Work-related upper extremity musculoskeletal disorders among computer programmers in a selected software company in the eThekweni Municipality

By

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I, Roxanne Jane Coetzee, do declare that this dissertation is representative of my own work in both conception and execution and the use of work by others is duly acknowledged in the text

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DEDICATION

I dedicate this thesis to my parents and to my partner.
Without your emotional and financial support, I wouldn't be able to be where I am and who I am today.

Words cannot express my gratitude and the love I have for you.

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To my parents, Ann and Len – Words cannot express how grateful I am for everything you've been to me. I wouldn't be where I am today without you both. Thank you for helping me and supporting me to achieve my goals.

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ABSTRACT

Background: Upper extremity musculoskeletal disorders (UEMSDs) are a significant and common occupational health concern, impacting work attendance and performance. A high prevalence rate of UEMSDs has been reported among computer users yet limited research has been conducted on computer programmers' specifically. Certain studies have linked these higher prevalence rates to typical daily computing tasks including prolonged sitting, incorrect ergonomics, awkward/abnormal postures and repetitive movements, but limited research has been conducted on this population specifically.

Objectives: To determine the point and lifetime prevalence of UEMSDs of the sample population of computer programmers in a selected software company in the eThekwini Municipality; to determine the injury profile of the population and compare to international studies; to identify selected risk factors of the population (demographic, ergonomic and physical risk factors); and to determine any associations between prevalence and selected risk factors of injury in the population.

Methods: This was a quantitative, descriptive, questionnaire-based survey conducted to assess selected associated risks factors for UEMSDs in computer programmers in a selected software company. Participants who met the inclusion criteria (N = 155) were invited to complete self-administered questionnaires. The study population consisted of computer programmers in a selected eThekwini software company, over the age of 18 years, who worked full-time for 8 hours or more per day, that were symptomatic or asymptomatic concerning UEMSDs.

The scores for each sub-group were expressed as percentages and summarised using mean, standard deviation and range, with 95% confidence intervals. Bivariate associations from categorical variables were conducted using a Pearson's chi-square test or Fischer's exact test as appropriate. Cross tabulations were conducted using contingency tables to determine whether there was an association between variables. Graphical representation of scores by groups were conducted using various types of tables and graphs such as bar graphs, tables, and pie charts. Factors were entered individually into the model to evaluate their Pearson's chi-square values and partial Eta scores. A p value of < 0.05 was considered as statistically significant for the Pearson's chi-squared test; a partial Eta score greater than 0.14 was considered as highly significant.

Results: Of the 155 completed questionnaires, the lifetime prevalence of work-related UEMSDs in the sample population was 41.3% and the point prevalence of 21.9% in the upper limb. The lifetime prevalence of the three most common anatomical areas affected were the right shoulder at 25.8%, the right wrist at 23.9% and the right hand at 17.4%. The point prevalence of the three most common anatomical areas affected were the right shoulder at 9%, right wrist at 7.7% and right hand and left shoulder both at 4.5%. There was a large effect size with increasing age and severity in lifetime prevalence ($\eta p2 = 0.200$) and a medium effect size in point prevalence ($\eta p2 = 0.084$). There was a large effect size in increasing age and duration of injury in both lifetime ($\eta p2 = 0.244$) and point prevalence ($\eta p2 = 0.282$).

Fourteen point seven percent of the participants took sick leave and 85.3% of the affected sample population have some degree of productivity loss in point prevalence. Incorrect workstation setup and type of injury was a high-risk factor in work-related injury in both point and lifetime prevalence in this study. Ethnicity and gender were not risk factors in this study. Increasing age, a history of sports injury, increased work experience ($p = 0.021$), increased working hours per week ($p = 0.012$), increased hours on the computer per week ($p = 0.001$) and overtime ($p = 0.018$) were shown to have a statistically significant association with UEMSDs. Participants who worked > 40 hours on the computer per week were prone to injury 16.769 (O.R.) times more often than participants who worked 20 to 30 hours on the computer per week ($p = 0.037$) and 3.563 (O.R.) times more often than a programmer who worked 31 to 34 hours per week ($p = 0.013$). Cofounding risk factors to injury were sick leave ($p = 0.000$) and productivity loss/work interference ($p = 0.000$).

Conclusion: This is the first South African study, to our knowledge, that highlights point and lifetime prevalence rates for work-related UEMSDs among computer programmers as well as significant DASH findings. This draws attention to the need for implementation of intervention programmes to prevent and/or reduce the development of work-related UEMSDs.

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LIST OF ACRONYMS

COMMS	Council of Musculoskeletal Speciality Societies
CTD	Cumulative trauma disorder
CTS	Carpal tunnel syndrome
DASH	Disabilities of the arm, shoulder and hand
NSAP	Non-specific arm pain
OCRA	Occupational repetitive action
PINS	Posterior interosseous nerve syndrome
PRWHE	Patient-rated wrist/hand evaluation
RSI	Repetitive Strain Injuries
RTS	Radial tunnel syndrome
UECTD	Upper extremity cumulative trauma disorder
UEMSD	Upper extremity musculoskeletal disorders
WHO	World Health Organization
WRUEMSD	Work-related upper extremity musculoskeletal disorders

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 Introduction

Musculoskeletal pain is a frequently occurring problem both globally and in South Africa (Andersson 1999). Musculoskeletal disorders (MSDs) are usually associated with pain and loss of function (World Health Organization [WHO] 2003; Brooks 2006; Woolf et al. 2010; March et al. 2014). Upper extremity musculoskeletal disorders (UEMSDs) represent a significant occupational health problem internationally, especially in industrial developed countries (Sekulová et al. 2014), and are particularly prevalent in office workers using computers for extended periods (Cooper 2000). This may be attributed to muscle overload resulting from repetitive work of the upper extremities in unnatural postures, and exerting abnormally high forces while typing (Marcus et al. 2002; Tarrek 2003; Wahlstrom 2005). Computer programmers, also known as software developers, write code or create software for a living. Programmers typically spend long periods seated at a computer and use their keyboards far more than the average computer user (Mantid 2000; Van den Heuvel 2007). They are prone to joint strain from continuous and repetitive movements, particularly in forced and unnatural positions (Juul-Kristensen et al. 2005; Bhanderi et al. 2008; Sekulová et al. 2014).

The prevalence of MSDs associated with work-related awkward sitting postures is very high (Gerbaudo et al. 2008). Physical factors such as high typing speed and a lack of forearm support is indicated as a risk factor for upper extremity symptoms (Baker et al. 2005). Associated risk factors include duration of keyboard and mouse use between rest breaks, duration of computer use (Bergqvist et al. 1995; Smith et al. 1996), physical factors affecting work posture such as height of work equipment (Hunting et al. 1981; Bergqvist et al. 1995) and psychosocial factors such as stress (Stock 1991; Hales et al.1994; Gerr et al. 1996; Smith et al. 1996; Buckle 1997). When considering the number of hours worked a week by programmers and the associated risk factors, they are likely to be at greater risk than the average computer user for the development of UEMSDs.

1.2 Aim

The aim of this study was to investigate the prevalence of UEMSDs among full time computer programmers at a selected software company in the eThekwini Municipality and to identify selected factors associated with an increased risk of injury.

1.3 Objectives

1.3.1 First objective

To determine point and lifetime prevalence of UEMSDs in the sample population.

1.3.2 Second objective

To describe the injury profile of computer programmers in the selected software company, and to compare this profile with other international studies. The factors relating directly to the injury include current and past injury/injuries location/s, duration, severity, nature of onset, degree of disability and received treatment.

1.3.3 Third objective

To identify selected risk factors (demographic, ergonomic and work history) of computer programmers in a selected software company in the eThekweni Municipality. This was achieved by means of data collection and documentation with respect to:

- Demographic information including age, gender, race and history of surgery or non work-related history of injury.
- Work history including work experience, number of hours worked, hours worked overtime, dominant hand and equipment use.
- Ergonomic factors including lack of/inadequate equipment support and/or incorrect workstation setup.
- Degree of disability factors including the ‘Disabilities of the arm, shoulder and hand’ (DASH) score.

1.3.4 Fourth objective

To determine any association between prevalence and selected risk factors.

1.4 Rationale

While a vast amount of research had been conducted on the association between computer use and MSDs, there is limited data to identify risk factors specifically among computer programmers, and the extent of the problem in this population in South Africa. The prevalence of UEMSDs, level of disability or amount of work-absence in this unique group of computer workers (i.e. programmers) is unknown; and few studies have attempted to identify risk factors for UEMSDs in this population specifically. This is the case despite the fact that the job demands of programmers suggest that they may be at increased risk for UEMSDs; and programmers constitute a significant proportion of the workforce of South African software development companies.

This study investigated the point and lifetime prevalence of injury, characteristics of injury (e.g. location, severity and duration), disability and other impacts due to injury, as well as risk factors for injury, among full-time computer programmers at a selected software company in the eThekwini Municipality. This information will help the company studied to become more aware of the extent to which their programming employees suffer from UEMSDs, and to identify and mitigate risk factors. This could in turn lead to a reduction in the incidence of UEMSDs (and associated disability), and improve job satisfaction and productivity. The results of this study could be of use to other employers of programmers; but further research would be required to gain a better understanding of UEMSDs among the entire population of South African computer programmers. Specific information gained from this study regarding risk factors and prevalence of UEMSDs among computer programmers could lead to better prevention of injury in this population.

1.5 Limitations

Although the scope of the study is to identify risk factors for injuries within a selected software company in the eThekweni Municipality, external and unrelated factors to computer programmers may have been the cause of predisposing factors to injury. While the identification and role of these risk factors was beyond the scope of the study, there was some control over these extraneous variables as they were included to some extent in the demographics section of the questionnaire.

For logistical reasons, the study was limited to computer programmers working at a selected software company in the eThekweni Municipality. While the entire population of eligible participants was invited to participate, the number of volunteers was limited which may have affected the potential to identify trends. Authenticity of data relied on participants being open and honest.

While the data collected represents injuries from computer programmers at a selected software company in the eThekweni Municipality, the potential scenario of an injured computer programmer who was unable to differentiate whether the injury occurred during occupational related activities or in an unrelated circumstance was a limiting factor.

1.6 Benefits

The researcher identified employees' risk of UEMSDs, this would lead to possible strategies to mitigate risk and manage employees' with work-related UEMSDs in computer usage from the evaluation of their performance.

A completed dissertation will be made available at the relevant library for access to the Durban University of Technology (DUT) staff, students, and visiting persons who wish to read the dissertation.

1.7 Outline of the rest of the dissertation

The following points outline the key concepts in the chapters that follow:

- An expansion of current related literature and proposed theoretical factors that will lend some understanding of the rationale behind the study
- The methodological approach utilised in this investigation
- The results of this study (prevalence, incidence, related risk factors for UEMSDs and ergonomic comparisons)
- Discussion, interpretation and integration of the findings with comparison of other empirical, theoretical and methodological approaches
- Conclusion to this investigation and recommendations for future studies.

CHAPTER 2: LITERATURE REVIEW

2.1 Definition and types of musculoskeletal disorders

Musculoskeletal disorders (MSDs) are a diverse group of painful disorders affecting muscles, tendons, joints and nerves. All parts of the body can be affected, although upper limb and neck are the most common areas and population studies suggest that 6% to 48% of adults have pain in one of these areas (Andersson et al. 1993; Pope et al. 1997a; Urwin et al. 1998; Walker-Bone and Palmer et al. 2004; European Agency for Safety and Health at Work [EU-OSHA] 2010).

MSDs may affect one or more anatomic areas by their association with pain and impaired physical function (WHO 2003; Brooks 2006; Huisstede et al. 2007; Woolf et al. 2010; March et al. 2014). MSDs encompass a large spectrum of specific disorders with detailed pathophysiology, including: inflammatory diseases such as rheumatoid arthritis or gout; degenerative disorders such as osteoarthritis or osteoporosis; and disorders related to injury such as sport injuries or consequences of falls and minor or major trauma. Together, these specific disorders account for less than half of all MSDs (EU-OSHA 2010). The majority of MSDs fall into the category called nonspecific disorders that can be defined as disorders with no known underlying pathophysiology or diagnosis and the absence of evidence that a specific structure is linked to the pain or other symptoms. Often these nonspecific disorders are related to deconditioning or work-related overexertion (EU-OSHA 2010).

MSDs cover a wide range of inflammatory diseases of the locomotor system (EU-OSHA 2010). They include inflammation of tendons (tendonitis and tenosynovitis) especially in the forearm, wrist, elbow and shoulder. They are evident in occupations involving prolonged periods of repetitive and static work. Myalgia i.e. pain and functional impairments of muscles occur predominantly in the shoulder and neck region in occupations with large static work demands. Nerve compression i.e. entrapment syndromes occur especially in the wrist and forearm in work-related upper extremity musculoskeletal disorders (WRUEMSDs).

MSDs may have either an acute or gradual onset and their outcomes may vary from complete restoration of health to a chronic progressive course or a recurrent and/or lifelong disorder. This course is not always predictable, although certain patterns predominate (EU-OSHA 2010). Chronic MSDs are known to result in work absenteeism and early retirement which creates an economic impact on employees. These can develop slowly, taking months or even years before diagnosis is concluded (Abdulmonem et al. 2014). MSDs are an increasing and significant health problem. In Europe, musculoskeletal diseases are the most common occupational diseases. In 2005, they made up about 39% of the total occupational diseases according to the obligatory list (EU-OSHA 2010).

2.2 Upper extremity musculoskeletal disorders (UEMSDs)

UEMSDs affecting the soft tissues of the shoulders, arms, and hands are prevalent worldwide (Huisstede et al. 2006; Hassard et al. 2014; WHO 2014), and are the second most common cause of absence and work-related disabilities (Cherry et al. 2001; Wilson-d'Almeida et al. 2008; EU-OSHA 2010; Armijo-Olivo et al. 2016). Data from international studies report a prevalence of 5% to 10% for non-specific complaints of strain that interferes with daily activities, but rates vary as high as 22% to 40% in specific working populations (van Tulder et al. 2007; Petreanu et al. 2017). Disease labels and case definitions vary considerably between studies which may explain the differences between prevalence rates (Parent-Thirion et al. 2007).

The strong correlation between the incidence of UEMSDs and physical risk factors (such as working conditions) is well known. Work overexertion, stress and other psychosocial factors may also be contributing factors to the onset of these disorders (Health and Safety Commission [HSE] 2002; EUROFUND 2007; EU-OSHA 2008; EU-OSHA 2011).

Literature reviews and epidemiological studies have shown that in UEMSDs three sets of risk factors can be considered (Bernard 1997; Buckle et al. 1999; Bongers et al. 2006; Nunes 2009):

1. Physical factors such as sustained or awkward postures, frequent repetition of the same movements, excessive forceful exertions, poor workstation setup, static work, hand-arm vibration, all-body vibration, mechanical compression and cold temperature environment.
2. Psychosocial factors such as work pace, autonomy, monotony, work/rest cycle, task demands, social support from colleagues, management uncertainty and job uncertainty.
3. Individual factors such as age, gender, professional activities, sport activities, domestic activities, recreational activities, duration of hours worked, overtime and previous WRUEMSDs.

There is little evidence of the use of standardised diagnostic criteria for UEMSDs and a range of terms have been used globally to describe these disorders. When they affect the upper limbs, the terms include Repetitive Strain Injuries (RSI), Work-Related Upper Limb Disorders (WRULDs) and Cumulative Trauma Disorders (CTD). These variations are used in reported data and research literature which make comparisons among different countries difficult (EU-OSHA 2010).

2.3 Upper extremity musculoskeletal disorders in the work place

UEMSDs are referred to as 'work-related' when the work environment, equipment and procedures of work are significant contributors to their development or exacerbation, and in varying magnitude to the causation of the disease (Buckle et al. 1999; WHO 2003; Vijay 2013).

There are substantial differences in reported prevalence rates on UEMSDs mainly due to the absence of a universally accepted way of labelling or defining UEMSDs. Although it is difficult to precisely estimate the extent of upper extremity musculoskeletal pain, many people suffer from shoulder, arm and hand symptoms. The point prevalence for WRUEMSDs has been reported to range from 2% to 53% and the 12-month prevalence from 2% to 41% depending on the setting, definition and classification used (Huisstede et al. 2006). Van Tulder et al. (2007) reported the prevalence of 5% to 10% for non-specific complaints of strain that interfered with daily activities, but rates could be as high as 22% to 40% in specific working populations in a 12-month prevalence for WRUEMSDs. Currently, South African data on WRUEMSDs are not available; however, a study by Collins et al. (2011) indicated that the incidence of carpal tunnel syndrome (CTS) is remaining static.

In the year 2002, 28% of the general Dutch working population suffered from UEMSDs in the previous 12 months (Blatter and Van den Heuvel 2005b), and European data showed a prevalence of 25% for work-related neck or shoulder pain and a prevalence of 15% for work-related arm pain (Blatter and Van den Heuvel 2005b; Bongers et al. 2006). In France, WRUEMSDs accounted for two-thirds of all occupational disorders, with the leading cause being biomechanical factors such as repetitive motion, overexertion and joint posture (Aptel et al. 2002). A study by Keogh et al. (2000b) reported one-third to half of all disability claims were related to upper extremity injuries and 25% of cases were computer related.

In support of this proposed mechanism of injury for UEMSDs, epidemiological studies have shown that physical exposure to work tasks are associated with UEMSDs (National

Research Council 2001). The commonly accepted categories of upper extremity physical exposures include highly repetitive movements of the hands and arms, forceful hand activities, use of vibrating hand tools, and working in a wrist position that is deviated away from a straight wrist posture (Stetson et al. 1992; Bernard 1997; Roquelaure et al. 1997; Punnett et al. 2000; Sluiter et al. 2001). Each of these physical exposures varies by three characteristics: the intensity of a single exposure, the frequency of the exposure, and the total duration of the exposure in a defined period of time (Burdorf et al. 1999; Jansen et al. 2004).

Associated risk factors such as prolonged awkward postures and poor workstation design can lead to development of symptoms of WRUEMSDs. Awkward posture increases the discomfort and pain experienced in different areas such as neck and shoulders (Ghosh et al. 2010). The prevalence of UEMSD WRMSDs associated with awkward sitting postures were as high as 71% and 25.7% (Gerbaudo et al. 2008). According to Punnett et al. (1997), the repetitive finger movements when using a keyboard and the location, height and design of the keyboard affects the posture of the wrist, elbow and shoulder. Non-neutral position of the wrist such as wrist extension or ulnar deviation have been reported as risk factors for arm, wrist and hand pain (Punnet et al. 1997; Simoneau et al. 2003). Physical factors such as high typing speed and a lack of forearm support have been indicated as risk factors for upper extremity symptoms (Baker et al. 2005). The prevalence of WRUEMSDs among keyboard users has been reported to be as high as 81% (Kamwendo et al. 1991). Recognised factors associated with keyboard use include duration of time between rest breaks, duration of computer use (Bergqvist et al. 1995; Smith et al. 1996), physical factors affecting work posture such as height of work equipment (Hunting et al. 1981; Bergqvist et al. 1995) and psychosocial factors such as stress (Stock 1991; Hales et al.1994; Gerr et al. 1996; Marcus et al. 1996; Smith et al. 1996; Buckle 1997). One of the most significant UEMSDs is CTS and 25% of CTSs are associated with “keyboarding”.

Non-keyboard input devices, such as the computer mouse, can also be related to physical strain. Repetitive ‘clicking’ in addition to the sustained low-level muscle activity when holding and moving the mouse may increase sustained muscle activity and tendon strain. Non-neutral position of the wrist and usage of the mouse daily, have also been reported as risk factors for hand and/or wrist complaints (Punnet et al. 1997). In a study by Foley et al. (2004), 50% of computer users from their focus group had mouse-related UEMSDs. As the computer mouse became a necessity in modern computer work, there has been an increased incidence rate of UEMSDs of computer users who worked on the mouse for 6 to 8 hours per day compared to that of computer users who worked without a mouse (Cook et al. 2000). In research reported by Atkinson et al. (2004), nearly half of the mouse users who used the mouse 6 hours per day on average reflected musculoskeletal pain and discomfort in wrists, hands and fingers. Studies have shown that the mouse has a high incidence rate of CTS and other UEMSDs (Hedge et al. 1999; Ali et al. 2006; Shiri et al. 2015) because the mouse causes the wrist to bend at an acute angle and the lack of forearm support increases compression on the wrists.

Juul-Kristensen et al. (2004) reported that office workers who spent 75% and more of their work time on the computer were at risk of experiencing UEMSDs and Ijmker et al. (2010) reported that computer users who worked 4 to 6 hours per day were twice more likely to develop risk of UEMSDs than users working 4 hours per day. A study conducted by Blatter et al. (2002) reported that working on the computer more than 6 hours per day was associated with UEMSDs. Ali et al. (2006) study revealed computer users with more than 4 years or more of work experience and who worked more than 8 hours per day had a higher risk for CTS compared to those that had worked less than 4 years and worked less than 8 hours per day. Kamwendo et al. (1991) reported the length of employment increased risk of injury to the neck/shoulder region, whereas Jensen (2003) reported increased risk of injury in the hand/wrist but not in the neck/shoulder region.

Age and gender have been reported by some studies to have an effect on symptom prevalence (Knave et al.1985; Rossignol et al. 1987; Stock 1991; Bergqvist et al. 1992; Hales et al. 1996). However, Bergqvist et al. (1995) did a follow up prospective study of computer workers and found that female gender with UEMSDs was significantly associated with a cofounder non-occupational risk factor. Such factors were oral contraceptives, pregnancy, child care and housekeeping which are difficult to control or examine in epidemiologic studies. Juul-Kristensen et al. (2005) conducted a prospective survey among office workers involved in repetitive computer work in order to determine the frequency of self-reported upper extremity musculoskeletal symptoms during the previous 12 months. Less men than women reported upper extremity musculoskeletal symptoms, and areas most affected were the neck/shoulder (39%) and elbow/hand (51%). Advancing age was linked to MSDs due to proprioceptive degeneration linked to increased tissue susceptibility to physical workload, which is often intensified when faced with daily occupational risk factors (Cassou et al. 2002). Some studies have reported advancing age as being a risk factor for UEMSDs in computer users (Punnett et al. 1997; Cook et al. 2000; Jensen and Finsen et al. 2002; Gerr et al. 2002; Kryger et al. 2003; Lassen et al. 2004; Ali et al. 2006; Tornqvist et al. 2009), whereas other studies have found no association (Jensen et al. 2003; Juul-Kirstensen et al. 2004; Brandt et al. 2004; Shuval et al. 2005; Lassen et al. 2005).

Single epidemiologic studies of UEMSDs in the workplace have tended to focus on one or two specific disorders (such as rotator cuff tendonitis or CTS) or on general signs and/or symptoms indicative of UEMSDs. The literature remains limited on the proportions and progression of specific UEMSDs that occur in particular working populations (Bovenzi et al. 1991; Roquelaure et al. 2002; Gerr et al. 2002; Aublet-Cuvelier et al. 2007). There are few epidemiologic studies identifying the relative frequency of such non-specific disorders (Silverstein et al. 1986; Latko et al. 1999; Gold et al. 2009).

The majority of UEMSDs are characterised by recurrent episodes of pain accompanied by functional disability, degree of severity and impact. Most episodes are self-limiting and subside within days or weeks, but some end up with long-term chronic problems (Johan et al. 2011). Risk factors from physical, psychological, and social domains have been acknowledged, but the relative influence of the several risk factors on the onset and exacerbation of UEMSDs is uncertain. This leads to arguments that still exist regarding the degree of WRUEMSDs, computer use and productivity loss in the occupational sector (Silverstein et al. 1996; Boström et al. 2008).

2.4 Work-related upper extremity musculoskeletal disorders among computer programmers

There is limited research on computer programmers. In a study by Jensen and Finsen et al. (2002), programmers comprised 3% of the sample and in a study by Karlqvist et al. (2002), 9.7% of the sample. There was a higher sample population of programmers of 35.7% in a study by Sharan et al. (2011). None of the studies focused on specific risk factors and prevalence rates of UEMSDs among computer programmers as an entity on their own. Shuval et al. (2005) researched the relationship between ergonomic risk factors and UEMSDs in computer workers at a hi-tech company in Israel. The study population of 84 workers, 61.1% of whom were computer programmers. The authors concluded that computer programmers encountered specific risk factors compared with those found in other computer usage work, especially taking into account the numerous hours worked a week, the high job stress setting and the young age of employees. The study also concluded that programmers were up to six times more uncomfortable at their workstation compared to non-programmers. However, the number of computer programmers in this study was only 52 which is small so may have only have been able to detect a few risk factors.

Programmers use their keyboards far more than the average computer user and typically spend long periods seated at a computer (Mantid 2000; Van den Heuvel et al. 2007). A programmer's job can be demanding and they often have time-restricted deadlines that require them to work 12 to 24 hours on the computer (White 2006). When considering numerous hours worked a week by programmers and associated risk factors, they are likely to be at greater risk for the development of UEMSDs. While there is a vast amount of research conducted on the association between computer use and UEMSDs, there is limited data to identify risk factors specifically among computer programmers and the extent of the problem in this population. With the intensive use of the keyboards and of the mouse in the recent years, computer programmers are more at risk to injury than they were previously (Foley et al. 2004).

2.5 The impact of upper extremity musculoskeletal disorders

UEMSDs are a cause of concern not only because of health effects, but because they may result in temporary and sometimes long-term work functional disability. The economic impact is considerable bearing in mind direct health expenditures related to treating the sequelae of the disorders for employers, the indirect costs for businesses' due to sick leave and reduced productivity while at work, and to society due to social security benefits (WHO 2003; Palmer et al. 2005; Brooks 2006; Ryall et al. 2007; Palmer et al. 2008; Wilson-d'Almeida et al. 2008; Martimo et al. 2010; Woolf et al. 2010; March et al. 2014).

The duration of sick leave has been shown to vary among the various MSDs (Abasólo et al. 2007). Of all upper extremity disorders, shoulder MSDs and CTS cause the longest sickness absences (Ijzelenberg et al. 2004; Wilson-d'Almeida et al. 2008). There is limited literature on work-related disability specific to UEMSDs (Shiri et al. 2011). WRUEMSDs account for almost a quarter of all sick leave and contribute even more significantly to impaired in-work productivity also known as presenteeism (the reduction in working performance while at work because of ill health), although this is more challenging to quantify accurately.

The total annual costs of UEMSDs in the Netherlands in 2004 due to decreased productivity, sick leave, chronic disability for work and medical costs, was estimated at 2.1 billion euros (Blatter et al. 2006). Studies by Keogh et al. (2000) reported that in the USA one-third to half of all disability claims are related to UEMSDs, with a cost of between $15 billion to $20 billion in 1999. Of these disorders, 78% was CTS, making it one of the most significant and costly health care problems to affect the working population (Keogh et al. 2000; Ligh 2002;

Roquelaure et al. 2009). Upper extremity pain in France was six times higher in 1994 than in 1985, resulting in an increase in disability and time off work (Cassou et al. 2002). It is estimated that the total cost of lost productivity to WRUEMSDs among people in the European Union might be as high as 2% of gross domestic product (Storheim et al. 2014). Currently, there is limited data on UEMSDs among the working population in South Africa, although one study indicated that the incidence of CTS is remaining static (Collins et al. 2011).

2.5.1 Work-related shoulder pain

Musculoskeletal problems of the shoulder are common among the general population and are usually short-term and not debilitating (Pope et al. 1997a). Shoulder pain is the third most common type of musculoskeletal pain presenting to the manual therapy office along with low back and neck pain (Pribecevic et al. 2009). There are difficulties associated with assessing and diagnosing shoulder pain because of the highly mobile nature of the shoulder joint and the possibility of more than one cause, which may influence the outcome of specific tests (Burbank et al. 2008). Shoulder pain can originate from many structures such as the subacromial bursa, the glenohumeral joint and the acromio-clavicular joint as well as the brachial plexus and cervical column. Muscular structures such as the tendons of the rotator cuff (especially the supraspinatus), or other muscular tendons such as the biceps, pectoralis minor and major can contribute to work-related shoulder pain singularly and sometimes even in combination. The challenge is to differentiate and pinpoint the origin of the pain, and then determine how or if it relates to the work the person is doing (Kirsten 2005).

Rotator cuff syndrome is inflammation of structures in the subacromial space due to a decrease in vascularisation and degenerative change caused by repeated impingement of various types of tissues under the shoulder tectum. The structures responsible for the accompanying symptoms include the supraspinatus muscle, the infraspinatus muscle, the tendon of the caput longum of the biceps brachii muscle, the subacromial bursa, the subscapular muscle, and the tendons of the teres major and minor muscles. The main symptom is intermittent, activity-dependent pain in the shoulder region. Symptoms are provoked with elevation movements of the upper arm, in comparison with those of the trunk, occur, such as the kinds of movements that would occur as a result of incorrect desk or chair height. Possible limitations of shoulder movements are caused by pain or stiffness and do not follow the capsular pattern of the glenohumeral joint (Sluiter et al. 2001).

Impingement syndrome is a condition mainly affecting the supraspinatus and to a lesser degree the infraspinatus muscle. When the arm is raised, the subacromial space narrows, through which the supraspinatus muscle tendon passes. Anything that causes further narrowing has the tendency to impinge the tendon and cause an inflammatory response, resulting in impingement syndrome. Symptoms are provoked when the arm is raised in abduction and flexion (Kirsten 2005). Examples of situations in which these kinds of movements occur would be incorrect workstation setup such as incorrect desk height or using a touch screen monitor where the arm is raised in a prolonged posture.

2.5.1.1 Causes of work-related shoulder pain

Work-related shoulder pain may be due to physical work with heavy loads, awkward postures, mental stress and obesity (Miranda et al. 2001). Pope et al. (1997b) found that physical risk factors such as working with arms at or above shoulder level, insufficient rest breaks and repetitive movements of the arm were strongly related to the development of shoulder pain.

Physical factors such as work load, awkward posture and repetitive movements were risk factors for work-related shoulder pain (Cassou et al. 2002; Harkness et al. 2003, Andersen et al. 2003 and 2007). Repetitive movements of the upper extremity involving flexion and/or abduction of the glenohumeral joint increased the frequency of effects such as fatigue and tendon circulation disruption. There is evidence that shoulder tendonitis is associated with highly repetitive work. Some of the significant associations reported have been related to exposure to repetitive work in the distal upper extremity while the shoulder and upper arm are maintained in a static posture (Chiang et al. 1993; Ohlsson et al. 1989; 1994 and 1995). The prolonged non-neutral posture of the shoulders in a flexed and abducted position at a desk is associated with musculoskeletal symptoms of the upper extremity (Punnet et al. 1997; Tittiranonda et al. 1999), and the risk of shoulder injury is increased when the inner elbow angle is < 121° (Marcus et al. 2002). The continuous activation of muscles of the arms, shoulder girdle, neck and flexed trunk to maintain a quasi-static position to allow the hands and arms to operate the keyboard has been proposed as one of the factors causing upper extremity symptoms (Bergqvist et al. 1995; Miranda et al. 2001). A study by Alavi et al. (2016) reported that the risk of experiencing shoulder symptoms was higher among office workers who had discomfort in relation to their sitting posture. Janwantanakul et al. (2010) and Hamberg-Van Reenen et al. (2008) refer to positional discomfort as a potential predictor of shoulder disorders among workers. Musculoskeletal symptoms caused by posture-related discomfort may be the result of an overuse of low threshold muscle fibres affecting muscle load and exerting compressive forces causing trauma in the muscle cells (Hagg 2000).

Diagnoses of work-related shoulder pain include impingement syndrome, cervical syndrome, and rotator cuff syndrome (Rempel et al. 2007). Workers are predisposed to these conditions when sustaining awkward, constrained or static postures, such as cervical and thoracic spine flexion, shoulder elevation and abduction, and performing forceful or repetitive precision tasks (Keogh et al. 2000; Rempel et al. 2007). Rotator cuff syndromes in the workplace include impingement, tendinosis, and rupture of the tendons. They are associated with high static or repetitive loads, particularly in combination with abduction, elevation, rotation and flexion (Shaw et al. 2008). The posture associated with computer work, described as “forward head posture”, is a combination of extension of the upper cervical spine and flexion of the lower cervical spine and is believed to be associated with an increased risk of shoulder pain (Collins et al. 2011).

2.5.1.2 Incidence and prevalence of work-related shoulder pain

Shoulder pain is a frequent problem in primary health care (van der Windt et al. 1995). The prevalence of shoulder pain in the general population is 6% to 25% (Miranda et al. 2001), 6% to 11% in people less than 50 years of age and 16% to 25% in people above 50 years of age (van der Windt et al. 2000).

Shoulder pain has been found to have a higher prevalence rate among occupational groups when compared to the general population (Pope et al. 1997a). In a study by Shuval et al. (2005), 47.6% of a population of computer users had pain or discomfort of the neck/shoulder region in the last year which was a higher prevalence compared to Blatter et al. (2002) who found 10.3% and Jensen and Finsen et al. (2002) who found 35%. Cook et al. (2000) conducted a study on mouse usage and UEMSDs and found that 45.7% of the computer users had shoulder pain due to their non-neutral posture. A study by Brandt et al. (2004) found that the prevalence of moderate-to-severe pain in the neck and right shoulder was 4.1% and 3.4%, and the one-year incidence for no or minor baseline symptoms was 1.5% and 1.9%. These findings indicate that computer mouse use is associated with an increased risk of moderate-to-severe pain in the neck and right shoulder, especially with prolonged mouse and keyboard use.

A study by Chaiklieng et al. (2015) reported that the risk of shoulder pain among computer users was at a moderate level of 21.2%, a high level of 17.3% and a very high level of

12.6%. The cumulative incidence of shoulder pain increased with duration of working time from 24.8% at the first month to 30.2% at the second month. The overall finding of this study was that computer users who worked more than 4 hours per day were at high risk of work-related shoulder pain.

2.5.1.3 Treatment

Approximately 50% of patients with shoulder pain seek medical care, with nearly 95% of these cases being treated in primary health care practices including medical and physiotherapy practices. Of all new episodes of shoulder pain presenting to primary care, approximately 50% seem to resolve within 6 months, with about 40% persisting for up to 12 months (van der Heijden 1999). According to van der Windt et al. (1995), shoulder pain is usually self-limiting (less than 3 months), and treated in primary health care if necessary. Where the condition is not resolved, persistent pain or a limited range of motion may last for several years.

The treatment of shoulder pathology depends on clinical and/or radiographic diagnosis and usually involves conservative, medical or surgical care (Vassallo 2008). Conservative treatment does not involve surgical intervention and is aimed at preventing the progress of a disease process, controlling symptoms, pain management and activity modification (Pandya 2011). Surgical treatment is a more invasive form of treatment for diseases or injuries that involves operative procedures to provide pain relief and restore function (Colledge et al. 2010).

Conservative care refers to the use of modalities and techniques by a practitioner such as a physiotherapist or chiropractor. Conservative treatment may involve rest, inflammation and pain control, soft tissue therapy, range of motion and proprioception exercises as well as stretching and strengthening exercises to increase functioning of the shoulder (Burbank et al. 2008; Gonzalez 2011). Cryotherapy, heat, mobilisation, physiotherapy, manipulation and home care can be used in the treatment regime (Hains 2002).

Pain control is a significant part of medical management, often involving the prescription of nonsteroidal anti-inflammatory drugs (NSAIDs), paracetamol and even short-term opiate medication. Corticosteroids can be injected directly into the affected area and have been found to be effective in rotator cuff tendonitis (Burbank et al. 2008). When conservative treatment fails, orthopaedic referral and surgery may be required (Mitchell et al. 2005). Studies by Ortiz-Hernández et al. (2003) and d’Errico et al. (2010) confirmed the supportive role of rest breaks in UEMSDs. Short breaks helped prevent or alleviate muscle damage from overuse (McLean et al. 2001). A rest break can include the performance of another task, which can involve the use of other muscle groups.

Interventions such as adjusting seat height and curved seat pan chairs have been effective in preventing shoulder pain in seated workers (Rempel et al. 2007). Other ergonomic interventions such as a change in desk height or computer monitor angle may also be of value in preventing shoulder pain and upper limb conditions (Driessen et al. 2008; Keogh et al. 2000). In designing tools and workplaces, attention to human factors can prevent many injuries. However, ergonomic changes usually occur in response to injuries, rather than as a measure to prevent them (Keogh et al. 2000).

2.5.2 Work-related elbow, forearm & arm pain

MSDs of the arm are common among the working populations and are a frequent cause of absenteeism worldwide (Silverstein et al. 1998). Epicondylitis is one of the most prevalent disorders of the upper extremity. Lateral epicondylitis is commonly called 'tennis elbow' among sportspeople and 'mouse elbow' among the computer working population, and medial epicondylitis is called 'golfer's elbow'. Epicondylitis is clinically defined by intermittent pain in the muscle-tendon junction or at insertion points of the wrist extensors (lateral epicondylitis) or wrist flexors (medial epicondylitis) in the elbow region. It is provoked by resistance or overuse of either the extensor or flexor muscles of the wrist and/or forearm (Harrington et al. 1998 and Sluiter et al. 2001). The clinical features of epicondylitis are described as a primary pain symptom, generally localised around the lateral or medial epicondyles but sometimes radiating distally to the forearm. Weakness of grip can also be present (Sarwark 2010). Symptoms are often provoked by grasping objects such as a computer mouse, supination and pronation movements of the forearm or upon elbow extension.

Lateral epicondylitis is an overuse injury of the elbow that occurs as a result of degenerative tendinosis of the extensor muscles of the forearm, particularly the extensor carpi radialis brevis, and is the most common overuse injury of the elbow (Chumbley et al. 2000). Medial epicondylitis arises from the inflammation of medial epicondylian muscles due to micro tears (Allander et al. 1974) in any of the following muscles: the flexor digitorum superficialis, pronator teres, flexor carpi radialis, palmaris longus and flexor carpi ulnaris (Helliwell et al. 1996). These muscles have in common their insertion on the medial epicondyle of the humerus and anterior position in the forearm.

Any discomfort or pain in the forearm may occur on its own or be present with arm pain as a whole, elbow pain, wrist pain, hand and/or finger pain. The pain may only be present when moving the forearm, hands or fingers since many of the muscles of these neighbouring parts are located within the forearm. Often forearm pain is included in broad terms such as RSI, cumulative trauma disorders (Macfarlane et al. 2000), peritendinitis or intersection syndrome (Harrington et al. 1998). The causes of work-related forearm pain are still unknown, but local vascular abnormalities (Pritchard et al. 1999), thermographic changes (Sharma et al. 1997) and minor nerve entrapment (Greening et al. 1998; Jensen and Pilegaard et al. 2002) have been proposed symptoms. Non-specific forearm pain has been reported as a common complaint among computer workers.

The ulnar nerve is a motor and sensory nerve for the hand. At the elbow, the ulnar nerve passes posterior to the medial epicondyle and enters the cubital tunnel. The cubital tunnel consists of osseous walls formed by the medial epicondyle and olecranon. The floor of the tunnel is the medial collateral ligament of the elbow; the roof is a fibrous band (retinaculum) extending from the medial epicondyle to the olecranon (Sluiter et al. 2001). The cubital tunnel is the most common site of ulnar nerve compression, and cubital tunnel syndrome is the second most common peripheral compression neuropathy of the upper extremity (Idler 1996). The clinical features of ulnar neuropathy at the elbow are numbness or tingling in the 4th and 5th digits and the ulnar border of the palm (Moore 2010). Weakness may or may not be present and may vary in nature from a very mild clumsiness to a pronounced hand weakness. Pain and tenderness may occur at the elbow and radiate toward the hand (Moore 2010; Hobson-Webb et al. 2017). Symptoms are provoked when resting or pressing elbows on arm rest of chairs or incorrect desk height while typing or when the keyboard or mouse is too far away from the body. (Sluiter et al. 2001; Moore 2010).

The radial nerve arises from the posterior cord of the brachial plexus. Near the elbow, the nerve divides into the deep motor posterior interosseous nerve and the superficial sensory radial nerve (Matsubara et al. 2006). The radial nerve is close to the origin of the supinator muscle (the arcade of Frohse) and the origin of the extensor carpi radialis brevis muscle with both structures having the potential of causing compression of the nerve. The distal edge of the supinator muscle and an intramuscular fibrous band can also cause compression. The nerve can be compressed in the radial tunnel, which extends from the radial head to the inferior border of the supinator muscle (Sluiter et al. 2001; Matsubara et al. 2006). Entrapment of the radial nerve in the forearm can produce a variety of symptoms and signs, depending on the location of the compression. Signs and symptoms of radial tunnel syndrome (RTS) is generally characterised by forearm pain without motor weakness, and posterior interosseous nerve syndrome (PINS) is generally characterised by forearm muscular paresis, with or without pain (Han et al. 2014). Symptoms are provoked when using the wrist rest while typing for prolonged periods, gripping the mouse too hard and twisting fingers to hit two keys on the keyboard at once with one hand.

Tendonitis, tenosynovitis, peritendinitis, tendinosis, and tendinopathy are pathoanatomic terms that are used for the pathological process in or around the tendon (Sluiter et al. 2001). In medical dictionaries, tendonitis is defined as inflammation of tendons and of tendon-muscle attachments. In sports literature, this inflammation is perceived to be caused by micro-injuries of tendon tissue as a result of repetitive mechanical load. The degenerative rather than inflammatory features of chronic tendon injuries are more clearly recognised (Almekinders et al. 1998). Textbooks describe tendonitis of the flexor tendons in the forearm or wrist region as characterised by intermittent pain on movement of the hand or wrist, crepitus and local swelling of the tendon surroundings. Most commonly, the tendons of the deep flexors of 2nd to 4th digits are involved. In contrast to wrist flexor tendonitis, the tendons of the wrist extensors can be involved separately (Adams et al. 2015). The tendons of the wrist extensors are easy to observe because they are superficial muscles and have relatively more direct friction from the retinaculum. The wrist extensors have been shown to be more active than the flexors in wrist stabilisation and due to the action and biomechanics of the muscles, more tenosynovitis occurs at the dorsal aspect of the wrist. Patients have pain when grasping or picking up objects and when moving the wrist and hand (Sluiter et al. 2001; Adams et al. 2015).

2.5.2.1 Causes of work-related elbow, forearm and arm pain

The most common work-related injury in the elbow and forearm is epicondylitis (Ono et al 1998; Leclerc et al. 2001). Most of the previous studies of epicondylitis have been conducted among small and selected occupational populations. Few studies have reported the prevalence and risk factors of lateral and medial epicondylitis in the general population (Walker-Bone and Reading et al. 2004). According to numerous studies, the pathogenesis of epicondylitis is still unclear. Repeated micro trauma at the origin of the common extensor or flexor tendon may initiate the disease. Repetitive accumulative forces applied to tissues over prolonged periods in the same muscle group, joint or tendon may cause soft tissue micro tears and trauma and the resulting inflammatory reaction may lead to tendon, synovial, muscle, and ligamentous disorders, degenerative joint disease, bursitis, and/or nerve entrapment (Rempel et al. 1992).

In cases of lateral epicondylitis occurring in workplaces, the forearm extensors are repetitively contracted and produce a force that is transmitted by the muscles to their origin on the lateral epicondyle. These repetitive contractions produce chronic overload of the bone-tendon junction, which in turn leads to changes at this junction. The most common pathologic findings are chronic micro ruptures with formation of granulation tissue in the origin of the extensor carpi radialis brevis (Nirschl et al. 1979; Moore 2002) which causes inflammation. Two possible mechanisms have been proposed: the role of eccentric exertions and contact pressure from the radial head. Repetitive dorsiflexion of the wrist and supination of the forearm may contribute to this process, given the asymmetric axis of rotation of the radial head on the end of the radius. The injury initiates a natural repair response, and accumulated connective tissue may account for the clinical and pathologic manifestations (Shiri et al. 2006).

A few studies have linked the associations between individual and work-related physical factors and epicondylitis (McCormack et al. 1990; Piligian et al. 2000; Descatha et al. 2003). The associated risk factors such as forceful work tasks, a combination of forceful and repetitive activities of the upper extremity, and extreme non-neutral postures of the hands and arms (Kuurpa et al.1991; Ono et al. 1998; Haahr et al. 2003). However, there is insufficient evidence to support an association with repetitive work alone (Bernard 1997; Piligian et al. 2000; Descatha et al. 2003; Haahr et al. 2003). Punnett et al. (1997) concluded that prolonged keyboard use, high job demands and postural stress are associated with upper extremity disorders among computer users. In a prospective study by Macfarlane et al. (2000), psychological factors were found to predict the onset of forearm pain in addition to work-related risk factors such as repetitive movements of arms.

Descartha et al. (2003) concluded medial epicondylitis was strongly associated with other work-related musculoskeletal disorders. Eighty four percent of those with medial epicondylitis suffered from another work-related musculoskeletal disorder, most often shoulder tendonitis, carpal tunnel syndrome or lateral epicondylitis. Ulnar nerve entrapment at the elbow was associated with medial epicondylitis. The association with ulnar nerve entrapment is consistent with the literature. Tschantz et al. (1993) and Gabel et al. (1995) found no association between medial epicondylitis and repetitive work. Lateral epicondylitis was associated with age, repetitive pressing with a hand and psychosomatic problems. Forceful work was the only risk factor significantly associated with medial epicondylitis. The underlying mechanism may be that the first disorder induces unusual movements that in turn cause epicondylitis.

Chen et al. (2007) studied the relationship of mouse angles and muscle activity. The study concluded that activity of the four examined muscles, extensor carpi ulnaris, extensor digitorum, pronator teres and upper trapezius muscles, were affected by the slanted angles of designed ergonomic mice in repetitive, continuous computer mouse tasks. Among the five mice tested, the 25° or 30° slanted mice caused lower muscle activity and more neutral working postures for extensor carpi ulnaris, upper trapezius and pronator teres muscles. For the extensor digitorum muscle, a larger slanted angle increased the height of the tested mouse, and this might lead to a larger wrist extension and a higher risk of CTS. The study concluded two possible ways to decrease this wrist extension which was to use an ergonomic mouse with a lower right-side height for a specified slanted angle, or to use a mouse with an elongated rear inclined part on which the wrist can rest and be lifted.

The forces applied to the computer mouse and keyboard may be a risk factor for musculoskeletal symptoms. It has been observed that three to four hours of computer mouse work could lead to fatigue in the muscles of the forearm (Johnson-Smaragdi et al. 1998). A large British national survey found that keyboard use for more than four hours per day increased the risk of wrist/hand and shoulder symptoms, but not elbow symptoms (Palmer et al. 2001). However, a study by Kryger et al. (2003) found that keyboard use for more than 15 hours per week revealed a slightly increased risk of forearm pain. The combination of high repetitiveness in the fingers and wrist, the static loading imposed on the thumb to grip the mouse, the prolonged extension and ulnar deviation of the wrist and the long duration were contributing factors to the development of musculoskeletal symptoms in the forearm and hand/wrist (Palmer et al. 2001).

A moderate level of evidence suggested that the use of forearm supports during keyboard use decreased muscle activity in neck and shoulders and reduced musculoskeletal discomfort in the shoulders, wrist, and arms (Aaras et al. 1997; Lintula et al. 2001; Delisle et al. 2006; Conlon et al. 2008; Rempel et al. 2011). Forearm support use has been associated with a decrease in wrist extension and ulnar deviation (Lintula et al. 2001; Cook et al. 2003; Cook et al. 2004), though the use of wrist rests has been associated with increased carpal tunnel pressure (Cook et al. 2003).

2.5.2.2 Incidence of work-related elbow, forearm and arm pain

Epicondylitis is an uncommon disorder, with the overall prevalence in the general population reported to be from 1% to 5% (Allander 1974). There are few epidemiologic studies addressing workplace risk factors for elbow MSDs compared to other MSDs. Most of these studies compare the prevalence of epicondylitis in workers in jobs known to have highly repetitive, forceful tasks to workers in less repetitive, forceful work (such as computer users); the majority of these studies were not designed to identify individual workplace risk factors.

Ulnar nerve compression at the elbow is the second most common nerve entrapment of the upper extremity, after carpal tunnel syndrome, with an estimated annual incidence of 21 to 25 cases per 100,000 population (Huisstede et al. 2006; Bartels et al. 2007). The cubital tunnel is the most common location of ulnar nerve compression at the elbow, and the most common structural abnormality of the cubital tunnel is the anconeus muscle, an anomalous muscle reported in 23% to 34% of asymptomatic elbows of the population (Husarik et al. 2009). Radial nerve compression in the forearm, the arcade of Frohse, is the most common site of compression due to a thickened tendinous proximal edge of the superficial head of the supinator. The tendinous thickening is developmental, occurring in 30% to 100% of people, most likely due to repetitive pronation-supination (Clavert et al. 2009). In a MRI study, the edge of the extensor carpi radialis brevis muscle was 4 mm or less in 10 asymptomatic volunteers (Ferdinand et al. 2006). In an MRI investigation of 25 patients with clinical suspicion of posterior interosseous nerve syndrome, the most common finding (52%) was denervation oedema or atrophy of the supinator or extensor muscles; 28% of patients had a visible mass effect on the nerve due to extensor carpi radialis brevis thickening, and distended bicipitoradial bursa (Ferdinand et al. 2006).

Lassen et al. (2005) found persistent pain in 68% of elbow cases, 67% in forearm cases and in 74% of the wrist-hand cases in computer users. In a study by Kryger et al. (2003), the prevalence of reported symptom cases was 4.3% in the right forearm and 1% in the left forearm in computer users. Fifty three percent of right forearm cases were also right elbow cases and 58% were also right wrist/hand cases. Only 0.2% had clinical signs of nerve entrapment. Among the participants with moderate to severe right side forearm complaints, 97% reported that the pain was exacerbated during the last year, and 77% reported having had pain for more than 30 days.

One-year incidence of self-reported symptom cases was 1.3% in the right forearm and 0.4% in the left forearm. Around half of the participants who reported onset of forearm pain at follow up also reported onset of elbow and hand pain (Andersen et al 2003).

2.5.2.3 Treatment

According to Ernst (1992) most authors seem to agree upon a conservative approach to the treatment of lateral epicondylitis before progressing to more complex and invasive therapies. Viola (1998) adds that although conservative treatment of this condition have been examined in a number of studies, there is no unanimous agreement as to the most effective therapy. Treatments suggested include: rest, laser, ultrasound, steroid injection, bracing and surgery.

Medial epicondylitis is relatively uncommon and usually responds to conservative management by methods which may include anti-inflammatory drugs, electrical stimulation, iontophoresis, stretching, exercises, a forearm band and steroid injections. When conservative management fails and there is persistent pain after 6 to 12 months, surgical treatment must be considered. This is mentioned in two studies which are mainly concerned with lateral epicondylitis (Coonrad et al. 1973; Baumgard et al. 1982).

Non-operative treatment should be tried first in all patients, beginning with an initial phase of rest, ice, nonsteroidal anti-inflammatory agents, and possibly corticosteroid injection. A second phase includes coordinated rehabilitation, consisting of range-of-motion and strengthening exercises and counterforce bracing, as well as technique enhancement and equipment modification if a sport or occupation is causative. Non-operative treatment has been deemed highly successful, yet the few prospective reports available suggest that symptoms frequently persist or recur. Operative treatment is indicated for debilitating pain that is diagnosed after the exclusion of other pathologic causes for pain and that persists in spite of a well-managed non-operative regimen spanning a minimum of 6 months. The surgical technique involves excision of the pathologic portion of the tendon, repair of the resulting defect, and reattachment of the origin to the lateral or medial epicondyle. Surgical treatment results in a high degree of subjective relief, although objective strength deficits may persist (Jobe et al. 1994).

In a study of 51 patients with various clinical neuropathies of the upper extremity but with ambiguous findings on physical examination, MRI identified the cause of the neuropathy in 93% of the cases and had a moderate to major impact on the clinical management in 86% of cases (Andreisek et al. 2008). Usually conservative treatment is advised for the first 6 to 12 weeks and surgical intervention when conservative methods fail (Charles et al. 2009; Novak et al. 2009; Keiner et al. 2009).

Upper extremity support has been reported to reduce muscular load in work tasks and has been proposed as a way of reducing static shoulder and neck muscle load during keyboard use (Aaras et al. 1997 and 2001). In a recent prospective epidemiological study of computer users, Marcus et al. (2002) reported that use of the keyboard placed more than 12 cm from the edge of the desk was associated with a lower risk of hand arm symptoms.

2.5.3 Work-related hand and wrist pain

Work-related hand and wrist injuries are common problems in the workplace. An average of 110,000 workers in the United States suffer annually hand and wrist injuries that require them to take sick leave. There are many kinds of medical conditions that have ergonomic causes among office workers, including muscle, tendon, and nerve disorders. The umbrella terms for non-specific work-related disorders are called repetitive strain injury (RSI), CTD and overuse syndrome. Overuse syndrome is a recent term to describe work related upper limb disorders. The syndrome describes musculoskeletal disorders characterised by pain, tenderness, and often functional loss in muscle groups and ligaments subjected to heavy or unaccustomed use (Fry 1988). Cumulative trauma disorder has been defined as a disorder of the muscles, tendons, nerve and blood vessels that are caused, precipitated, or aggravated by repeated exertions or movements of the body (Gerr et al. 1991). RSI is a condition commonly described in young adults whose occupation demands repetitive movements of the wrist and hand. Specific work-related disorders in the hand and wrist are known as carpal tunnel syndrome (CTS), Guyon's canal syndrome and de Quervains tenosynovitis (Ranney 1993).

The median nerve enters the hand above the carpal bones of the wrist by passing beneath the transverse carpal ligament. Compression of the median nerve at the wrist, or carpal tunnel syndrome (CTS), is the most common compressive neuropathy (Elman et al. 2004). With the expanding use of computers, people whose jobs require long periods of intensive mouse use may be at an increased risk of median neuropathy due to the increased carpal tunnel pressure (Keir et al. 1999). The typical symptom pattern is paraesthesia in the median nerve distribution often described as numbness, tingling, burning or pain in the first three digits of the hand (Phalen 1966; Helliwell et al. 1996; Bekkelund et al. 2001). The symptoms are usually intermittent and occur nocturnally in the early stages. Variations of this classic pattern include the presence of symptoms during active hand use or location of symptoms in a larger area of the hand than the distal sensory distribution of the median nerve. In more advanced stages of the disorder, symptoms may include the motor component of the median nerve causing weakness, incoordination and visible muscle atrophy (Brain et. al. 1947; Haase 2007). It affects people performing intensive work with their hands and is reported to be present in up to 25% of active workers, but more than half of patients are asymptomatic (Werner et al. 1998). It has also been reported that CTS disability time is significantly longer than that of other WRMSDs (Falkiner et al. 2002; Daniell et al. 2009; Butler et al. 2002).

Ulnar nerve entrapment at the wrist is known as Guyon's canal syndrome or ulnar tunnel syndrome (Hatch 2014) and occurs infrequently. Compression of the ulnar nerve can occur in Guyon's canal, which lies ulnar to the carpal tunnel between the hook of the hamate bone and the pisiform bone. Only the ulnar nerve and artery pass through the canal, and it contains no tendons (Hatch 2014). The canal has been divided into three anatomic zones; one containing both sensory and motor fibres, one with motor fibres only, and one with sensory fibres only (Hatch 2014). The motor branch innervates the hypothenar muscles, the two ulnar lumbricals, the adductor pollicis muscle, and part of the flexor pollicis brevis muscle (Zeiss et al. 1992). The pattern of sensory and motor symptoms associated with ulnar nerve compression at the wrist depends on the location of the compression within the canal. The clinical features are numbness or paraesthesias of the 4th and 5th digits, often nocturnal (Hatch 2014; Zeiss et al. 1992). Hand or forearm pain can be present.

De Quervain's tenosynovitis is the entrapment of the tendons of the extensor pollicis brevis and abductor pollicis longus. Other similar conditions are trigger thumb and triggering of the middle and ring fingers, characterised by pain with motion of the affected tendon. Symptoms are pain at the radial side of the wrist, spasms, tenderness, swelling over the thumb side of the wrist, occasional burning sensation in the hand, and difficulty gripping with the affected side of the hand. The onset is often gradual and pain is worse by movement of the thumb and wrist (Ilyas et al. 2007).

2.5.3.1 Causes of work-related hand and wrist pain

Overuse syndrome is characterised by pain, tenderness, and often functional loss in muscle groups and ligaments subjected to heavy or unaccustomed use. Tears of the muscle-tendon junction, due to high (eccentric) loads are the most obvious pathology; more likely, though less visible, are micro tears within the tendons after undue loading (Ranney 1993). Tenosynovitis can occur due to friction. Fatigue also results from the disruption of the muscle due to static contraction. Hypoxia presents in nerves around the affected region from compression of blood supply by the tendon and muscles. Cumulative trauma disorder has been defined as a disorder of the muscles, tendons, nerve and blood vessels that are caused, precipitated, or aggravated by repeated exertions or movements of the body (Gerr et al. 1991). This condition is described as common in young adults whose occupation demands repetitive movements of the wrist and hand. Several synonymous definitions are available which suggest that RSI is a collective term for a range of conditions characterised by discomfort or persistent pain in muscles, tendons, and other soft tissues, with or without physical manifestations. The syndrome is usually caused or aggravated by work, and associated with repetitive movement, sustained or constrained postures and/or forceful movements (Gerr et al. 1991; Fry 1988).

Extreme positions of the wrist have been considered to be a risk factor for musculoskeletal symptoms of the hand and wrist (Wahlstrom 2005). A published study by Liu et al. (2003) suggested wrist extension of > 20° increased the risk of CTS. De Quervain's disease and other tenosynovitis of the hand, wrist, and forearm have been associated for decades with repetitive and forceful hand activities as one of the possible causal factors (Amadio 1995).

Bamac et al. (2014) findings provide evidence regarding the close association between computer use and a reduced median nerve conduction velocity. Both ulnar deviation and extension of the wrist increased carpal tunnel pressure (Weiss et al. 1995; Werner et al. 1997). Keir et al. (1999) suggested that two factors accounted for the elevated carpal tunnel pressure during computer mouse use: wrist extension and the fingertip force applied to depress the button and to grip the sides of the mouse. With wrist extension angles greater than 15°, pressure in the carpal tunnel could result in more pressure against the median nerve, and this could contribute to the development of CTS (Simoneau et al. 2003). Werner et al. (1997) noted that wrist extension stretched the flexor tendons and median nerve, exerting pressure on their dorsal face. Low extra neural compression of the median nerve in the carpal tunnel is sufficient to produce oedema within the nerve, and to impair endoneurial microcirculation. This compression has been demonstrated to be strongly influenced by repetitive fingertip loading of the hand and wrist and forearm postures which may be seen during keyboard activity (Rempel et al. 1994; Johnston et al. 2008).

Nelson et al.'s (2000) study concluded that friction as a result of sliding of tendons within their sheaths during the performance of repetitive activities, such as typing, was associated with disorders of tendons, their sheaths or adjacent nerves (Nelson et al. 2000). This association between computer use and median nerve neuropathies has been investigated before. Jepsen (2004) studied a series of computer users with upper extremity complaints in the dominant upper limb and concluded that the median nerve was most common injury. Greening et al. (1998) reported a significantly raised vibration threshold within the median nerve in a group of asymptomatic office workers using computer keyboard equipment, and concluded that the results indicated a change in the function of large sensory fibres. Al-Hashem et al. (2008) assessed the effect of the long-term use of computer mouse devices on the median nerve in healthy frequent computer users and found increased risk of right median nerve entrapment neuropathy at the wrist.

Working on a computer for more than five hours has been associated with hand/wrist disorders. Several previous studies reported a positive association between the duration of computer use and hand/wrists symptoms (Ortiz-Hernández et al. 2003; Jensen and Finsen et al. 2002; Jensen 2003; Punnett et al. 1997; Marcus et al. 2002). Different criteria in different studies were assessed such as computer use for more than four hours per day (Katz et al. 2000), 15 hours a week (Gerr et al. 2002), or more than 75% of work time (Jensen 2003), all of which were defined as high risk factors related to computer use. Therefore, further research is required regarding the time period that might contribute to upper extremity MSDs. Based on the above results, an uncomfortable sitting posture and working on a computer for more than five hours were predictive variables of hand/wrist MSDs.

A study by Bamac et al. (2014) showed that computer users had a tendency to experience median and ulnar sensory nerve damage despite being neurologically asymptomatic. Sustained wrist extension and ulnar deviation resulted in the stretching of these nerves across the wrist during computer mouse use and typing. These results may represent pre-symptomatic or asymptomatic neuropathy similar to the type of subclinical entrapment neuropathy. Therefore, the study concluded that the clinicians interpreting CTS in computer users should ask routinely about the symptoms of ulnar neuropathy at the wrist.

Ergonomic risks pertaining to the development of CTS include a high level of repetitive hand movements, awkward wrist posture and higher forces at the hand and wrist at work (Werner et al. 1998; Bekkelund et al. 2001).

2.5.3.2 Incidence and prevalence of work-related hand and wrist pain

Work-related injuries of the hand and wrist are the most common repetitive motion injuries of the upper limb. The U.S. Bureau of Labor Statistics reported workers lose an average of 14 days of work from a hand sprain, strain, or tear and has resulted in over 12,000 job transfers or restrictions each year. The average workers' compensation hand injury claim was over $7,500 in 2016. About 20% of all workplace injuries involve the hands and fingers.

CTS is one of the most common nerve compression disorder of the upper extremity. The prevalence of this disorder has been estimated to be 1% in the general population and 5% in the working population (Atroshi et al. 1999; de Krom et al. 1992; Concannon et al. 2000; Papanicolaou et al. 2001), with higher estimated rates of 10% or more reported among workers in some industries (Frost et al. 1998; Homan et al. 1999; Rosecrance et al. 2002).

According to the National Centre for Health Statistics (NCHS), in 2000 CTS affected over 8 million Americans with 50% accounting for all work-related injuries and 25% of the reported cases being computer related, with this percentage estimated to increase to 50% in the next couple of years. Approximately 260 000 carpal tunnel release operations are performed each year in America, with 47% of the cases considered to be work-related.

A few studies of CTS exist revealing a similar incidence and prevalence to the United States in developed countries. For example, the incidence in the Netherlands was approximately 2.5 cases per 1000 subjects per year and the prevalence in the United Kingdom was 70 to 160 cases per 1000 subjects (Atroshi et al. 1999; de Krom et al. 1992). CTS research is limited in some developing countries, for example, among non-white South Africans (Goga 1990; Ashworth 2008).

A study conducted by Feuerstein et al. (1977) of approximately 186 000 computer workers during the period 1993 to 1994 found that CTS accounted for 93% of disability claims and for 67% of all direct medical costs. Brogmus et al. (1996) found that the incidence of work-related musculoskeletal and nerve entrapment syndromes of the upper extremity increased from less than 0.5% of all injuries and illnesses in 1986 to more than 2.5% of all injuries and illnesses in 1993. UEWRMSD claims for computer-related injuries increased from 1.6% of all WRUEMSD claims in 1986 to 14.6% of all such claims in 1993 (Fogleman et al. 1995). CTS was second only to forearm muscle strain injuries among computer-related WRMSDs (Fogleman et al. 1995).

There has not been significant research conducted regarding incidence and prevalence of de Quervain’s tenosynovitis, but it has been suggested that it is diagnosed 8 to 10 times more often in women than men (Patry et al. 1998). On average approximately 0.5% of men and 1.3% of women suffer from work-related de Quervains tenosynovitis (Walker-Bone and Palmer et al. 2004). In particular, women are commonly affected postpartum and in general the condition is most common between 30 to 50 years of age (Gonzalez-Inglesias et al. 2010; Patry et al. 1998). A study of 485 patients with upper extremity musculoskeletal disorders (mostly musicians and computer users) found that 17% were diagnosed with de Quervains tenosynovitis in the right hand and 5% in the left hand when a positive Finkelstein's test was present. A study by Ali et al. (2008) reported 22% of de Quervains in the right hand and 2% in the left hand of computer workers who worked 6 hours or more a day. Her findings also found 13% of cubital tunnel syndrome in the right elbow and 2% in the left elbow; and 28% of CTS in the right hand and 6% in the left hand. Her study concluded prolonged keyboard use increased risk injury to soft tissue to the upper extremity more predominantly on the right side.

2.5.3.3 Treatment

In the acute stage of wrist pain, the American Academy of Orthopaedic Surgeons (AAOS) Task Force on Clinical Algorithms recommend ruling out serious underlying conditions. A two to six week course of conservative therapy involving activity modification including: no repetitive tasks, limited exposure to vibration, and avoiding extreme wrist positions. Ice, rest, splinting and NSAIDs are also recommended. If there is little or no response after the initial course of therapy, the algorithm recommends further activity modification, rest, injection, and referral to a specialist.

Conservative treatment from a practitioner such as a physical/occupational therapist or chiropractor involves treatments based on the rationale that they reduce inflammation and pain and promote healing. Treatments include: ultrasound, electrical stimulation, laser, heat or ice, manipulation, dry needling and/or acupuncture, strapping or brace support and use of NSAIDs (Piazzini et al. 2007; Padua et al. 2016).

If conservative treatment fails, then surgical intervention may be required (MacKinnon 2002). Surgical decompression has a 75% success rate of cases in ordinary practice and leaves 8% of patients worse than previously (Bland 2007).

Ergonomic interventions in symptomatic workers have resulted in the reduction of CTS surgical treatment and assists in recovery (Keogh et al. 2000; Bekkelund et al. 2001). Up to 50% of CTS could be avoided if effective intervention programmes were implemented in the workplace environment (Roquelaure et al. 2009) such as safety evaluations, change of equipment or work setup, change of employee duties, and change of work pace (Keogh et al. 2000).

2.6 Summary

Musculoskeletal disorders of the upper extremity affect thousands of workers annually causing temporary and permanent disabilities. The long-term development and variability of symptoms makes identification of these disorders difficult, particularly in the early stages of the disease when interventions are most effective. Personal and work factors have been associated with work-related UEMSDs but the available literature is unable to show a decisive dose-response relationship of work exposures and health outcomes. To clearly show this relationship, there is a need to develop precise and accurate measures and tools for use in research studies of UEMSDs. From the review of the literature in this chapter, there were several gaps noted in the literature, particularly related to studies investigating work-related UEMSDs in the computer programming population as well as limited data recorded of UEMSDs in South Africa.

CHAPTER 3: MATERIALS AND METHODS

This chapter describes the collection of data, the research methodology utilised, and the statistical analysis.

3.1 Study design

This was a quantitative, descriptive, questionnaire-based survey which documented the injury profile of computer programmers. The purpose of the descriptive study is to describe the distribution of an injury/injuries in the computer programming population in relation to age, gender, region etc. In order for the study to be effective and efficient, the data was required to be of good quality in recording the programmers' injury/injuries and hence the use of an expert group and pilot study were utilised to strengthen the questionnaire development process. The questionnaire (Appendix K) contained sections for demographic details, occupational details and the participants' injury/injuries that were sustained during work-related activities. In addition, the DASH questionnaire (Appendix L) was used to measure the disability for any disorder affecting the upper extremity by assessing severity of symptoms and difficulty completing specific tasks.

3.2 Study population

The study population consisted of computer programmers in a selected eThekweni software company, over the age of 18 years, who worked full-time for 8 hours or more per day, that were symptomatic or asymptomatic concerning upper extremity musculoskeletal disorders (as per inclusion and exclusion criteria Section 3.3.2 & 3.3.3). This particular population was chosen as they generally use computer equipment more than the general computer user. Other factors which make this group unique from general computer users are increased hours working on the computer, workstation factors and overtime. In order to determine the effect of computer use on work-related injury a minimum of one year's work experience and 8 hours or more of computer use per day were required.

3.3 Sampling

3.3.1 Sample size

The sample number of 150 completed questionnaires, as determined by the biostatistician, was required to make this study viable. A selected software company in the eThekwini municipality was chosen, in which computer programmers from this company were given the opportunity to participate, dependant on whether they met the stringent inclusion and exclusion criteria outline below. If they accepted participation, they then read through the Letter of Information (Appendix F), informed consent (Appendix G) and then the questionnaires (Appendix K & Appendix L). The participant was asked to complete the questionnaire. Once this had been completed the questionnaires were placed in a sealed box to ensure anonymity of the participants. No particulars of the participant (e.g. identification number, residential address etc.) appeared anywhere on the questionnaires, which helped ensure anonymity of the participant.

3.3.2 Inclusion criteria

- Participants must be 18 years of age or older.
- Participants must be full-time workers (35-40 hours per week) for a year or more.
- Participants must be a computer programmer from the selected software company.
- Participants may be symptomatic or asymptomatic at the time of the study.

3.3.3 Exclusion criteria

- Subjects who participated in the focus group.
- Subjects who participated in the pilot study.
- Subjects who were absent on the day of data collection.
- Subjects who were not willing to sign the Participant’s Letter of Information (Appendix F) and Letter of Informed Consent (Appendix G).
- Subjects who had underlying musculoskeletal pathology that is not occupationally based (e.g. rheumatoid arthritis).

3.4 Methods

3.4.1 Focus group discussion

After receiving partial DUT Institutional Research and Ethics Committee (IREC) ethical clearance, a focus group was arranged and organised by the researcher. A focus group was conducted to test the face validity and reliability of the research procedure and data measurement tool. Connelly (2015) stated that focus group discussions allowed for dialogues to generate data which the researcher would be unable to otherwise obtain; it develops and identifies possible problems with the data collection tool.

The focus group members consisted of five members:

- The researcher
- The researcher supervisor
- The researcher co-supervisor
- One qualified full-time computer programmer
- One chiropractic lecturer/clinician

Each focus group participant had to sign a code of conduct (Appendix C) and confidentiality agreement (Appendix D). Each participant was given a Letter of Information (Appendix A), a Letter of Informed Consent (Appendix B) and a copy of the drafted questionnaire (Appendix J). The researcher gave a brief introduction to the study and to the purpose of the focus group. The participants then completed the questionnaire after which each question was discussed sequentially and individually, and suggestions were given by the participants. Any suggestions that were proposed by any participant was scrutinised and voted on by the group; an amendment was only implemented if there was a unanimous vote. The members of the focus group critically assessed the relevance of questions presented in the questionnaire, as well as add to, delete or clarify any questions to ultimately strengthen the face validity of the questionnaire. A list of amendments that were implemented was drawn up and used to adjust the questionnaire. The researcher and supervisor were present to answer any questions. The whole procedure was chaired and minuted by the researcher and saved for future reference. The content of the proceedings from the focus group will be kept confidential. The data from the focus group will be stored in a locked unit at DUT for 5 years as per requirements and thereafter destroyed as per arrangements made by the researcher and the university.

3.4.2 Ethical approval

Following the focus group, partial ethical approval was granted, subject to the completion of a pilot study to validate the data collection tool.

3.4.3 Pilot study

A pilot study involved taking a very small population for which it is intended to be used and administer the questionnaire exactly as it would be administered to the research sample. The purpose of the pilot study was to determine the time taken and any problematic areas in the questionnaire (Fink and Kosekoff, 1985). A pilot study was conducted to validate the questionnaire so that it would read well and be understood by the computer programmers.

After permission from the selected software company in the eThekwini municipality was granted, five computer programmers were given a Letter of Information (Appendix H), a Letter of Informed Consent (Appendix I) and two questionnaires and asked to complete them. Thereafter, the researcher did an observational assessment called the Occupational Repetitive Action (OCRA) checklist with each participant individually at their work stations. The researcher then worked through each of the questionnaires, addressed any problems and developed the final questionnaire (Appendix K).

3.5 Data collection measurement tool

A self-administered questionnaire (Appendix K) was used in this study along with the DASH questionnaire (Appendix L). The self-administered questionnaire (Appendix K) was constructed and adapted by the researcher, critiqued by both focus group and a pilot group.

The questionnaires consisted of six pages and took approximately 15 to 20 minutes to complete. Completion of the questionnaires resulted in gathering the following data:

- Demographic profiles.
- Work history.
- Past work-related upper limb injury/injuries (with possible associated risk factors).
- Present work-related upper limb injury/injuries (with possible associated risk factors).
- Degree of disability to upper limb in present injury/injuries.

3.6 Disability of the arm, shoulder and hand questionnaire (DASH)

The DASH is the most widely tested instrument in the upper extremity literature (Institute for Health & Work of Ontario 2011). The DASH is a 30-item questionnaire, developed in 1994 by the institute for work and health of Ontario, the American Academy of Orthopaedic Surgeons and the Council of Musculoskeletal Speciality Societies (Hudak et al. 1996; McConnell et al. 1999). It is used to evaluate symptoms and physical function with a five-response option for each item. Scoring is done by summing up the circled responses and subtracting by 30. This figure is then divided by 1.2 to get a DASH function/symptom score out of a possible 100 (a higher score indicates more severe disability) (Figure 3.1). Missing responses to items, up to 3 items or 10% of items, are replaced by the mean value of the responses to the other items before summing it up. If responses to more than 3 items are missing, the overall score cannot be calculated (McConnell et al. 1999). The questionnaire assesses severity of symptoms and difficulty completing specific tasks. The score however, does not distinguish between left and right extremities (McMillan et al. 2009). DASH is the most responsive for MSDs, especially for disorders such as CTS (Kotsis et al. 2005). The DASH has been developed accordingly to recognised methodologies and is well supported by scientific evidence on reliability, validity and responsiveness (Beaton et al. 2001) (Table 3.1). According to MacDermid (2004), the DASH has been proven valid in a variety of circumstances and is the most recognised upper extremity disability self-report scale.

DASH disability/symptom score =

$$\frac{[(\text{sum of n responses}) - 1] \times 25,}{n}$$

where n is equal to the number of completed responses.

Figure 3.1: The scoring system of the DASH questionnaire

Table 3.1: Scientific reporting's of validity, reliability and responsiveness of the DASH questionnaire

Article Title	Author	Validity	Reliability	Responsiveness
Responsiveness of the Disability of the Arm, Shoulder, and Hand (DASH) and Patient-Rated Wrist/Hand Evaluation (PRWHE) in Evaluating Change after Hand Therapy.	MacDermid, J. C. & Tottenham, V. (2004)	✓	✓	✓
Which Outcome Measure is the Best? Evaluating Responsiveness of the Disabilities of the Arm, Shoulder, and Hand Questionnaire, the	McMillan, C. R. and Binhammer, P. A. (2009)			✓

Michigan Hand Questionnaire and the Patient-Specific Functional Scale Following Hand and Wrist Surgery				
Responsiveness of the Michigan Hand Outcomes Questionnaire and the Disabilities of the Arm, Shoulder and Hand questionnaire in carpal tunnel surgery.	Kotsis, S. V. and Chung, K. C. (2005)	✓	✓	✓
Measuring the whole or the parts? Validity, reliability, and responsiveness of the Disabilities of the Arm, Shoulder and Hand outcome measure in different regions of the upper extremity.	Beaton, D. E., Katz, J. N., Fossel A. H., Wright, J. G., Tarasuk, V. and Bombardier, C. (2001)	✓	✓	✓
The Disabilities of the Arm, Shoulder and Hand (DASH) Outcome Questionnaire: reliability and validity of the Swedish version evaluated in 176 patients	Atroshi, I., Gummesson, C. and Andersson, B. (2001)	✓	✓	

3.7 Data collection

Following completion of the pilot study, an amendment was approved (Appendix M) to omit the OCRA checklist assessment as it was time consuming and not consistent with this study

Thereafter, full ethical approval was granted by the DUT IREC (Appendix N) and data collection commenced. The researcher obtained permission from the selected software company by the means of a Letter of Informed Consent (Appendix E). The research procedure was briefly explained to the participants on site at the selected software company, and those who fulfilled the inclusion and exclusion criteria and were willing to participate, were then handed a Letter of Information (Appendix F) and a Letter of Informed Consent (Appendix G), a copy of the questionnaire designed by the researcher (Appendix K) and the DASH questionnaire (Appendix L). The researcher allowed the participants to complete the questionnaires within one to two weeks, thereby ensuring that participation in the study had no interference with their work, and collected the Letter of Informed Consent forms and questionnaires at a suitable time, as discussed with the participants and company. The Informed Consent forms and questionnaires were collected separately to ensure confidentiality of the participants.

The completed questionnaires were then electronically captured, statically analysed and subsequently reported on.

3.8 Ethical considerations

- Institutional ethical clearance was obtained prior to onset of the research procedure.
- Each computer programmer received a Letter of Information (Appendix F) outlining the summary of the intended study, and assuring them of the voluntary nature of the participation, and of confidentiality.
- A Letter of Informed Consent (Appendix G) was signed.
- A Letter of Permission (Appendix E) was obtained from the selected software company to conduct the study on their premises with their staff.
- This research procedure did not cause interference to the participants, as the questionnaires were completed in their own time, and initial information was provided during their break.
- Confidentiality was ensured through separate collection of the Letter of Informed Consent (Appendix G), questionnaire designed by the researcher (Appendix K) and DASH questionnaire (Appendix L) in designated boxes.

- Access to the questionnaires was limited strictly to the researcher and statistician.
- The questionnaires were numbered and the data was coded to ensure anonymity and confidentiality.
- The data will be stored in a locked unit at the Department of Chiropractic, DUT, for five years. The information obtained will be available in the form of a dissertation at the DUT.

3.9 Statistical analysis

The data was analysed using IBM SPSS version 23.0. The scores for each sub-group were expressed as percentages and summarised using mean, standard deviation and range, with 95% confidence intervals. Bivariate associations from categorical variables were conducted using a Pearson's chi-square test or Fischer's exact test where appropriate. Cross tabulations were conducted using contingency tables in order to determine whether there was an association between variables. Graphical representation of scores by groups was ascertained using various types of tables and graphs such as bar graphs, tables, and pie charts (Singh 2015). Factors were entered individually into the Pearson's chi-squared and Eta squared score models to evaluate their Chi-square values and Eta scores. A *p* value of < 0.05 was considered as statistically significant for the Chi-squared test; an Eta score greater than 0.45 was considered as highly significant.

3.9.1 Pearson's chi-square test

The Chi-square (χ^2) is a statistical hypothesis test used to determine if there is an association between two variables in a contingency table (Jensen et al. 2016; Gray 2013; Sapsford and Jupp 1996). It is based on the null hypothesis, which assumes that there is no relationship or association between the two measured phenomena in the sample population:

- H_o: there is no association between the two variables; and
- H_i: there is an association between the two variables.

The formula used to test the null hypothesis is called the Chi-square test, where:

$$\chi^2 = \Sigma \, (O-E)/E$$

The χ^2 test compares the observed frequency (O) in each table cell with the corresponding expected frequency (E).

Confidence intervals were set at the 95% level (Jensen et al. 2016; Gray 2013; Sapsford and Jupp 1996). Generalisation within unambiguously identified confidence intervals is informed by the probability theory, which provides a basis for making deductions about populations based on samples and for analysing relationships between variables. In reference, a less than 1 in 20 chance of making an inaccurate generalisation is set as a tolerable level of Type 1 error in quantitative research (Jensen et al. 2016; Gray 2013; Sapsford and Jupp 1996). This is expressed as $p < 0.05$ (*p* stands for the risk of making a Type 1 error). If the *p*-value is > than 0.05 then the H_o is accepted; if the *p*-value is < than 0.05 then the H_o is rejected.

3.9.2 Eta-squared score

The Eta-squared score (η^2) is used when the variables being tested consists of one that is categorical and the other that is quantitative (Meyers, Gamst and Guarino 2012). It is based on a correlation and is used to test the strength of effect. The Eta-squared score has values that range from 0 to 1, with 0 indicating that no relationship exists between the two variables, whereas 1 indicates a strong relationship (Meyers, Gamst and Guarino 2012). η^2 is interpreted as the percentage of the total variance explained by a given effect. It is formulated by dividing the sum of squares of the effect by the total sum of squares, which can be directly translated into a percentage. The eta-squared column in SPSS F-table output is actually partial eta-squared (η_p^2) in versions of SPSS V23.0. To interpret the strength of a relationship when considering an Eta score, the protocol that is applied is shown in Table 3.1 (Morgan *et al.* 2004).

Table 3.2: Interpretation of Partial Eta score

Interpretation of the strength of a relationship.	Partial Eta score (η_p^2)
Much larger than typical.	.26 +
Large or larger than typical.	.14
Medium or typical.	.06
Small or smaller than typical.	.01

An attempt was made to determine whether any potential risk factors, as identified in previous and international studies, existed in participants of this study; if so, whether any significance was noted between these risk factors and work-related upper extremity injuries that emerged in this study. This was achieved by using Pearson's chi-squared and Eta squared score models to evaluate their Chi-square values and Eta scores. Significant *p* value scores and effect size is reported in Chapter 4.

3.10 Summary

A quantitative, descriptive, questionnaire-based study involving the sampling of computer programmers in a selected software company in the eThekwini municipality was conducted, using a self-administered questionnaire along with a disability questionnaire to gather information that provided the prevalence and selected risk factors for upper limb pain. The study design, sampling, focus group, pilot study and main research study procedures, as well as the ethical considerations; data collection measurement tool and statistical analysis have been presented and discussed.

CHAPTER 4: FINDINGS, INTERPRETATION AND DISCUSSION OF THE PRIMARY DATA

4.1 Introduction

This chapter presents the results and discusses the findings obtained from the questionnaires in this study. The questionnaire was the primary tool that was used to collect data and was distributed to 300 computer programmers in a selected software company in the eThekweni Municipality. The data collected from the responses was analysed using SPSS version 24.0. The results are presented in the form of graphs, cross tabulations and other figures for the quantitative data that was collected. Inferential techniques include the use of correlations and Pearson's chi-square test values; which are interpreted using the *p*-values.

4.2 The sample

In total of the 300 questionnaires distributed among computer programmers in a selected software company in the eThekweni municipality, 157 were completed and returned. Two questionnaires were excluded since they did not meet the inclusion criteria. The final sample number for this study was thus 155 (N = 155). This was above the minimum requirement of 150 questionnaires, as determined by the biostatistician. A final response rate of 51.7% was achieved.

4.3 The research instruments

The research instrument consisted of 32 items, with a level of measurement at a nominal or an ordinal level. The questionnaire was divided into four sections which measured various themes as illustrated below:

1. Demographic data
2. Work history
3. Past work-related Injury/Injuries
4. Present work-related Injury/Injuries

4.4 Demographic data

This section summarises the demographic characteristics of the respondents.

4.4.1 Age and gender

The mean and standard deviation for age of a female was 31.5 ± 4.78 years, with a minimum age of 26 years and maximum age of 38 years (n = 11). The mean and standard deviation of a male was 32.2 ± 6.5 years, with a minimum age of 21 years old and a maximum age of 54 years of age (n = 144).

Table 4.1: Gender distribution by age

Gender	N	Mean	Median	Std. Deviation	Minimum	Maximum
Female	11	31.5455	31.0000	4.78254	26.00	38.00
Male	144	32.2083	31.0000	6.51934	21.00	54.00
Total	155	32.1613	31.0000	6.40159	21.00	54.00

4.4.2 Age distribution

A large percentage (45.8%, n = 71) were in the 31 to 40 year age group. This age group generally represents the majority of the sample with the age group 21 to 30 at a close second of 44.5% (n = 69).

Table 4.2: Age distribution by percentage

Age	Frequency (n)	Percentage
21-30	69	44.5
31-40	71	45.8
41-50	13	8.4
51-54	2	1.3

Overall, there was no significant difference in the mean age by gender (p = 0.742). There was greater variation in the ages of males compared to females.

4.4.3 Gender distribution

The sample population is largely male (92.9%, n = 144) with a small percentage of females (7.1%, n = 11). This may not be a full representative of the whole work force at the selected company, but may give some indication of gender proportions in the computer software field at this particular software company.

The ratio of males to females was approximately 13:1 (92.9%:7.1%).

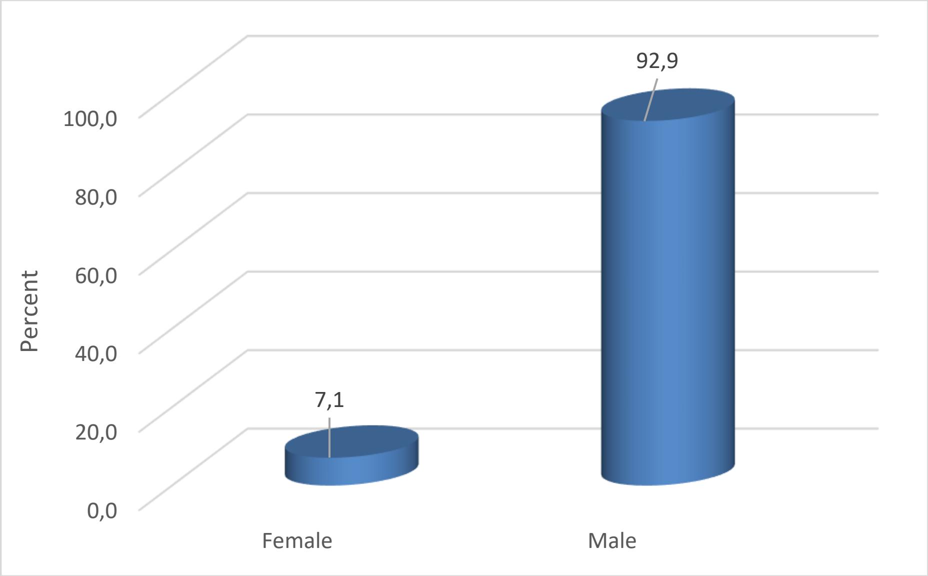

Figure 4.1: Gender distribution

4.4.4 Ethnic distribution

Nearly half of the respondents were White (48.4%, n = 75), with a little more than a third being Indian (36.8%, n = 57) and the remainder of 9% (n = 14) Black, 3.2% (n = 5) Coloured and 2.6% (n = 4) other racial groups.

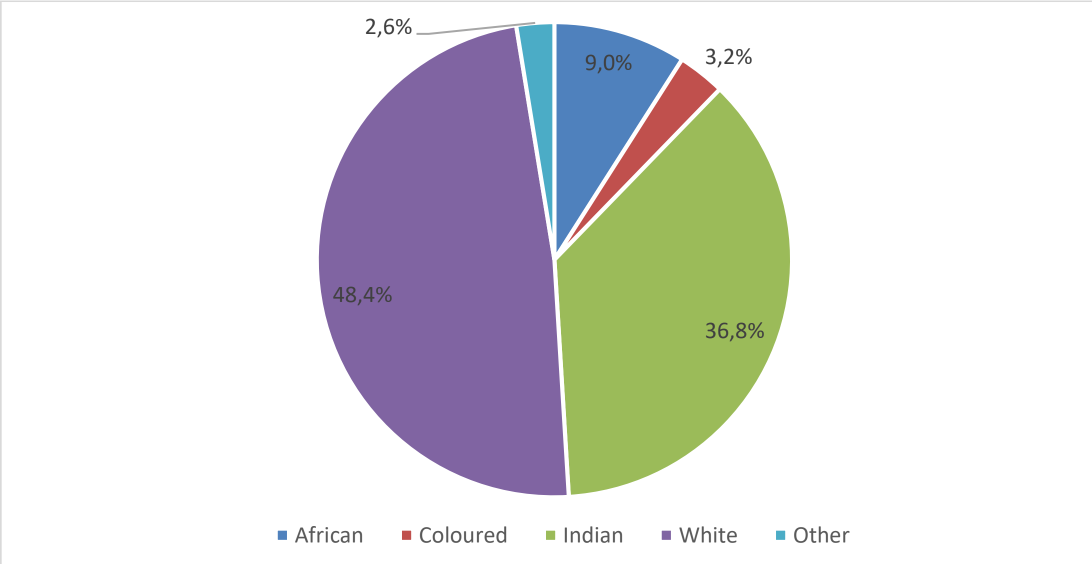

Figure 4.2: Ethnic distribution

4.4.5 History of non work-related upper limb injury or surgery

Three-quarters of the respondents reported to have had no previous injury or surgery (n = 117), and 21.9% (n = 34) had a history of a sports injury to the upper limb.

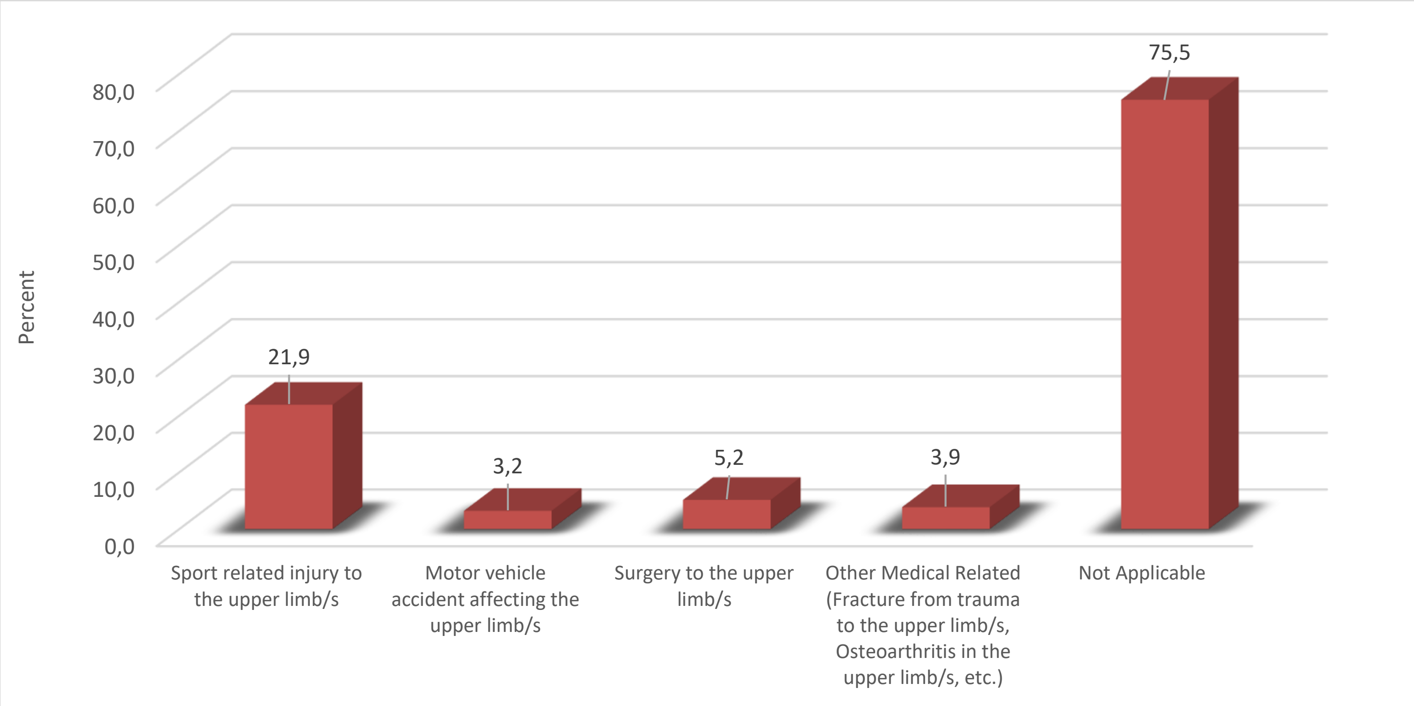

Figure 4.3: History of non work-related upper extremity injury or surgery

4.5 Work history

This section summarises work experience, work hours and basic ergonomics at work stations.

4.5.1 Work experience

Almost half of the sample population worked between 6 to 10 years (39.4%, n = 61) as a computer programmer, 27.1% (n = 42) worked between 2 to 5 years, 21.9% (n = 34) worked between 11 to 20 years, 6.5% (n = 10) worked for more than 20 years and 5.2% (n = 8) worked for a year as a computer programmer.

A large number of respondents worked between 2 to 20 years, with more than two-thirds having worked more than five years. This is a useful statistic as it indicates the the sample population have many years of work experience.

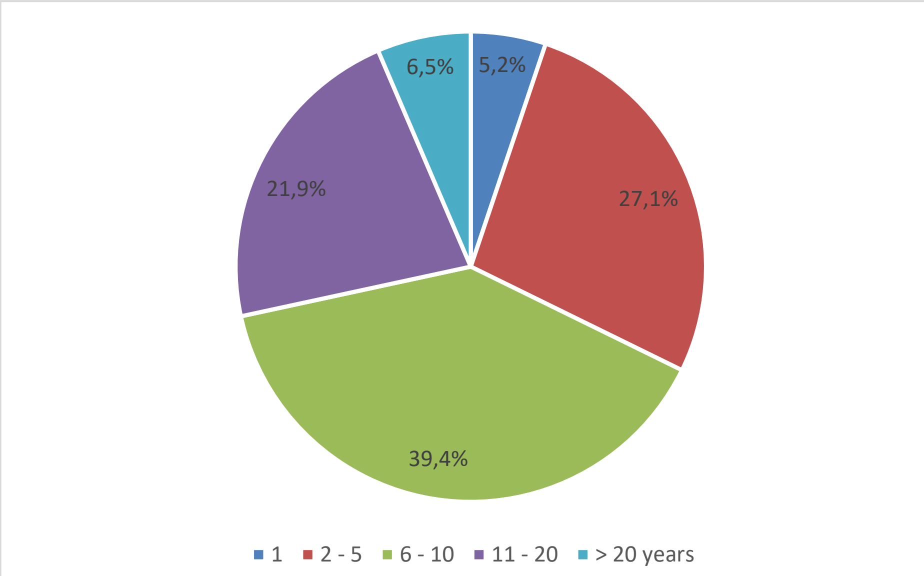

Figure 4.4: Work experience distribution

4.5.2 Work hours

More than half of the participants worked 7 to 8 hours per day (57.4%, n = 89) and that less than half worked more than 8 hours per day (41.9%, n = 65). Only a fraction (0.6%, n = 1) worked 4 to 6 hours per day.

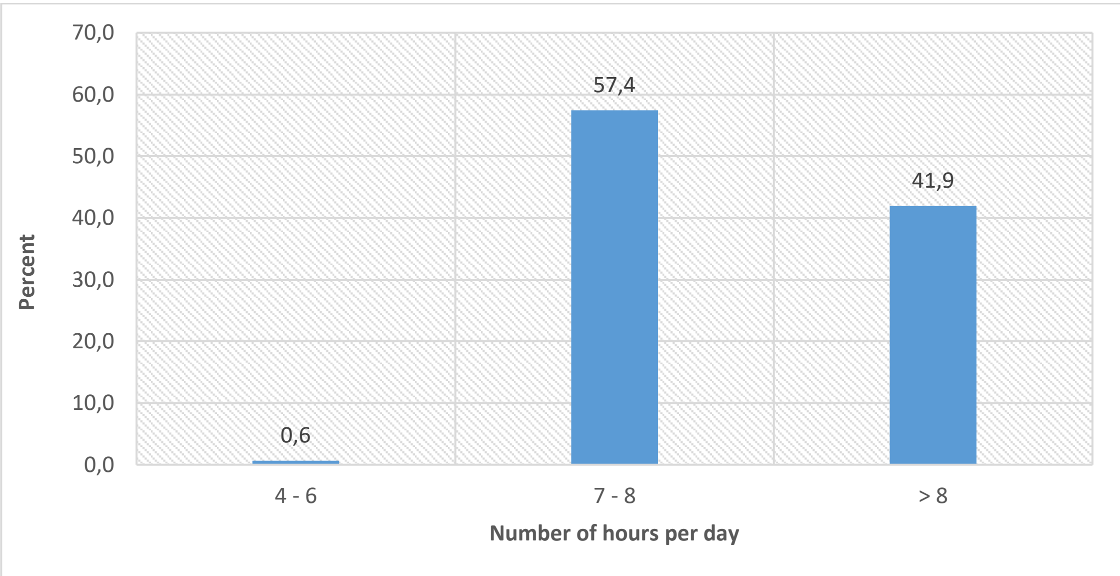

Figure 4.5: Hours worked daily distribution

Almost two-thirds of the participants worked 35 to 40 hours per week (56.8%, n = 88) and 43.2% (n = 67) worked more than 40 hours per week.

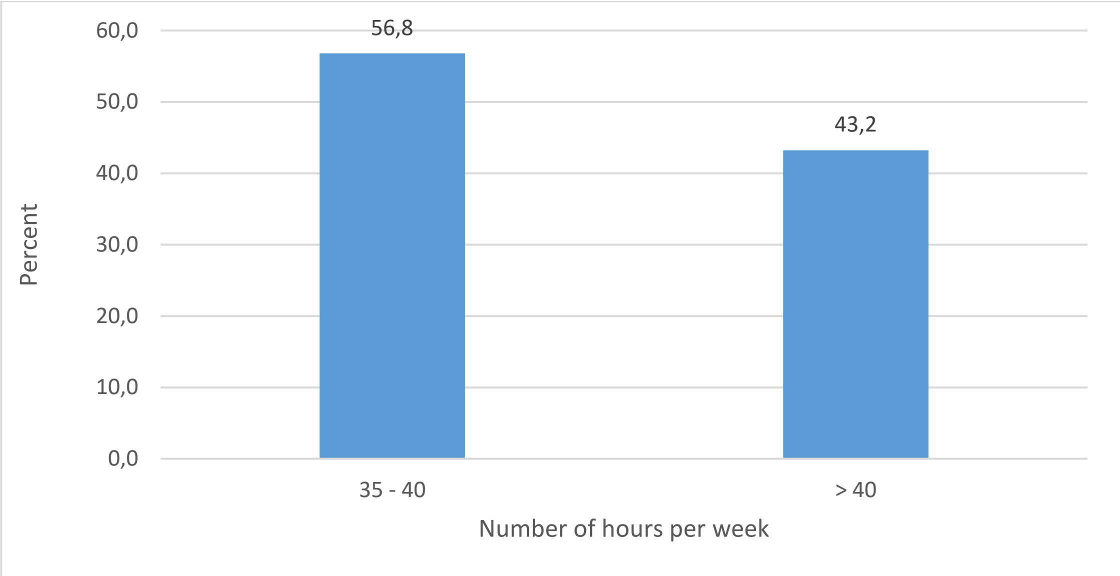

Figure 4.6: Hours worked weekly distribution

Figure 4.7 illustrates that 61.3% (n = 95) of the participants worked 31 to 40 hours on the computer per week, and 32.3% (n = 50) worked more than 40 hours and the remainder 6.5% (n = 10) worked between 16 to 30 hours.

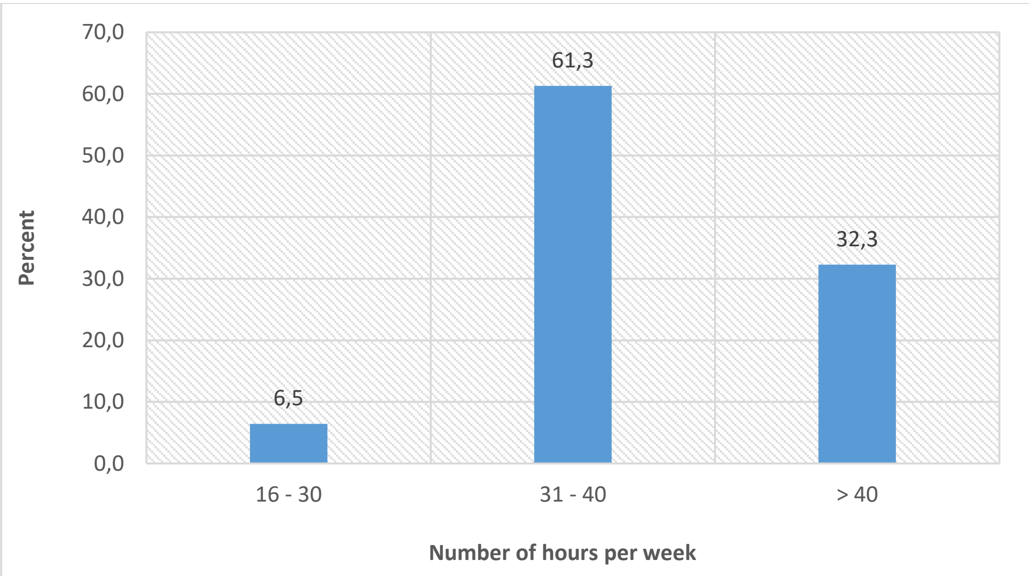

Figure 4.7: Hours worked weekly on the computer distribution

All respondents worked full time at 35 to more than 40 hours per week and with more than 90% of the sample population working the same number of hours on their computers. This is a useful statistic as it indicates that the majority of the participants worked full time on their computers and no other related tasks in their working hours.

4.5.3 Overtime

A third of the sample population (32.9%) did not work overtime within the year, almost half (46.5%) worked about 30 days or less overtime, 12.3% worked overtime between 31 to 100 days and a small fraction of 8.4% worked overtime frequently.

Table 4.3: Overtime worked in a year

Variables	Frequency	Percent
Never	51	32.9
< 30 days	72	46.5
31-100 days	19	12.3
Frequently	13	8.4

Figure 4.8 illustrates that 76.8% (n = 119) of the sample population worked 0 to 5 hours overtime per week on the computer, 16.8% (n = 26) worked 6 to 10 hours and 6.5% (n = 10) worked more than 10 hours. Half the of the sample population (51%, n = 79) spent 0 to 5 hours on the computer outside of work, 25.2% (n = 39) spent 6 to 10 hours and 23.9% (n = 37) spent more than 10 hours per week on the computer outside of work.

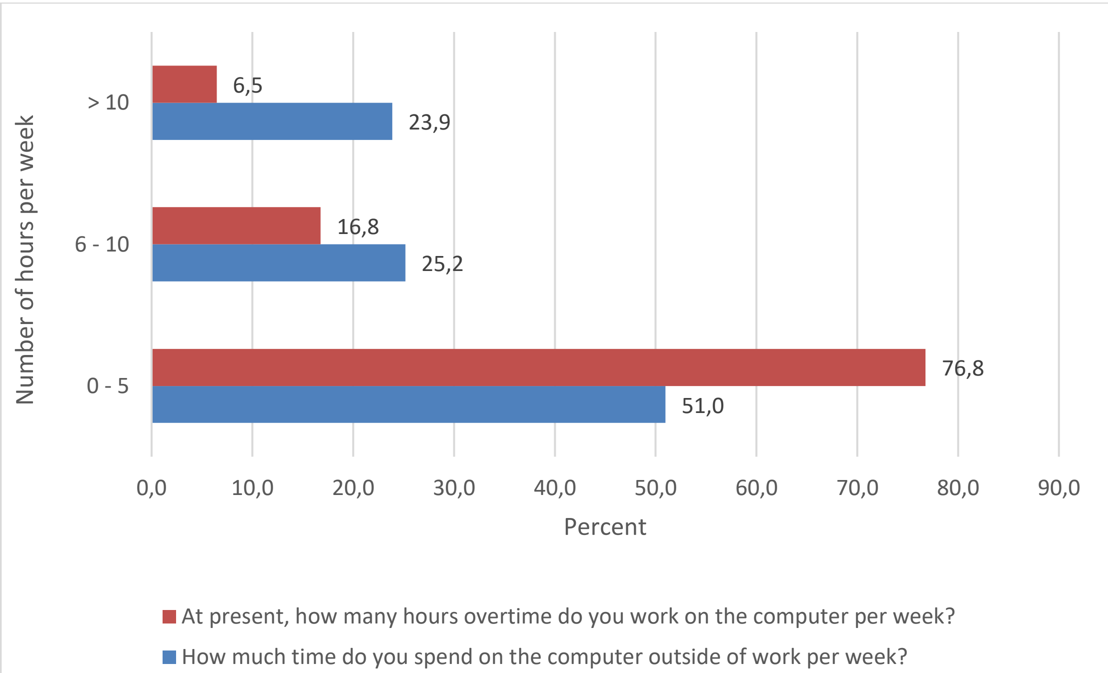

Figure 4.8: Number of hour's overtime on the computer vs. use of computer outside of work per week

A third of the respondents (32.9%) did not work overtime, 46.5% worked a reasonable amount of overtime per week and within the year and a small fraction worked overtime frequently (more than 10 hours per week). Half of the sample population either worked minimal to no hours per week on the computer outside of work (whether recreational or work-related) and the other half of the sample population worked between 6 to more than 10 hours per week on the computer outside of work. This is a useful statistic as it indicates more than half of the repondents worked 40 to more than 50 hours in total on the computer per week.

4.5.4 Equipment

Majority of the sample population (92.9%, n = 144) worked on the mouse and keyboard.

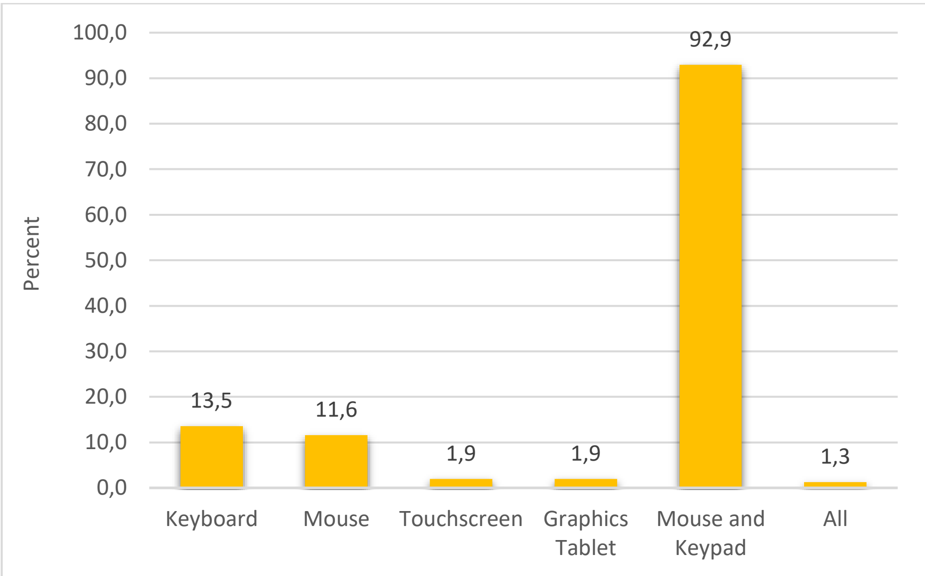

Figure 4.9: Most used equipment distribution

All the respondents were right hand dominant in this study. Dominance does not seem to play a role in affecting the side of injury as all the individuals were right hand dominant.

Table 4.4: Dominant hand distribution

Dominant hand	Frequency	Percent
Right	155	100,0

4.6 Lifetime prevalence of work-related upper limb injury/injuries

This section summarises the lifetime prevalence of work-related upper limb injury/injuries, diagnosis, treatment and prevention of injury of the sample population.

4.6.1 Lifetime prevalence of work-related upper extremity disorders

Table 4.5 shows that 41.3% (n = 64) of the sample population have had a past work-related injury/injuries in the upper extremity.

Table 4.5: Lifetime prevalence of work-related upper extremity disorders

Variables	Frequency	Percent
Yes	64	41,3
No	91	58,7

4.6.2 Lifetime prevalence of work-related injury of the upper limb

Figure 4.10 illustrates that of the 41.3% of the sample population that experienced a past work-related upper limb injury, the most common past injury was the right shoulder (25.8%), the second most common injury was the right wrist (23.9%) and the third most common injury was the right hand (17.4%).

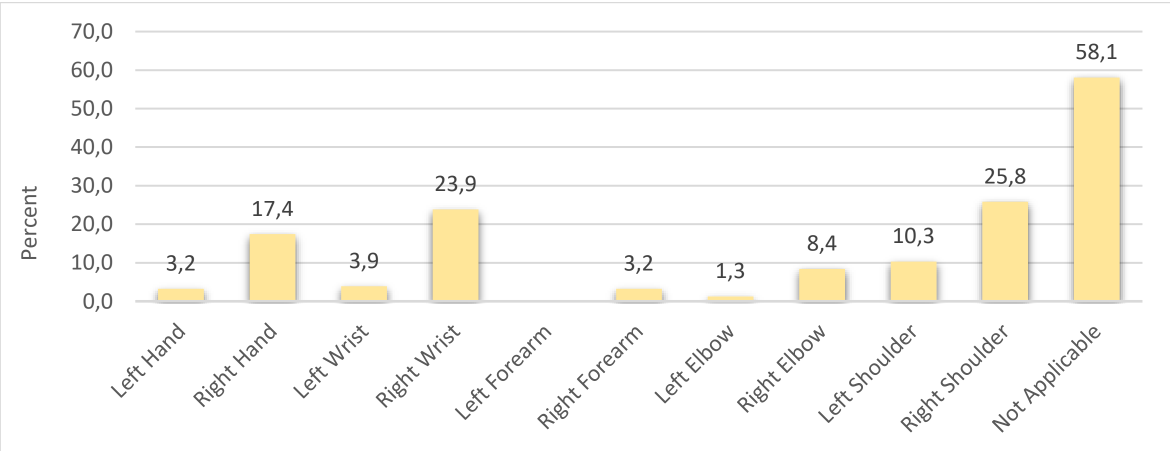

Figure 4.10: Lifetime prevalence of work-related injury of the upper limb distribution

4.6.3 Lifetime prevalence of worst work-related upper limb injury

Figure 4.11 illustrates that of the 41.3% of the sample population that had experienced a past work-related injury, the worst injury that was most common was the right shoulder (18.7%). The second worst past work-related injury was the right wrist (13.5%) and the third worst past work-related injury was the right hand (9.7%).

The three most common work-related upper limb injuries of the affected sample population had occurred in their dominant arm.

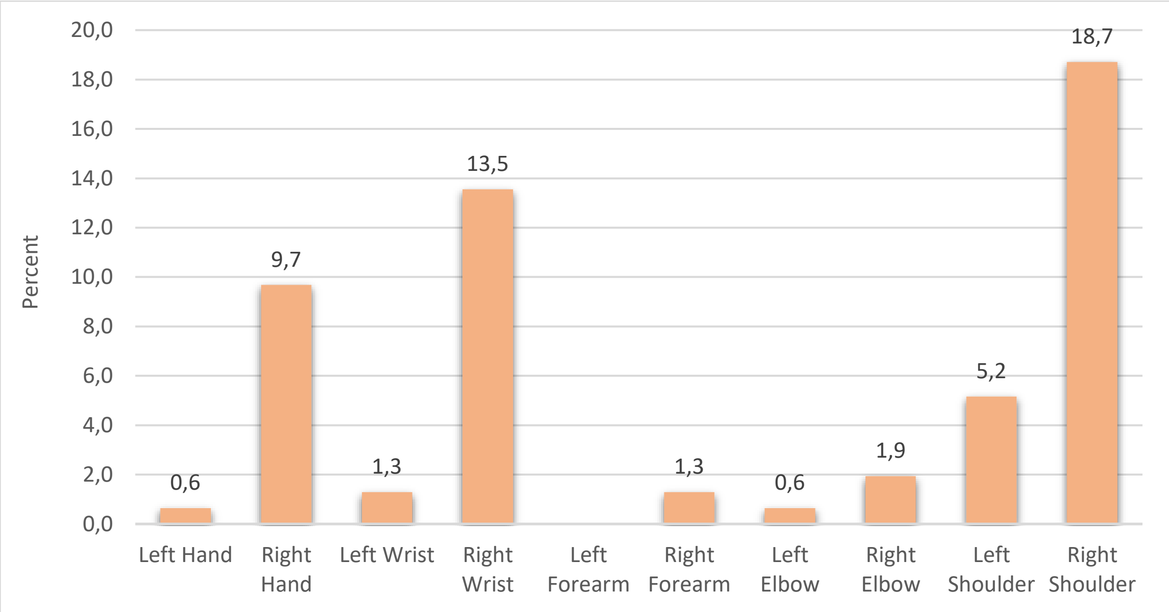

Figure 4.11: Lifetime prevalence of worst work-related injury of the upper limb distribution

The severity of pain was mild for almost half (n = 31, 48.4%) of the affected sample population (41.3%), 43.8% (n = 28) had moderate pain, and 7.8% (n = 5) experienced severe pain.

Table 4.6: Lifetime prevalence of severity of pain of worst work-related upper limb injury distribution (n = 64)

Pain	Frequency	Percent
Mild	31	20,0
Moderate	28	18,1
Severe	5	3,2
Total	64	41,3

The duration of pain was almost a third for each acute (n = 20), subacute (n = 22) and chronic (n = 22) of the sample population affected by past work-related upper limb injury/injuries (n = 64).

Table 4.7: Lifetime prevalence of duration of pain of worst work-related upper limb injury distribution (n = 64)

Weeks	Frequency	Percent
0 - 6	20	12,9
7 - 12	22	14,2
> 12	22	14,2
Total	64	41,3

Figure 4.12 illustrates that of the 41.3% (n = 64) of the sample population affected with a past work-related upper limb injury, almost half (n = 28) did not know the diagnosis of their injury. Almost a third of the sample (n = 19) were diagnosed (self or by practitioner) with a muscle strain and that the third common diagnosis was nerve compression (n = 14).

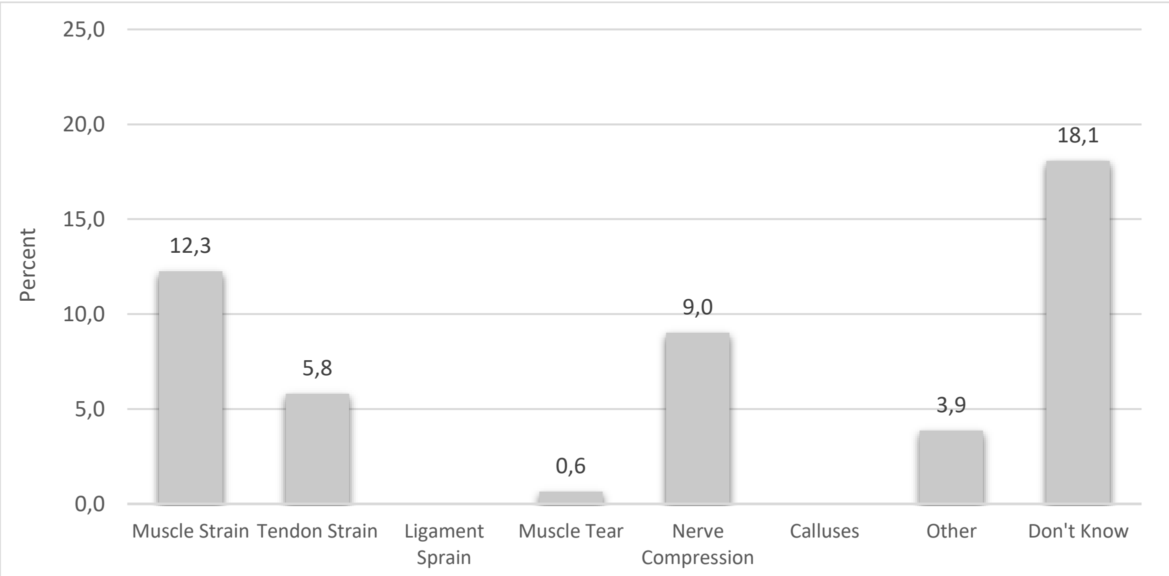

Figure 4.12: Diagnosis (self or practitioner) of lifetime prevalence of the worst work-related upper limb injury (n = 64)

Over a third (n = 24) of the affected sample population (n = 64) did not treat their condition and just over a quarter (n = 17) treated it with medication and/or injections.

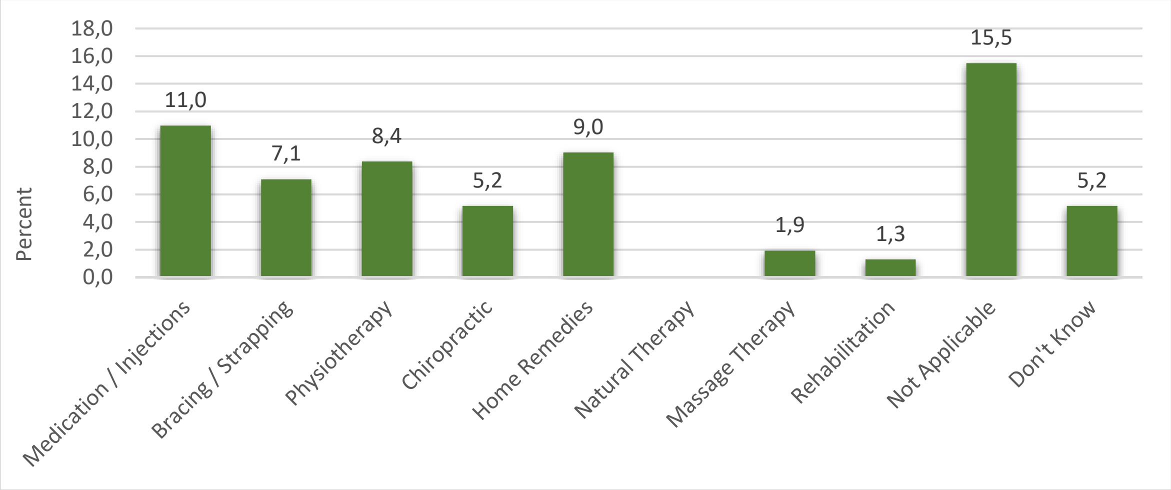

Figure 4.13: Treatment distribution of lifetime prevalence of the worst work-related upper injury (n = 64)

Figure 4.14 illustrates that 42.2% (n = 27) of the affected sample population (n = 64) had changed their chair to improve their upper limb injury, 34.3% (n = 22) had changed their mouse equipment, and 37.5% (n = 24) did not change anything at all.

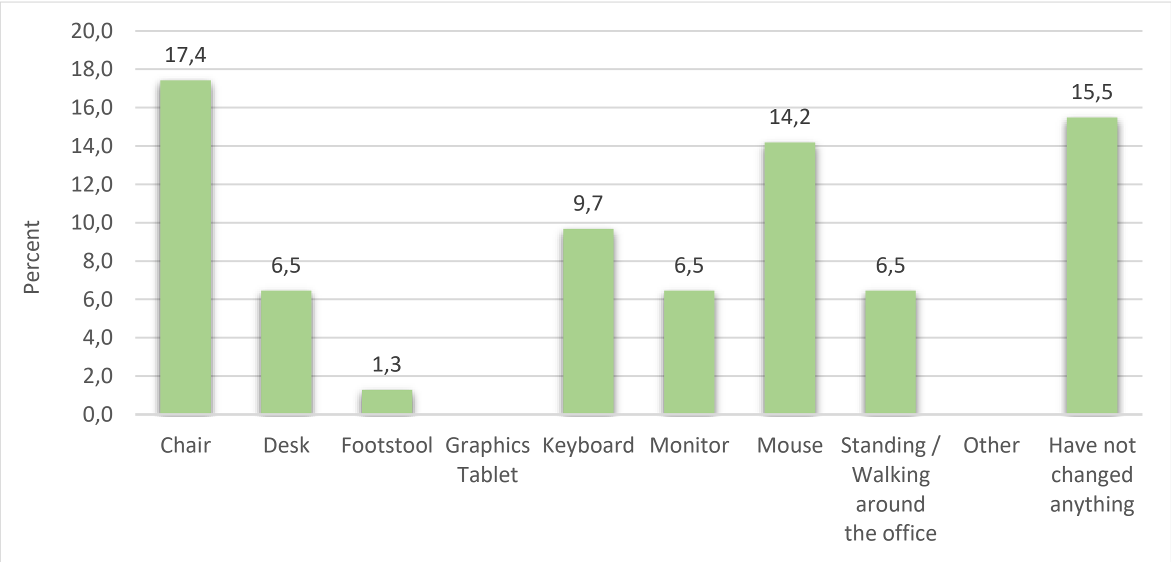

Figure 4.14: Workstation changes to improve lifetime prevalence of work-related upper limb injury (n = 64)

Work-related upper limb injuries of over half (n = 33) of the affected sample (n = 64) had improved when they changed their work stations.

Table 4.8: Frequency of sample population who changed their work station to improve pain/injury (n = 64)

Change in workstation	Frequency	Percent
Yes	33	21,3
No	6	3,9
Not Applicable	25	16,1
Total	64	41,3

4.7 Point prevalence of work-related upper limb injury/injuries

This section summarises the present work-related upper limb injury/injuries, diagnosis, treatment and prevention of injury of the sample population.

4.7.1 Point prevalence of work-related upper extremity disorders

Less than a quarter (21.9%, n = 34) of the sample population had a present work-related injury/injuries in the upper extremity.

Table 4.9: Point prevalence of work-related upper extremity disorders

Variables	Frequency	Percent
Yes	34	21,9
No	121	78,1
Total	155	100,0

Figure 4.15 illustrates that of the 21.9% of the sample population that were experiencing a present work-related upper limb injury, the most common injury was the right shoulder (n = 14), the second most common injury was the right wrist (n = 12) and the third most common injury was the right hand (n = 7) and left shoulder (n = 7).

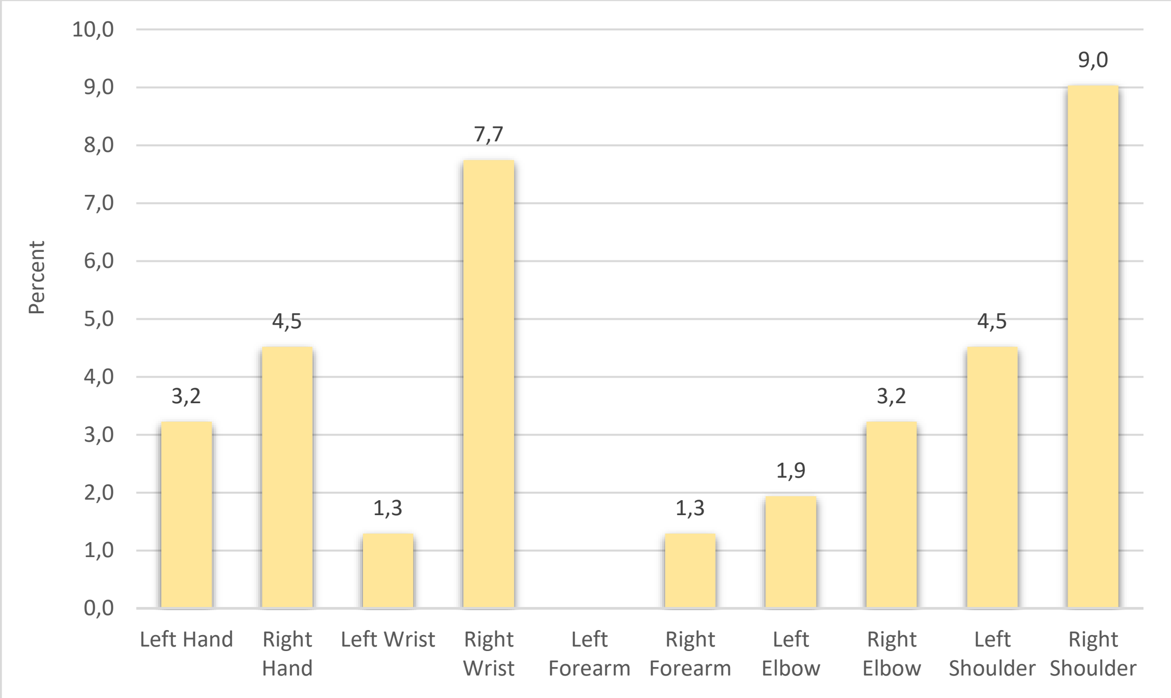

Figure 4.15: Point prevalence of work-related upper limb injury distribution

The severity of pain was mild for two-thirds (n = 23) of the affected sample population (n = 34). Less than a quarter (n = 8) of the affected sample population (n = 34) had moderate pain, and 8.8% (n = 3) experienced severe pain.

Table 4.10: Point prevalence of severity of pain of work-related upper limb injury distribution (n = 34)

Pain	Frequency	Percent
Mild	23	14,8
Moderate	8	5,2
Severe	3	1,9
Total	34	21,9

The duration of pain was mostly either acute (n = 14) or chronic (n = 15) of the sample population (n = 34) presently affected by work-related upper limb injury/injuries. Only a small percentage of the affected sample had subacute pain (n = 5).

Table 4.11: Point prevalence of duration of pain of work-related upper limb injury (n = 34)

Duration	Frequency	Percent
0 - 6	14	9,0
7 - 12	5	3,2
> 12	15	9,7
Total	34	21,9

Almost half (n = 16) of the 21.9% (n = 34) of the sample population affected by a present work-related upper limb injury didn't know the diagnosis to their injury. Almost a quarter of the affected sample (n = 8) were diagnosed (self or by practitioner) with a muscle strain and the third most common diagnoses was a nerve compression (n = 6).

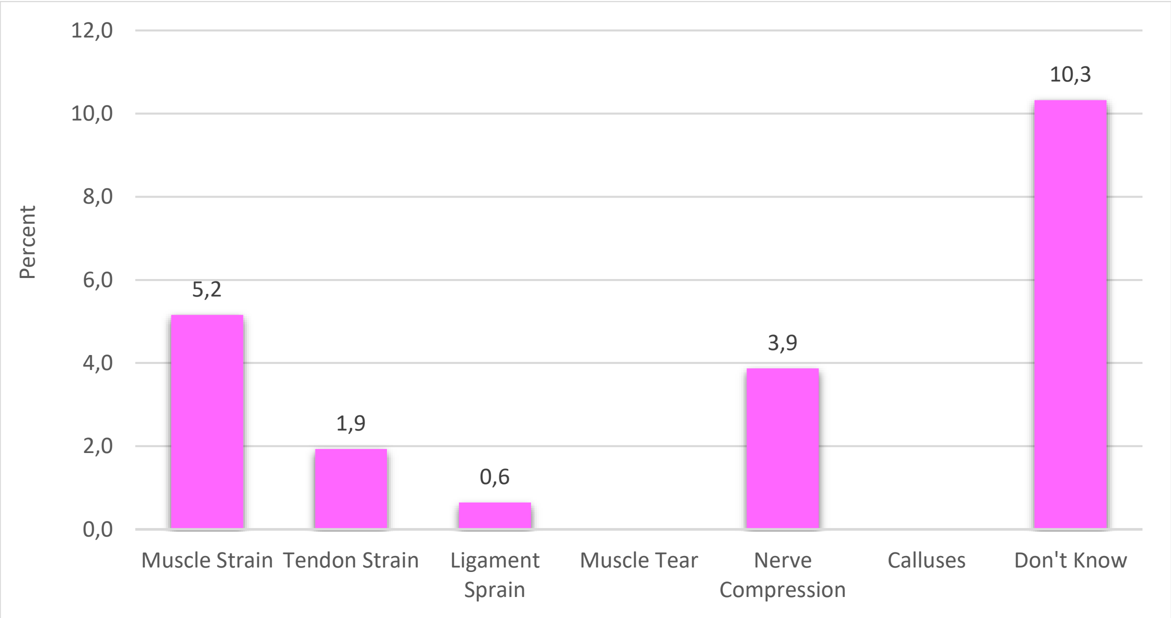

Figure 4.16: Diagnosis (self or practitioner) of point prevalence of work-related upper limb injury (n = 34)

Almost a half (41.2%, n = 14) of the affected sample population (n = 34) didn't treat their condition and just under a third (29.4%, n = 10) treated it with medication and/or injections.

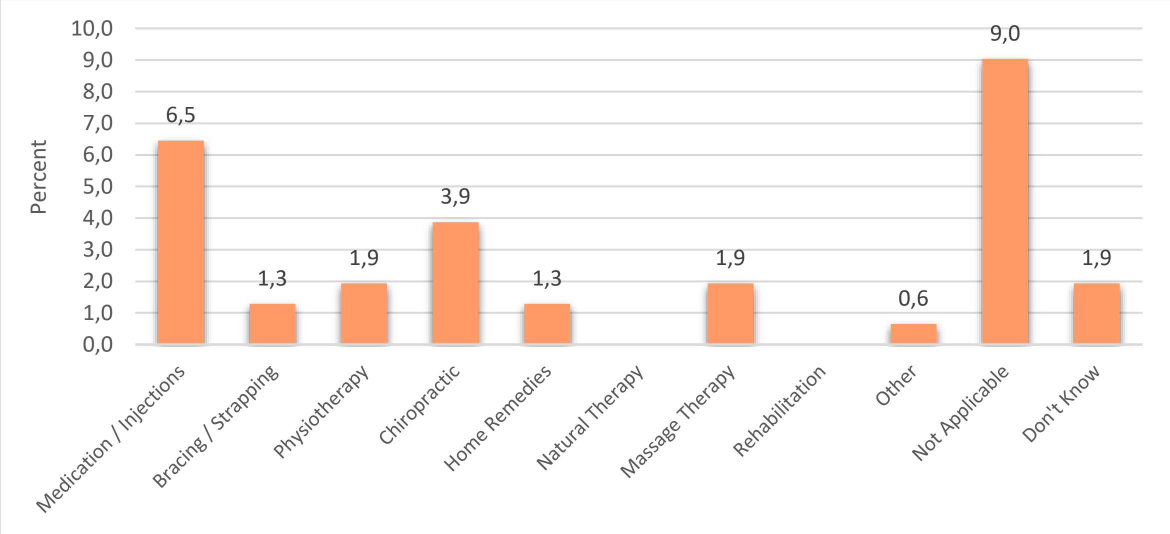

Figure 4.17: Treatment distribution of point prevalence of work-related upper limb injury (n = 34)

Among the affected sample population (n = 34) presently suffering with work-related upper limb injury, working significantly aggravated the injury (82.4%, n = 28), and after a week away from work the pain was significantly relieved (79.4%, n = 27).

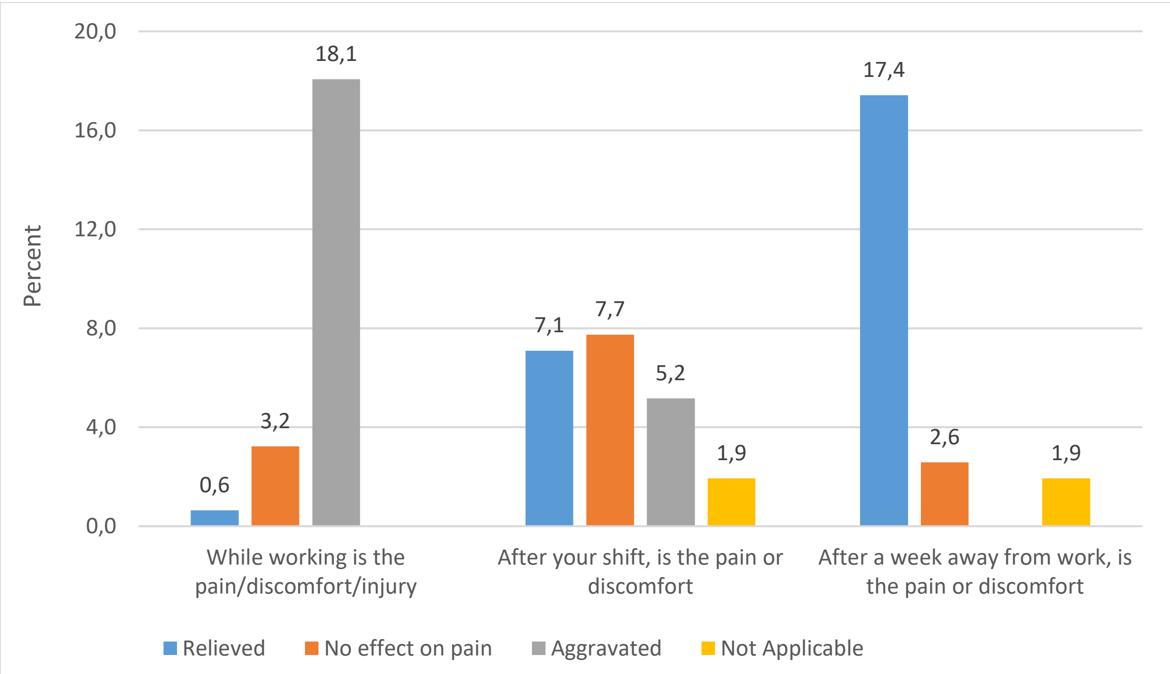

Figure 4.18: Point prevalence of aggravating or relieving factors of work-related upper injury (n = 34)

The majority (85.3%, n = 29) of the affected sample population presently (n = 34) suffering work-related upper limb injury/injuries had not taken any sick leave.

Table 4.12: Point prevalence of sick leave due to work-related upper limb injury (n = 34)

Sick leave	Frequency	Percent
Yes	5	3,2
No	23	14,8
Not Applicable	6	3,9
Total	34	21,9

The small percentage that took sick leave (14.7%, n = 5), the number of days varied between 2 and 15 days.

Table 4.13: Number of sick days taken due to point prevalence work-related upper limb injury (n = 34)

Days	Frequency	Percent
nil	29	18,7
2 days	3	1,9
10 days	1	0,6
15 days	1	0,6

The majority (85.3%, n = 29) of the affected sample population (n = 34) with injuries have some interference with their work.

Table 4.14: Point prevalence of work-related upper limb injury and interference with work (n = 34)

Variables	Frequency	Percent
No Interference	5	3,2
Some Interference	26	16,8
Took time off work due to pain injury	3	1,9
Total	34	21,9

Two-thirds (67.6%, n = 23) of the affected sample population (n = 34) injuries have some interference outside of their work.

Table 4.15: Point prevalence of work-related upper limb injury and interference outside of work (n = 34)

Variables	Frequency	Percent
No Interference	11	7,1
Some Interference	21	13,5
Had to stop enjoying activity due to pain	2	1,3
Total	34	21,9

The minority (11.8%, n = 4) of the affected sample population (n = 34) with work-related upper limb injury presently stopped any activities between 1 day to 50 days.

Table 4.16: Point prevalence of work-related upper limb injury and interference with activities (n = 34)

Days	Frequency	Percent
nil	30	19,4
1 day	1	0,6
15 days	1	0,6
31 days	1	0,6
50 days	1	0,6

Table 4.17 depicts that 41.3% of the sample population experienced neck pain associated with their work-related upper limb injury/injuries.

Table 4.17: Point and lifetime prevalence and neck pain associated with work-related upper limb injury

Variables	Frequency	Percent
Yes	64	41,3
No	91	58,7
Total	155	100,0

4.8 Risk factors and computer programmer injuries

4.8.1 Participant characteristics

4.8.1.1 Age and injury

A Partial Eta score was used to determine the strength of the association between age and type of previous and current injuries. Age does not seem to play a role in terms of the score obtained. There was a medium size effect for ‘other’ ($\eta_p^2 = 0.075$) in current injuries. Age was also examined for an association with the type of previous injury. The results of the association are portrayed in Table 4.18. There was no significance associated with increasing age and injury type, as suggested by the Pearson's chi-squared value.

Table 4.18: The association between age and injury type

Injury Type	Partial Eta score		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Muscle strain	0.000	0.001	Small	Small
Tendon strain	0.003	0.002	Small	Small
Ligament sprain	0.000	0.003	Small	Small
Muscle tear	0.001	0.000	Small	Small
Nerve compression	0.011	0.000	Small	Small
Callouses	0.000	0.000	Small	Small
Other	0.049	0.075	Small	Medium
I don't know	0.005	0.006	Small	Small

A Partial Eta score was used to determine the strength of the association between age, in both point and lifetime prevalence for injury. Age seems to play a role in terms of the score obtained. Age was also examined for an association with the type of previous injury. The results of the association are portrayed in Table 4.19. There was significance associated with increasing age and the left wrist (η_p^2 = 0.134), the right wrist (η_p^2 = 0.163), the right forearm (η_p^2 = 0.062), the left elbow (η_p^2 = 0.208) and the right elbow (η_p^2 = 0.075) in lifetime prevalence. There was significance associated with increasing age and the left hand (η_p^2 = 0.063), the right wrist (η_p^2 = 0.425), the left elbow (η_p^2 = 0.418), the right elbow (η_p^2 = 0.268), the left shoulder (η_p^2 = 0.515) and the right shoulder (η_p^2 = 0.513) in point prevalence. There was also a large effect size with increasing age and severity in lifetime prevalence (η_p^2 = 0.200), a medium effect size in point prevalence (η_p^2 = 0.084) and a large effect size in increasing age and duration of injury in both lifetime (η_p^2 = 0.244) and point (η_p^2 = 0.282) prevalence.

Table 4.19: The association between age and injury

Injury	Partial Eta score		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	0.025	0.063	Small	Medium
Right hand	0.043	0.548	Small	Small
Left wrist	0.134	0.000	Large	Small
Right wrist	0.163	0.425	Large	Large
Left forearm	0.000	0.000	Small	Small
Right forearm	0.062	0.000	Medium	Small
Left elbow	0.208	0.418	Large	Large
Right elbow	0.075	0.268	Medium	Large
Left shoulder	0.000	0.515	Small	Large
Right shoulder	0.027	0.513	Small	Large
Severity	0.200	0.084	Large	Medium
Duration	0.244	0.282	Large	Large

4.8.1.2 Ethnic group and injury

The *p*-value was used to determine the strength of the association between ethnicity, in both point and lifetime prevalence for injury (Table 4.20). This shows a small effect size concerning both point and lifetime prevalence for injury. Race does not seem to play a role in terms of the score obtained.

Table 4.20: The association between ethnic group and injury

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	1.000	0.846	Small	Small
Right hand	0.867	0.533	Small	Small
Left wrist	0.409	1.000	Small	Small
Right wrist	0.443	0.738	Small	Small
Left forearm	-	-	-	-
Right forearm	0.642	1.000	Small	Small
Left elbow	1.000	0.740	Small	Small
Right elbow	1.000	0.630	Small	Small
Left shoulder	0.728	0.444	Small	Small
Right shoulder	0.712	0.521	Small	Small

4.8.1.3 Gender and injury

The *p*-value was used to determine the strength of the association between gender, in both point and lifetime prevalence for injury (Table 4.21). This shows a small effect size concerning both point and lifetime prevalence for injury. Gender does not seem to play a role in terms of the score obtained.

Table 4.21: The association between gender and injury

Variables	*P*- value			Strength	
	Previous Injury	Current Injury		Previous Injury	Current Injury
Left hand	1.000	1.000		Small	Small
Right hand	1.000	0.079		Small	Small
Left wrist	1.000	1.000		Small	Small
Right wrist	0.362	1.000		Small	Small
Left forearm	-	-		-	-
Right forearm	1.000	1.000		Small	Small
Left elbow	1.000	1.000		Small	Small
Right elbow	1.000	1.000		Small	Small
Left shoulder	0.102	0.079		Small	Small
Right shoulder	1.000	0.063		Small	Small

The *p*-value was used to determine the strength of the association between gender, and point and lifetime prevalence for type of injury (Table 4.22). This shows a small effect size concerning both point and lifetime prevalence. Gender does not seem to play a role in terms of the score obtained.

Table 4.22: The association between gender and injury type

Injury Type	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Muscle strain	0.626	0.102	Small	Small
Tendon strain	1.000	1.000	Small	Small
Ligament sprain	-	1.000	-	Small
Muscle tear	1.000	-	Small	-
Nerve compression	1.000	0.362	Small	Small
Callouses	-	-	-	-
Other	1.000	1.000	Small	Small
I don’t know	0.690	0.317	Small	Small

4.8.1.4 Non work-related history and Injury of the upper limb

The *p*-value was used to determine the strength of the association between sports injury and point and lifetime prevalence for injury (Table 4.23). This shows a small effect size concerning both point and lifetime prevalence for injury. The right hand ($p = 0.009$), right shoulder ($p = 0.002$) and left wrist ($p = 0.047$) showed a significant association for lifetime prevalence for work related injury and an associated link of previous sports injury to this particular region. The left wrist ($p = 0.047$) showed a significant association for point prevalence for work related injury and an associated link to sports injury to this region. This may demonstrate that a previous sports injury may or may not be the cause of the work related injuries.

Table 4.23: The association between sports injury and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	0.219	0.071	Small	Small
Right hand	0.009	0.648	Large	Small
Left wrist	0.047	0.047	Medium	Medium
Right wrist	0.782	0.138	Small	Small
Left forearm	-	-	-	-
Right forearm	1.000	0.392	Small	Small
Left elbow	1.000	0.527	Small	Small
Right elbow	1.000	1.000	Small	Small
Left shoulder	0.374	0.648	Small	Small
Right shoulder	0.002	0.191	Large	Small

The *p*-value was used to determine the strength of the association between motor vehicle accidents (MVA), point and lifetime prevalence for injury (Table 4.24). This shows a small effect size concerning both point and lifetime prevalence for work related injuries. The right shoulder ($p = 0.046$) showed a significant association for lifetime prevalence for work related injury and an associated link to MVA to this region. This may demonstrate that a MVA injury may or may not be the cause of the work related injuries.

Table 4.24: The association between MVA and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	1.000	1.000	Small	Small
Right hand	0.403	1.000	Small	Small
Left wrist	1.000	1.000	Small	Small
Right wrist	0.522	1.000	Small	Small
Left forearm	-	-	-	-
Right forearm	1.000	1.000	Small	Small
Left elbow	1.000	1.000	Small	Small
Right elbow	1.000	1.000	Small	Small
Left shoulder	1.000	1.000	Small	Small
Right shoulder	0.046	1.000	Medium	Small

The *p*-value was used to determine the strength of the association between surgery, point and lifetime prevalence for injury (Table 4.25). This shows a small effect size concerning both point and lifetime prevalence for work related injuries. Surgery does not seem to play a role in terms of the score obtained.

Table 4.25: The association between surgery and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	1.000	0.236	Small	Small
Right hand	0.174	1.000	Small	Small
Left wrist	0.101	0.101	Small	Small
Right wrist	1.000	0.119	Small	Small
Left forearm	-	-	-	-
Right forearm	1.000	0.101	Small	Small
Left elbow	1.000	1.000	Small	Small
Right elbow	1.000	1.000	Small	Small
Left shoulder	0.056	1.000	Small	Small
Right shoulder	1.000	1.000	Small	Small

The *p*-value was used to determine the strength of the association between other medical related history, point and lifetime prevalence for injury (Table 4.26). This shows a small effect size concerning both point and lifetime prevalence for work related injuries. The right shoulder ($p = 0.012$) showed a significant association for lifetime prevalence for work related injury and an associated link to medical relations to this region. This may demonstrate that medical relations may or may not be the cause of the work related injuries.

Table 4.26: The association between other medical related and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	1.000	0.181	Small	Small
Right hand	0.463	1.000	Small	Small
Left wrist	1.000	1.000	Small	Small
Right wrist	1.000	1.000	Small	Small
Left forearm	-	-	-	-
Right forearm	1.000	1.000	Small	Small
Left elbow	1.000	1.000	Small	Small
Right elbow	1.000	1.000	Small	Small
Left shoulder	1.000	1.000	Small	Small
Right shoulder	0.012	0.439	Large	Small

The *p*-value was used to determine the strength of the association between no history, point and lifetime prevalence for injury (Table 4.27). This shows a small effect size concerning both point and lifetime prevalence for work related injuries. The right shoulder ($p = 0.008$) showed a significant association for lifetime prevalence for work related injury and an associated link to no history of previous injury to this region. This may demonstrate that no history of previous injuries may be the cause of the work related injuries.

Table 4.27: The association between no history and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	0.245	0.095	Small	Small
Right hand	0.202	1.000	Small	Small
Left wrist	0.059	0.059	Small	Small
Right wrist	1.000	0.169	Small	Small
Left forearm	-	-	-	-
Right forearm	1.000	0.431	Small	Small
Left elbow	1.000	0.573	Small	Small
Right elbow	1.000	1.000	Small	Small
Left shoulder	0.102	0.680	Small	Small
Right shoulder	0.008	0.333	Large	Small

4.8.1.5 Work experience and injury

The *p*-value was used to determine the strength of the association between years worked as a computer programmer, point and lifetime prevalence for injury (Table 4.28). This shows a small effect size concerning both point and lifetime prevalence for work related injuries. The right shoulder (*p* = 0.000) and right elbow (*p* = 0.001) showed a significant association for lifetime prevalence of increased work experience and work related injuries.

Table 4.28: The association between work experience and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	0.788	0.599	Small	Small
Right hand	0.055	0.325	Small	Small
Left wrist	0.798	1.000	Small	Small
Right wrist	0.050	0.251	Medium	Small
Left forearm	-	-	-	-
Right forearm	0.701	0.266	Small	Small
Left elbow	0.458	1.000	Small	Small
Right elbow	0.001	0.850	Large	Small
Left shoulder	0.080	0.292	Small	Small
Right shoulder	0.000	0.251	Large	Small

The *p*-value was used to determine the strength of the association between years worked as a computer programmer and severity of lifetime prevalence for injury (Table 4.29). There was a significant association concerning lifetime prevalence for work related injury (*p* = 0.021) however, not in point prevalence (*p* = 0.266).

Table 4.29: The association between work experience and severity of pain (lifetime prevalence)

Severity of previous injury		How many years have you worked as a computer programmer?				
	Frequency	1	2 - 5	6 - 10	11 - 20	> 20
Mild	n =	1	7	8	9	6
	Percentage	12,5	16,7	13,1	26,5	60,0
Moderate	n =	7	33	52	24	3
	Percentage	87,5	78,6	85,2	70,6	30,0
Severe	n =	0	2	1	1	1
	Percentage	0,0	4,8	1,6	2,9	10,0

The *p*-value was used to determine the strength of the association between years worked as a computer programmer and duration of lifetime prevalence for injury (Table 4.30). There was no significant association concerning both lifetime (*p* = 0.147) and point prevalence for work related injuries (*p* = 0.330).

Table 4.30: The association between work experience and duration (lifetime prevalence)

Duration of previous Injury		How many years have you worked as a computer programmer?				
	Frequency	1	2 - 5	6 - 10	11 - 20	> 20
0 - 6	n =	1	7	6	3	3
	Percentage	12,5	16,7	9,8	8,8	30,0
7 - 12	n =	4	28	50	26	5
	Percentage	50,0	66,7	82,0	76,5	50,0
> 12	n =	3	7	5	5	2
	Percentage	37,5	16,7	8,2	14,7	20,0

4.8.1.6 Work hours and injury

The *p*-value was used to determine the strength of the association between hours worked per week, point and lifetime prevalence for injury (Table 4.31). This shows a small effect size concerning both point and lifetime prevalence for work related injuries. The right shoulder ($p = 0.036$) showed a significant association for lifetime prevalence for work related injury and this was supported by a medium effect size on Pearson's chi-squared test.

Table 4.31: The association between hours worked per week and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	0.432	0.166	Small	Small
Right hand	0.790	1.000	Small	Small
Left wrist	1.000	0.185	Small	Small
Right wrist	0.236	0.365	Small	Small
Left forearm	-	-	-	-
Right forearm	1.000	0.185	Small	Small
Left elbow	0.432	0.579	Small	Small
Right elbow	0.579	0.653	Small	Small
Left shoulder	0.293	0.466	Small	Small
Right shoulder	0.036	0.778	Medium	Small

Table 4.32 predicts the number injuries in the upper extremity in relation to the hours worked per week in lifetime prevalence for injury. The two most affected regions were the right shoulder and right wrist. The number of work related injuries were greater in participants that worked > 40 hours or more.

Table 4.32: The association between present hours worked and lifetime prevalence of work related injury

Previous work related Injury		At present, how many hours do you work per week?	
	Frequency	35 - 40	> 40
Left Elbow	n =	0	1
	Percentage	0,0	1,5
Right Elbow	n =	1	2
	Percentage	1,1	3,0
Left Shoulder	n =	3	5
	Percentage	3,4	7,5
Right Shoulder	n =	11	18
	Percentage	12,5	26,9
Left Hand	n =	0	1
	Percentage	0,0	1,5
Right Hand	n =	8	7
	Percentage	9,1	10,4
Left Wrist	n =	1	1
	Percentage	1,1	1,5
Right Wrist	n =	9	12
	Percentage	10,2	17,9
Left Forearm	n =	0	0
	Percentage	0,0	0,0
Right Forearm	n =	1	1
	Percentage	1,1	1,5

Table 4.33 predicts the number of injuries in the upper extremity in relation to the hours worked per week in point prevalence for injury. The two most affected regions were the right shoulder and right wrist. The number of work related injuries were greater in participants that worked > 40 hours or more.

Table 4.33: The association between present hours worked and point prevalence of work related injury

Current work related injury		At present, how many hours do you work per week?	
	Frequency	35 - 40	> 40
Left Hand	n =	1	4
	Percentage	1,1	6,0
Right Hand	n =	4	3
	Percentage	4,5	4,5
Left Wrist	n =	0	2
	Percentage	0,0	3,0
Right Wrist	n =	5	7
	Percentage	5,7	10,4
Left Forearm	n =	0	0
	Percentage	0,0	0,0
Right Forearm	n =	0	2
	Percentage	0,0	3,0
Left Elbow	n =	1	2
	Percentage	1,1	3,0
Right Elbow	n =	2	3
	Percentage	2,3	4,5
Left Shoulder	n =	3	4
	Percentage	3,4	6,0
Right Shoulder	n =	7	7
	Percentage	8,0	10,4

The *p*-value was used to determine the strength of the association between hours worked per week and severity of point and lifetime prevalence for injury (Table 4.34 and Table 4.35). There was no significant association concerning both lifetime (p = 0.114) and point prevalence for work related injuries (p = 0.185).

Table 4.34: The association between present hours worked and severity of pain (lifetime prevalence) (n = 64)

Severity of pain for previous injuries		At present, how many hours do you work per week?		Total
	Frequency	35 - 40	> 40	
Mild	n =	15	16	31
	Percentage	23,4	25,0	48,4
Moderate	n =	11	17	28
	Percentage	17,2	26,6	43,8
Severe	n =	1	4	5
	Percentage	1,6	6,2	7,8

Table 4.35: The association between present hours worked and severity of pain (point prevalence) (n = 34)

Severity of pain for current Injuries		At present, how many hours do you work per week?		Total
	Frequency	35 - 40	> 40	
Mild	n =	14	9	23
	Percentage	73,7	60,0	67,6
Moderate	n =	5	3	8
	Percentage	26,3	20,0	23,5
Severe	n =	0	3	3
	Percentage	0,0	20,0	8,8

The *p*-value was used to determine the strength of the association between hours worked per week and duration of point and lifetime prevalence for injury (Table 4.36 and Table 4.37). There was no significant association concerning point prevalence of work related injuries ($p = 0.584$). However, there was a significance in lifetime prevalence for work related injuries ($p = 0.012$).

Table 4.36: The association between present hours worked and duration of injury (lifetime prevalence) (n = 64)

Duration of previous injuries		At present, how many hours do you work per week?		Total
	Frequency	35 - 40	> 40	
0 – 6 weeks	n =	12	8	20
	Percentage	18,8	12,4	31,2
7 – 12 weeks	n =	10	12	22
	Percentage	15,6	18,8	34,4
> 12 weeks	n =	6	16	22
	Percentage	9,4	25	34,4

Table 4.37: The association between present hours worked and duration of injury (point prevalence) (n = 34)

Duration of current injuries		At present, how many hours do you work per week?		Total
	Frequency	35 - 40	> 40	
0 – 6 weeks	n =	7	7	14
	Percentage	36,8	46,7	41,2
7 – 12 weeks	n =	4	1	5
	Percentage	21,1	6,7	14,7
> 12 weeks	n =	8	7	15
	Percentage	42,1	46,7	44,1

The *p*-value was used to determine the strength of the association between hours worked on the computer per week, point and lifetime prevalence of injury (Table 4.38). This shows a small effect size concerning both point and lifetime prevalence for injury. The right shoulder (*p* = 0.004) and the right wrist (*p* = 0.001) showed a significant association for lifetime prevalence and in the right wrist (*p* = 0.020) in point prevalence or work related injury. There was a significant association between duration and lifetime prevalence of injury (*p* = 0.001) with hours worked on the computer per week however, not in point prevalence of injury (p = 0.237). There was no strong association with severity and hours worked on the computer per week in lifetime (*p* = 0.175) and point prevalence for work related injuries (*p* = 0.307).

Table 4.38: The association between hours worked on the computer per week and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	0.098	0.098	Small	Small
Right hand	0.107	0.256	Small	Small
Left wrist	0.267	0.228	Small	Small
Right wrist	0.001	0.020	Large	Large
Left forearm	-	-	-	-
Right forearm	1.000	0.228	Small	Small
Left elbow	0.228	0.406	Small	Small
Right elbow	0.089	0.529	Small	Small
Left shoulder	0.208	0.809	Small	Small
Right shoulder	0.004	0.818	Large	Small

The *p*-value was used to determine the strength of the association between hours worked on the computer outside of work, point and lifetime prevalence for injury (Table 4.39). This shows a small effect size concerning both point and lifetime prevalence for injury. The left hand (*p* = 0.025) and right wrist (*p* = 0.027) showed a significant association for point prevalence of work related injuries and the right wrist (*p* = 0.020) and the right shoulder (*p* = 0.013) showed significant associations for lifetime prevalence of work related injuries.

Table 4.39: The association between hours worked outside of work on the computer and injury (point and lifetime prevalence)

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	0.490	0.025	Small	Large
Right hand	0.769	0.083	Small	Small
Left wrist	0.056	0.056	Small	Small
Right wrist	0.020	0.027	Large	Large
Left forearm	-	-	-	-
Right forearm	0.484	0.056	Small	Small
Left elbow	0.490	0.115	Small	Small
Right elbow	0.803	0.716	Small	Small
Left shoulder	0.348	0.121	Small	Small
Right shoulder	0.013	0.500	Large	Small

4.8.1.7 Overtime and injury

The *p*-value was used to determine the strength of the association between overtime, point and lifetime prevalence for injury (Table 4.40). This shows a small effect size concerning both point and lifetime prevalence for injury. The left hand ($p = 0.024$) showed a significant association for point prevalence of work related injuries and the right shoulder ($p = 0.004$) showed a significant association for lifetime prevalence of work related injuries.

Table 4.40: The association between overtime and injury (point and lifetime prevalence)

Variables		*P*- value		Strength	
		Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand		1.000	0.024	Small	Large
Right hand		1.000	0.076	Small	Small
Left wrist		0.152	0.152	Small	Small
Right wrist		0.634	0.312	Small	Small
Left forearm		-	-	-	-
Right forearm		1.000	1.000	Small	Small
Left elbow		1.000	0.250	Small	Small
Right elbow		0.550	0.316	Small	Small
Left shoulder		0.788	0.226	Small	Small
Right shoulder		0.004	0.374	Large	Small

Table 4.41 predicts the number of injuries in the upper extremity in relation to the hours worked overtime per week in lifetime prevalence for injury. The three most affected regions were the right shoulder, right wrist and right hand. There were 16 injuries in the right

shoulder for overtime worked 0 to 5 hours per week, 11 injuries for 6 to 10 hours and 2 injuries > 10 hours of overtime worked per week.

Table 4.41: The association between overtime and lifetime prevalence of injury

Previous Injuries		At present, how many hours overtime do you work on the computer per week?		
	Frequency	0 - 5	6 - 10	> 10
Left Hand	n =	1	0	0
	Percentage	0,8	0,0	0,0
Right Hand	n =	12	2	1
	Percentage	10,1	7,7	10,0
Left Wrist	n =	1	0	1
	Percentage	0,8	0,0	10,0
Right Wrist	n =	15	5	1
	Percentage	12,6	19,2	10,0
Left Forearm	n =	0	0	0
	Percentage	0,0	0,0	0,0
Right Forearm	n =	2	0	0
	Percentage	1,7	0,0	0,0
Left Elbow	n =	1	0	0
	Percentage	0,8	0,0	0,0
Right Elbow	n =	2	1	0
	Percentage	1,7	3,8	0,0
Left Shoulder	n =	6	2	0
	Percentage	5,0	7,7	0,0
Right Shoulder	n =	16	11	2
	Percentage	13,4	42,3	20,0

Table 4.42 predicts the number injuries in the upper extremity in relation to the hours worked overtime per week in point prevalence for injury. The three most affected regions were the right hand, right wrist and right shoulder. There were 15 injuries in the right hand for overtime worked 0 to 5 hours per week, 5 injuries for 6 to 10 hours and 1 injury > 10 hours of overtime worked per week.

Table 4.42: The association between overtime and point prevalence of injury

Current Injuries		At present, how many hours overtime do you work on the computer per week?		
	Frequency	0 - 5	6 - 10	> 10
Left Hand	n =	1	0	0
	Percentage	0,8	0,0	0,0
Right Hand	n =	12	2	1
	Percentage	10,1	7,7	10,0
Left Wrist	n =	1	0	1
	Percentage	0,8	0,0	10,0
Right Wrist	n =	15	5	1
	Percentage	12,6	19,2	10,0
Left Forearm	n =	2	0	0
	Percentage	0,0	0,0	0,0
Right Forearm	n =	2	0	0
	Percentage	1,7	0,0	0,0
Left Elbow	n =	2	0	1
	Percentage	1,7	0,0	10,0
Right Elbow	n =	4	0	1
	Percentage	3,4	0,0	10,0
Left Shoulder	n =	4	2	1
	Percentage	3,4	7,7	10,0
Right Shoulder	n =	10	2	2
	Percentage	8,4	7,7	20,0

The *p*-value was used to determine the strength of the association between overtime and severity of point and lifetime prevalence for injury (Table 4.43 and Table 4.44). There was no significant association concerning point prevalence of injury ($p = 0.091$) however, there was a significance for lifetime prevalence of injury ($p = 0.018$). There was also no significance in association between overtime and duration of lifetime ($p = 0.100$) and point prevalence for work related injuries ($p = 0.908$).

Table 4.43: The association between overtime and severity of pain (lifetime prevalence) (n = 64)

Severity of previous injuries		At present, how many hours overtime do you work on the computer per week?			Total
	Frequency	0 - 5	6 - 10	> 10	
Mild	n =	23	9	0	32
	Percentage	35,6	14,1	0,0	49,7
Moderate	n =	17	9	2	28
	Percentage	26,6	14,1	3,2	43,9
Severe	n =	2	0	2	4
	Percentage	3,2	0,0	3,2	6,4

Table 4.44: The association between overtime and severity of pain (point prevalence) (n = 34)

Severity of current injuries		At present, how many hours overtime do you work on the computer per week?			Total
	Frequency	0 - 5	6 - 10	> 10	
Mild	n =	18	2	3	23
	Percentage	72,0	50,0	60,0	67,6
Moderate	n =	6	2	0	8
	Percentage	24,0	50,0	0,0	23,5
Severe	n =	1	0	2	3
	Percentage	4,0	0,0	40,0	8,8

4.8.1.8 Point and lifetime prevalence of work-related upper limb injuries

The *p*-value was used to determine the strength of the association between point and lifetime prevalence for injury (Table 4.45). There was a significant association between of the right hand (p = 0.002), left wrist (p = 0.026), right wrist (p = 0.000), left elbow (p = 0.019), left elbow and left wrist (p = 0.038), right elbow and left elbow (p = 0.032), right elbow (p = 0.002), left shoulder and left elbow (p = 0.045) and left shoulder (p = 0.043). (Please note only the most or close to significant results are listed in the table below).

Table 4.45: The association between point and lifetime prevalence injuries

Variables		*P*- value	Strength
Previous Injury	Current Injury		
Left hand	Left wrist	0.064	Small
Right hand	Right hand	0.002	Large
Right hand	Left wrist	0.089	Small
Left wrist	Left wrist	0.026	Large
Right wrist	Right wrist	0.000	Large
Left elbow	Left elbow	0.019	Large
Left elbow	Right elbow	0.057	Small
Left elbow	Left wrist	0.038	Large
Right elbow	Left elbow	0.032	Large
Right elbow	Right elbow	0.002	Large
Right elbow	Left wrist	0.064	Small
Left shoulder	Left elbow	0.045	Medium
Left shoulder	Left shoulder	0.043	Medium
Left shoulder	Left wrist	0.089	Small
Right shoulder	Left elbow	0.090	Small

The *p*-value was used to determine the strength of the association between severity and injury type (Table 4.26). This shows a small effect size concerning both point and lifetime prevalence of injury. Nerve compression showed a significant association for lifetime prevalence of work related injury with severity.

Table 4.46: The association between severity and injury type (point and lifetime prevalence)

Injury Type	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Muscle strain	0.149	1.000	Small	Small
Tendon strain	0.055	0.239	Small	Small
Ligament sprain	-	1.000	-	Small
Muscle tear	0.232	-	Small	-
Nerve compression	0.001	0.615	Large	Small
Callouses	-	-	-	-
Other	0.072	0.221	Small	Small
I don't know	0.000	0.556	Large	Small

The *p*-value was used to determine the strength of the association between frequency and injury type (Table 4.47). Muscle strain (p = 0.002), nerve compression (p = 0.026) and other (p = 0.008) showed significant association for lifetime prevalence of work related injuries. Tendon strain (p = 0.002) showed significant association for point prevalence of work related injuries. Individuals specified 'other' as carpal tunnel syndrome, ganglion, knots and muscle cramping.

Table 4.47: The association between duration and injury type (point and lifetime prevalence)

Injury Type	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Muscle strain	0.002	0.367	Large	Small
Tendon strain	0.849	0.002	Small	Large
Ligament sprain	-	1.000	-	Small
Muscle tear	0.271	-	Small	-
Nerve compression	0.026	0.846	Large	Small
Callouses	-	-	-	-
Other	0.008	1.000	Large	Small
I don't know	0.000	0.900	Large	Small

4.8.1.9 Workstation and injury

The *p*-value was used to determine the strength of the association between change in work station and point prevalence for injury (Table 4.48). Left hand (p = 0.034), right wrist (p = 0.031), right elbow (p = 0.034) and right shoulder (p = 0.048) showed significant associations when the monitor was changed. Right hand (p = 0.018) showed significant association when the chair was changed. The right hand (*p* = 0.020) and left wrist (*p* = 0.009) showed significant association when the keyboard was changed. The right hand (*p* = 0.008) showed significant association when the mouse changed. The change in work station shows a large effect size concerning current injuries and seems to play a role in terms of the score obtained. (Please note only the most or close to significant results are listed in the table below).

Table 4.48: The association between change in work station and point prevalence

Variables		*P*- value	Strength
Current Injury	Equipment change		
Left hand	Keyboard	0.074	Small
Left hand	Monitor	0.034	Large
Right hand	Chair	0.018	Large
Right hand	Desk	0.066	Small
Right hand	Keyboard	0.020	Large
Right hand	Monitor	0.066	Small
Right hand	Mouse	0.008	Large
Left wrist	Keyboard	0.009	Large
Right wrist	Keyboard	0.095	Small
Right wrist	Monitor	0.031	Large
Right wrist	Mouse	0.380	Small
Right elbow	Monitor	0.034	Large
Left shoulder	Haven’t changed anything	0.075	Small
Right shoulder	Monitor	0.048	Medium

The *p*-value was used to determine the strength of the association between change in workstation and injury type (Table 4.49). This shows a large effect size concerning lifetime prevalence for injury in chair, desk, keyboard, monitor and mouse, and in point prevalence for injury in chair, keyboard, mouse and monitor. Change in workstation does seem to play a role in type of injury in terms of the score obtained below. (Please note only the most or close to significant results are listed in the table below.)

Table 4.49: The association between change in work station and injury type (point and lifetime prevalence)

Variables		*P*-value		Strength	
Injury Type	Equipment Change	Previous Injury	Current Injury	Previous Injury	Current Injury
Muscle Strain	Chair	0.006	0.629	Large	Small
Muscle Strain	Desk	0.003	1.000	Large	Small
Muscle Strain	Did not change anything	0.013	0.359	Large	Small
Tendon Strain	Chair	0.009	1.000	Large	Small
Tendon Strain	Desk	0.013	1.000	Large	Small
Tendon Strain	Stand/Walk	0.013	1.000	Large	Small
Nerve Compression	Chair	0.000	0.009	Large	Large
Nerve Compression	Desk	0.007	0.334	Large	Small
Nerve Compression	Keyboard	0.000	0.012	Large	Large
Nerve Compression	Monitor	0.007	0.049	Large	Large
Nerve Compression	Mouse	0.000	0.004	Large	Large
Nerve Compression	Stand/Walk	0.048	1.000	Large	Small
Other	Keyboard	0.012	1.000	Large	Small
Other	Mouse	0.038	0.265	Large	Small

4.8.1.10 Pain, work interference and point prevalence

The *p*-value was used to determine the strength of the association between the point prevalence of pain while working ($p = 0.000$) (Table 4.50). It was significantly aggravated during work.

Table 4.50: The association between pain/discomfort/injury while working (n = 34)

While working is the pain/discomfort/injury		
Variables	Frequency	Percent
Relieved	1	0,6
No effect on pain	5	3,2
Aggravated	28	18,1
Total	34	21,9

The *p*-value was used to determine the strength of the association between the point prevalence of pain after working ($p = 0.124$) (Table 4.51). There was no significance.

Table 4.51: The association between pain/discomfort/injury after working (n = 34)

After your shift, is the pain or discomfort		
Variables	Frequency	Percent
Relieved	11	7,1
No effect on pain	12	7,7
Aggravated	8	5,2
Not Applicable	3	1,9
Total	34	21,9

The *p*-value was used to determine the strength of the association between the point prevalence of pain after a week away from work ($p = 0.000$) (Table 4.52). It was significantly relieved.

Table 4.52: The association between pain/discomfort/injury a week away from work (n = 34)

After a week away from work, is the pain or discomfort		
Variables	Frequency	Percent
Relieved	27	17,4
No effect on pain	4	2,6
Not Applicable	3	1,9
Total	34	21,9

The *p*-value was used to determine the strength of the association between the point prevalence of pain and sick leave ($p = 0.000$) (Table 4.53).

Table 4.53: The association between pain/discomfort/injury and sick leave (n = 34)

Has the pain or discomfort caused you to take time off work in the past year?		
Variables	Frequency	Percent
Yes	5	3,2
No	23	14,8
Not Applicable	6	3,9
Total	34	21,9

The *p*-value was used to determine the strength of the association between the point prevalence of pain and interference with work ($p = 0.000$) (Table 4.54). It was a significant interference with work.

Table 4.54: The association between pain/discomfort/injury and interference with work (n = 34)

How much does it interfere with your work?		
Variables	Frequency	Percent
No Interference	5	3,2
Some Interference	26	16,8
Took time off work due to pain injury	3	1,9
Total	34	21,9

The *p*-value was used to determine the strength of the association between the point prevalence of pain and interference outside of work (p = 0.000) (Table 4.55). It was a significant interference outside of work.

Table 4.55: The association between pain/discomfort/injury and interference outside of work (n = 34)

How much does it interfere with your life outside of work?		
Variables	Frequency	Percent
No Interference	11	7,1
Some Interference	21	13,5
Had to stop enjoying activity due to pain	2	1,3
Total	34	21,9

4.8.1.11 Treatment and injury

The *p*-value was used to determine the strength of the association between choice in treatment and injury type (Table 4.56). This shows a large effect size concerning lifetime prevalence in medication/injections, physiotherapy, brace/strapping, home remedies, chiropractic and massage, and in point prevalence in home remedies, chiropractic, medication/injections, brace/strapping and massage. Choice in treatment does seem to play a role in type of injury in terms of the score obtained below. (Please note only the most or close to significant results are listed in the table below.)

Table 4.56: The association between injury type and choice of treatment (point and lifetime prevalence of injury)

Variables		*P-value*		*Strength*	
Injury Type	Treatment	Previous Injury	Current Injury	Previous Injury	Current Injury
Muscle Strain	Meds/Injections	0.000	0.085	Large	Small
Muscle Strain	Physiotherapy	0.002	1.000	Large	Small
Muscle Strain	Chiropractic	0.059	0.276	Small	Small
Muscle Strain	Home remedies	0.073	0.002	Small	Large
Tendon Strain	Meds/Injections	0.009	0.182	Large	Small
Tendon Strain	Brace/Strap	0.000	1.000	Large	Small
Tendon Strain	Physiotherapy	0.003	1.000	Large	Small
Tendon Strain	Home remedies	0.036	0.038	Large	Large
Tendon Strain	Massage	0.003	1.000	Large	Small
Nerve Compression	Meds/Injections	0.000	0.000	Large	Large
Nerve Compression	Brace/Strap	0.000	1.000	Large	Small
Nerve Compression	Physiotherapy	0.019	0.112	Large	Small
Nerve Compression	Chiropractic	0.000	0.018	Large	Large
Nerve Compression	Home remedies	0.000	1.000	Large	Small
Nerve Compression	Massage	0.022	0.112	Large	Small
Other	Brace/Strap	0.059	0.026	Small	Large
Other	Massage	0.112	0.038	Small	Large
Other	Home remedies	0.010	1.000	Large	Small

4.8.1.12 Neck pain, point and lifetime prevalence

The *p*-value was used to determine the strength of the association between neck pain, point and lifetime prevalence for injury. The right elbow ($p = 0.002$), left shoulder ($p = 0.000$) and right shoulder ($p = 0.000$) showed a significant association for lifetime prevalence of work related injury. The left shoulder ($p = 0.002$ and right shoulder ($p = 0.001$) showed significant association for point prevalence of work related injury. Neck pain shows a large effect size concerning shoulder injuries and seems to play a role in terms of the score obtained.

Table 4.57: The association between neck and point and lifetime prevalence of injury

Variables	*P*- value		Strength	
	Previous Injury	Current Injury	Previous Injury	Current Injury
Left hand	0.405	0.405	Small	Small
Right hand	0.132	0.700	Small	Small
Left wrist	0.691	1.000	Small	Small
Right wrist	0.182	0.074	Small	Small
Left forearm	-	-	-	-
Right forearm	0.649	0.512	Small	Small
Left elbow	0.169	0.068	Small	Small
Right elbow	0.002	0.160	Large	Small
Left shoulder	0.000	0.002	Large	Large
Right shoulder	0.000	0.001	Large	Large

4.8.1.13 DASH and injury

A Partial Eta score was used to determine the strength of the association between DASH, severity and duration of point prevalence for injury (Table 4.58). A medium effect size is noted for the severity of point prevalence for injury (η_p^2 = 0.099) and a much larger size effect for duration of injuries (η_p^2 = 0.395). The results of the association are portrayed in Table 4.58.

Table 4.58: The association between DASH, severity and duration of point prevalence for injury

Variables	Partial Eta score	Strength
Severity	0.099	Medium
Duration	0.395	Large

4.8.1.14 Linear regression model

The R^2 values tell us approximately how much variation in the outcome is explained by the model. The Nagelkerke R Square suggests that the model explains roughly 21.9% of the variation in the outcome. This demonstrates that the models used (Pearson's chi-squared and Eta-square score) was reliable in the outcome of the study.

Table 4.59: Model summary

Model Summary			
	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
	139.282[a]	0,142	0,219

Table 4.60 demonstrates the overall percentage that this approach to prediction is correct 79.4% of the time. This percentage obtained is therefore a reliable model to use.

Table 4.60: Classification table

Classification Table				
Observed		Predicted		
		Are you presently suffering from pain/discomfort/injury you think is caused by your programming work?		Percentage Correct
		Yes	No	
Are you presently suffering from pain/discomfort/injury you think is caused by your programming work?	Yes	4	30	11,8
	No	2	119	98,3
Overall Percentage				79,4

Table 4.61 is based on the linear regression model. There was a directly proportional association between hours worked on the computer per week and work related injury. Computer programmers who worked > 40 hours per week were prone to injury 16.769 (O.R.) times more often than a programmer who worked 20 to 30 hours per week ($p = 0.037$) and 3.563 (O.R.) times more often than a programmer who worked 31 to 34 hours per week ($p = 0.013$).

Table 4.61: The association between different dependent variables vs work related injury

Variables	*P*-value	Odds Ratio
Age vs work-related injury	0,281	1,071
Race (Black) vs work related injury	0,423	
Race (Other) vs work related injury	0,999	0,000
Race (White) vs work related injury	1,000	2,319
Race (Indian) vs work related injury	0,999	0,000
Race (Coloured) vs work related injury	0,999	0,000
Gender (Female compared to Male) vs work related injury	0,078	0,240
At present, how many hours do you work on the computer per week?	0,019	
At present, how many hours do you work on the computer per week? (> 40 hours per week) vs work related injury	0,037	16,769
At present, how many hours do you work on the computer per week? (35-40 hours per week) vs work related injury	0,013	3,563
How many years have you worked as a computer programmer? (1 year)	0,423	
How many years have you worked as a computer programmer? (more than 20 years) vs work related injury	0,589	2,829
How many years have you worked as a computer programmer? (11-20 years) vs work related injury	0,856	1,334
How many years have you worked as a computer programmer? (6-10 years) vs work related injury	0,975	1,045
How many years have you worked as a computer programmer? (2-5 years) vs work related injury	0,408	0,359

CHAPTER 5: DISCUSSION

In this chapter the results of the study as well as the statistical analysis presented in Chapter 4 are discussed.

5.1 First objective

The first objective was to determine the point and lifetime prevalence of upper extremity musculoskeletal disorders of computer programmers in a selected software company in the eThekwini Municipality.

5.1.1 Point and lifetime prevalence

Point prevalence refers to injuries that participants reported to be suffering from at the time of data collection. Lifetime prevalence refers to injuries that participants reported to have suffered prior to the time of data collection. Participants were asked to list all previous occupational work-related injuries but were asked more specific questions on their worst previous injury. The study participants were allowed to list more than one current injury and were asked specific questions relating to such injuries. The point prevalence of current injury at the time of data collection was 21.9% (n = 34) (Table 4.9), and the lifetime prevalence of previous injury was 41.3% (n = 64) (Table 4.5). A total of 57 current injuries were reported by the participants, indicating that each participant was currently suffering from 1.68 injuries on average. A total of 151 previous injuries were reported by the participants, indicating that each participant has suffered 2.34 previous injuries on average. Regardless of the point prevalence being lower than the lifetime prevalence, there were still a fair amount of injuries reported.

This finding contrasts with other studies (Blatter and Van den Heuvel et al. 2005a; Huisstede et al. 2006; Bongers et al. 2006; van Tulder et al. 2007), which concluded that occupational computer use is relatively medium risk for injury formation. When comparing the results of this study with other international studies, the point prevalence is lower while the lifetime prevalence was similar. Huisstede et al. (2006) reported the point prevalence ranged from 2% to 53% and the 12-month prevalence from 2% to 41%. In the working population reported by van Tulder et al. (2007), the 12-month prevalence was higher with percentages ranging from 22% to 40%. Twenty eight percent of the general Dutch working population suffered from UEMSDs in the previous 12 months (Blatter and Van den Heuvel et al. 2005b), whereas European data showed a prevalence of 25% for work-related neck or shoulder pain and a prevalence of 15% for work-related arm pain by Blatter, Van den Heuvel S. G., Boshuizen, et al. (2005) and Bongers et al. (2006). This is also interesting as the above studies looked at working populations and occupational computer use and did not focus on computer programmers as an entity alone. Not enough research has been published in South African literature on the point and lifetime prevalence of UEMSDs to be able to compare results. In a study by Jensen and Finsen et al. (2002), programmers comprised 3% of the sample, and in a study by Karlqvist et al. (2002), 9.7% of the sample were programmers. Shuval et al.'s (2005) study comprised 61.1% of computer programmers or in a related field. Neither study focused on specific risk factors and prevalence rates of UEMSDs among computer programmers.

5.2 Second objective

The second objective of this study was to describe the injury profile of computer programmers in the selected software company, and to compare this profile with other international studies. The factors relating directly to the injury included the current and past injury/injuries location/s, duration, severity, nature of onset, degree of disability and received treatment.

5.2.1 Injury location, duration and severity

For lifetime prevalence, the most common area of injury was the right shoulder (n = 40, 25.8%), followed by the right wrist (n = 37, 23.9%) and the third most common injury was the right hand (n = 27, 17.4%). The lifetime prevalence for the worst work-related upper limb injury was most commonly the right shoulder (n = 29, 18.7%), followed by the right wrist (n = 21, 13.5%) and the third worst was the right hand (n = 15, 9.7%). Interestingly, the three worst work-related upper limb injuries of the affected sample population occurred in their dominant arm.

For point prevalence, the most common sites of injury were the right shoulder (n = 14, 9%), followed by the right wrist (n = 12, 7.7%) and the right hand (n = 7, 4.5%) and left shoulder (n = 7, 4.5%). It is also noted that injuries were more common in the dominant arm. The *p*-value was used to determine the strength of the association between point and lifetime prevalence. There was a significant association of the right hand ($p = 0.002$), left wrist ($p = 0.026$), right wrist ($p = 0.000$), left elbow ($p = 0.019$), left elbow and left wrist ($p = 0.038$), right elbow and left elbow ($p = 0.032$), right elbow ($p = 0.002$), left shoulder and left elbow (*p* = 0.045) and left shoulder (*p* = 0.043).

Neck pain associated with their work-related upper limb injury/injuries was experienced by 41.3% of the sample population which may be associated to the high prevalence of shoulder injuries in this study. There was a strong association between neck pain and the right elbow (*p* = 0.002), left shoulder (*p* = 0.000) and right shoulder (*p* = 0.000) in lifetime prevalence of injury, and the left shoulder (*p* = 0.002) and right shoulder (*p* = 0.001) in point prevalence of injury. Neck pain showed a large effect size concerning shoulder injuries and seems to play a role in terms of the score obtained.

In comparison with the results of this study, a similar prevalence was reported by Bernard et al. (1994) with 27% of their sample population having neck/shoulder symptoms, Yu and Wong (1996) with 22%, and Polanyi et al. (1997) with 16% to 31%. Higher prevalence was reported in studies by Juul-Kristensen et al. (2005), where the areas most affected were the neck/shoulder (39%) and elbow/hand (51%), and by Bamac et al. (2014) with 57% of participants reporting shoulder pain, 48% wrist pain and 28% elbow pain. In a study by Shuval et al. (2005), 47.6% of the sample population of computer users had pain or discomfort of the neck/shoulder region in the last year which had a higher prevalence compared to Blatter et al. (2002) of 10.3% and Jensen and Finsen et al. (2002) of 35%. A higher prevalence of neck/shoulder symptoms was found by Bergqvist et al. (1995) of 61.5% and Cook et al. (2000) of 59.9% among participating computer users. In terms of hand/wrist or finger symptoms, Shuval et al. (2005) reported a prevalence of 32.1%, which was a lower prevalence than this study, Bergqvist et al. (1995) reported 29.9%, Marcus et al (1996) reported 34.2%, Cook et al (2000) reported 36.8% and Jensen and Finsen et al (2002) reported 26%. A study by Kryger et al. (2003) found that the prevalence of reported symptom cases in participant computer users was 4.3% in the right forearm and 1% in the left forearm. Fifty-three percent of right forearm cases were also right elbow cases, and 58% were also right wrist/hand cases.

The severity of pain of previous injuries in this study was mild for almost half (n = 31) of the affected sample (n = 64), followed by moderate pain (n = 28) and severe pain (n = 5). The duration of pain was almost a third for each acute period of 0 to 6 weeks (n = 20), subacute period of 7 to 12 weeks (n = 22) and chronic period of 12 weeks or more (n = 22).

Point prevalence in this study, the severity of pain was mild for two-thirds (n = 23) of the affected sample population. Less than a quarter (n = 8) of the affected sample population had moderate pain and a few (n = 3) experienced severe pain. The duration of pain was mostly either an acute period of 0 to 6 weeks (n = 14, 41.2%) or a chronic period of 12 weeks or more (n = 15, 44.1%) of the affected sample population (n = 34). Only a small percentage of the affected sample had subacute pain (n = 5, 14.7%).

Lassen et al. (2005) found persistent pain in 68% of the elbow cases, 67% of the forearm cases, and 74% of the wrist-hand cases in participant computer users. Sixty one percent had severe pain in one region, 27% experienced pain in two regions and 12% had pain in three regions. Seventy percent of the sample had severe pain. A study by Kryger et al. (2003) reported that 97% of participants with moderate to severe right-side forearm complaints also reported that the pain was exacerbated during the last year, and 77% reported having had pain for more than 30 days. A study by Brandt et al. (2004) found that the prevalence of moderate-to-severe pain in the neck and right shoulder was 4.1% and 3.4%, and the one-year incidence for no or minor baseline symptoms was 1.5% and 1.9%. These findings indicate that computer mouse use is associated with an increased risk of moderate-to-severe pain in the neck and right shoulder, especially with prolonged mouse and keyboard use. In contrast to this study's findings, there was a mild to moderate pain with an even distribution of duration of pain unanimously in previous injury and mild injury in mostly acute or chronic current injuries of the affected sample.

5.2.2 Injury type

When considering the most severe injuries ever experienced, the most common diagnoses were nerve compression (n = 14, 9%) and muscle strain (n = 19, 12.3%). Nearly 20% of participants (n = 28) in this group were not sure what type of injury they had experienced. The most common type of current injury reported was muscle strain (n = 8, 5.2%), followed by nerve compression (n = 6, 3.9%). Over 10% of this group were not sure of the type of current injury they had.

There was a strong association between severity of pain and nerve compression in previous injuries ($p = 0.001$), and a strong association between duration of injury and muscle strain ($p = 0.002$), nerve compression ($p = 0.026$) and 'other' ($p = 0.008$). Tendon strain ($p = 0.002$) showed significant association for current work-related injuries. Individuals specified 'other' as being carpal tunnel syndrome, ganglion, knots and muscle cramping.

Sharan et al. (2011) found that 34% of participants experienced numbness and tingling in their fingers after working on the computer. Loss of strength in hands was reported by 33% of participants with a significant association with loss of productivity ($p = 0.001$).

5.2.3 Degree of disability

The participants reported significant aggravation of pain while working in current work-related injuries (n = 28, 82.4%), and a week away from work resulted in significant pain relief (n = 27, 79.4%). There was, as expected, a significant association of a participant experiencing pain while working (p = 0.000). There was, however, no significant association of a participant experiencing pain after working (p = 0.124) but, a significant association of a participant having relief of pain after a week away from work (p = 0.000).

The majority of the affected sample population presently suffering work-related upper limb injury/injuries had not taken any sick leave (n = 29, 85.3%). Although, only a small percentage of participants had taken sick leave (n = 5, 14.7%), where the number of days taken off varied between 2 days to 15 days, there was a significant association between pain of injury and sick leave taken (p = 0.000). More than 85% of the participants (n = 29) presently had significant interference with their work due to their work-related injuries (p = 0.000). Two-thirds (n = 23) of the affected sample population had significant interference outside of their work (p = 0.000) due to pain and a minority (n = 4) stopped any activities between 1 day to 50 days due to their current injuries.

A study by van den Heuvul (2007) reported that in most computer workers with neck/shoulder or hand/arm symptoms, productivity loss derived from a decreased performance at work and not from sickness absence. In 26% of symptom-related cases, productivity loss was involved. Productivity loss involved sickness absence in 11% of the arm/hand cases, 32% of the neck/shoulder cases and 43% of the cases reporting both. Sharan et al. (2011) reported that 63% of participants reported pain and discomfort during or shortly after work on the computer and 13% of participants indicated a loss of productivity due to the symptoms of pain and discomfort (p < 0.0001). Less than 1% of participants indicated sick leave was taken due to pain symptoms.

A study by Lassen et al. (2005) found that 9% of participants reported sick leave due to pain in the right elbow, forearm, hand, or wrist region. Jensen's (2003) study reflected the strong correlation of interference at work with hand/wrist/elbow pain (p < 0.0001 for women and p = 0.050 for men). These results are similar to those reported by Kamwendo et al. (1991) where neck and shoulder pain prevented daily activity at home and at leisure in 13% of subjects. This demonstrates along with this study that work-related injury not only causes severe pain and a longer duration of injury to the affected area of the participants but is an increased risk to work interference and productivity loss.

5.2.4 Injury treatment

Over a third (n = 24) of participants in the lifetime incidence group reported having received no treatment for their condition and for just over a quarter (n = 17) treatment included medication and/or injections.

When considering the two most severe point prevalence injury in this study, the results of the participants' chosen form of treatment did not differ from the above, with 41.2% (n = 14) of the affected sample population not treating their current injuries and just under a third (n = 10) treating them with medication and/or injections.

There was a significant association between muscle strain and use of medication/injections (p = 0.000) and physiotherapy (p = 0.002) in previous injuries and home remedies (p = 0.002) in current injuries. There was a significant association between tendon strain and use of medication/injections (p = 0.009), brace/strap (p = 0.000), physiotherapy (p = 0.003), home remedies (p = 0.036) and massage (p = 0.003) in lifetime prevalence and home remedies (p = 0.038) in point prevalence. There was a significant association between nerve compression and use of medication/injections (p = 0.000), brace/strap (p = 0.000), physiotherapy (p = 0.019), chiropractic (p = 0.000), home remedies (p = 0.000) and massage (p = 0.022) in previous injuries and medication/injections (p = 0.000) and chiropractic (p = 0.018) in current injuries. There was also a significant association in 'other' and use of home remedies (p = 0.010) in lifetime prevalence and brace/strap (p = 0.026) and massage (p = 0.038) in point prevalence.

Chiu et al. (2002) found that the majority of their respondents (60%) in Hong Kong received treatment from medical doctors (general practitioner or specialist not specified). Other studies do not specify the type of care seeking in general terms such as this study. Peek (2005), reported that received treatment of computer users were from physiotherapists (38%) and chiropractors (20%) followed by pharmacists (14%), massage therapists (13%) and general practitioners (11.6%). There was limited recorded data on received treatment of computer users in South African literature.

5.3 Third objective

The third objective was to identify selected risk factors (demographic, ergonomic and work history) for computer programmers in a selected software company in the eThekweni Municipality. This was achieved by means of data collection and documentation with respect to:

- Participant's information including age, gender, race and history of surgery or unrelated work injury.
- Participants work history including work experience, number of hours worked, hours worked overtime, dominant hand and equipment use.
- Ergonomic factors include lack of/inadequate equipment support and/or incorrect workstation setup.
- Degree of disability factors include the DASH score.

5.3.1 Participant demographics

5.3.1.1 Ethnicity

Nearly 50% of the participants in this study were White (n = 75), with more than a third Indian (n = 57) and the minority were Black (n = 14, 9%), Coloured (n = 5, 3.2%) and other racial groups (n = 4, 2.6%). There was a small effect between ethnicity, and point and lifetime prevalence indicating that race was not a significant risk factor. A review of the literature does not reveal any studies that have investigated this association. However, one literature review by Goga et al. (1990), did a study on idiopathic CTS among non-White South Africans. There was a small population group of non-white participants to draw a significant conclusion. Ethnicity could possibly be an associated risk factor if more non-White South Africans' were included in research studies.

5.3.1.2 Age

The inclusion criteria for this study allowed for any age ≥ 18 years. This was based on most individuals with at least one year work experience are 18 years and/or older. The mean and standard deviation for age of a female was 31.5 ± 4.78 years, with a minimum age of 26 years and maximum age of 38 years (n = 11). The mean and standard deviation of a male was 32.2 ± 6.5 years, with a minimum age of 21 years old and a maximum age of 54 years of age (n = 144). A large percentage of participants in this study were between the ages of 31 and 40 (n = 71). This age group generally represents the majority of the working class with the age group 21 to 30 at a close second (n= 69). These results are similar to those found by Sauter et al. (1991), Holmström et al. (1992) and Owens and Patterson (2000), where mean age was found to be 35.9, 39.5 and 31.5 years respectively.

Age was not found as a significant factor to type of injury in this study. However, there was a significant association with increasing age and the left wrist (η_p^2 = 0.134) (large effect), the right wrist (η_p^2 = 0.163), the right forearm (η_p^2 = 0.062) (medium effect), the left elbow

(η_p^2 = 0.208) and the right elbow (η_p^2 = 0.075) in lifetime prevalence. There was a significant association with increasing age and the left hand (η_p^2 = 0.063), the right wrist (η_p^2 = 0.425), the left elbow (η_p^2 = 0.418), the right elbow (η_p^2 = 0.268), the left shoulder (η_p^2 = 0.515) and the right shoulder (η_p^2 = 0.513) in point prevalence. There was also a large effect size with increasing age and severity in lifetime prevalence (η_p^2 = 0.200) and a medium effect size in point prevalence (η_p^2 = 0.084) and a large effect size in increasing age and duration of injury in both lifetime (η_p^2 = 0.244) and point prevalent (η_p^2 = 0.282) injuries.

These findings are similar studies to other studies that reported advancing age was associated with an increased risk for the onset of UEMSDs in computer users (Punnett et al. 1997; Cook et al. 2000; Gerr et al. 2002; Kryger et al. 2003; Lassen et al. 2004). Jensen and Pilegaard et al. (2002) reported that higher odds were shown in the age group above 30 years of age for shoulder, hand and wrist symptoms for computer usage than for the age group 18 to 29 years. CTS prevalence was higher in the age group above 30 years of age compared to 20 to 30 years (Ali et al. 2006). Kamwendo et al. (1991) and Tornqvist et al. (2009), found increased risk of shoulder symptoms with advancing age in computer users whereas other studies have not (Jensen 2003; Juul-Kirstensen et al. 2004; Brandt et al. 2004; Lassen et al. 2005; Shuval et al. 2005).

5.3.1.3 Gender

The gender distribution in the sample population was largely male 92.9% (n = 144) with females making up 7.1% (n = 11). This may not be fully representative of the whole work force at the selected company, but may give some indication of gender proportions in the computer software field at this particular software company. Gender was not a risk factor to injury or type of injury in this study. Overall, there was no significant difference in the mean age by gender (p = 0.742).

Age and gender have been reported by some authors to have an effect on symptom prevalence (Knave et al. 1985, Rossignol et al. 1987, Bergqvist et al. 1992, Stock 1991, Hales et al. 1996; Palmer et al. 2001; Jensen and Pilegaard et al. 2002; Jensen 2003). This may be due to the high female population in their studies compared to this study. However, Bergqvist et al. (1995) did a follow up prospective study of computer workers and found that female gender with upper extremity disorders was significantly associated with cofounding non work-related risk factors (housework and childcare) and that men have a different occupational exposure compared to women. Cook et al. (2000) and Hales et al. (1994) also found no association between UEMSDs and gender.

5.3.1.4 History of non work-related surgery or injury of the upper limb

Over 75% of the participants had no reported history of a sports injury to the upper limb (n = 117) and 21.9% (n = 34) had such a history. The association between sports injury and lifetime prevalence showed a significant association with the right hand ($p = 0.009$), right shoulder ($p = 0.002$) and left wrist ($p = 0.046$) and the left wrist ($p = 0.046$) in point prevalence. The association between other medical related history and lifetime prevalence showed to be significant in the right shoulder ($p = 0.012$). The association between no history and lifetime prevalence also proved to be significant in the right shoulder ($p = 0.008$). The association between MVA, point and lifetime prevalence was insignificant. The association between surgery, point and lifetime prevalence was also insignificant. This may or may not indicate that history of injury not associated to occupational reasons could lead to a potential risk of work-related injury.

Lassen et al. (2005) contradicted this study which reported the presence of a medical condition was not a significant association for upper limb pain with computer use. Shuval et al. (2005) found that physical inactivity was an independent risk factor for neck/shoulder symptoms in computer use although, this was not statistically significant. It was suggested that if the sample population was larger it would have been significant. However, other studies have found physical inactivity to have no association with MSDs (Marcus et al. 1996; Yun et al. 2001).

5.3.2 Work history

5.3.2.1 Work experience

Nearly 40% of participants worked between 6 and 10 years (n = 61) as a computer programmer. A large number of respondents worked between 2 and 20 years, with more than two-thirds having worked more than 5 years. There was a significant association between work experience and injury. The right shoulder ($p = 0.000$), the right wrist ($p = 0.050$) and right elbow ($p = 0.001$) showed a significant association for lifetime prevalence. There was also a significant association between years worked as a computer programmer and severity of current injuries ($p = 0.021$).

Ali et al. (2006) found a statistically significant higher risk of CTS among computer users with more than 4 to 8 years of experience ($p = 0.004$) and 8 years or more ($p = 0.001$) compared to those with less than 4 years experience. Kamwendo et al. (1991) found a strong association between length of employment and neck/shoulder pain.

5.3.2.2 Work hours

The majority of the participants worked 7 to 8 hours per day (n = 89) and over 40% of the participants worked more than 8 hours per day (n = 65). More than half of the participants worked 35 to 40 hours per week (n = 88) and the remainder (n = 67) worked more than 40 hours per week.

This study found that 61.3% (n = 95) of the participants worked 31 to 40 hours on the computer per week, 32.3% (n = 50) worked more than 40 hours on the computer per week and the remainder 6.5% (n = 10) worked between 16 to 30 hours on the computer per week. All respondents worked full time i.e. from 35 to more than 40 hours per week with more than 90% of the sample population working the same number of hours on their computers.

There was a strong correlation between hours worked per week and the right shoulder (p = 0.036) and duration of injury (p = 0.012) in previous injuries. There was a significant association between hours worked on the computer per week and the right shoulder (p = 0.004) and the right wrist (p = 0.001) in previous injuries and the right wrist (p = 0.020) in current injuries. There was also a strong correlation between duration of injury and hours worked on the computer per week in previous injuries (p = 0.001). The association between hours worked on the computer outside of work was significant in the left hand (p = 0.025) and right wrist (p = 0.027) in point prevalence of injury, and the right wrist (p = 0.020) and the right shoulder (p = 0.013) in lifetime prevalence of injury. Computer programmers who worked > 40 hours on the computer per week were prone to injury 16.769 (O.R.) times more often than a programmer who worked 20 to 30 hours on the computer per week (p = 0.037) and 3.563 (O.R.) times more often than a programmer who worked 31 to 34 hours per week (p = 0.013).

Several previous studies reported a significant association between the duration of computer use and hand/wrists symptoms (Punnett et al. 1997; Marcus et al. 2002; Jensen and Finsen et al. 2002; Ortiz-Hernández et al. 2003; Jensen 2003). Different criteria in different studies were assessed such as computer use for more than four hours per day (Katz et al. 2000), 15 hours a week (Gerr et al. 2002), or more than 75% of work time (Jensen 2003). Ali et al. (2006) reported a strong association of CTS with computer users who worked 8 to 12 hours a day (p = 0.020) and more than 12 hours (p = 0.020). Sharan et al. (2011) found that 64% of participants who worked 8 to12 hours on the computer was a significant predictor of pain (p = 0.0001) and loss of productivity (p = 0.0004). Ijmker et al. (2010) reported that computer users who worked 4 to 6 hours per day were twice more likely to develop UEMSDs than users of 4 hours per day and that there was a moderate association between mouse usage of 4 hours per day and UEMSDs.

Jensen (2003) reported that duration of computer use at work was a predictor for hand/wrist symptoms but not neck/shoulder symptoms. The risk of developing symptoms was increased in work with a computer for 3 to 4 months or more of worktime. Marcus et al. (2002) reported that the risk of hand/wrist symptoms increased with 20 hours keying a week. Such findings are supported by the greater body of literature in that prolonged static postures are a significant risk factor for the development of musculoskeletal disorders. Working on a computer for more than five hours per day was associated with hand/wrist disorders.

5.3.3 Overtime

Of the total sample population (N = 155), over 75% of participants (n = 119) worked 0 to 5 hours overtime per week on their computer, 16.8% (n = 26) worked 6 to 10 hours overtime per week and a few (n = 10) worked more than 10 hours overtime per week. Half the of the sample population (n = 79) spent 0 to 5 hours per week on the computer outside of work, a quarter (n = 39) spent 6 to 10 hours and the remainder (n = 37) spent more than 10 hours.

A third of the respondents (32.9%) did not work overtime, 46.5% worked a reasonable amount of overtime per week and a small fraction worked overtime frequently (more than 10 hours per week). Half of the sample population either worked minimal to no hours per week on the computer outside of work (whether recreational or work-related) and the other half of the sample population worked between 6 to more than 10 hours per week on the computer outside of work. More than half of the repondents worked 40 to more than 50 hours in total on the computer per week.

There was a strong correlation between overtime and in the left hand ($p = 0.024$) in current injuries, and the right shoulder ($p = 0.004$) in previous injuries. There was a significant association between overtime and severity of pain ($p = 0.018$) in previous injuries.

Shuval et al. (2005) found in their study that 65.5% of participants worked on their computer 8 to 10 hours a day, 34.5% worked 10 hours or more per day, 11.9% worked 1 to 5 hours a day, 44% worked 6 to 8 hours on a day, and 44% worked 8 to 12 hours a day. Working between 7 and 9 hours a day showed a significant association for hand and wrist symptoms. Literature by Bernard et al. (1994) and Yun et al. (2001) found a strong correlation of working on a computer 6 to 9 hours a day an increased risk for neck/shoulder symptoms ($p < 0.020$).

5.3.4 Equipment

The majority of the sample population (n = 144, 92.9%) worked on the mouse and keyboard.

5.3.5 Dominant hand

All respondents were right hand dominant in this study. Dominance did not seem to play a role in affecting the side of injury as all the individuals were right hand dominant.

5.3.6 Ergonomic work station

Over half (n = 33) of the participants with previous work-related upper limb injuries had improved when they had changed their work stations.

There was a strong correlation between change in work station and in the left hand (p = 0.034), right wrist (p = 0.031), right elbow (p = 0.034) and right shoulder (p = 0.048) in previous injuries when the monitor was changed. Right hand (p = 0.018) showed a strong association when the chair was changed. The right hand (p = 0.020) and left wrist (p = 0.009) showed significant association when the keyboard was changed. The right hand (p = 0.008) showed a strong association when the mouse was changed. Muscle strain had a significant impact on the change in ergonomic equipment of the chair (p = 0.006) and desk (p = 0.003) in previous work-related injuries; and tendon strain had a significant impact on the change in ergonomic equipment of the chair (p = 0.009), desk (p = 0.013) and stand/walk around (p = 0.013) in current work-related injuries. Nerve compression had a significant impact on the change in ergonomic equipment of the chair (p = 0.000), desk (p = 0.007), keyboard (p = 0.000), monitor (p = 0.007), mouse (p = 0.000) and stand/walk around (p = 0.048) in previous injuries; and chair (p = 0.009), keyboard (p = 0.000), monitor (p = 0.049) and mouse (p = 0.004) in current injuries. Incorrect workstation setup and type of injury was a high-risk factor in work-related injury in this study.

Jensen and Finsen et al. (2002) study showed a strong association between shoulder symptoms and mouse use (p = 0.019) which contradicted this study. However, similar studies such as Tittiranonda et al. (1999), revealed that change of keyboard equipment decreased CTS and tendonitis in hand/wrist ($p < 0.050$), and Fogleman et al. (2002)

reported that improper monitor, keyboard and mouse position were significantly associated with shoulder discomfort.

An unadjusted desk and increased mouse use were significant associations for persistent arm, hand and wrist pain ($p \leq 0.025$) (Lassen et al. 2005). Park et al (2000), stated that change in chair work station reduced fatigue in the finger flexor/extensor muscles. The prevalence of musculoskeletal disorders among keyboard users has been reported to be as high as 81% (Kamwendo et al. 1991). One of the most significant cumulative trauma disorders are CTS and 25% of CTS were associated with "keyboarding". Incorrect work station was a high risk factor in work-related injury in computer programmers' in this study.

5.3.7 Degree of disability

Partial Eta score was used to determine the correlation between DASH and severity of pain and duration of injury in current injuries. A medium effect size was noted for the severity of pain ($\eta_p^2 = 0.099$) and a much larger effect size for duration of injuries ($\eta_p^2 = 0.395$).

Lassen et al. (2005) reported that 55% of participants had a DASH score of below 20, 5.4% had a dash score of ≥ 50 and 5% to 10% had a score above 50 (this only comprised 1% of the whole cohort study). This demonstrated that only a small effect size of severe disability occurred as a result of computer usage.

5.4 Fourth objective

The fourth objective was to determine any association between prevalence and selected risk factors. Associations between the selected risk factors and prevalence of injury were tested using Pearson's chi-square tests in the case of categorical values and partial Eta scores in the case of independent scale variables (such as age) and categorical variables (such as gender) respectively. Pearson's chi-square values are only considered significant if the *p*-value is greater than 0.05. Pairs of variables that have significant relationships (medium/typical strength or higher) demonstrate the degree of risk potential which that particular relationship carries.

5.4.1 Lifetime prevalence

In this study many participant characteristics were found to have a statistical significance concerning injury prevalence. Ethnicity and gender was shown to have a small effect on injury risk. Increasing age was a risk factor of region of injury, severity of pain and duration of injury.

Previous history of sports injury, MVA, ‘other’ medical related history and no history of injury showed to be a significant risk factor. This may be linked to the high prevalence of shoulder injuries in this study of participants when requiring an explanation for the increased risk of injury.

Increased working hours as well as increased hours worked on the computer per week were shown to have a statistical significance on injury risk. There was an increased risk of injury for participants in the right shoulder (p = 0.036) who worked 35 hours or more per week. There was a significant association between hours worked per week and duration of injury (p = 0.012) and duration of injury (p = 0.001) and hours worked on the computer per week. Computer programmers who worked > 40 hours on the computer per week were prone to injury 16.769 (O.R.) times more often than a programmer who worked 20 to 30 hours on the computer per week (p = 0.037) and 3.563 (O.R.) times more often than a programmer who worked 31 to 34 hours per week (p = 0.013). The association between hours worked on the computer outside of work per week was an increased risk of injury in the right wrist (p = 0.020) and the right shoulder (p = 0.013) as well as overtime was an increased risk of injury in the right shoulder (p = 0.004) and severity of pain (p = 0.018). The increased hours worked on the computer gave the participant an increased exposure time to injury. Work experience demonstrated to be another risk factor in the right shoulder (p = 0.000), the right wrist (p = 0.050) and right elbow (p = 0.001) and severity of pain (p = 0.021).

Neck pain had an increased risk of development from injuries in the right elbow (p = 0.002), left shoulder (p = 0.000) and right shoulder (p = 0.000). Nerve compression (p = 0.001) had a high risk of pain severity. Muscle strain (p = 0.002), nerve compression (p = 0.026) and ‘other’ (carpal tunnel syndrome, ganglion, knots and muscle cramping) (p = 0.008) were high risk factor of duration of injury. The choice of conservative treatment showed a significant correlation to muscle strain, tendon strain and nerve compression.

Incorrect work station was a high risk factor in work-related injury in this study. Muscle strain, tendon strain and nerve compression were the three most affected injuries in the change of ergonomic equipment.

5.4.2 Point prevalence

Ethnicity and gender were not risk factors in this study. Increasing age was a risk factor of region of injury, severity of pain (η_p^2 = 0.084) and duration of injury (η_p^2 = 0.282). History of non work-related injury or surgery were not risk factors in this study except for sports injury which was an increased risk factor in the left wrist (p = 0.046). This shows that history of non work-related injury or surgery does not increase the likelihood of sustaining an injury, however they do increase the risk of sustaining a more severe injury.

Increased working hours were also shown to have a statistical significance on injury risk. There was an increased risk of injury for participants who worked on the computer outside of work per week in the left hand (p = 0.025) and right wrist (p = 0.027) and those who worked overtime in terms of injury in the left hand (p = 0.024). There was a significant association between increased hours worked on the computer per week and the right wrist (p = 0.020) in point prevalence. The association between increased hours worked on the computer outside of work was significant in the left hand (p = 0.025) and right wrist (p = 0.027) in point prevalence. The greater the number of hours of computer work the greater the exposure time for injury therefore the greater the risk.

Neck pain had an increased risk of development of injuries in the left shoulder (p = 0.002) and right shoulder (p = 0.001). Tendon strain (p = 0.002) was a high-risk factor of pain duration. There was a significant association between muscle strain and use of home remedies (p = 0.002), tendon strain and use of home remedies (p = 0.038), and nerve compression and use of medication/injections (p = 0.000) and chiropractic (p = 0.018). There was also a significant association in 'other' and use of brace/strap (p = 0.026) and massage (p = 0.038) in point prevalence.

A medium effect size was noted for the severity of pain (η_p^2 = 0.099) and a much larger effect size for duration of injuries (η_p^2 = 0.395) with the degree of disability of the injury.

Ergonomic setup was also shown to have a statistical significance on injury risk. There was a decreased risk of injury for participants in the left hand (p = 0.034), right wrist (p = 0.031), right elbow (p = 0.034) and right shoulder (p = 0.048) when the monitor was changed. Right hand (p = 0.018) injury risk decreased when the chair was changed. The right hand (p = 0.020) and left wrist (p = 0.009) injury risk decreased when the keyboard was changed. This shows incorrect work station setup and equipment use is a high-risk factor for work-related injury in the upper extremity. There was a significant association of nerve compression and chair (*p* = 0.009), keyboard (*p* = 0.000), monitor (*p* = 0.049) and mouse (*p* = 0.004). Incorrect workstation setup and type of injury was a high-risk factor in work-related injury in this study.

The *p*-value was used to determine the strength of the association between the point and lifetime prevalence. There was a significant association of the right hand (*p* = 0.002), left wrist (*p* = 0.026), right wrist (*p* = 0.000), left elbow (*p* = 0.019), left elbow and left wrist (*p* = 0.038), right elbow and left elbow (*p* = 0.032), right elbow (*p* = 0.002), left shoulder and left elbow (*p* = 0.045) and left shoulder (*p* = 0.043). Aggravating factors of injury, such as pain, increased during work (*p* = 0.000), interference with work (*p* = 0.000) and interference outside of work (*p* = 0.000). There was no significant association for point prevalence of pain after working (*p* = 0.124).

This study found that the main relieving factor of injury was a week away from work (*p* = 0.000). Productivity loss seem to be a risk factor for work-related injury as there was a significant association for point prevalence of pain and sick leave (*p* = 0.000).

5.5 Conclusion

The results of this study as discussed in this chapter illustrate the nature and complexity of factors involved in the development of WRUEMSDs. Integration of these findings with other related studies support the multifactorial development of these disorders. The effect of individual, working and cofounding factors are reiterated here. The findings of this study show that these disorders have an effect on work productivity and absenteeism within the selected working environment. Overall study conclusions and recommendations follow in chapter six.

CHAPTER 6: CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

This chapter provides a summary of the results of the study as well the conclusions drawn from these results, together with the limitations and recommendations for future studies.

6.1 Conclusions

This study noted that injuries in the shoulder were more prevalent in the upper limb than other upper extremity injuries. The most common anatomical location of injury in computer programmers in this study was the right shoulder, the right hand and the right wrist. Factors that increase the risk of a computer programmer becoming injured include increasing age, increased work experience, increased number of hours worked per week and number of hours worked on the computer per week, increased number of hours on the computer outside of work per week, overtime, history of sports injury, and incorrect ergonomic setup such as keyboard, mouse, monitor and chair use. Surprisingly, gender, ethnicity, history of non work-related surgery and dominant hand had no effect on injury prevalence. Even though some factors had no association with injury prevalence, a few had associations concerning injury severity, work interference/productivity and/or duration. Although work-related injuries to the upper extremity did not have a great impact on absenteeism, it still had a significant effect on interference in the workplace. There are clear signs that in a substantial number of cases, pain resulted in decreased activity both at home and in the workplace, with a few participants reporting they took time off work as a result of the pain and discomfort. The findings of this study found an association between upper extremity injuries and neck pain. The most common type of work-related injuries were muscular strains and nerve compression. Medication and/or injections were the most common form of treatment utilised by the participants.

The results of this study identified risk factors for sustaining injuries in computer programmers. Both programmers and their associated companies should implement the following strategies to prevent injuries from occurring, as well as to reduce the risk of injury:

1. Computer programmers should include a time for breaks so that their upper extremities can have a rest period.

2. Programmers should have the correct ergonomic workstation setup and use correct equipment in order to prevent injuries from occurring.

3. The majority of participants reported their injuries to be a result of hours worked overtime at the computer. Since programming is an occupation in which deadlines play a role, overtime cannot be avoided. Therefore, correct strengthening and stretching exercises of the upper limb should be incorporated to prevent injuries from forming.

4. The majority of previous injuries are chronic in nature. To avoid injuries of a long-standing duration programmers must seek appropriate treatment as soon as the injuries occur or manifest themselves, and must rest the injured area.

5. Associated companies should be encouraged to allow their injured programmers to appropriately modify their work sessions in order to avoid productivity loss.

6.2 Limitations

The study was limited in participant numbers due to the location inclusion criteria. A greater sample size could have been made available and this would have resulted in more significant conclusions. The data collection was performed by means of participants' self-reporting due to resource constraints; therefore, the accuracy of the collected data may be compromised. Self-reported data may also increase recall bias. In addition, self-reporting may cause workers with UEMSDs to be compared to people without disorders who over estimate their symptoms. Hence, further interventional studies are suggested. In addition, human error needs to be considered: a participant may have made an error on the questionnaire, failed to understand a question properly, or forgotten a noteworthy incident which would have been significant for inclusion in the study results.

6.3 Recommendations

- The sampling technique in this study may not fully represent the participant population. Future studies should use a stratified random sampling technique.

- This study utilised one software development company to collect the data; future studies should select participants from many different sites in order to effectively establish more findings of the study.

- Future studies should be conducted with much larger sample sizes to determine clear associations and draw more definitive conclusions.

- Comparisons in the findings of this study and future studies should be conducted; it is thus important that they be of similar design and utilise similar objective measurement tools. Definitions of incidence, prevalence and severity according to this study should be the same in future studies. This will facilitate valid and more comparable results.

- Future studies should focus on more defined areas of the working environment, such as the workstation setup and posture and more objective measurement tools should be utilised.

- Further research is warranted to establish intervention strategies, such as postural and ergonomic advice. This will ultimately aid in understanding the development and progression of disorders.

- Longitudinal study designs should be conducted to determine the role of the healthy worker effect i.e. studies should be conducted over years to monitor the effect of employees changing jobs as a result of these disorders.

- The disability associated with work-related upper extremity disorders should be further investigated in order to determine its economic and health care impact.

- The lack of general population surveys with regard to neck and shoulder disorders within the local context is critical and will give greater understanding in terms of comparison to work related studies such as this one.

- Psychosocial factors should be included in future studies as to their benefit in considering the effect of mental problems (such as perceived job stress and anxiety) on injury formation.

- Software development companies should be made aware of the high-risk injury factors in order to prevent any injuries, as well as to include certain training elements in order to strengthen and protect injury-prone sites.

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APPENDICES

APPENDIX A: Letter of information - Focus Group

Letter of Information

Dear Participant

I would like to welcome you into the focus group of my study.

Title of the research study: Work-related upper extremity musculoskeletal disorders among computer programmers in a selected software company in the eThekwini Municipality.

Principle Researcher: Roxanne Coetzee, B. Tech: Chiropractic

Supervisor: Dr Anthony van der Meulen, M. Tech: Chiropractic
Co-supervisor: Dr Yomika Venketsamy, M. Tech: Chiropractic

Introduction and Purpose of the Study: Due to the painful effects of occupational related upper extremity musculoskeletal disorders, there is a need for proper assessment and early diagnosis of computer programmers. To date, there is no validated assessment tool that measures the degree of the disability caused for work-related upper extremity musculoskeletal disorders. The purpose of this study is to investigate the prevalence of disorders among full time computer programmers at Derivco and to identify selected factors associated with an increased risk of injury, in order to improve the management and treatment of programmers.

Outline of the procedure:
After discussing a schedule with DUT, a scheduled meeting with you will be arranged in a room provided by DUT on the university premises. There will be a certain number of participants (no more than 10) in this meeting and the course of the meeting should last an estimated 1 hour in total. In this meeting, a detailed description of the research will be explained to you. Should you agree to partake in the research, you will now be asked to sign the letter of information, informed consent and two questionnaires provided.

Role of participant:
You are expected to abide by the code of conduct (Appendix C). It is your role to make comments and suggestions with regards to the study. Every comment will be discussed thoroughly by the researcher, supervisor and participants until such time all participants are satisfied.

Benefits, risks and costs:
This study would be able to contribute the necessary information to stimulate research in the area of the prevalence and incidence of upper extremity musculoskeletal pain/disorders in computer programmers in eThekwini. Results of the study will be available in the form a dissertation on the DUT library. There are no risks, costs or remuneration associated with your participation in this study.

Participant withdrawal from focus group:

You as the participant may withdraw from the focus group at any time.

Confidentiality: All participants must abide by the confidentiality statement (Appendix D).

Persons to contact in the event of any problems or queries:
Researcher: Ms Roxanne Coetzee (083 775 5806)
Supervisor: Dr A. van der Meulen (0312620776)
Institutional Research Ethics administrator: 031 373 2375.
Complaints can be reported to Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

APPENDIX B: Letter of Informed Consent - focus group

LETTER OF INFORMED CONSENT

Statement of Agreement to Participants in the Focus Group:

- I hereby confirm that I have been informed by the researcher, Roxanne Coetzee, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,
- I have also received, read and understood the above written information (Focus group Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

_____________________ _____________________ _____________________

Full Name of Participant **Date** **Signature**

I, Roxanne Coetzee herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Roxanne Coetzee_______ _____________________ _____________________

Full Name of Researcher **Date** **Signature**

_____________________ _____________________ _____________________

Full Name of Witness **Date** **Signature**

APPENDIX C: Code of conduct – Focus Group

Code of Conduct during meetings

Behaviour during meetings:
It is expected of all the members of the focus group, the researcher and supervisor to adhere to the basic rules and regulations of a focus group meeting.
Any comments may be raised during the procedure should a participant feel the need to address any of the focus group members or the researcher and supervisor of the study.
Every participant of the meeting must:

- Act appropriately and treat all participants of the meeting with respect.
- Make no derogatory comments either through speech or action.
- Act in a manner that is unbiased and fair.
- Be open and honest about any action or comments and give a reason for them.
- Be clear and honest when giving a personal view of any part of the meeting or questionnaire.
- Participants should not interrupt a member during his or her addressing of the group.

Declaration of interest:
Should any of the participants have a financial, personal or other material interest in the outcome of the study, it is expected that this standing will be raised to the researcher and/or supervisor.

Confidentiality:
In conjunction with the letter of information and informed consent and confidentiality agreement, it is noted that all information discussed during the focus group meeting will be kept confidential.

Breach of code of conduct:
Any participant not adhering to the above speculated rules may be asked to leave the focus group meeting with no discrimination for future attendance to meetings as such.

Please print in block letters:

Focus group Member: ___________________________ Signature: __________________

Witness Name: __________________________ Signature: ____________________

Researcher's Name: ___________________________ Signature: __________________

Supervisor's Name: ___________________________ Signature: ____________________

APPENDIX D: Confidentiality Statement - Focus Group

IMPORTANT NOTICE: This form is to be read and filled in by every member participating in the focus group, before the focus group meeting convenes.

CONFIDENTIALITY STATEMENT: Focus group

1. All information contained in the research documents and any information discussed during the focus group meeting must be kept private and confidential. This is especially binding to any information that may identify any of the participants in the focus group.

2. None of the information shall be communicated to any other individual or organisation outside of this specific focus group as to the decisions of this focus group.

3. The information from this focus group will be made public in terms of a dissertation/thesis and/or journal publication, which will in no way identify any of the participants involved in this focus group.

4. The returned questionnaires will be coded and kept anonymous in the research process.

5. The focus group may be either voice or video recorded, as a transcript of the proceedings will need to be made. The data will be stored securely under password protection.

6. All data generated from this focus group (including the recording) will be kept for 15 years in a secure location at Durban University of Technology and thereafter will be destroyed.

Once this form has been read and agreed to, please fill in the appropriate information below and sign to acknowledge agreement.

Please print in block letters:

Focus group Member: ___________________________ Signature: __________________

Witness Name: __________________________ Signature: ___________________

Researcher's Name: ___________________________ Signature: __________________

Supervisor's Name: ___________________________ Signature: ___________________

APPENDIX E: Request For Permission sent to Derivco. Sent after IREC approval to EACH clinic indicated for the study

APPENDIX E2: Request For Permission sent to Derivco. Sent after IREC approval to EACH clinic indicated for the study

DUT DURBAN UNIVERSITY OF TECHNOLOGY — INSTITUTIONAL RESEARCH ETHICS COMMITTEE

To ______________________ / whom it may concern

My name is Roxanne Coetzee. I am currently a Chiropractic student at Durban University of Technology completing my Masters dissertation.

The title of the research study is *"Work-related upper extremity musculoskeletal disorders among computer programmers in a selected software company in the eThekweni Municipality."*

The purpose of my study is to investigate the prevalence of upper extremity musculoskeletal disorders among full time computer programmers at Derivco and to identify selected factors associated with an increased risk of injury, in order to improve the management of programmers. In order to accomplish this, participants are to complete two questionnaires. Due to the effect that upper extremity musculoskeletal pain/disorders has on computer programmers, there is a need for early diagnosis and assessment of patients. I would appreciate the opportunity and permission from [redacted] (name of clinic\ institute) to conduct my study by recruiting participants from this premises.

I would require approximately 10-15 minutes with each participant. Each participant go through the letter of information and participants fill in two questionnaires. There should be minimal to no interference on the normal running of the participants' office schedule.

These questionnaires are anonymous and no personal/identifying information will be recorded. All information that is obtained will be treated as strictly confidential.

[redacted] (name clinic\ institute) may at any stage withdraw consent and permission for the study to be conducted at their premises.

All Intellectual Property Rights belonging to a Party prior to the execution of this Agreement shall remain vested in that Party.

None of the Intellectual Property Rights in the company trademarks and brands shall be used by the researcher for any purpose without the company's prior written consent.

Please feel free to contact me (Roxanne Coetzee) on 083 775 5806, my supervisor Dr. A. van der Meulen 0312620776, or my co-supervisor Dr Y. Venketsamy on 0722113936 at any stage if you require further information.

I, [redacted] hereby give permission for the researcher (Roxanne Coetzee) to make effective use of ______________________ (name of clinic\ institute) as a platform to conduct this study.

[redacted]	5/06/2017	[redacted]
Name	Date	Signature

APPENDIX F: Letter of information - Participants

LETTER OF INFORMATION

Dear Participant

Firstly I would like to thank you for your involvement in my study.

Title of the research study: Work-related upper extremity musculoskeletal disorders among computer programmers in a selected software company in the eThekweni Municipality.

Principle Researcher: Roxanne Coetzee, B. Tech: Chiropractic
Supervisor: Dr Anthony van der Meulen, M. Tech: Chiropractic
Co-supervisor: Dr Yomika Venketsamy, M. Tech: Chiropractic

Introduction and Purpose of the Study: Due to the painful effects of occupational related upper extremity musculoskeletal disorders, there is a need for proper assessment and early diagnosis of computer programmers. To date, there is no validated assessment tool that measures the degree of the disability caused for work-related upper extremity musculoskeletal disorders. The purpose of this study is to investigate the prevalence of disorders among full time computer programmers at Derivco and to identify selected factors associated with an increased risk of injury, in order to improve the management and treatment of programmers.

Outline of the Procedures:
After discussing a schedule with HR, a scheduled meeting with you will be arranged in a room provided by company on the company's premises. The course of the meeting should last an estimated 20 minutes in total. In this meeting, a detailed description of the research will be explained to you. Should you agree to partake in the research, you will now be asked to sign informed consent provided.

For you to be included in this study you need to meet the following requirements:

- You must be a full time worker at Derivco and worked for a year or more.
- You may be symptomatic or asymptomatic participants of the upper extremity.
- You must be willing to complete of all the required forms for the focus group (Letter of Information and Informed consent, Code of conduct, Confidentiality Statement).
- You must be 18 years or older.
- You must complete all questionnaires in full.

Time duration: one session of approximately 20 minutes. It will require the filling out of the two questionnaires provided.

Benefits, risks and costs: This study would contribute the necessary information to stimulate research in the area of the prevalence or incidence of upper extremity musculoskeletal pain/disorders in the computer programming community. Results of this study will be available in the form of a dissertation in the DUT Library. There are no risks, costs or remuneration associated concerning your participation in this study

Reasons/s why participants may be withdrawn from the study: You, as the participant may withdraw from the study at any time.

Confidentiality: The questionnaires are anonymous and no person/ identifying information will be recorded. All information that is obtained will be treated as strictly confidential. The usage of the data collected in this study will be used solely as outlined above.

Persons to contact in the event of any problems or queries:
Researcher: Ms Roxanne Coetzee (083 775 5806)
Supervisor: Dr A. van der Meulen (0312620776)
Institutional Research Ethics administrator: 031 373 2375.
Complaints can be reported to Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

APPENDIX G: Letter of Informed Consent – participants

LETTER OF INFORMED CONSENT

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, Roxanne Coetzee, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.

I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ ____________________ ____________________

Full Name of Participant **Date** **Signature**

I, Roxanne Coetzee herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Roxanne Coetzee__ ____________________ ____________________

Full Name of Researcher **Date** **Signature**

____________________ ____________________ ____________________

Full Name of Witness **Date** **Signature**

APPENDIX H: Letter of information – Pilot Study

LETTER OF INFORMATION

Dear Participant

Firstly, I would like to thank you for your involvement in my study.

Title of the research study: Work-related upper extremity musculoskeletal disorders among computer programmers in a selected software company in the eThekweni Municipality.

Principle Researcher: Roxanne Coetzee, B. Tech: Chiropractic
Supervisor: Dr Anthony van der Meulen, M. Tech: Chiropractic
Co-supervisor: Dr Yomika Venketsamy, M. Tech: Chiropractic

Introduction and Purpose of the Study: Due to the painful effects of occupational related upper extremity musculoskeletal disorders, there is a need for proper assessment and early diagnosis of computer programmers. To date, there is no validated assessment tool that measures the degree of the disability caused for work-related upper extremity musculoskeletal disorders. The purpose of this study is to investigate the prevalence of disorders among full time computer programmers at Derivco and to identify selected factors associated with an increased risk of injury, in order to improve the management and treatment of programmers.

Outline of the Procedures:
A scheduled meeting with you will be arranged in a room provided by the researcher. There will be a certain number of participants in this meeting and the course of the meeting should last an estimated 1 hour in total. In this meeting, a detailed description of the research will be explained to you. Should you agree to partake in the research, you will now be asked to sign the letter of information, informed consent and two questionnaires provided.

For you to be included in this study you need to meet the following requirements:

- You must be a full time worker at Derivco and worked for a year or more.
- You may be symptomatic or asymptomatic participants of the upper extremity.
- You must be willing to complete of all the required forms for the focus group (Letter of Information and Informed consent, Code of conduct, Confidentiality Statement).
- You must be 18 years or older.
- You must complete all questionnaires in full.

<u>Time duration:</u> one session of approximately 20 minutes. It will require the filling out of the two questionnaires provided.

Benefits, risks and costs: This study would contribute the necessary information to stimulate research in the area of the prevalence or incidence of upper extremity musculoskeletal pain/disorders in the computer programming community. Results of this study will be available in the form of a dissertation in the DUT Library. There are no risks, costs or remuneration associated concerning your participation in this study

Reasons/s why participants may be withdrawn from the study: You, as the participant may withdraw from the study at any time.

Confidentiality: The questionnaires are anonymous and no person/ identifying information will be recorded. All information that is obtained will be treated as strictly confidential. The usage of the data collected in this study will be used solely as outlined above.

Persons to contact in the event of any problems or queries:
Researcher: Ms Roxanne Coetzee (083 775 5806)
Supervisor: Dr A. van der Meulen (0312620776)
Institutional Research Ethics administrator: 031 373 2375.
Complaints can be reported to Director: Research and Postgraduate Support, Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

APPENDIX I: Letter of Informed Consent – Pilot Study.

LETTER OF INFORMED CONSENT

Statement of Agreement to Participate in the Research Study:

I hereby confirm that I have been informed by the researcher, Roxanne Coetzee, about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: ___________,

I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.

I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.

In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.

I may, at any stage, without prejudice, withdraw my consent and participation in the study.

I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.

I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

____________________ ____________________ ____________________

Full Name of Participant **Date** **Signature**

I, Roxanne Coetzee herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

Roxanne Coetzee__ ____________________ ____________________

Full Name of Researcher **Date** **Signature**

____________________ ____________________ ____________________

Full Name of Witness **Date** **Signature**

APPENDIX J: Questionnaire designed by researcher for Focus group

Name:	**Questionnaire number:**
Section 1: Participants Information (Please place a tick in the relevant box. If the question does not apply to you, please tick the "Not Applicable" box. Your responses will be kept strictly confidential.)	
1.	What is your age (in years)? years
2.	Which race group do you belong? White ☐ Black ☐ Indian ☐ Coloured ☐ Other ☐
3.	What gender are you? Male ☐ Female ☐
4.	Do you have any history of: (You can tick more than one box)
	☐ Sport related injury to the upper limb/s
	☐ Motor vehicle accident affecting the upper limb/s
	☐ Surgery to the upper limb/s
	☐ Other (Fracture from trauma to the upper limb/s, Osteoarthritis in the upper limb/s, etc.)
	☐ Not Applicable
Section 2: Work History	
5.	How many years have you worked as a computer programmer?
	☐ Less than a year ☐ 1 year ☐ 2-5 years ☐ 6-10 years ☐ 11-20 years ☐ more than 20 years
6.	At present, how many hours do you work per day?
	☐ 4-6 hours a day ☐ 7-8 hours a day ☐ More than 8 hours a day
7.	At present, how many hours do you work per week?
	☐ 20-30 hours per week ☐ 31-34 hours per week ☐ 35-40 hours per week ☐ more than 40 hours per week
8.	At present, how many hours do you work on the computer per week?
	☐ 0-15 hours per week ☐ 16-30 hours per week ☐ 31-40 hours per week ☐ More than 40 hours per week
9.	At present, how many hours overtime do you work per day?
	☐ 0-5 hours a day ☐ more than 5 hours a day ☐ Not Applicable
10.	At present, how many hours overtime do you work on the computer per week?
	☐ 0-5 hours per week ☐ 5-10 hours per week ☐ more than 10 hours a week

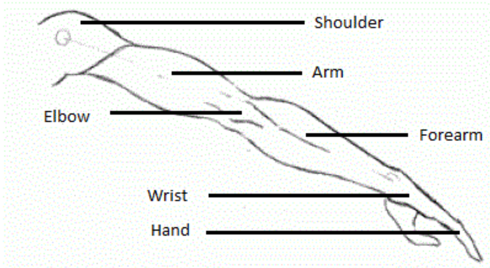
11.	How much time do you spend on the computer outside of work per week?
	☐ 0-5 hours per week ☐ 5-10 hours per week ☐ more than 10 hours per week
12.	Which equipment do you use more frequently at work?
	☐ Keyboard ☐ Mouse ☐ Both (the same amount)
13.	Which hand do you use your mouse with?
	☐ Left ☐ Right
Section 3: Past Work-Related injury/injuries (please tick where necessary)	
14.	Since working as a computer programmer, have you experienced any upper extremity pain/discomfort/injury in any
	of the regions: (You can tick more than one box)
	☐Left Hand ☐ Right Hand
	☐Left Wrist ☐ Right Wrist
	☐Left Forearm ☐ Right Forearm
	☐Left Elbow ☐ Right Elbow
	☐Left Shoulder ☐ Right Shoulder
	☐ Not Applicable (Please go to question 24)
15.	Which injury from question 14 would you think of as the worst injury you have sustained from occupational
	reasons? (Tick one box only)
	☐ Hand ☐ Wrist ☐ Forearm ☐ Elbow ☐ Shoulder ☐ Not Applicable
16.	How would you describe the type of pain?
	☐ Mild ☐ Moderate ☐ Severe
17.	How long have/did you have the pain/discomfort?
	☐ 0-6 weeks ☐ 7-12 weeks ☐ More than 12 weeks
18.	What type of injury did you have?
	☐ Muscle strain ☐ Tendon strain ☐ Ligament sprain ☐ Muscle tear ☐ Nerve compression
	☐ Other (Please specify)__________. ☐ I don't know
19.	Have you received treatment for this area? Please tick which type of treatment you have received.
	(You can tick more than one box)
	☐ Medication/Injections

	☐ Bracing/Strapping
	☐ Physiotherapy
	☐ Chiropractic
	☐ Home remedies (e.g. Ice)
	☐ Natural therapy (e.g. homeopathy, naturopathy)
	☐ Massage therapy
	☐ Rehabilitation
	☐ Other (Please specify)____________.
	☐ Not Applicable
20.	Have you changed your posture due to the pain/discomfort/injury? Yes ☐ No ☐
21.	If you said yes in question 20, did you change in posture to help alleviate the pain/discomfort/injury?
	Yes ☐ No ☐
22.	Have you changed your equipment (mouse, keyboard, chair, desk etc.) since you had experienced
	pain/discomfort/injury?
	Yes ☐ No ☐
23.	If you said yes, please tick which you equipment you had changed and if it had made a difference:
	(You can tick more than one box)
	☐ Mouse ☐ Keyboard ☐ Computer Monitor ☐ Chair ☐ Desk
Section 4: Present Work-related injury/injuries (Please tick)	
24.	Are you presently suffering from pain/discomfort/injury you think is caused by your programming work?
	☐ Yes ☐ No
25.	If yes, please specify in which region your injury is?
	☐ Left Hand ☐ Right Hand
	☐ Left Wrist ☐ Right Wrist
	☐ Left Forearm ☐ Right Forearm
	☐ Left Elbow ☐ Right Elbow
	☐ Left Shoulder ☐ Right Shoulder
	☐ Not Applicable
26.	While working is the pain/discomfort/injury:

	☐ Relieved	☐ No effect on pain	☐ Aggravated	☐ Not Applicable
27.	After your shift, is the pain or discomfort:			
	☐ Relieved	☐ No effect on pain	☐ Aggravated	☐ Not Applicable
28.	After a week away from work, is the pain or discomfort:			
	☐ Relieved	☐ No effect on pain	☐ Aggravated	☐ Not Applicable
29.	Has the pain or discomfort caused you to take time off work in the past year?			
	☐ Yes	☐ No	☐ Not Applicable	
30.	If yes in question 29, how many days off in total? _____ days			
31.	How much does it interfere with your work?			
	☐ No interference			
	☐ Some interference			
	☐ Took time off work due to pain/injury			
	☐ Not Applicable			
32.	How much does it interfere with your life outside of work?			
	☐ No interference			
	☐ Some interference			
	☐ Had to stop enjoying activity due to pain			
	☐ Not Applicable			
33.	If you had to stop activity, how many days in the past year did you stop? _____			

Thank you for your time.

Appendix K: Questionnaire designed by researcher used in main study.

Name:	**Questionnaire number:**
Section 1: Participants Information (Please place a tick in the relevant box. If the question does not apply to you, please tick the "Not Applicable" box. Your responses will be kept strictly confidential.)	
	Diagram of the upper limb which includes the shoulder, arm, elbow, forearm, wrist and hand. 
1.	What is your **age** (in years)? years
2.	Which **race group** do you belong? Black ☐ Coloured ☐ Indian ☐ White ☐ Other ☐
3.	What **gender** are you? Female ☐ Male ☐
4.	Do you have any **history** of: (You can tick **more than one** box)
	☐ Sport related injury to the upper limb/s
	☐ Motor vehicle accident affecting the upper limb/s
	☐ Surgery to the upper limb/s
	☐ Other medical related (e.g. Fracture from trauma to the upper limb/s, Osteoarthritis in the upper limb/s.)
	☐ Not Applicable
Section 2: Work History	
5.	How many years have you worked as a computer programmer?
	☐ Less than a year ☐ 1 year ☐ 2-5 years ☐ 6-10 years ☐ 11-20 years ☐ more than 20 years
6.	At present, how many hours do you work **per day**?
	☐ 4-6 hours a day ☐ 7-8 hours a day ☐ More than 8 hours a day
7.	At present, how many hours do you work **per week**?
	☐ 20-30 hours per week ☐ 31-34 hours per week ☐ 35-40 hours per week ☐ more than 40 hours per week
8.	At present, how many hours do you work on the **computer per week**?

	☐ 0-15 hours per week ☐ 16-30 hours per week ☐ 31-40 hours per week ☐ More than 40 hours per week
9.	How often do you work **overtime** in a year?
	____________.
10.	At present, how many hours **overtime** do you work on the computer **per week**?
	☐ 0-5 hours per week ☐ 5-10 hours per week ☐ more than 10 hours a week
11.	How much time do you spend on the computer **outside of work per week**?
	☐ 0-5 hours per week ☐ 5-10 hours per week ☐ more than 10 hours per week
12.	Which equipment do you use **more frequently** at work?
	☐ Keyboard ☐ Mouse ☐ Touchscreen ☐ Graphics tablet ☐ Mouse and Keyboard ☐ All
13.	Which hand do you use your mouse or graphics pad with?
	☐ Left ☐ Right ☐ Not Applicable
Section 3: Past Work-Related injury/injuries (please tick where necessary)	
14.	Since working as a computer programmer, have you experienced any upper extremity pain/discomfort/injury in any
	of the following regions: (You can tick **more than one** box)
	☐Left Hand ☐ Right Hand
	☐Left Wrist ☐ Right Wrist
	☐Left Forearm ☐ Right Forearm
	☐Left Elbow ☐ Right Elbow
	☐Left Shoulder ☐ Right Shoulder
	☐ Not Applicable (**Please go to question 18**)
15a.	Which injury from question 14, if any, would you think of as the **worst injury** you have sustained from occupational
	reasons? (Tick **one box** only)
	☐Left Hand ☐ Right Hand
	☐Left Wrist ☐ Right Wrist
	☐Left Forearm ☐ Right Forearm
	☐Left Elbow ☐ Right Elbow
	☐Left Shoulder ☐ Right Shoulder
15b.	How would you describe the **severity of pain**?

	☐ Mild ☐ Moderate ☐ Severe
15c.	How long have/did you have the pain/discomfort?
	☐ 0-6 weeks ☐ 7-12 weeks ☐ More than 12 weeks
15d.	What type of injury did you have?
	☐ Muscle strain ☐ Tendon strain ☐ Ligament sprain ☐ Muscle tear ☐ Nerve compression ☐ Callouses
	☐ Other (Please specify)__________. ☐ I don't know
15e.	Have you received treatment for this area? Please tick which type of treatment you have received.
	(You can tick **more than one** box)
	☐ Medication/Injections
	☐ Bracing/Strapping
	☐ Physiotherapy
	☐ Chiropractic
	☐ Home remedies (e.g. Ice)
	☐ Natural therapy (e.g. homeopathy, naturopathy)
	☐ Massage therapy
	☐ Rehabilitation
	☐ Other (Please specify)____________.
	☐ Not Applicable
	☐ I don't know
16.	Have you **changed your posture** with any of the following due to the pain/discomfort/injury?
	☐ Chair ☐ Desk ☐ Footstool ☐ Graphics tablet ☐ Keyboard
	☐ Monitor ☐ Mouse ☐ Standing/walking around the office
	☐ Other (please specify)____. ☐ Have not changed anything
17.	In question 17, did your change in posture **help alleviate** the pain/discomfort/injury?
	☐ Yes ☐ No ☐ Not applicable
Section 4: Present Work-related injury/injuries (Please tick where necessary)	
18.	Are you **presently** suffering from pain/discomfort/injury you think is caused by your programming work?
	☐ Yes ☐ No (**If no please go to question 32**)
19.	If yes, please specify in which region your injury is?
	☐ Left Hand ☐ Right Hand

	☐ Left Wrist ☐ Right Wrist
	☐ Left Forearm ☐ Right Forearm
	☐ Left Elbow ☐ Right Elbow
	☐ Left Shoulder ☐ Right Shoulder
	☐ Not Applicable
20.	How would you describe the **severity of pain**?
	☐ Mild ☐ Moderate ☐ Severe
21.	How long have you had the pain/discomfort?
	☐ 0-6 weeks ☐ 7-12 weeks ☐ More than 12 weeks
22.	What type of injury do you have?
	☐ Muscle strain ☐ Tendon strain ☐ Ligament sprain ☐ Muscle tear ☐ Nerve compression ☐ Callouses
	☐ Other (Please specify)__________. ☐ I don't know
23.	Have you received treatment for this area? Please tick which type of treatment you have received.
	(You can tick **more than one** box)
	☐ Medication/Injections
	☐ Bracing/Strapping
	☐ Physiotherapy
	☐ Chiropractic
	☐ Home remedies (e.g. Ice)
	☐ Natural therapy (e.g. homeopathy, naturopathy)
	☐ Massage therapy
	☐ Rehabilitation
	☐ Other (Please specify)____________.
	☐ Not Applicable
	☐ I don't know
24.	While working is the pain/discomfort/injury:
	☐ Relieved ☐ No effect on pain ☐ Aggravated ☐ Not Applicable
25.	After your shift, is the pain or discomfort:
	☐ Relieved ☐ No effect on pain ☐ Aggravated ☐ Not Applicable
26.	After a week away from work, is the pain or discomfort:

	☐ Relieved	☐ No effect on pain	☐ Aggravated	☐ Not Applicable
27.	Has the pain or discomfort caused you to take time off work in the past year?			
	☐ Yes	☐ No	☐ Not Applicable	
28.	If yes in question 27, how many days off in total? _____ days			
29.	How much does it interfere with your work?			
	☐ No interference			
	☐ Some interference			
	☐ Took time off work due to pain/injury			
	☐ Not Applicable			
30.	How much does it interfere with your life outside of work?			
	☐ No interference			
	☐ Some interference			
	☐ Had to stop enjoying activity due to pain			
	☐ Not Applicable			
31.	If you had to stop activity, how many days in the past year did you stop? _____			
32.	Have you ever experienced neck pain associated with your upper limb pain/injury/discomfort?			
	☐ Yes ☐ No			

Thank you for your time.

APPENDIX L: DASH Questionnaire

DISABILITIES OF THE ARM, SHOULDER AND HAND – British English

Please rate your ability to do the following activities in the last week by circling the number below the appropriate response.

	NO DIFFICULTY	*MILD DIFFICULTY*	*MODERATE DIFFICULTY*	*SEVERE DIFFICULTY*	*UNABLE*
1 Open a tight or new jar	1	2	3	4	5
2 Write	1	2	3	4	5
3 Turn a key	1	2	3	4	5
4 Prepare a meal.	1	2	3	4	5
5 Push open a heavy door	1	2	3	4	5
6 Place an object on a shelf above your head	1	2	3	4	5
7 Do heavy household jobs (e.g. wash windows, clean floors)	1	2	3	4	5
8 Garden or outdoor property work	1	2	3	4	5
9 Make a bed	1	2	3	4	5
10 Cary a shopping bag or briefcase	1	2	3	4	5
11 Carry a heavy object (over 10 lbs/ 5kgs)	1	2	3	4	5
12 Change a lightbulb overhead	1	2	3	4	5
13 Wash or blow dry your hair	1	2	3	4	5
14 Wash your back	1	2	3	4	5
15 Put on a jumper	1	2	3	4	5
16 Use a knife to cut food	1	2	3	4	5
17 Recreational activities which require little effort (e.g. card playing, knitting, etc)	1	2	3	4	5
17 Recreational activities which require you to take some force or impact through your arm, shoulder or hand (e.g. golf, hammering, tennis etc)	1	2	3	4	5
18 Recreational activities in which you move your arm freely (e.g. playing Frisbee, badminton etc)	1	2	3	4	5
20 Manage transport needs (getting from one place to another)	1	2	3	4	5
21 Sexual activities	1	2	3	4	5

	NOT AT ALL	SLIGHTLY	MODERATELY	Quite a bit	Extremely
22 During the past week, *to what extent* has your arm, shoulder or hand problem interfered with your normal social activities with family. friends, neighbours or groups? *(circle number)*	1	2	3	4	5

	NOT LIMITED AT ALL	SLIGHTLY LIMITED	MODERATELY LIMITED	VERY LIMITED	UNABLE
23 During the past week, were you limited in your work or other regular daily activities as a result of your arm, shoulder or hand problem? *(circle number)*	1	2	3	4	5

Please rate the severity of the following symptoms in the last week *(circle number)*	NONE	MILD	MODERATE	SEVERE	EXTREME
24 Arm, shoulder or hand pain	1	2	3	4	5
25 Arm, shoulder or hand pain when you do any specific activity	1	2	3	4	5
26 Tingling (pins and needles) in your arm, shoulder or hand	1	2	3	4	5
27. Weakness in your arm, shoulder or hand	1	2	3	4	5
28 Stiffness in your arm, shoulder or hand	1	2	3	4	5

	NO DIFFICULTY	MILD DIFFICULTY	MODERATE DIFFCULTY	SEVERE DIFFCULTY	SO MUCH DIFFICULTY THAT I CAN'T SLEEP
29 During the past week, how much difficulty have you had sleeping because of the pain in your arm, shoulder or hand? *(circle number)*	1	2	3	4	5

	STRONGLY DISAGREE	DISAGREE	NEITHER AGREE OR DISAGREE	AGREE	STRONGLY AGREE
30 I feel less capable, less confident or less useful because of my arm, shoulder or hand problem *(circle number)*	1	2	3	4	5

DASH DISABILITY/SYMPTOM SCORE = [(sum of n responses)–1] x 25 (where n is the number of completed responses)
n

A DASH score may not be calculated if there are greater than 3 missing items.

3

APPENDIX M: Amendment approval from IREC.

DUT DURBAN UNIVERSITY OF TECHNOLOGY

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

6 June 2017

Ms R J Coetzee
P O Box 785
Gillitts
3610

Dear Ms Coetzee

Application for Amendment of Approved Research Proposal

Work-related upper extremity musculoskeletal disorders among computer programmers in a selected software company in the eThekwini Municipality

I am pleased to inform you that your application to exclude Appendix L from your research proposal has been Approved.

Yours Sincerely

[redacted]

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2017 -06- 06
INSITUTUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

Appendix N: IREC approval for data collection.

DUT DURBAN UNIVERSITY OF TECHNOLOGY

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

9 June 2017

IREC Reference Number: **REC 8/17**

Ms R J Coetzee
P O Box 785
Gillitts
3610

Dear Ms Coetzee

Work-related upper extremity musculoskeletal disorders among computer programmers in a selected software company in the eThekwini Municipality

The Institutional Research Ethics Committee acknowledges receipt of your final data collection tool for review.

We are pleased to inform you that the questionnaire has been approved. Kindly ensure that participants used for the pilot study are not part of the main study.

In addition, the IREC acknowledges receipt of your gatekeeper permission letter.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

Yours Sincerely,

[redacted]

Professor J K Adam
Chairperson: IREC

DUT DURBAN UNIVERSITY OF TECHNOLOGY
2017 -06- 09
INSTITUTIONAL RESEARCH ETHICS COMMITTEE
P O BOX 1334 DURBAN 4000 SOUTH AFRICA

APPENDIX O: Editing certificate

DR RICHARD STEELE
BA, HDE, MTech(Hom)
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Practice No. 0807524
Freelance academic editor
Associate member: Professional Editors' Guild, South Africa

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031-201-6508/082-928-6208
Fax 031-201-4989
Postal: P.O. Box 30043, Mayville 4058
Email: rsteele@telkomsa.net

EDITING CERTIFICATE

Re: **Roxanne Jane Coetzee**
Master's dissertation: **Work-related upper extremity musculoskeletal disorders among computer programmers in a selected software company in the eThekweni Municipality**

I confirm that I have edited this dissertation and the references for clarity, language and layout. I am a freelance editor specialising in proofreading and editing academic documents. I returned the document to the student with track changes so correct implementation of the changes in the text and references is the responsibility of the student. My original tertiary degree which I obtained at the University of Cape Town was a B.A. with English as a major and I went on to complete an H.D.E. (P.G.) Sec. with English as my teaching subject. I obtained a distinction for my M.Tech. dissertation in the Department of Homeopathy at Technikon Natal in 1999 (now the Durban University of Technology). During my 13 years as a part-time lecturer in the Department of Homoeopathy at the Durban University of Technology I supervised numerous Master's degree dissertations.

Dr Richard Steele
11 November 2017
electronic