 Thousand Oaks. London: Sage.

Descartha, A., Leclerc, A., Chastang, J.F. & Roquelaure, Y. (2004) Incidence of ulnar nerve entrapment at the elbow in repetitive work. *Scandinavian Journal of Work Environment and Health. 30 (3) 234-240*

Desrosiers, J., Bravo, G., Herbert, R. & Mercier, L (1995) Impact of elbow position on grip of elderly men. Journal of Hand Therapy 8: 27-30

Devereux, J. & Buckle, P. (2000) The risk of neck, shoulder and upper limb musculoskeletal disorders due to interactions between physical and psychosocial work risk factors. Proceedings of the XIVth triennial Congress of the International

Ergonomics Association and the 44th meeting of the Human Factors and Ergonomic Society, July 29- August 4 San Diego California pp 5-597

Dickenson, C. E., Campion, K., Foster, A. F., Newman, S. J., O'Rouke, A. M. T. & Thomas, P. G. (1992) Questionnaire development: an examination of the Nordic Musculoskeletal Questionnaire. *Applied Ergonomics.* 23. (3) June: 197-200

Dul, J. & Weerdmeester, B (2001) Ergonomics for beginners: *a quick reference guide.* London: Taylor and Francis.

Dyer, C. (1994) Court awards record settlement for worker with RSI. *British Medical Journal* 308. (29 Jan): 293

Edwards, A. & Talbot, R. (1994) The hard pressed researcher. London: Longman.

Eklund, J.A.E. (1995) Relationship between ergonomics and quality in assembly work. *Applied Ergonomics* 26 (1): 15-20

Epstein, O., Perkin, G.D., Cookson, J. & De bono, D.P. (2003) Clinical Examination. 3rd Ed. .Mosby. Elsevier. Spain

Ergonomics Today (1999) OSHA's official statement on ergonomics proposal (Part 1 &2). Nov 22

Ergonomics Today (2000) Work-related musculoskeletal disorders affects 40 million European workers. Nov 20

Ergonomics Today (2000b) European leaders discuss prevention of MSDs. Dec 13

Ergonomics Today (2001) National Academy of sciences releases second study on MSDs. Some jobs increase risk for musculoskeletal disorders, intervention programmes can be effective. January 18.

Ergonomics Today (2001b) NIOSH expands focus on women and MSDs Nov 19

Ergonomics Today (2001c) Data on CTS and computer work. Dec 28

Ergonomics Today (2002) Supreme court releases decision involving ADA and carpel tunnel syndrome. Jan 8

Ergonomics Today (2002) MSD risk factors cost even before they injure. May 3

Ergonomics Today (2002) Citations for workplace MSDs and the California State. May 6

Essendrop, M., Schibye, B. & Hansen, K. (2001) Reliability of isometric muscle strength tests for the trunk, hands and shoulders. *International Journal of Industrial Ergonomics* 28: 379-387

European Agency for Safety and Health at Work (2000) *Annual Report.* Luxemburg

European Agency for Health and Safety at work (2001) Quality of work: A future community strategy for safety and health at work. Proceedings of a workshop organised in Bilbao 24-25 April 2001 by the Swedish presidency of the EU commission and the EU Agency for Safety and Health at Work

European Agency for Safety and Health at Work (2001b), Forum Fact Sheets 1-6 & 9

Evening Gazette (2003) Former miners warned over claims cut-off-date. 21 April: 3

Faucett, J. & Werner. R.A. (1999) *Non-biomechanical factors potentially affecting musculoskeletal disorders.* In work-related musculoskeletal disorders. Conference report National Research Council. Washington DC National Academy Press.:1175-1195

Fine, L., Silverstein, B., Armstrong, T., Joseph, B. & Bucholz, B. (1985) Postural Characteristics of Jobs associated with an elevated risk of rotor cuff tendonitis. Proceedings of the 9th Congress of the International Ergonomics Association, 2-6 September. Bournemouth, England.

Fishbain, D.A., Cutler, R., Rosomoff, H.L & Rosomoff, R.S.(1999) Chronic pain disability exaggeration/malingering and submaximal effort research. *Clinical Journal of Pain* 15 (4) December: 244-274

Fleming, A.J. (1996) The many faces of occupational health. *Journal of Occupational Medicine.* Anniversary Issue. 8 (4) January: 201-207

Freivalds, A. (1999) Ergonomics of hand tools. In Karwoski, W. & Marras, W.S (Eds) *The Occupational Ergonomics Handbook.* Boca Raton. CRC Press: 461-478

Frost, P., Andersen, J. H. & Nielson, V.K. (1998) Occurrence of Carpal Tunnel Syndrome among slaughterhouse workers. *Scandinavian Journal of Work Environment and Health* 24 (4): 285-292

Gamberale, F. & Kjellberg, A. Akerstedt, T. & Johansson, G. (1990) Behavioural and psychophysiological effects of the physical work environment. Research strategies and measurement methods. *Scandinavian Journal of Work Environment and Health* 16 (1): 5-16

Gelberman, F., Herginroeder, P.T., Hargans, A.R., Lundborg, G.N. & Akeson, W.H. (1981) The carpal tunnel syndrome: a study of carpal canal pressures. *Journal of Bone Joint Surgery* 63(A): 380-383

Graveling, R.A., Symes, A.M., Love, R.G & Graves, R.J. (1990) Developing an aid to identify the elements which may predispose individuals to work-related upper limb disorders. Institute of Occupational Medicine. (40) 10M 90/08

Graves, R.J. (1990) Repetition strain injury: Are we handling it properly?
Safety and Health Practitioner. December: 11-14

Graves, R.J., Sinclair, D.T., Jamieson, D.W. Ratcliffe, B. Watt, M. & Doherty, S. (2000) Development and evaluation of diagnostic support aids for upper limb disorders. Contract research report 280 HSE Books (ISBN 0717618242).

Griffith, D. A. (1993) Correlates of isokinetic trunk strength with back injury history among workers in the mineral processing industry. *Ergonomics in manual work.* London.Taylor and Francis: 279-286

Grunert, B.K., Hargarten, S.W., Matloub, H.S., Sanger, J.R., Hanel, D.P. & Yousif, J. (1992) Predictive Value of psychological screening in acute hand injuries. *Journal of Hand Surgery* (17A) :196-199

Hadler, N.M. (1992) Arm pain in the workplace: A small area analysis. *Journal of Occupational Medicine* 2: 113-119

Hagberg, M. (1981) Work load and fatigue in repetitive arm elevations *Ergonomics* 24 (5-8): 543-555

Hagberg, M., Silverstein, B., Wells, R., Smith, M. J., Hendrick, H.W., Carayon, P & Perusse, M. (1995) work-related musculoskeletal disorders (WMSDs): *A reference book for prevention.* Basingstoke: Taylor & Francis

Hagberg, M. (1996) Exposure considerations when evaluating musculoskeletal diagnoses. *Advances in Occupational Ergonomics and Safety* 1 (2)

Hagen, K.B., Magnus, P., & Vetlesen, K. (1998) Neck/shoulder and low-back disorders in the forestry industry: Relationship to tasks and perceived psychosocial job stress. *Ergonomics* 41 (10): 1510-1518.

Hakkanen, M., Vikari-Juntura, E, & Martikainen, R. (2001) Incidence of musculoskeletal workers among newly employed manufacturing workers. *Scandinavian Journal of Work Environment and Health* 27 (6):381-387

Hales, T.R., Sauter, S.L., Peterson, M.R., Fine, L.J., Putz-Anderson, V., Schleifer, L.R., Ochs, T.T. & Bernard, B.P. (1994) Musculoskeletal disorders among visual display users in a telecommunications company. *Ergonomics* 37 (10): 1603-1621

Halligan, M.C. (1994) Physiotherapy audit into the use of objective measurements in physiotherapists' assessment of pain. BSc Dissertation. University of Teesside.

Halpern, C.A. & Fernandez, J.E (1993) The effect of wrist posture and pinch type on endurance time. *Ergonomics of manual work.* London: Taylor and Francis: 323-327

Hammer, A. (1934) Tenosynovitis Medical record 140: 353-355

Hammersley, M. & Atkinson, P. (1996) Ethnography principles in practise. 2nd Edn London: Routledge.

Harrington, J.M., Hancock, J., Gompertz, D. & Spurgeon, A. (1996) Work-related upper limb pain syndromes: Origin and management . Workshop sponsored by the HSE. Institute of Occupational Health. University of Birmingham. 10-11 October 1995.

Harrington, J. M., Carter, J. T., Birrell, L. & Gompertz, D. Surveillance case definitions for work related upper limb pain syndromes. *Occupational & Environmental Medicine.* 55:264-271

Hazzard, L., Mautz, J. & Wrightsman, D. (1992) Job rotation cuts cumulative trauma cases. *Personnel Journal.* v71 (n2) February: 29-32

Helliwell, P.S., Mumford, D.B., Smeathers, J.E. & Wright, V. (1992). Work-related upper limb disorder: The relationship between pain, cumulative load disability and psychological factors. *The Annals of Rheumatoid Disease* 51: 1325-1329

Hendrick, H. (1996) *Good ergonomics is good economics* Proceedings of the Human factors and Ergonomics Society 40th Annual Meeting 1-15

Herberts, P., Kadefors, R. & Broman, H. (1980) Arm positioning in manual tasks: An electromyographical study of localised muscle fatigue. *Ergonomics* 8: 7-16

Herberts, P., Kadefors, R., Andersson, G. & Petersen, I. (1981) Shoulder pain in industry: An epidemiologic study on welders. *Acta Orthopaedica* 52: 299-306

Herberts, P., Kadefors, R. & Sigholm, G. (1984) Shoulder pain and heavy manual labour. *Clinical Orthopaedic Related Research* 191:166-178

Hignett, S. & McAtamney, L. (2000) Rapid entire body assessment (REBA*). Applied Ergonomics* 31 : 201-205

Hignett, S. & McAtamney, L. (1997) *Rapid entire body assessment (REBA) in the health care industry*. Proceedings of the 13th Triennial Congress of the International Ergonomics Association. Tampere, Finland: 162-164

Hignett, S. (1994) Using computerised OWAS for postural analysis of nursing work. In Robertson, S. (Ed) *Contemporary ergonomics.* London Taylor and Francis: 253-258

HSE at Work Act (1974) London: HMSO (ISBN 0105437743) CH3

HSE (1988) Working with VDUs. Leaflet INDG36 (Rev 1) Sudbury: HSE books

HSE (1988) HSG 45 Safety in meat preparation: Butcher's guide. Sudbury HSE Books

HSE (1990) HSG 60 Work-related upper limb disorders: A guide to prevention London: HMSO (ISBN 0717604756)

HSE (1992) Display Screen Equipment work Regulations London: HMSO

HSE (1992) Manual Handling. Guidance on Regulations London: HMSO

HSE (1994) A pain in your workplace: Ergonomic problems & solutions. Sudbury HSE Packing on a production line (ISBN 0717608263)

HSE (1994) Upper limb disorders: Assessing the risks. Sudbury. HSE.

HSE (1995) Riddor: A guide to the reporting of injuries disease and dangerous occurrences regulations. Sudbury: HSE Books (ISBN0717610128)

HSE (1997) Workplace injury: Comparison of Great Britain with Europe and the USA. Sudbury HSE books.

HSE (1998) Review of the risks associated with pushing and pulling heavy loads RR228 / L23

HSE (1999) Levels and trends in workplace injury: Reported injuries and labour force survey. HSE books

HSE (1999) Management of health and safety and work regulations: Approved code of practise and guidance (L21) 2nd Edn, Sudbury: HSE books

HSE (1999) HSG 40 Safe handling of chlorine from drums and cylinders. Sudbury HSE Books.

HSE (2000) Good health is good business: Managing health risks in manufacturing industry. Employers Guide MICS 45. Sudbury: HSE books

HSE (2000b) Information sheet: Secondary analysis of the 1995 self-reported work-related illness survey (SW195) 4 EMSU

HSE (2001b) Work-related back disorders: Statistics information sheet: 3/01/EMSU. Sudbury. HSE.

HSE (2000/2001) National statistics: Health and Safety Commission. Sudbury: HSE Books(ISBN 0717621103)

HSE (2002) Upper limb disorders in the workplace. HSG60 (rev) Sudbury: HSE Books (ISBN 0717619788)

Hofstede, G. (1980) Culture's consequences: International differences in work related values. Newbury Park CA: Sage.

Hofstede, G (2003) Culture's consequences: Comparing values, behaviours, institutions and organisations across nations. Newbury Park. Sage

Hoogendoorn, W.E., Bongers, P.M., De Vet, H.C.W., Houtman, I.L.D., Ariens, G.A.M., Van Mechelen, W. & Bouter, L.M. (2001) Psychosocial work characteristics and psychological strain in relation to low-back pain. *Scandinavian Journal of Work Environment and Health* 27 (4):258-267

Hunting, W. Grandjean, E. & Maeda, K. (1980) Constrained postures in accounting machine operators. *Applied Ergonomics.* 11 (3): 145-149

Huppes, G., Ijff, M. & Maas, K. (1993) Repetitive work and RSI: Recognizing work situations at risk. An instrument for diagnosis. *Ergonomics of Manual Work.* London: Taylor & Francis:319-322

Hymovich, L. & Lindholm, M. (1966) Hand, wrist and forearm injuries: The result of repetitive motion. *Journal of Occupational Medicine* 8 :573-577

Ilbo, H. (1995) Backward health care for modern causes of death. *Korea Focus* 3 (1) January-February: 155-156

Ippolito, E., Postacchini, F., Scolo, E., Bellocci, M. & Matino, C. (1985) De Quervains disease: An ultrastructural study (Sicot). *International Orthopaedics* 9: 41-47

IM group action (2003) Work related illness Vibration white finger. www.imonline.co.uk/groupaction/our_work/work_related_illness

IRS (2002) Repetitive Strain Injury (RSI): *Practical workplace management.* Report of Conference Thistle Charring Cross Hotel. London Thursday 21st March

Jackson, W.T., Viegas, S.F., Coon, T.M., Stimpson, K.D., Frogameni, A.D.& Simpson, J.M. (1986) Anatomical variations in the first extensor compartment of the wrist. *Journal of Bone and Joint Surgery* 68(A): 923-926

Jarvholm, U., Palumerud, G., Styf, J., Herberts, P. & Kadefors, R. (1988) Intramuscular pressure in the supraspinatus muscle. *Journal of Orthopaedic Research* 6: 230-238

Jobe, F.W., Hamner, D.L. & Pink, M.M. (1997) Overuse injuries of the elbow. Current Orthopaedics. Mini-symposium Elbow problems. 11 (4): 249-254 Harcourt Brace & Co.

Jones, J.R., Hodgson, J.T., Clegg, T.A. & Elliot, R.C. (1998) Self –reported work-related illness in 1995. Results from a Household Survey. SW195 Norwich. HSE Books (ISBN 071761509X)

Jonsson, B., Persson, J. & Kilbom, A. (1998) Disorders of the cervicobrachial region among female workers in the electronics industry: A two year follow up. *International Journal of Industrial Ergonomics.* 3: 1-12

Kaergaard, A. & Anderson, J.H. (2001) Musculoskeletal disorders of the neck and shoulders in female sewing machine operators: Prevalence, incidence and prognosis. *Occupational and Environmental Medicine.* 57 (8): 528-534

Kannis, J& Bergmann, J. (1993) Full consent may bias outcomes of trials. *British Medical Journal.* 307:1497

Kant, I., Notermans, H.V. & Borm, P.J.A. (1990) Observation of working posture in garages using the Ovako Working-posture Analysing System (OWAS) and consequent workload reduction recommendations 33. (2): 209-220

Karhu, O., Kansi , P. & Kuorinka, I. (1977) Correcting work postures in industry: A practical method for analysis. *Applied Ergonomics.* 8.(4): 199-201

Karlsson, B., Knutsson, A. & Lindahl, B. (2001) Is there an association between shift work and having a metabolic syndrome? Results from a population based study of 27 485 people. *Occupational Environmental Medicine* 58 November: 747-752

KTCU Korean Federation of Trade Unions (1996) Occupational Safety and Health in Korea. April 30. www.kctu.org/document

Keyserling, W.M., Stetson, D.S., Silverstein, B.A. & Brouwer, M.L. (1993) A checklist for evaluating ergonomic risk factors associated with upper extremity cumulative trauma disorders. *Ergonomics* 36 (7): 807-831

Keir, P.J. & Wells, R.P. (1992) MRI of the carpal tunnel: Implications for carpal tunnel syndrome. Advances in industrial ergonomics and safety In Kumar, S (Ed) London: Taylor & Francis. 753-760

Kesson, M. & Atkins, E. (1998) Orthopaedic medicine: A practical approach. Oxford: Heinemann.

Khaleque, A. & Hossain, M.M. (1993) Job satisfaction, fatigue and mental health of manual, semi-automated and automated workers. *The Ergonomics of Manual Work* London: Taylor & Francis: 441-443

Khang, H.S (1999) Korea fire kills 23 nursery children. The Independent, 1st July p.14

Kilbom, A. & Persson, J (1986) Disorders of the cervicobrachial region among female workers in the electronics industry. *International Journal of Industrial Ergonomics.* 1 (1): 37-47

Kilbom, A. & Persson, J. (1987) Work technique and its consequences for musculoskeletal disorders. *Ergonomics* 30 (2): 273-279.

Kilpatrick, J. (1956) Evaluation of grip loss. *California Medicine* 85: 314-320

Kim, T.K (1995) Fix the barn door before it's too late. *Korea Focus.* 3 (4) July-August:156-157

Kippers, V. (1999) EMG studies of upper limb. University of Queensland AN324 lecture. School of Biomechanical Sciences
http://www.uq.eduav/2annkipper/an324/upper.html

Kirwan, B. & Ainsworth L.K. (1992) *A guide to task analysis.* London: Taylor & Francis.

Knutson, J.S., Kilgore, K.L., Mansour, J.M. & Crago, P.E. (2000) Intrinsic and extrinsic contributions to the passive moment at the metacarpophalangeal joint. *Journal of Biomechanics* 33: 1675-1681.

Korean Occupational Safety and Health Agency (2000) *Annual Report* www.kosha.or.kr

Krause, N., Lynch, J. W., Kaplan, G. A., Cohen, R.D., Salonen, R. & Salonen, J.T. (2000) Standing at work and Progression of carotid atherosclerosis. *Scandinavian Journal of Work Environment and Health.* 26 (3): 227-236

Kuiper, J. I., Verbeek, J.H.A.M., Straub, J.P.,Everts, V. & Frings-Dresden, M. H. W. (2002) Physical workload of student nurses and serum markers of collagen metabolism. *Scandinavian Journal of Work Environment and Health* 28 (3):168-175

Kuzala, E.A., & Vargo, M.C. (1992) The relationship between elbow position and grip strength. *American Journal of Occupational Therapy* 46: 509-512.

Laflamme, L., Montreuil, S. & Tellier, C. (1993) Profile of musculoskeletal pain suffered by female textile spinning workers *Ergonomics of Manual Work.* London: Taylor and Francis. 291- 294.

Lavender, S.A (1990) *The development of preparatory response strategies in anticipation of sudden loading of the torso.* Proceedings of the Human Factors Society 34th Annual Meeting, Orlando, Florida 34 October 8-10 (1): 751-756

Leaver, R. (1999) Physiotherapy: Preventing pain in the workplace (Case Study 2) Land rover vehicles recovery programme. Landrover

Leaver, R. (2000) Evaluation of an ergonomic intervention programme within a manufacturing environment. MSc Ergonomics (Thesis) Department of Human Sciences. University of Loughborough

Lebeter, C. (1999) A half-century of health legislation. *Occupational Health* 50th anniversary March 21: 14-15

Lee, K., Swanson, N., Sauter, S., Wickstrom, R., Waiker, A. & Mangum, M. (1992) A review of physical exercises recommended for VDT operators. *Applied Ergonomics.* 23 (6): 387-408

Li, G. & Buckle, P. (1999) Evaluating change in exposure to risk for musculoskeletal disorders : A practical tool. Practical. Robens Centre for Health Ergonomics, University of Surrey Health and Safety Executive Contract Research Report 251 HSE Books (ISBN 071761722X)

Li, G. & Buckle, P.(1999) Current techniques for assessing physical exposure to work-related musculoskeletal risks, with emphasis on posture-based methods. *Ergonomics* 42 (5): 674- 695

Lindman, R., Hagberg, M,. Angqvist, K.A., Soderlund, K., Hultman, E. & Thornell, L.E. (1991) Changes in muscle morphology in chronic trapezius myalgia *Scandinavian Journal of Work Environment and Health.* 17: 347-355

Liu, F., Carlson, L. & Watson, H.K. (2000) Quantitative abductor pollicis brevis strength testing: Reliability and normative values. *American Journal of Hand Surgery.* 25(A) July: 752-759

Luopajarvi, T., Kourinka, I., Virolainen, M. 7 Holmberg, M. (1979) Prevalence of tenosynovitis and other injuries of the upper extremity in repetitive work *Scandinavian Journal of Work and Environment and Health* 3: 48-55

Lucire,Y. (1986) Neurosis in the workplace. *Medical Journal of Australia* 145 October :323-327

Lundberg, U.L.F., Granqvist, M., Hansson, T., Magnusson, M. & Wallin, L. (1989) Psychological and physiological stress responses during repetitive work at an assembly line. Work and Stress 3:143-153

Lundberg, U.& Melin, B. (1995) Stress muscular tension and musculoskeletal disorders presentation stress at work (11) Premus 95 September:167-168

Maccoby, M. (1997) Is there a best way to build a car? *Harvard Business Review* November- December: 161-170

MacFarlane, G.J., Hunt, I.M. & Silman, A.J. (2000) Role of mechanical and psychosocial factors in the onset of forearm pain: Prospective population based study. *British Medical Journal* 7262: 321 16 (September): 676-678

Mackay, C., Burton, K., Bookcock, M., Tillotson, M. & Dickinson, C. (1998) *Musculoskeletal disorders in supermarket cashiers.* HSE and Spine Research Unit Huddersfield: HSE Books

MacLeod, D. & Kennedy, E. (1993) *Job rotation system.* Report to XYZ Co.1-13 www.danmacleod.com/articles/job.htm

Maganaris, C.N. & Paul, J.P (2000) Hysteresis measurements in intact human tendon. *Journal of Biomechanics.* 33 December: 1723-1727

Makhan, D.W. (2001) Musculoskeletal strain: A comparison of two undercarriage assembly line methodologies within the automotive industry. MSc Ergonomics University of Loughborough.

Marklin, R.W. (1999) Biomechanical aspects of cumulative trauma disorders. *Occupational ergonomics handbook* Ohio:CRC press: 822-823

Marland, I. (1997) Worker wins record cash. The Journal newspaper. January 24: 1

Mathiowetz, V., Weber, K., Vollarol, G. & Kashnan, N. (1984) Reliability of grip and pinch strength evaluations. *Journal of Hand Surgery* 9 (A): 222-226

Mathiowetz, V., Rennells, C & Donohoe, L. (1985) Effect of elbow position on grip and key pinch strength. *Journal of hand surgery* 10 (A): 694-697

Mattila, M. & Vilkki, M. (1999) OWAS Methods. *In the occupational ergonomics handbook.* Boca Raton CRC Press: 447-459

McAtamney, L. & Corlett, N. (1993). A rapid upper limb assessment tool: A survey method for investigation of work-related upper limb disorders. *Applied Ergonomics* 24 (2): 91-99

McCormack, R.R., Inman, R.D., Wells, A., Bernsten, C. & Imbus, H.R. (1990) Prevalence of tendonitis and related disorders of the upper extremity in a manufacturing workforce. *The Journal of Rheumatology.* 17 (7) 956-964

McDermott, F.T. (1986) Repetition strain injury: A review of current understanding. *The Medical Journal of Australia.* 144. (4): 196-200

McGregor (2003) Team building exercises, management techniques, human resource management, motivation resources to improve productivity in your organisation based on the theories X-Y / http:www.accel-team.com

McGuire, D. (1984) The measurement of clinical pain. *Nursing Research* 33 (3): 152-156

Melzack, R. & Wall, P.D. (1996) *The challenge of pain.* London: Penguin books.

Melzack, R. (1987) The short McGill questionnaire. *Pain* 30: 191-199

Mercer, D. (1999) Future revolutions at work. Open University Business School.

Moir, S. & Buchholz, B. (1995) Using ethnographic methods for collecting qualitative data on musculoskeletal disorders and intervention among heavy and highway construction workers. Premus second international scientific conference on prevention of work-related musculoskeletal disorders: 471-473

Moore, A., Wells, R. & Ranney, D. (1991) Quantifying exposure in occupational manual tasks with cumulative trauma disorders potential. *Ergonomics* 34 (12): 1433-1453

Moraes, A. Guidine, S. Dias, P. C. G. & Robson, M. (1993) A biomechanical grasp: Some examples. *Ergonomics of Manual Work*: London: Taylor and Francis: 179-182

Morris, L. & Way, K. (2002) Tackling upper- limb disorders: A management approach. *Occupational Health Review* 96 March/April: 12-16

Nevill, A.M. & Holder, R.L. (2000) Modelling handgrip strength in the presence of confounding variables: Results from the Allied Dunbar National Fitness Survey. *Ergonomics* 43 (10): 1547-1558

Niebuhr, B.R. & Marion, R. (1987) Detecting sincerity of effort when measuring grip strength. *American Journal of Physical Medicine* 66 (1) February: 16-24

Niebuhr, B. Marion, R. & Fibe, M. (1994) Reliability of grip strength assessment with the computerised Jamar dynamometer *Occupational Therapy Journal of Research* 14: 3-17

NIOSH National Institute for Occupational Safety and Health (1997) Musculo skeletal disorders and workplace factors: A critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity and back. US Department of Health and Human Services. Pub 97-141 Cincinnati

Noteboom, T., Cruver, R., Keller, J., Kellogg, B. & Nitz, A.J. (1994) Tennis Elbow: A review. *Journal of Orthopaedic Sports Physical Therapy* 19 (6): 357-366

Occhipinti E. & Columbini ,D. (1993) Occurrence of spine disorders in different groups of workers involved in manual handling tasks. *Ergonomics of Manual Work.* London: Taylor and Francis: 283-286

Occhipinti, E., Colombini, D., Bulgheroni, M. & Grieco, A. (1993) Evaluation of the strain in upper limbs muscles during different meat cutting tasks by means of vocational EMG *Ergonomics of Manual Work* London: Taylor and Francis: 331-334

Occupational Health Review (1997) £186,00 for toilet-roll worker wiped out of job 5 March/April: 19

Occupational Health Review OH (1998) Listening bank loses hearing 2 July / August: 15

Occupational Health Review (1999) Frimley Five win further famous victory 2 September/October: 16

Occupational Health Review (2000). Occupational health management. 4 (October):3

Occupational Health Review (2000) RSI is overused misnomer. November/December:2

Ohlsson, K., Attewell, R.G. & Palsson, B (1995) Repetitive industrial work and neck and upper limb disorders in females. *American Journal of Industrial Medicine* 27: 731-747

Oude Vrielink, H.H.E., Van Dulleman, E. & Van Dieen, J.H. (1995) Multiple factor involvement in work-related musculoskeletal complaints: A case study in female agricultural workers. Premus 95 Institute of Agricultural and Environmental Engineering Outremont Conference Sept 26th, 199-210

Oxenburgh, M. (1991) Redesign of an inspection station. *Health & Safety CCH International*: 152-155

Oxford Concise Colour Medical Dictionary (2002) Oxford paperback reference. Oxford 3rd Ed.

Oxford, K.L (2000) Elbow positioning for maximum grip performance. *Journal of hand therapy performance* 13 (1): 33-36

Palmer, M.L. Epler, M.E. (1998) Fundamentals of musculoskeletal assessment technique. Lipincott. Philadelphia

Palmer, K., Coggon, D., Cooper, C. & Docherty, M. (1998) Work related upper limb disorders getting down to specifics. Annals of Rheumatoid Disease. Aug. 57 (8): 445-456

Palmer, K., Walker-Bone, K., Linaker,C., Reading, I. Kellingray, S., Coggon, D. & Cooper, C. (2000) The Southampton examination schedule for the diagnosis of musculoskeletal disorders of the upper limb. Annals of Rheumatoid Disease. 59:5-11

Palmer, K.T., Griffin, M.J., Syddall, H.E., Pannett, B., Cooper, C. & Coggon, D. (2001) Exposure to hand-transmitted vibration and pain in the neck and upper limbs. Occupational medicine. 51 (7): 464-467

Palmer, K.T., Walker-Bone, K., Griffin, M.J., Syddall, H., Pannett, B., Coggon, D. & Cooper, C. (2001a) Prevalence and occupational associations of neck pain in the British population. *Scandinavian Journal of Work and Environmental Health.* 27 (1): 49-56

Parker, S. & Wall, T. (1998) Job and work design: *Organising work to promote well being and effectiveness*. London: Sage.

Pellegrini, S.R. & Rochester, N.Y. (1991) Osteoarthritis of the trapeziometacarpal joint. *American Journal of Hand Surgery* 16A (6): 967-982

Phalen, G. (1972) Carpal tunnel syndrome. *Journal of Bone and Joint Surgery* 48A: 211-228

Pheasant, S.T. (1992) Does RSI exist? *Occupational Medicine* 42 (3): 167-168

Piegorsch, K. (1993) Estimation of cumulative trauma risk under existing and proposed conditions in furniture manufacturing. *Ergonomics of Manual Work* London: Taylor and Francis 299-302

Proper, K. I., Staal, B. J., Hilderbrant, V. H., Van der Beek, A. J. & Van Mechelen, W. (2002) Effectiveness of physical activity programs at worksites with respect to work-related outcomes *Scandinavian Journal of Work Environment and Health* 28 (2):75-84

Punnet, L., Fine, L.J., Keyserling, L.J., Herrin, G.D. & Chaffin, D.B. (1991) Back disorders and non-neutral trunk postures of automobile assembly workers. *Scandinavian Journal of Work Environment and Health* 17 (5): 337-346

Punnet, L. (1999) *Epidemiological studies of psychological ergonomic stressors and musculoskeletal disorders*. In work-related musculo skeletal disorders. Conference Report. National Research Council. Washington DC: National Academy Press: 162-165

Putz-Anderson, V. (1988) Cumulative trauma disorders: *A manual for musculoskeletal disorders of the upper limbs*. London: Taylor & Francis

Quanbeck, D.S. (2000) Hypermobility can lead to musculoskeletal deformities and be associated with other serious conditions: A paediatric perspective. Gillette Children's Special Healthcare 9 (3) May/June: 3

Quintner, J. (1991) The RSI syndrome in historical perspective. International Disability Study 13 (3) July–September: 99-104

Raiman, J. (1986) Towards understanding pain and planning relief. *Nursing Times* 3 (11): 411-413

Rates of Workplace Injury (1996) Europe and the USA: Accidents at work in the EU Statistics in Focus Theme 3.4.

Ranney, D. Wells, R. Moore, J. (1995) Upper limb musculoskeletal disorders in highly repetitive industries: precise anatomical physical findings. *Ergonomics* 38 (7): 1408-1423

Reilly, B., Paci, P. & Holl, P. (1995) Unions, safety committees and workplace injuries. *British Journal of Industrial Relations* 33 (2 June): 274- 284

Repetitive Strain Injury Quarterly (2003) over 5.4 million working days were lost last year to work-related conditions that over 400,000 of us experience. New Look Magazine. March- May. 1.

Robson, C. (1993) Real world research. A resource for social scientists and practitioner researchers. Oxford: Blackwell. (ISBN0631176896)

Roman, D., Bugajska, J., Wiatr, R. & Konarska, M. (1993) EMG analysis of trapezius muscle load during operators work. *Ergonomics of Manual Work* London: Taylor and Francis:171-174

Roper, J.M. & Shapiro, J. (2000) Ethnography in nursing research. Methods in nursing research. Sage publications. London.

Rosecrance, J.C., Cook, T.M. & Zimmermann C.L. (1997) A comparison of musculoskeletal symptom profiles among workers from various occupations. Proceedings of the 13th Triennial Congress of the International Ergonomics Association Tampere, Finland (4): 103-105

Rosen, B., Lungorg, g. Abrahamsson, S.O.Hagberg, L. & Rosen, I. (2001) Sensory function after medium nerve decompression in carpal tunnel syndrome. Journal of Hand Surgery 22b.Apr. 5 : 602-606 British European Churchill Livingstone.

Rubenowitz, S. (1997) Survey and intervention of ergonomic problems at the workplace. *International Journal of Industrial Economics*. 19: 271-275

Ryan, G. A. (1989) The prevalence of musculo-skeletal symptoms in supermarket workers. *Ergonomics* 32, (4): 359-371.

Saxton, J. M. (2000) A review of current literature on physiological tests and soft tissue biomarkers applicable to work-related upper limb disorders. Occupational Medicine Feb 50 (2):121-130

Schibye, B., Skov, T., Ekner, D., Sjogaard, G. & Christiansen, J.U. (1995) Musculoskeletal symptoms among sewing machine operators. *Scandinavian Journal of Work Environment and Health* 21: 427-434

Schneider, S. (1998) Ergonomic intervention has a return investment of 17-1. *Applied Occupational and Environmental Hygiene* 13: 212-213

Scientific Societies London Theatre. (1992) Upper limb disorders among keyboard users. Sponsor human technology Conference proceeding papers (GO18 95293 Q92/ 17053): 1-12

Sharma, S.D., Smith, E.M., Hazelman, B.L. & Jenner, J.R. (1997) Thermographic changes in keyboard operators with chronic forearm pain *British Medical Journal* 314 (January): 118

SHE LRC (1991) 902.Vibration White Finger. Loss Prevention Council (CIRC C5)

Silman, A.J. & Newman, J. (1996) A review of diagnostic criteria for work-related upper limb disorders (WRULD) University of Manchester Medical School.

Silverstein, B., Fine, L., Armstrong, T., Joseph, B., Buchholz, B. & Robertson, M. (1985) cumulative trauma disorders of the hand and wrist in industry. Proceedings of the 9th congress of the International Ergonomics Association 2-6th Sept Bournemouth: Taylor and Francis

Silverstien, B.A., Fine, L.J.& Armstrong, T.J. (1986) Hand wrist cumulative trauma disorders in industry. *British Journal of Industrial Medicine* 43 :779- 784

Sinclair, D. T., Graves, R.J., Watt, M., Ratcliffe, B. & Doherty, S. (1997) Feasibility of developing a prototype decision aid for initial medically assessment of WRULDs. HSE Report. HMSO

Slaney, B. (1999) The road to recognition. Occupational Health. March: 18-19

Slaney, B.M. (2000) Nursing at Work Bushby: Slaney The Short Run Book Company (ISBN 0953928403)

Sleator, A., Gore, D. & Vidler, G. (1998) Work-related upper limb disorders. Research paper 51. April 20. House of Commons

Sluiter, J.K., Rest, K.M. & Frings Dresen, M.H.W (2001) Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. *Scandinavian Journal of Work Environment and Health* 27 (1) :1-102

Smith, I.T & Wood, J.C. (1989) Industrial Law. London. Butterworths (4)

Smyth, J. & Bennet, A. (2000) The management of ULD in a packing operation Boots contract manufacturing. In the IRS repetitive strain injury practical workplace management report of conference. Thistle Charring Cross Hotel. London: 2002 March 21

Solanki, P.V., Mulgaonkar, K.P.& Rao, S.A. (2000) Effect of early mobilisation on grip and work of hand muscles in cases of closed diaphyseal fracture radius-ulna treated with dynamic compression plating. *Journal of Postgraduate Medicine* 2: 84-87

Steed, A. (2002) Personal finance. Telegraph Money. March 5.

Steingrimsdottir, O.A., Knardahl, S. & Vallestad, N.K. (2004) Prospective study of the relationship between musculoskeletal and psychological complaints and the electromyographic activity during isometric muscular contractions in a working population. *Journal of Work Environment and Health.* 30 (5): 410-420

Stetson, D.S., Keyserling, W.M., Silverstein, B.A., Armstrong, T.J. & Leonard, J.A. (1991) Observational analysis of the hand and wrist a pilot study. *Applied Occupational Environmental Hygiene* 6: 927-937

Stinson, R. & Applegate, H. (1996) Nested case-control study of hand and wrist work-related musculoskeletal disorders in carpenters. *American Journal of Industrial Medicine* 6:695-701

Stratford P.W. & Balsor, B.E (1994) A comparison of make and break tests using a hand-held dynamometer and the Kin-Com. *Journal of Orthopaedic Sports Physical Therapy* 19: 28-32

Sullivan, J. & Au, S. (1998) Developing world class job rotation: *Programmes to improve retention.* The Orientation. Article 25 (June) 2: 11

Sunley, K (2002) Getting action on RSI. A guide for GMB safety representatives. GMB. Britain's general union. Ed Nigel Bryson.

Talsania, J.S. & Kozin, S.H. (1996) Normal digital contribution to grip strength assessed by a computerised digital dynamometer. Department of Orthopaedic Surgery. Temple University School of Medicine. Philadelphia. www.temple.edu/orthopaedics/hand/jays.html

Tichauer, E.R. (1996) Some aspects of stress on forearm and hand in industry. *Journal of Occupational Medicine* 8: 63-71

TUC press release (2000) Raise compensation for RSI victims, TUC tells judges 25 February

TUC press release (2002) Employers should get blame for pension's cuts. 21 March

Ulin, S.S., Armstrong, T.J., Snook, S.H. & Franzblau, A. (1993) Effect of tool shape and work locations on perceived exertion for work on horizontal surfaces. *American Industrial Hygiene Association Journal.* 54 (7) July:383-391

Underwood, J. C. E. (2004) General and systematic pathology. 4th Ed Churchill Livingstone Elsevier. China

Valencia, F. (1986) Local muscle fatigue a precursor to RSI? *Medical Journal of Australia* 145. (October): 327- 329

Van Eijsden-Besseling, M. D. F., Peeters, J. A. W., & De Bie, R.A. (2004) Perfectionism and coping strategies as risk factors for the development of non-specific work-related upper limb disorders (WRULD) *Occupational Medicine.* 54 (2): 122-127

Verbeek, J., Husman, K., Van Dijk, F., Jauhiainen, M. Pasternack, I. & Vainio H. (2004) Building an evidence base for occupational health interventions. *Scandinavian Journal of Work Environment and Health.* 30 (2): 164-168

Viikari-Juntura, & Silverstien, B. (1999) Role of physical load factors in carpal tunnel syndrome. *Scandinavian Journal of Work and Environmental Health.* 25 (3): 163-185

Waldron, H.A. (1990) Occupational Health Practice: Blackwell Scientifics
The Journal of Hand Surgery 25: 752-759

Waters, T.R., Putz-Anderson, V., Garg, A. & Fine, L.J. (1993) Revised NIOSH equation for the design and evaluation of manual lifting tasks. *Ergonomics* 36 (7): 749-776

Weislander, G., Norback, D., Gothe, C.J.& Juhlin, L. (1989) Carpal tunnel syndrome (CTS) and exposure to vibration, repetitive wrist movements and heavy manual work: A case-referent study. *British Journal of Industrial Medicine* 46:43-47

Wells, R. (2002) Forearm and Wrist. In Vanderbeck, A Haselgrove C, Chaffin DB eds. Working postures and movement. Taylor & Francis :282-304

Wergeland, E. L., Veiersted, B., Ingre, M., Ollson, B., Akersdtedt, T., Bjornaskau, T. & Varg, N.A. (2003) A shorter workday as a means of reducing the occurrence of musculoskeletal disorders. *Scandinavian Journal of Work Environment and Health.* 29 (1):27-34

Westgaard, R.H. & Vasseljen, O. (1995) The relationship between perceived tension, observed muscle tension in the trapezius muscle and psychosocial factors. Premus 95 Division of Organisation and Work Science The Norwegian Institute of Technology University of Trondheim, Norway, 26 September Session12.

Wilkinson, A., Graves, R., Leaver, R. & Chambers, S (1998) A Musculoskeletal risk screening tool for automotive line managers, *In contemporary ergonomics*, M.A. Hanson (Ed: 50-55