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OPERATOR WORK-RELATED MUSCULOSKELETAL DISCOMFORT DURING FORWARDING OPERATIONS IN SOUTH AFRICA: AN ERGONOMIC ASSESSMENT

By

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DECLARATION

I hereby certify that this thesis is my own work, except where duly acknowledged. I also certify that no plagiarism was committed in writing this thesis.

Signed_________________________

Kudakwashe Cletton Phairah

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DEDICATION

This thesis is dedicated to my parents, Mr and Mrs Elijah and Chiwoniso Phairah, your conviction that education is a key to a better society has always inspired me.

ABSTRACT

Forest machine operators are still experiencing work-related musculoskeletal disorders (WMSDs) despite extensive mechanisation and modernisation of harvesting systems. However, paucity of local ergonomics research and technology transfer problems threatens the sustainability of mechanised systems in South Africa. Consequently, this study was a field-based ergonomic assessment of local forwarding operations. PG Bison's North East Cape Forests (NECF) Eastern Cape operations and Komatiland Forests (KLF), Mpumalanga, operations were studied. The main aim of the study was to carry out an ergonomic assessment on local forwarder operator tasks, using Tigercat 1055 forwarders. The study specifically assessed WMSD prevalence and risk factors, investigated the frequency of awkward head postures, and evaluated work organisation.

A modified Nordic musculoskeletal questionnaire was used to survey WMSD prevalence and work organisation factors. During the shift, operators reported localised work-related musculoskeletal discomfort hourly. A video camera mounted in the cab was used to capture the footage of awkward head postures. The video footage was also used for the WMSD risk assessment using Health and Safety Executive (HSE) (HSG60) upper limb disorder assessment worksheets.

Operators reported that they had experienced WMSDs during the last 12 months, mainly in the lower back, neck, shoulders and upper back. The operators cited lower repetitive strain symptoms and higher lower back discomfort than in previous studies. Twenty three per cent of awkward head postures were extreme. Operators reported worse than normal psychological profiles. The study results support the assertion that causal pathways of WMSDs are complex and multifactorial. Repetition, awkward head posture, duration of exposure, vibration, psychological factors and individual differences were identified as the main WMSD risk factors.

Keywords: Musculoskeletal disorders, mechanised harvesting, ergonomics, South Africa

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UNITS OF MEASURE

1 centi-minute (cmin)	0.01 minute (min)
1 foot (ft)	0.305 metres (m)
1 pound (pound)	0.45359 kilograms (kg)
1 degree Fahrenheit (F)	-17.22222 degrees Celsius (°C)
1 inch (inch)	25.4 millimetres (mm)
1 United States dollar ($)	10.4850 South African rand (ZAR)
1 United States dollar ($)	0.7201 Euros (€)

LIST OF ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
HIV	Human Imuno-deficiency Virus
WMSD	Work-Related Musculoskeletal Disorder
TL	Tree Length
CTL	Cut-to-Length
FT	Full Tree
REBA	Rapid Entire Body Assessment
RULA	Rapid Upper Limb Assessment
LUBA	Loading on the Upper Body Assessment
OWAS	Ovaco Working Posture Analysis System

CHAPTER 1 INTRODUCTION

Global wood markets are characterised by progressively more severe competition. Operational cost reduction in the entire wood value chain has therefore become a necessity for survival in the industry. Timber harvesting and transport costs constitute an estimated 60% to 80% of the mill delivered costs (FESA, 2010). It is therefore necessary to invest considerable effort into the control and management of harvesting and transport costs. Technological and operational changes in harvesting are driven largely by the need to reduce costs (Brink, 1999).

Global forestry developments reflect a shift from traditional motor-manual to fully mechanised harvesting operations (Heinimann, 2007; Kastenholz, 2004; FESA, 2010; Längin & Ackerman, 2007). In contrast, transition in the developing regions of the world has been slow and fragmented (Heinimann, 2007; Längin & Ackerman, 2007). This is attributed mainly to the socio-economic contexts of these regions and the dilemma of technology transfer. Simply importing solutions without reference to local issues and resources is very likely to fail; modifications to imported solutions are generally necessary (Scott et al., 2010). The mechanisation drive has been driven largely by the need to improve productivity, health and safety.

Internationally, productivity has risen tremendously with the introduction of mechanised systems (Kastenholz, 2004; Komatsu Forest, 2011; FESA, 2010). In contrast, productivity in the developing regions has remained relatively low owing to the limited level of change in harvesting systems in the southern countries of the world. The South African forest industry has seen an estimated productivity drop of between 20% and 50% over the past 10 years (1997–2007) (Längin & Ackerman, 2007). Up to the last forest engineering survey that was completed in South Africa (Längin & Ackerman, 2007), harvesting was still done mainly with motor-manual systems. However, this trend has been changing towards mechanical systems in recent years. In their forest engineering survey, Längin and Ackerman (2007) reported that mechanisation was identified as one of the major future growth drivers of the South African industry and is driven largely by prevailing labour problems, low productivity and profound wage increases.

Mechanisation has led to a radical change in work methods. Modern forest machines are now technologically advanced, with the machine cab and work environment having largely improved. The operating environment is safer, with a lower risk of accidents. However, machine operators are still exposed to work-related musculoskeletal disorders (WMSDs) resulting from sub-optimal working conditions (Hansson, 1990; Axelsson & Pontén, 1990; Jack & Oliver, 2006; Gerasimov & Sokolov, 2009; Hagen et al., 1998). WMSD's are a range of conditions arising or associated with, work. They are marked by discomfort or persistent pain and/or other dysfunction in joints, muscles, tendons or other soft tissues of the body (Scott et al., 2010). These diseases result in production losses and higher production costs. The ErgoWood & European Commision (EC) (2005) carried out a survey on 358 machine operators in six countries. Twenty per cent reported working for up to a week while ill (work-related illness/symptoms); another 20% worked for more than a week while ill. Costs owing to working while ill and absence from work are often hidden and are not considered appropriately by machine owners. However, the ErgoWood & EC estimated that increased net machine availability and operator performance owing to good health might be worth €18 000 per year. In South Africa there is a general lack of ergonomics reseach data especially in mechanised harvesting operations, owing to the recent introduction of these technologies. Ergonomics reseach in South Africa has mainly focussed on heavy manual harvesting work such as timber handrolling (James, 2006) and chainsaw work (Scott et al., 2004).

The main problem is that the human factor is often overshadowed by a focus on technological aspects, although operators are the most important for the final outcome and the optimal use of technology (Ergowood & EC, 2006). The purpose of ergonomics is to enable a work system to function better by improving the interactions between users and machines (Bridger, 2003). The ergonomics approach focuses on the appropriate design of workplaces, systems, equipment, work processes and environments to accommodate workers (Scott et al., 2010).

Although good ergonomics research outputs are coming from developed countries, very little has been done in the developing countries. There is dire need for ergonomics research outputs in order to sustainably support the mechanisation drive, and optimise existing mechanical harvesting systems in South Africa. Consequently, this study focused on a field-based ergonomic assessment of the forwarding task in South Africa to assess the extent and impact of WMSDs on operators. Two operations were studied that are using Tigercat forwarders: one in the Eastern Cape, that is, PG Bison's North East Cape Forests (NECF) mechanised operation, and the other in Mpumalanga, namely the Komatiland Forests (KLF) mechanised operation. Both were in-house mechanised undertakings run by company staff and using company-employed operators.

1.1 Problem statement

Despite the technological development of forestry machines, machine operators are still experiencing WMSDs. If this problem of workplace hazards is so severe in more developed nations, it is likely to be exacerbated in industrially developing nations such as South Africa, since many compounding factors that are independent of the working environment (Christie, 2006) affect performance at work. These include technology transfer problems, the burden of diseases (including HIV/AIDS), and paucity of local research and development outputs. Sub-optimal work conditions threaten operational safety, productivity and long-term sustainability.

1.2 Main objective

The main objective of the current study was to carry out an ergonomic assessment of the forwarding task in harvesting operations in South Africa.

1.2.1 Specific objectives and associated research questions

In order to meet the main objective, the following specific objectives were defined for the study:

Specific objective 1: To assess the prevalence of WMSDs among forwarder operators in South Africa

a) What is the WMSD prevalence among operators?

b) What is the trend of localised work-related discomfort experienced by operators during a shift?

Specific objective 2: To investigate awkward operator head postures

a) How frequently are awkward head postures adopted by operators during the forwarding task (extreme lateral head rotation (LHR) to the right, minor LHR to the right, extreme LHR to the left, minor LHR to the left, extreme head flexion, minor head flexion, extreme head extension and minor head extension)?

b) How is the frequency of awkward head postures influenced by preferred backrest inclination?

Specific objective 3: To evaluate the work organisation factors

a) How do shift length, number of rest breaks and the length of rest breaks differ between NECF and KLF operators?
b) What are the psychological profiles of the operators?
c) Is there any difference in the psychological profiles between NECF and KLF operators?

Specific objective 4: To complete an operator WMSD risk assessment.

a) What are the WMSD risk factors associated with the local forwarding task?

1.3 Justification

Little ergonomics research and development has been done in the developing regions of the world and specifically in forestry operations. Transition of harvesting systems from traditional motor-manual to mechanised systems has resulted in a radical change in working methods. Mechanised operations are now safer and more productive, and modern ergonomically superior machines are being used. Nonetheless, operators in the developed regions still report WMSDs owing to the sub-optimal application of these work systems. Such work system problems will probably be aggravated in developing regions such as South Africa owing to their socio-economic environments and factors related to technology transfer problems. Guidelines or research output produced in developed countries may not reflect the biomechanical, physiological and socio-economic conditions of the South African work environment, hence the need for research that is highly contextualised to the requirements of the country (Todd, 2011).

The field-based approach of the current study deals with issues pertinent to the workplace, and therefore bridges the gap between theory and practice (Schreuder & Coetzee, 2010). The study enhances the understanding of operator WMSD prevalence and risk factors, awkward head postures, and work organisation factors of forwarding operations in South Africa. The knowledge gained by machine users and manufacturers through this study can assist in improving local mechanised harvesting systems. This will therefore lead to the alignment of health and performance objectives (ErgoWood & EC, 2006), by way of early detection of work hazards and early reaction to and prevention of uncontrolled, undesirable and unaccounted system outputs.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Sub-optimal work systems result in lower productivity and efficiency, compromised operator health and safety, and many other inappropriate system interactions (Bridger, 2003; Wilson, 2005a; Heleen et al., 2008; Scott et al., 2010). In this chapter, studies are reviewed on work-related musculoskeletal disorders (WMSDs) among forest machine operators, including timber harvesting, ergonomics, WMSD prevalence and risk factors and WMSD measurement methods.

2.2 Timber harvesting

Forest engineering is a critical part of the forestry value chain, and includes all activities required to transfer the standing tree into suitable products for further processing. These activities include timber harvesting, transport and road construction (Brink & Conradie, 2000). In literature, two different but related terms are normally confused or used interchangeably, that is, harvesting method and harvesting system (Pulkki, 1997).

'Harvesting method' refers to the form in which timber is delivered to the access road, and it depends on the amount of processing that occurs (Pulkki, 1997). Three harvesting methods are mostly used: full tree (FT), tree length (TL) and cut to length (CTL). 'Harvesting system' is defined by the tools, equipment and machines used to harvest an area (FESA, 2010). One can change the components of the harvesting system without changing the method. Harvesting systems can be manual, motor-manual or mechanised. According to Längin and Ackerman (2007), timber harvesting in South Africa is still predominantly done by motor manual methods in TL systems. However, this trend is changing towards more mechanical systems in line with global trends.

There has been a global transition from traditional motor-manual systems towards fully mechanised systems. Ownership of mechanised systems is capital intensive. It costs just over a million US dollars to purchase an entire mechanised harvesting system (Passicot & Murphy, 2013). These high ownership costs are likely to put more strain on operations in industrially developing countries, creating an even higher probability of sub-optimal work systems as operations try to offset these costs. To offset high initial investment costs, mechanical harvesting contractors often consider extended working hours in the form of increased working days, multiple shifts and increased shift length (Passicot & Murphy, 2013; Murphy & Vanderburg, 2007).

2.2.1 Forwarding

Forestry machines are normally named according to the work phases performed, the wood assortment on which the work is performed, the construction of the machine, and the place of its use (Pulkki, 1997). A single-grip harvester usually works together with a forwarder in a CTL mechanised harvesting system. A single-grip harvester fells and processes the tree into log products at the stump. A forwarder is a specialised forest machine that then transports the logs from the felling site to the landing area (Rehn et al., 2005a). The forwarder can be combined with other harvesting machines. The forwarder is explained in more detail since it is the machine type on which the current study was based. Figure 2.1 shows a Tigercat 1055B forwarder.

Figure 2.1: Tigercat 1055B forwarder in Witklip plantations, Mpumalanga

In some operations in South Africa, the forwarder is used in combination with motor-manual felling. In these operations, the felling, crosscutting and stacking tasks are completed with chainsaws combined with manual labour; more so in low volume thinning operations where saw timber is the primary crop. The forwarding cycle can be subdivided into the following work tasks:

- Travel empty
- Loading
- Travel loaded
- Offloading

Hydraulic booms of modern forest machines are controlled by two multifunctional levers engaging both hands of the seated operator. The levers are located in front of the armrests. They are moved forwards, backwards, and sideways by small hand and arm movements with maximum lever deviation of about 20° (Attebrant et al., 1997). The levers have two buttons that are controlled by the first and second fingers. In the forwarder, the levers control the rotations of the crane, the up/down motion of the boom, the in/out motion of the stick and opening, closing and rotation of the grapple. These motions facilitate the completion of two of the elements of the operating cycle of the forwarder, namely loading and offloading, and transport empty. Figure 2.2 shows the seat and controls of a Tigercat 1055 forwarder.

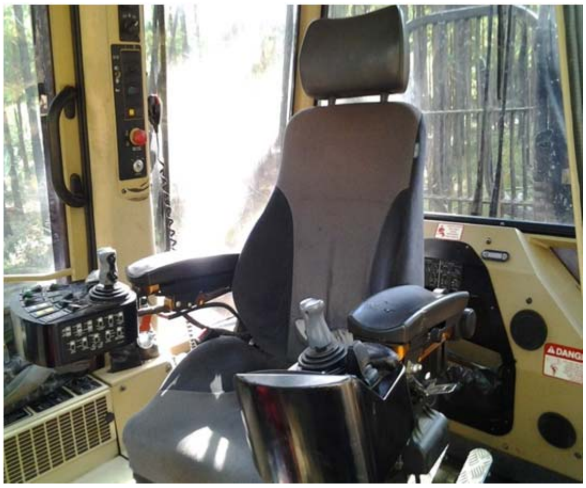


Figure 2.2: Tigercat 1055 forwarder seat and controls

2.3 Worker Capabilities

The human body is remarkably adaptable and capable of performance in a range of environments and circumstances. It however cannot be said that the body can perform equally well under all conditions. When faced with awkward tasks or environmental demands, the musculoskeletal system may endure substantial performance limitations (Gallager, 2005).

Hence, tasks need to be designed such that the demands of tasks are at or below the capacities of workers performing the task (Dempsey, 1998). Fig 2.3 shows primary factors influencing the task demands to worker capacity.

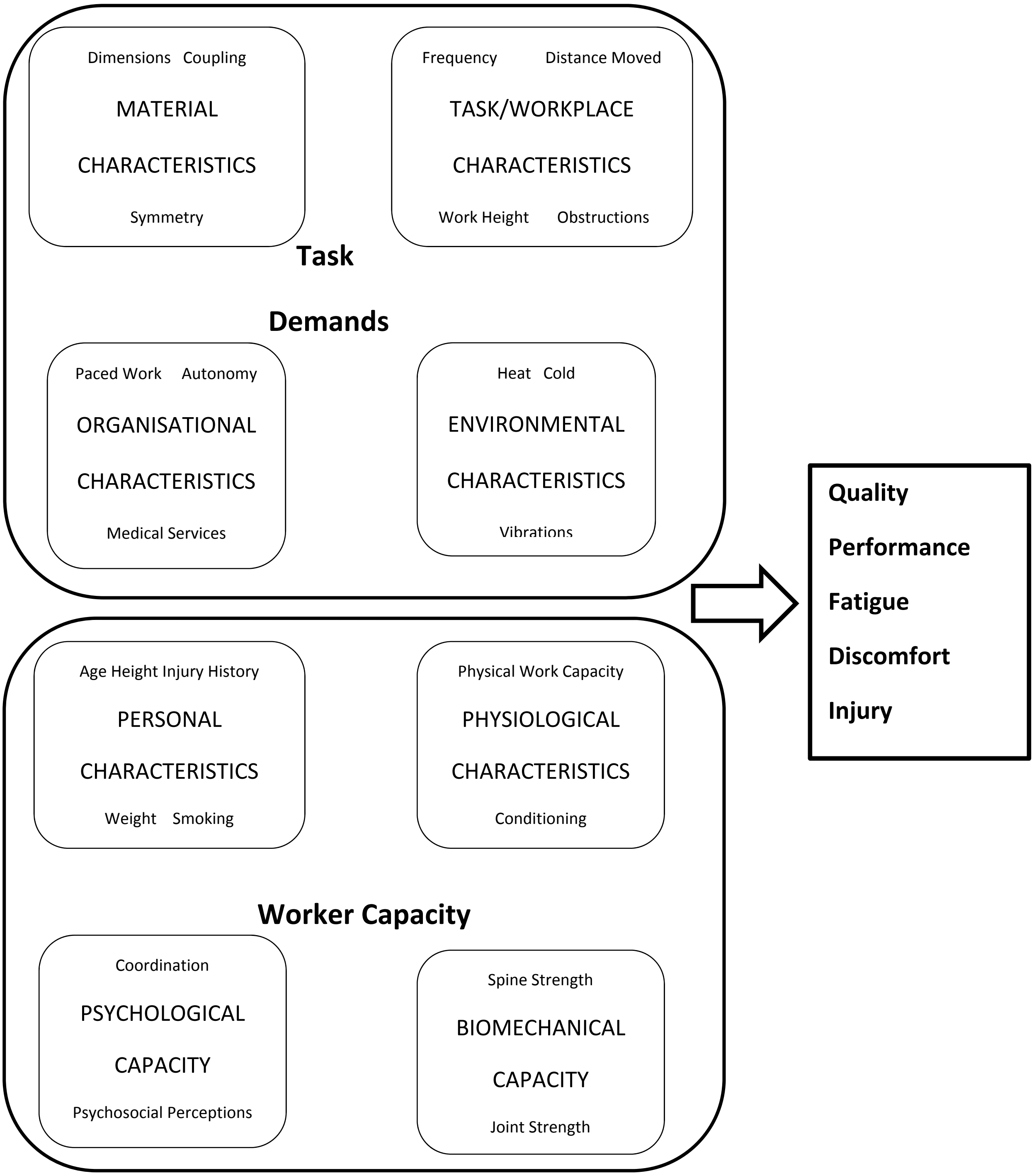


Figure 2.3: Primary factors influencing the task demands to worker capacity (adapted from: Dempsey, 1998)

According to Dempsey (1998) traditional manual materials handling task work, mainly included lifting, lowering, pushing, pulling, holding and carrying materials. However, owing to mechanisation and automation technologies within industry, these tasks have reduced or have been modified. Dempsey (1998) further elaborates, that the ratio of task demands to worker capabilities influences the occurance of potential undesirable outcomes such as fatigure, discomfort and injury. WMSDs among forestry machine operators have generally been associated with high job demands and low job control (Hanse & Winkel, 2008). Forestry machine operator work is characterised by monotony, excessive periods of sitting, excessive work intensity while working in fixed ergonomically inappropriate positions (Axelsson & Potén, 1990; Østensvick et al., 2008; Hansson, 1990), exposure to low-frequency whole-body vibration (Rhen et al., 2005a) and sub-optimal psychosocial work factors (Hagen et al., 1998). The situation in the developing countries is often made worse by the following factors that further limit worker outputs; shortage of high energy food (Bridger, 2003) , low level skills, HIV & AIDS, abnormally long shift periods, depreciation of equipment from overuse, trade union resistance, uncertainity (Steyn et al., 2010)

2.4 Ergonomics

According to Bridger (2003), 'ergonomics' is defined as the study of the interaction between people and machines and the factors that affect that interaction. Its purpose is to improve the performance of systems by improving human-machine interaction. Ergonomics is concerned with ensuring that work is designed to take account of people, their capabilities and limitations (Health and Safety Executive, 2002). Compatibility between the human operator and the entire work system can be achieved at a biomechanical, anatomical, physiological, behavioural and cognitive level (Bridger, 2003). The ergonomics approach focuses on the appropriate design of workplaces, systems, equipment, work processes and environments to accommodate the workers (Scott et al., 2004). Bridger (2003) adds that the purpose of ergonomics is to enable a work system to function better by improving the interactions between users and machines, thereby enhancing productivity, reliability and efficiency.

According to Adewumi (2008), ergonomics is an emerging branch of agricultural engineering in Africa. There has been limited ergonomics research in the forestry industry in the country. Research efforts have focused on jobs requiring heavy manual labour (Scott, 2006), such as timber hand rollers (James, 2006), manual peelers, stackers and chainsaw operators (Scott et al., 2004). Scott (2006) highlights that in South Africa and India, ergonomics research has focused on heavy manual labour, on the one hand, and on sedentary work related to computer use, on the other. Therefore, most of the previous work referenced in this study is from developed countries. In South Africa, there have been efforts to improve the ergonomic design of the tractor forwarding unit's workstation. Current mechanisation trends in South Africa are driven mainly by the importation of specialised purpose-built equipment. Extensive development of these machines has resulted in a much enhanced and more comfortable operator workstation. The workspace/station is the three-dimensional space in which work is carried out (Bridger, 2003). Figure 2.4 shows factors that influence working posture

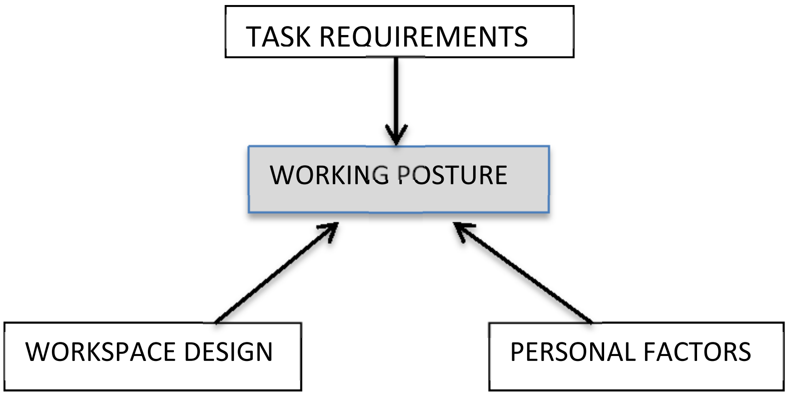


Figure 2.4: Postural triangle (adapted from: Bridger, 2003)

Attebrant et al. (1997) stated that in Sweden, owing to increased mechanisation of timber harvesting work, more people are working in an environment where they are using levers/controls. The ergonomic profiles of modern forestry machines have largely improved; machines are now safer and easier to maintain (Ergowood & EC, 2006; Hansson, 1990; Harstella, 1990). The ErgoWood and European Commission have developed ergonomic and safety guidelines that can be used to determine the ergonomic profiles of forestry machines by both manufacturers and users (ErgoWood & EC, 2006). According to Ergowood & EC (2006), standardised methods for measuring and interpreting machine profiles in 14 machine characteristics have been developed. The machine characteristics covered in the guidelines are cab access, cab design, visibility, operator's seat and armrests, controls, operating the machine, information from the machine, working posture, winch, noise, vibration, climate control, gases and particulates and lighting. The Ergowood & EC (2006) also stipulates that forest machines manufactured after 1 January 1995 shall carry a 'CE' mark and are presumed to meet the requirements in the Machinery Directive, 98/37/EMC-directive, 89/336/EEC and other standards. The CE marking is the manufacturers' declaration that the product meets the requirements of the applicable EC directives.

Such improvements over the years have contributed to fewer accidents and fewer problems owing to vibrations and working with levers, and machines are now being used for longer hours (Komatsu Forest, 2011; Jack & Oliver, 2006). However, many machine operators still experience WMSDs (Hansson, 1990; Axelsson & Pontén, 1990; Jack & Oliver, 2006; Gerasimov & Sokolov, 2009; Hagen et al., 1998; Komatsu Forest, 2011).

2.5 Musculoskeletal disorders

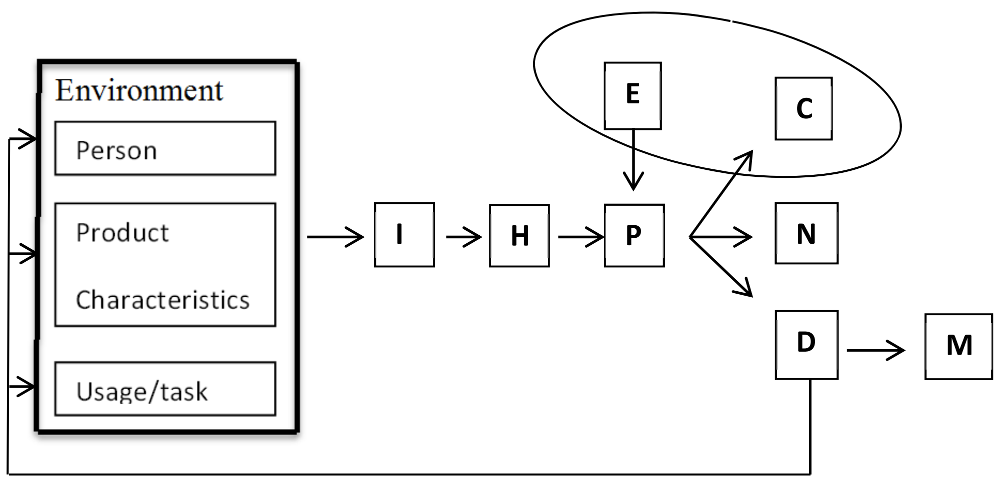
Musculoskeletal discomfort is measured as a short-term effect of an imbalance between physical capacity and exposure to work-related physical factors (i.e. the amount of discomfort on a particular day), and is defined by feelings of tension, fatigue, soreness, heat or tremors within the musculoskeletal system (Heleen et al., 2008). Tissues that are frequently injured because of exposure to occupational biomechanical hazards are ligaments, tendons, muscles, and nerves and less frequently bones and cartilage (Kumar, 2001). According to Bridger (2009), occupational stressors/hazards may be defined as the sum total of the individual stressors/hazards to which employees are exposed at work. These stressors may be physical, mental or psychosocial. Table 2.1 shows stress and fatigue at task- and job-based level.

Vink and Hallbeck (2012) define discomfort as an unpleasant state of the human body in reaction to its physical environment. Bridger (2003) stresses that discomfort is difficult to define and has both subjective and objective elements. Many studies use various systems to measure discomfort as a subjective phenomenon to be related to musculoskeletal injuries (Vink & Hallbeck, 2012). According to Vink and Hallbeck (2012), the interaction in an environment between the person and contact with a product and its usage results in a process that leads to feelings of discomfort, of comfort, both or feeling nothing. This interaction can ultimately end in musculoskeletal complaints. The person can respond to these feelings by shifting position or adjusting posture.

Table 2.1: Stress and fatigue at task- and job-based level (adapted from Bridger, 2009)

STRESSORS		STRAIN/FATIGUE	
Task level	Job level	Task level	Job level
Force	Work organisation	Muscle fatigue	High need for recovery
Posture	Shift system	Lack of substrate	Lack of resources
Repetition	Management style	Lactate build up	Depletion of neurotransmitters
Duration	Shift rotation/hours	Joint strain	Anxiety and depression
Work pacing	Autonomy and control	Musculoskeletal pain	Burnout
Climate	Effort-reward balance	Musculoskeletal disorder	
Environment	Progression/advancement		
Workstation design	Social support		
Interface design	Work family conflict		
User difficulties	Adequacy of resources		
	It support		

Bridger (2003) affirms the importance of exposure, dose, capacity and response processes in musculoskeletal disorder models. Figure 2.5 shows the comfort model.



(I) interaction, (H) human body effects, (P) perceived effects, (E) expectations, (C) feel comfort (N) feel nothing, (D) discomfort, and (M) musculoskeletal complaints

Figure 2.5: Comfort model (adapted from Vink & Hallbeck, 2012)

WMSDs are an issue of increasing concern internationally, and account for approximately 40–50% of all occupational injuries (Scott et al., 2004; Silvia & Naqvi, 2008; Hagen et al., 1998; Kumar, 2001). The work-relatedness of the disorders has been under much debate, with many researchers acknowledging that health problems are often exacerbated, if not caused by habitual daily activities (Bridger, 2003). This debate around the work-relatedness of the musculoskeletal disorders experienced by people is centred on two schools of thought (Bridger, 2003). The first draws little distinction between pain, disorder and injury, and prefers to use terms such as repetitive strain injury / cumulative trauma disorder to describe any kind of musculoskeletal problem, irrespective of whether it falls into a medical diagnostic category or not. The other school argues that there is lack of evidence that work causes musculoskeletal disorders apart from minor aches and pains that are reversible, avoids the use of superordinate categories, and favours distinct medical entities. They rather confine the discussion to symptoms (Bridger, 2003).

The ergonomics field is generally marked by a lack of scientific rigour and poor terminology (Bridger, 2003). This is often reflected by the confusion emanating from the use of the terms 'musculoskeletal discomfort', 'disorder' and 'injury'. In the literature, these terms are often used interchangeably. Musculoskeletal injury is defined as the mechanical disruption of tissues resulting in pain in addition to other biomechanical responses (Kumar, 2001). An injury can be idiopathic or traumatic (Kumar, 2001; Radwin et al., 2001). An idiopathic musculoskeletal injury cannot be assigned to a specific incident, whereas a traumatic injury can be clearly associated with an incident or action (Kumar, 2001). A musculoskeletal disorder is defined as any malfunctioning of an organ or organism and can result without mechanical perturbation of tissues; its onset is gradual and mediated by some pre-pathological progression (Kumar, 2001).

Invariable exposure to factors that place mechanical stresses on tissues results in musculoskeletal injuries. Most frequently such factors are repetitive and/or prolonged and forceful, and are thus considered risk factors (Kumar, 2001). A clear indisputable cause-effect relationship between exposure to risk factors and the onset of musculoskeletal injuries has not been established (Kumar, 2001; Bridger, 2003; Heleen et al., 2008; Radwin et al., 2001). Numerous ergonomics studies have used short-term cross-sectional methods, where exposures and outcomes are measured simultaneously (Heleen et al., 2008; Bridger, 2009). These cross-sectional studies have the limitation of failing to establish causality, and have a static view of working life. Such studies fail to capture the reality that in many occupations, job demands vary over time, as does the response to those demands (Bridger, 2009; Marras, 2012). Kumar (2001) argues that the ability of the tissues to undergo adaptation and recover from stress exposure make it difficult to easily determine a cause-effect relationship.

To date, few longitudinal studies have been done, compared with numerous cross-sectional short-term studies (Heleen et al., 2008; Bridger, 2009). Longitudinal studies are longer-term studies, in which a cohort of employees are observed, and multiple measures taken over a specified time on the same individuals. These studies are better at establishing causality. However, numerous studies have reported a strong relationship between exposure to risk factors and musculoskeletal injuries. Bridger (2003) elaborates that a number of well-documented musculoskeletal disorders exist that are often, but not always associated with work activities. Rotator cuff syndrome (Rhen et al., 2005b), carpal tunnel syndrome (Komatsu Forest, 2011) and cramp of the hand, among others, have been linked to the forwarding task.

Rotator cuff tendinitis is an inflammation or degeneration of the tendons in the region of the shoulder joint (Bridger, 2003; HSE, 2002). According to the HSE (2002), symptoms are aching and pain in the shoulder. Certain shoulder movements may be limited, depending on which tendon is affected. Rotator cuff tendinitis is associated with highly repetitive work and shoulder postures greater than 60 degrees flexion and abduction. Carpel tunnel syndrome is a peripheral nerve disorder resulting from compression of the median nerve as it enters the palm of the hand. Tingling, numbness and tenderness can occur several hours after activity, usually in the thumb, index and middle finger. Carpel tunnel syndrome is associated with a combination of risk factors, that is, force, repetition and posture. The HSE (2002) describes cramp of the hand as a focal dystonia, which affects the control and coordination of muscle activity. Spasm of the muscles in the hand or forearm is observed, which prevents the intended action from being performed. Cramp of the hand is associated with prolonged periods of repetitive movements of the fingers or arm.

2.5.1 Prevalence

Occupational driving (such as operating a forwarder) has been associated with the prevalence of back pain. Factors contributing to the pain are diverse and might include prolonged sitting, poor postures, exposure to whole body vibration and other non-driving factors such as heavy lifting, poor diet and other psychosocial factors (Robb & Mansfield, 2007; Bridger, 2003; Hanse & Winkel, 2008; Magnusson & Pope, 1998; Marras, 2012).

Despite improvements in the ergonomic profiles of machines, injuries and/or pain to the arms, neck, shoulder, legs and lower back are common in machine operators in the forestry industry (Hansson, 1990; Axelsson & Pontén, 1990; Jack & Oliver, 2006; Gerasimov & Sokolov, 2009; Hagen et al. , 1998). According to Attebrant et al. (1997), heavy manual tasks have been replaced by long periods of lever operations, placing a low and steady static load on the operator's shoulder/neck region.

Hagen et al. (1998) reported that harvester and forwarder operators are 3.37 times more likely to develop neck and shoulder pain than administrative workers, and the prevalence of lower back disorders increases significantly with age. Back pain is the most common form of WMSD, usually associated with manual handling of loads, awkward or static postures, or arising from vibration. Disorders of the neck, shoulders, arms and hands may be referred to as repetitive strain injury (Scott et al., 2010).

A study by the Swedish Institute of Occupational Health and the Swedish Foundation of Occupational Health compared 241 forestry machine operators, 107 forwarder operators ,49 harvester operator and 61 processor workers with 119 loaders in mines, and 484 professional drivers of cars, lorries and special purpose vehicles. The forestry equipment operators reported high prevalence of musculoskeletal symptoms in neck, shoulders and lower back. No difference was found between operators of forwarders, harvesters and processors in prevalence and location of symptoms. The symptom profile for forestry equipment operators was similar to that of loaders and professional drivers (Hansson, 1990).

According to time and motion studies (Hansson, 1990) on forestry machines, the duration per day of working with controls varies between machines. In forwarders, work with controls is limited to 30% to 50% of the total 8–12 hours' work per day, with each sequence lasting only one or two minutes. Axelsson and Potén (1990), in their results of health investigations of 1174 machine operators, indicated a prevailing average WMSDs of 50%, characterised mainly by neck and shoulder complaints. Prevalence over one year for shoulder/neck disorders was 50–80% among forestry machine operators. Prevalence increased with age; young operators' (20–25years) prevalence was 44%, increasing to 60% for the older (45–55 years) age group, with a working time of 10–19 years as machine operators. The lowest value of 27% was for the 35–44 age group with 1–4 years' working time.

Hanse and Winkel (2008), in a survey of 358 European forest machine operators, reported musculoskeletal symptom frequencies of 55% lower back, 49% neck and 41% shoulders, followed by 31% knees, 27% wrists/hands and 26% upper back. The lowest frequencies were for the hips 14%, elbows 14%, and ankles and feet 13%. The study used hierarchical multiple regression, and the overall model explained 3% ($p<0.05$) of variance in musculoskeletal symptoms. They noted that higher job control corresponds to a decrease in musculoskeletal symptoms and that many professional active years in forestry contribute statistically to an increase in musculoskeletal symptoms. Hagen et al. (1998) also reported a prevalence of 34 % in neck and shoulder disorders among forest machine operators; and noted that neck and shoulder disorders increased prominently with age.

Similarly, Jack and Oliver (2006), in a study on forestry mobile machine operators, reported 2.3 times more musculoskeletal symptoms in the neck, 1.9 times more shoulder symptoms, 2.4 times more upper-back and 1.1 times lower back symptoms than the control group. The symptoms corresponded to 61%, 56%, 20% and 47% of forestry mobile machine operators for musculoskeletal symptoms of the neck, shoulder, upper back and lower back, respectively. Østensvick et al. (2008) reported high postural exposures for the head, arms, trunk and wrist during forwarding activities measured during the value-adding work that constituted 30% of total working time.

2.6 Risk factors

A risk factor is an aspect that is associated with an increased likelihood of disease (Østensvick et al., 2008). According to Kumar (2001), all musculoskeletal injury risk factors can be placed in one of four categories: genetic, morphological, psychological and biomechanical (Figure 2.4). All occupational musculoskeletal injuries are largely biomechanical in nature. The main occupational factors associated with musculoskeletal conditions are force, posture, repetition, duration, fatigue, work organisation (shifts and rest breaks), psychosocial factors and work environment (i.e. vibration and lighting) (Bridger, 2003; HSE, 2006).

Kumar (2001) states that most risk factors may influence causation (directly or indirectly), but the one that starts the problem must first reach its threshold level for the given individual. Owing to the complex nature of human work systems, causation of musculoskeletal conditions is therefore multifactorial; exposure to more than one factor increases the prevalence of the disorder (Kee & Karwowski, 2007; Bridger, 2003; Kumar, 2001). Genetic and morphological factors are generally considered non-manipulatable, while psychological and biomechanical factors are manipulatable (Kumar, 2001).

Forestry conditions identified in the literature that put machine operators at increased risk of musculoskeletal injuries are repeated and intensive hand and foot movements to operate controls, constrained and awkward body postures, long exposure to whole-body vibration, high levels of perceptual and psychomotor demands, and joystick design (Jack & Oliver, 2006; ErgoWood & EC, 2006; Axelsson & Potèn, 1990; Attebrant et al., 1997). The forwarding task is generally characterised by monotonous, bilateral hand-intensive work in constrained body postures (Attebrant et al., 1997). No single factor dominates the behaviour of an operator, resulting in a multi-stress situation (Harstella, 1990). While acknowledging the complex multifactorial (Kee & Karwowski, 2007; Kumar, 2001; Marras, 2012) interaction of musculoskeletal risk factors to injuries, this study investigates operator exposure to awkward postures and work organisational factors. Figure 2.6 shows the multivariate interaction theory of musculoskeletal injury precipitation.

2.6.1 Awkward posture

According to Bridger (2003), the aetiology of musculoskeletal problems involves several factors. It is also known that pain can be caused or exacerbated by excessive loading of joints and muscles. This can occur not only because of traumatic events, but also owing to sustained exposure to particular working postures. The biomechanical strain placed on the human musculoskeletal system is primarily dependent on the posture adopted (Todd et al., 2007; Magnusson & Pope, 1998). Body posture is a major physical factor associated with occurrence of musculoskeletal disorders (Qu et al., 2012; Bridger, 2003). The human body moves and works more efficiently when joints are in the neutral range and the muscles are around mid length (Scott et al., 2010).

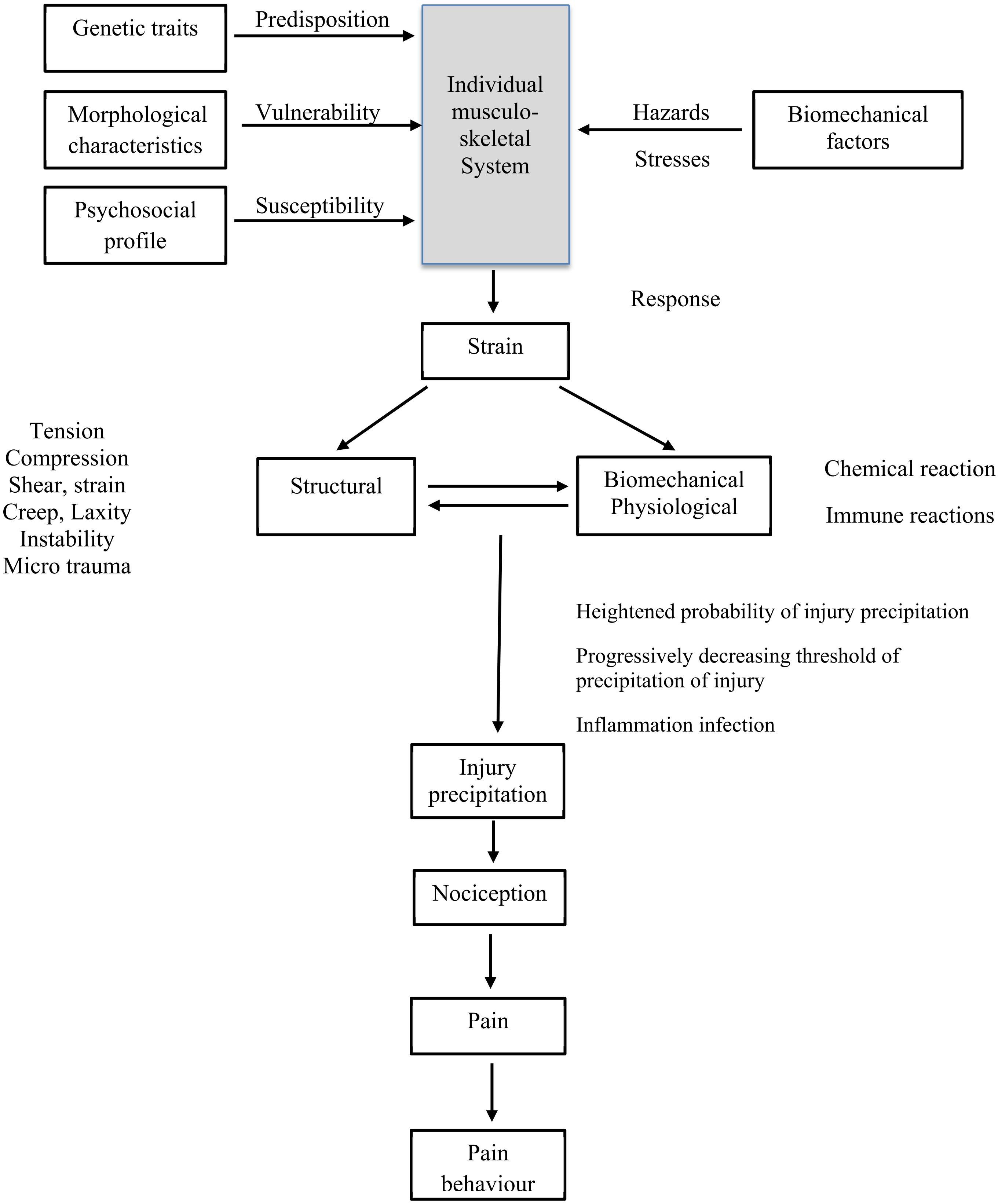


Figure 2.6: Multivariate interaction theory of musculoskeletal injury precipitation (adapted from Kumar, 2001)

Scott et al (2010) define an awkward working posture as a posture or working action required to execute a task that creates some discomfort, or cannot be maintained by the worker. An awkward posture is adopted when a body part is used well beyond its neutral position (HSE, 2002). A neutral position is where the trunk and head are upright, the arms are by the side of the body, the forearms are hanging straight or at right angles to the upper arm, and the hand is in the handshake position (HSE, 2002). Key components of exposure that contribute to loads experienced are angular relationships between the body parts, redistribution of masses of the body parts, forces exerted on the environment during the posture, the length of time that the posture is held, and the effects on the person maintaining the posture (Corlett, 2005).

According to Magnusson and Pope (1998), any prolonged posture will lead to static loading of muscles and joint tissues, and can consequently cause discomfort. They also point out that seated posture is influenced by a number of factors. These include the design of the seat, the task to be performed, the height and inclination of the seat, the position and shape of the backrest, and the presence of armrests. Guidelines for body posture and operator movement in the cab are influenced by the design of the cab, seats and controls, visibility and manipulation of controls, machine vibration and jolting (ErgoWood & EC, 2006; Magnusson & Pope, 2008). Tasks that require the adoption or repetition of postures at the extremes of the range of motion can lead to imbalances in antagonistic tendon units, resulting in degradation of joint function Kumar (2001). Mismatches between operator anthropometry and the workspace envelope can result in awkward postures (refer to Figure 2.3). Modern machine cab design is guided by several standards. ISO standard 3411 shows that 90% of a large sample of forest machine operators from all over the world are between 155 cm and 190 cm tall (well built, dressed in winter clothing, but not wearing a hard hat) and weigh between 55 kg and 109 kg, and that all forest machines should allow for all except the weakest 5% in that population (ErgoWood & EC, 2006).

Task demands, especially visibility, influence the operators' postures (Gerasimov & Solkolov, 2009; Jack & Oliver, 2006; Bridger 2003; Graf et al., 1995). The operator must have free view of the operating zone without having to adjust his or her posture. Mirrors and video camera assistance normally improve visibility (ErgoWood and EC, 2006). According to the ErgoWood & EC (2006), forest machine operators' visibility is aggravated if the operator has to follow the boom movement from a fixed cab. They stipulate that the head should not be turned more than 30° to the side or tilted more than 5° up or 25° down.

Occasionally turning the head sharply or bending it forward is not detrimental. Magnusson and Pope (1998) recommend that extreme postures of the head, especially neck flexion under whole-body vibration, must be avoided. Little is known about which postures are optimal. However, the human body is quite adaptable (Kumar, 2001) and can work in a wide range of postures, but poorly designed work systems force individuals to adopt awkward postures. According to Harstella (1990), work postures often contribute to strains that have long-term far-reaching effects, but have no immediate impact on the worker's behaviour or injury rates.

The need for good visibility in forest machines conflicts with machine design elements such as suitable boom position, thick cab pillars, sturdy rollover protection (ROPS) and protective grills (ErgoWood & EC, 2006, Eklund et al., 1994). Jack and Oliver (2006) highlighted that different postures can create conditions that more readily transmit or attenuate vibration. Similarly, Bridger (2003) comments that the loss of the 'S' shape of the spine in sitting operators or drivers of trucks and farm vehicles exposed to vibration in the vertical plane means that they are prone to back pain. Studies of seated postures indicate that backrest inclinations greater than 100° and lumber support reduce disk pressure and muscle activity (Magnusson & Pope, 1998).

In a study comparing a convectional harvester cab to a self-levelling swivelling cab, Gellerstedt (1998) found that the amount of time the harvester operators spent with their heads rotated beyond 22.5° was reduced by 10 to 28 minutes per hour in the self-levelling swivelling cab. Although the head rotation may still be within the ErgoWood & EC (2006) guidelines of 30°, any reduction in the repetition of postures at the extremes of the range of motion is likely to reduce the risk of WMSDs (Kumar, 2001). This demonstrates that operator postures can be improved through cab design. Similarly, Eklund et al. (1994) assert that rotatable and movable driver cabins improve head postures and viewing angles substantially.

According to a study by Gerasimov and Sokolov (2009), forwarders spent 73% of their time loading and unloading, 16% travel loaded (forwarding), 8% travel empty and 3% idling motionless when orienting. Results of this study also showed that forwarder operators spent 23% of total work time in uncomfortable work postures. Uncomfortable postures involved turning the head and body through large angles during loading and moving the machine. Rhen et al. (2005b) also reported that Swedish forwarder operators twist their necks more than 15° two to three times per minute. The load of the neck is correlated with the trunk and head position (Magnusson & Pope, 1998).

2.6.2 Work organisation

According to Bridger (2003), 'work organisation' refers to the immediate organisation of human-machine interaction. that is, the rate of work. More broadly, it refers to the organisational structure in which work activity is embedded and the technical and social system that supports it. The optimal utilisation of technology depends on an appropriate system of work organisation that determines the social organisation of the workforce and the relations and interdependencies between individuals. Organisational aspects of work are difficult and complex to operationalise, owing to different operational definitions (Hanse & Winkel, 2008). A study by Hanse and Winkel (2008) focused on work organisation aspects relating to monotony, job control, job rotation and work pressure, work organisational factors related positively to job satisfaction and to a minor extent to musculoskeletal symptoms. They concluded that it is difficult to find consistent evidence in literature that work organisation is a significant risk factor for musculoskeletal health. This was probably owing to 'healthy worker selection' or delay response to factors.

Contrary to these findings, Østensvick et al (2008), in a comparative study between Norwegian (n=19) and French (n=18) male operators, noted that the Norwegians reported higher levels of pain/discomfort in the right side of the neck in the morning, noon and afternoon compared with the French. Significant organisational factors related to diagnosis in the neck, shoulder and wrist. 'Use of control lever' in percentage of time was related to all diagnoses, whereas 'duration of lunch breaks', 'leaving the cab' and 'non-value-adding hand activity' were related to radiating neck pain. Both duration and frequency of non-value-adding hand activity were related to rotator cuff syndrome. The outcomes of these studies underline the complexities relating to operational definitions or terms used in the industry when referring to work organisation.

Hagen et al (1998) reported that an increasing level of psychological demands was significantly associated with increased prevalence of lower back disorders. They recommended that the forestry industry should pay more attention to psychological and organisational factors in future preventative programmes. Attebrant et al (1997) also recommended a reduction of lever control operations and adding other tasks in order to achieve an expanded and enriched job exposure.

Work organisation is generally guided by production needs and only to a minor extent ergonomics (Attebrant et al., 2007). In South Africa, owing to its socio-economic status, mechanical forestry work is characterised by mass production and employees with low-level skills engaging in repetitive tasks, operating complex machines while rotating on an eighteen-hour shift schedule six to seven days a week (Steyn et al., 2010). They add that such sub-optimal conditions are potentially harmful to the shift worker, starting with slight discomfort and then later triggering more devastating consequences.

According to Lilley et al (2002), fatigue and aspects of work organisation that are likely to be draining may be associated with compromised safety for forest workers. In their study, Lilley et al (2002) reported that 78% of forestry workers (including machine operators) experience fatigue at least ‘sometimes’ and they indicated the need for further investigation of shift and workload management among forestry workers. The South African case is more complex. Although most managers say rest breaks are mandatory, Steyn et al (2010) indicated that this is not always the case because of production targets and incentive schemes being in place. Incentives generally negate the benefits that can be derived and the viability of work systems (Steyn et al., 2010).

Forest machine operators do not seem to adapt to 10 hr or 12 hr schedules and none of the shift schedules are more advantageous than the others (Lebel et al., 2010). In fact, Steyn et al (2010) assert that there is no evidence of a single universal shift scheduling process applicable across the spectrum of mechanised harvesting operations. However, Lebel et al (2010) indicate that rigorous break management scheduled at times when their effect would be most beneficial is ideal. Steyn et al (2010) concur and stress that a balance needs to be found between production, remuneration and allocation of mandatory breaks. Forestry machine operators need a well-adapted shift scheme (Gellerstedt, 1997). Murphy and Vanderburg (2007) indicated that extending the hours worked per year may not be the best solution for improving profitability of all harvesting operations. Even though hourly costs are reduced, hourly productivity and safety may be negatively compromised. According to Harstella (1990), machine operator strain is very much dependent on the skill, work methods and their applications and the organisation of work.

2.7 Work-Related Musculoskeletal Disorder risk measurement methods

A range of methods have been developed to assess exposure to risk factors for work-related musculoskeletal disorders. These assessment techniques can be categorised into self-reports from workers, observational methods, and direct measurement methods (David, 2005). Drury (2005) comments that several methods and measures can be used in one study, especially when carrying out evaluations in the field. When this is done, it is referred to as triangulation. Validation of ergonomic assessment methods is a major challenge (David, 2005). Ideally, longitudinal studies over a sufficient period and method triangulation (Wilson, 2005b; David, 2005) can be used.

Developers of assessment techniques designed for use by practitioners have not adequately addressed the issue of ideal sample size for adequate representation of the occupational group being investigated (David, 2005). David (2005) states that 15 to 25 workers from a group was probably the minimum number for an adequate estimation of group average exposure to trunk flexion. According to Drury (2005), the main issue in study design is human variability and obtaining reliable results despite this variability. Within participants and between participants, variability can be minimised by choosing the correct independent variables. The downside of using a restricted sample is that the study findings cannot be generalised (Drury, 2005). This field-based study uses a combination of self-reports and observation methods to assess forwarder operator exposure to WMSD risk factors.

2.7.1 Self-reports

Self-reports from workers can be used to collect data on workplace exposure to physical and psychosocial factors (David, 2005). There are few methods to address psychosocial and work organisational factors (David, 2005). Those often used are diaries (Østensvik et al., 2008), interviews, questionnaires (David, 2005; Wilson, 2005a), scaling and rating (Wilson, 2005b). The Nordic musculoskeletal discomfort questionnaire (Robb & Mansfield, 2007; Hagen et al., 1998; Hanse & Winkel, 2008; Østensvik et al., 2008) and Karesek's demand/control questionnaire (Hagen et al., 1998) have been used extensively in forestry-related studies.

Scaling and rating measures are generally used as subjective assessments of the demands on people (Wilson, 2005b). The Borg CR-10 scale of intensity of discomfort/pain and body discomfort map (Østensvik et al., 2008; Scott et al., 2004; Heleen et al., 2008; Kee & Lee,

2012) is normally used. in a cohort (longitudinal) study to evaluate whether peak and cumulative musculoskeletal discomfort may predict future lower back, neck or shoulder pain among symptom-free workers, Heleen et al. (2008) reported that peak discomfort was a predictor of back pain (relative risk (RR)) 1.79); neck pain (RR 2.56); right or left shoulder pain (RR 1.91 and 1.90); cumulative discomfort predicted neck pain (RR 2.35); and right or left shoulder pain (RR 2.45 and 1.64). They concluded that peak and cumulative discomfort could predict future musculoskeletal pain. Discomfort per body region was rated on a ten-point scale six times per day. However, Heleen et al. question whether a ten-point scale is appropriate to measure musculoskeletal discomfort among healthy workers in an ergonomically well designed workplace. In agreement, Juul-Kristesen et al. (2001) recommend a reduction in class categories in observation methods.

According to Østensvik et al. (2008), the choice of category ratio scale of discomfort/pain could easily make participants fall into the habit of using the same numbers in repeated assessments, but this is usually not the case when rating lower exposures. Similarly, Vink and Hallbeck (2012) state that discomfort scales are more useful for low forces, and long testing periods may be useful to see differences in discomfort. They add that comfort or discomfort scales are useful to estimate the physical loading, especially above 65% maximal voluntary contractions (MVC).

According to David (2005), worker perception of exposure has been found to be imprecise and unreliable. Similarly, Graf et al. (1995) emphasis that those single measures using rating scales are not completely reliable long-term indicators of comfort/discomfort. They suggest that postural behaviour studies may be more revealing. Postural behaviour studies check the frequency and range of posture change. Drury et al (2006) argue that the worker must remain part of the ergonomic change process, and therefore direct worker discomfort self-ratings cannot be replaced by indirect rating by others.

2.7.2 Observation methods

In observation techniques, the angular deviation of a body segment from the neutral position is obtained from visual perception (Kee & Karwowski, 2007). According to Qu et al. (2012), observation techniques entail static and dynamic methods. Static methods involve estimation of working postures using videotapes or digital images, while in dynamic methods the observers do so in real time and record the data onto checklists. The number of exposure factors assessed by dynamic methods varies and is dependent on the observation method selected (David, 2005). These methods include OWAS, RULA, NIOSH lifting equation, REBA, LUBA, and HSE (HSG60) upper limb disorder guidelines. David (2005) comments on the downside of these methods, in their poor reliability resulting from the difficulty of observers in remembering all the values of variables and making a record immediately in the workplace. However, static methods are more complex and allow several joint segments to be analysed simultaneously. In addition, the images can be replayed.

Observational methods are valid, reliable, and low cost, and ease of use means they can be used to assess working postures without interfering with work. These methods are therefore more widely used in industry (Kee & Karwowski, 2007; David, 2005). Camera location has an impact on the visual estimation of errors of body postures. Qu et al. (2012) reported that 90° and 135° camera locations would be ideal for evaluation of all body segments combined. However, they recommend the 180° camera location for head-only motion observation.

In a study on the relationships between subjective and objective measures in assessing postural stress, Kee and Lee (2012) reported that the discomfort measured with magnitude estimation was linearly related to that measured with the Borg CR-10. They concluded that discomfort might be used as a measure for quantifying postural stress. Observation methods and technical measurements complement each other well (Juul-Kristensen et al., 2001).

2.7.3 Direct measurements

Direct methods rely on sensors that are attached directly to the subject to measure exposure to variables at work (David, 2005). Wilson (2005a) highlights that direct measurement methods for assessing demands and effects on people can be physical or physiological. Direct physical posture measurement methods include electromyography (EMG), electronic goniometry, inclinometers and body posture scanning systems (Kee & Lee, 2012; David, 2005; Attebrant et al., 2007; Østensvik et al., 2008). David (2005) indicates that direct methods have the advantage of providing large quantities of highly accurate data on a range of exposure variables. Wilson (2005b) argues that direct methods have a degree of bias or subjectivity when data is reanalysed and summarised. Their downside is that attachment sensors may result in discomfort and possibly modify participant behaviour, the equipment is expensive, and requires highly skilled personnel (David, 2005; Drury, 2005).

2.8 Conclusion

There is a paucity of ergonomics research in the developing world in general and the forestry industry in particular. Global trends show an increase in lever operations in forestry owing to a drive in mechanisation in many parts of the developed world. Sub-optimal harvesting work systems resulting from working in awkward postures over long periods, high concentration requirements, whole body vibration, repetitive hand, arm and head movements, and working in isolation have been linked to WMSDs. Forestry machine operators have shown discomfort/injury symptoms to the neck, shoulders, lower back and upper back. Owing to the complex and multifactorial nature of WMSD risk factors, a clear cause-effect relationship has not been established.

Traditional efforts in forestry to optimise machine operator work have been mainly through workstation improvement through better cab design. Modern forestry machine workstations are highly sophisticated and comfortable, and this has led to a significant reduction in accidents. However, despite such improvements, forest machine operators still have WMSD problems. The ergonomics approach focuses on optimising already complex human work systems. Measurement of exposure to risk factors for WMSDs can be done through self, observational or direct methods. For field studies, triangulation is an ideal method. Current ergonomic research shows that forestry organisations, other than mitigating physical risk factors at the workplace, must pay more attention to psychosocial and organisational factors.

CHAPTER 3 METHODOLOGY

In this chapter, the materials and methods used in the study are outlined. The key aspects presented include the study approach, description of study areas, harvesting systems, forwarder operator selection, WMSD prevalence and risk assessment, awkward head posture, work organisation and data analysis techniques.

3.1 Study approach

The study was a field-based ergonomic assessment on forwarding harvesting operations in South Africa. The limited number of mechanical operations in South Africa restricted selection to large corporate operations, which were using similar machine brands (Tigercat in this instance). Two pine mechanised harvesting operations were selected.

3.2 Description of study area

The study was done in the provinces of Eastern Cape and Mpumalanga (Figure 3.1). In the Eastern Cape, PG Bison's NECF Ugie harvesting operation was selected. In Mpumalanga, the KLF, Jessievale and Witklip harvesting operations were selected. Both operations were using Tigercat machines at the time of the study. The environmental conditions at each venue were not measured. This was because all the forwarders had a central cab climate-control system and therefore it was assumed that operators adjusted the internal cab climate to comfortable levels when operating the machine.

3.2.1 Ugie, Eastern Cape, South Africa

PG Bison's NECF Ugie estates are located between the longitudes 30°47′ S and 31°27′ S and between latitudes 27°58′E and 28°26′E. Terrain is variable, ranging from gently undulating slopes of the plateau to the southeast to foothills and steep slopes of the Drakensberg escarpment to the west and northwest. The climate is warm temperate, with the mean maximum temperature peaks at 25 °C between January and February, while minimum temperatures of minus 5 °C can be reached between June and July (SGS, 2010). NECF data were collected in July 2012. NECF data were collected in July 2012.

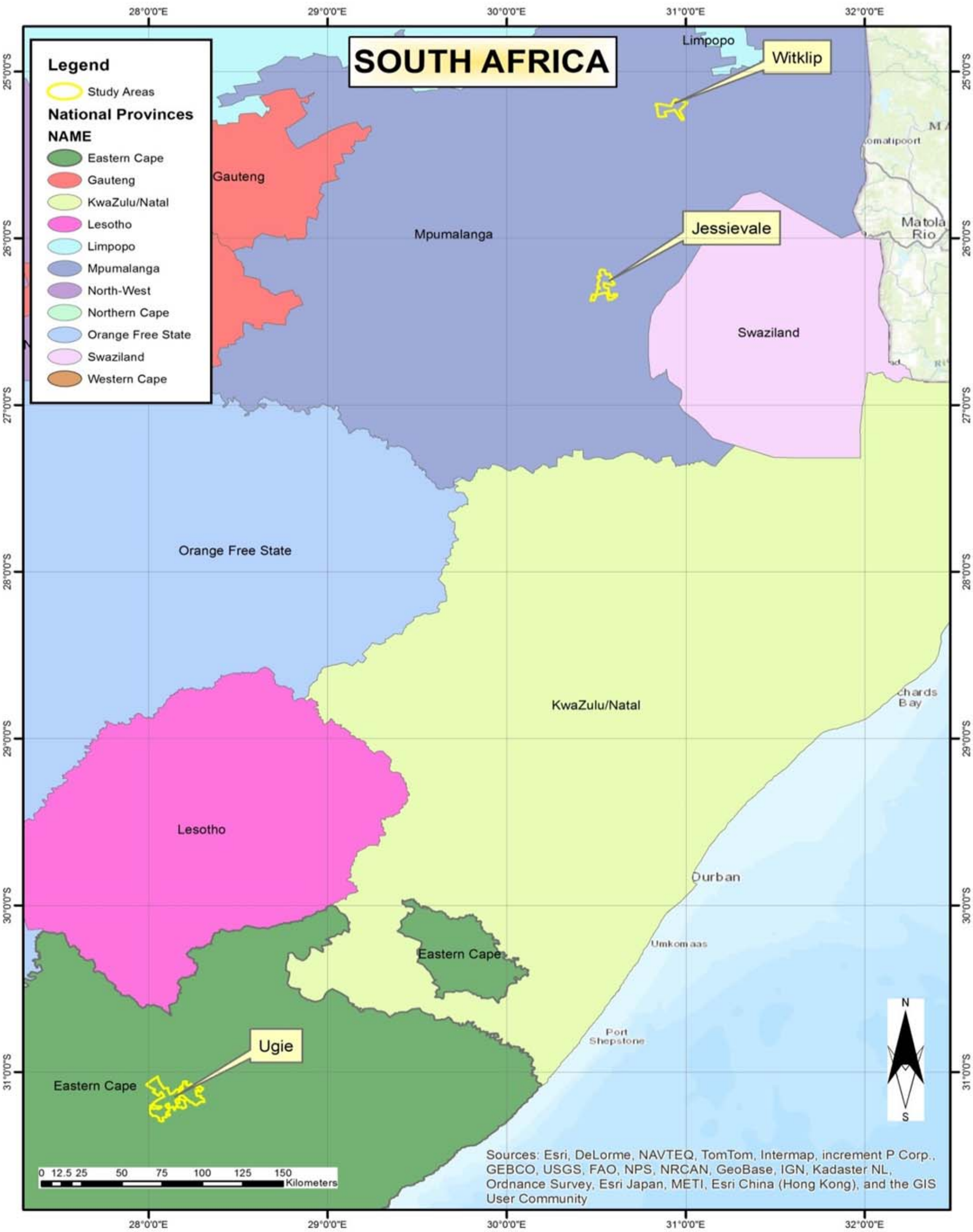


Figure 3.1: Map of study areas (source: York Timbers Planning Department)

3.2.2 Mpumalanga, South Africa

KLF Jessivale plantations are located in the Highveld region of Mpumalanga, between longitudes E/W 30°32′35 and latitudes N/S -26°17′04. The Witklip plantation is located in the escarpment region between longitudes E/W 30°55′04 and -25°13′20 latitude. The Highveld has generally level to very gentle undulating terrain conditions. The escarpment mainly has undulating slopes and foothills. The plantations are situated in the summer rainfall zone. Mean temperatures for summer and winter are around 18 °C to 24 °C and 10 °C to 16 °C, respectively (SGS, 2007). KLF data were collected in May 2013.

3.3 Description of harvesting systems

All operations investigated were using the cut-to-length harvesting method (CTL). The NECF Ugie clearfell operation was done mechanically using a combination of Tigercat LH822C harvesters and 1055 forwarders. Figure 3.2 shows the mechanised CTL harvesting system.

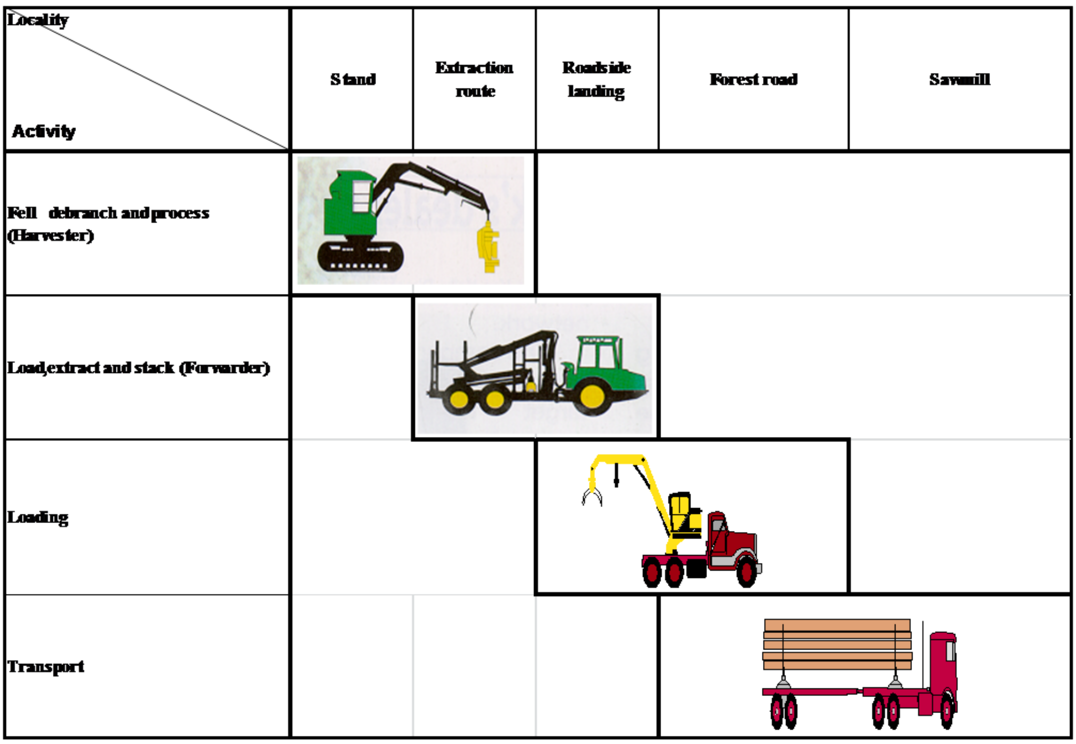


Figure 3.2: Mechanised cut-to-length harvesting system

The study followed compartments that were scheduled to be harvested at the time of data collection. These compartments were flat with good underfoot conditions. All compartments were clearfell, with the exception of Jessivale D13, which was a second thinning (refer to Table 3.1). Table 3.1 shows the compartments worked during the study. All Tigercat forwarders that were operational at the time of the study were included in the study. All these forwarders had comparable operating hours, except for the KLF Witklip forwarder, which was relatively new. Table 3.2 shows the forwarders used in the study.

Table 3.1: Compartments worked during study

Plantation	Cpt	Species	Vol/ tree m^3	Age	Slope class	Ground condition	Ground roughness
GlenCullen	F9	*Ppatula*	0.43	18	0–35%	very good	smooth
GlenCullen	G16a	*Ppatula*	0.41	17	0–35%	good	slightly uneven
GlenCullen	G17c	*Ppatula*	0.43	19	0–35%	good	slightly uneven
GlenCullen	F8	*Ppatula*	0.43	18	0–35%	very good	smooth
Witklip	F40a	*Ppatula*	0.51	18	0–35%	good	slightly uneven
Witklip	K28	*Ppatula*	0.42	17	0–35%	good to moderate	slightly uneven
Witklip	K18B	*Ppatula*	0.27	16	0–35%	good	slightly uneven
Jessievale	D13	*Ppatula*	0.37	15	0–35%	very good	smooth

Table 3.2: Forwarders used in study

Operation	Tigercat make/model	Machine identification	Machine hours
NECF	1055	VNE097	12733
NECF	1055	VNE094	12453
NECF	1055	VNE096	13172
KLF Witklip	1055B	754KLF	10700
KLF Witklip	1055B	058KLF	3829
KLFJessivale	1055	420KLF	12725

The NECF operated a 24-hour harvesting operation. The operation had three shifts working five days per week, namely a nine-hour morning shift from 0600 hrs to 1500 hrs, a nine-hour night shift from 1500 hrs to 0000 hrs, and a six hour late night shift from 0000 hrs to 0600 hrs. The late night shift also worked two 12-hour shifts from 0600 hrs to 1800 hrs on Saturday and Sunday. The shifts alternated weekly. From the night shift, operators went on a five-day off-duty break, and then came back for the late night shift. Owing to the field nature of the study, direct observations and video capture were done during daylight working hours from 0600 hrs to 1700 hrs. NECF data were collected for the morning and afternoon shifts between 2 July 2012 and 7 July 2012.

KLF operations had two harvesting systems in use, a mechanised CTL system using a Tigercat LH822C harvester, and a Tigercat 1055B forwarder in clearfelling (Figure 3.2) and a semi-mechanised CTL system (Figure 3.3). The semi-mechanised system involved felling and manual stacking and then extracting mechanically with a Tigercat 1055 forwarder. The Jessivale operations used the semi-mechanised system in thinnings, and one Witklip team also used the semi-mechanised system in clearfell operations. Transferring from manual cutting to mechanical cutting changes the character of the harvesters' wood bunching, leading to a more scattered pile structure (Nurminen et al., 2006). This might therefore have affected the loading efficiency of the forwarder. Figure 3.3 shows the semi-mechanised CTL harvesting system.

KLF operated a two-shift system in their clearfelling operation – a nine-hour morning shift from 0500 hrs to 1400 hrs and a nine-hour night shift from 1400 hrs to 2300 hrs. The shifts alternated weekly. After the night shift, operators had one day off duty and a relief operator filled in. The thinning operations worked on three nine-hour shifts, five days of the week, with potential overtime work on weekends for both systems. KLF data were collected done during daylight working hours from 0600 hrs to 1700 hrs between 29 April 2013 and 10 May 2013. All observations for both companies were done from the first day the operators came back from their scheduled rest break.

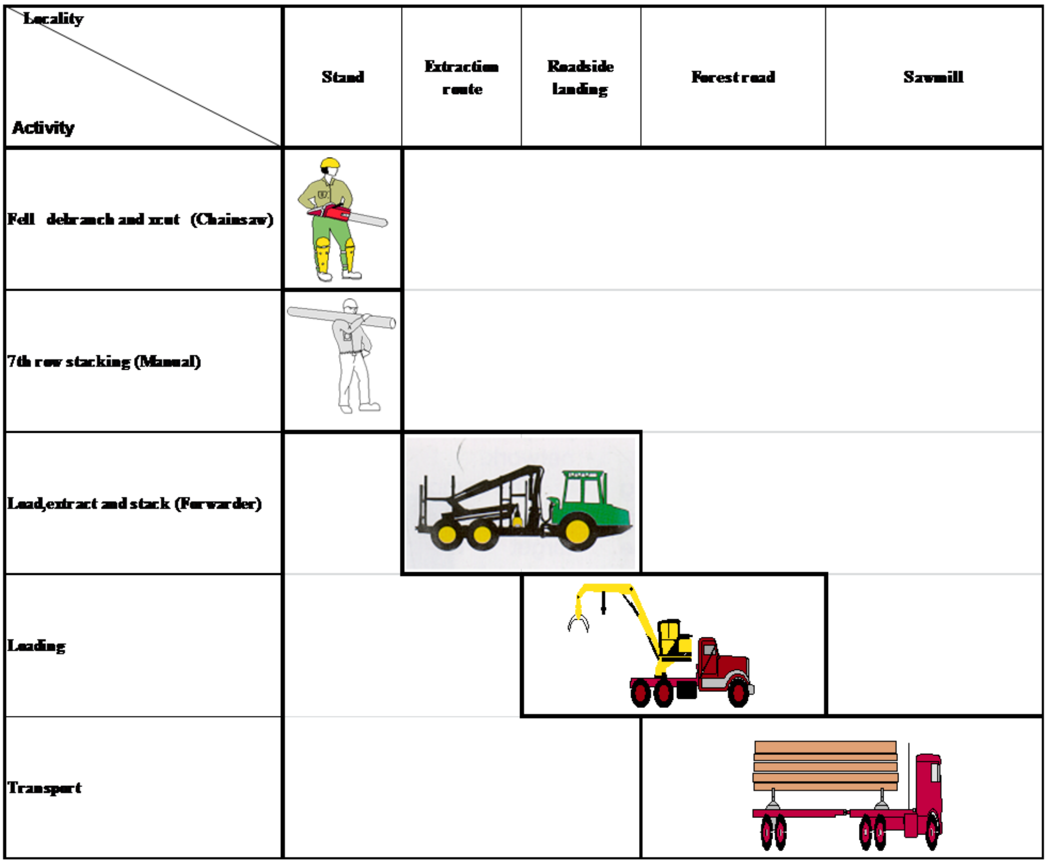


Figure 3.3: Semi-mechanised cut-to-length harvesting system

3.4 Forwarder operator selection

All male forwarder operators employed by NECF in the Eastern Cape Ugie operations and KLF in the Mpumalanga operations were approached for participation in the study (n=20). Only male operators were studied, this was done to limit participant variability (David, 2005). All twenty operators approached agreed to participate. Participation was anonymous, and operators were identified by random numbers, given at the beginning for data management only. WMSD prevalence and work organisation data was collected by means of survey. Awkward postures and WMSD risks were assessed through observation of video footage. Twelve NECF operators participated, of whom two were supervisors with experience in operating forwarders and who would sometimes operate the machines when an operator is unavailable. The two supervisors took part in the survey only, and were not observed operating a forwarder. Eight KLF operators participated in the study. Table 3.3 shows the study participants.

Table 3.3: Study participants

Method	Company	Participants
Survey	NECF	12
	KLF	8
	ALL	20
Observations	NECF	10
	KLF	8
	ALL	18

3.5 Forwarding tasks

The forwarder operator job was subdivided into the following tasks: travel empty, loading, travel loaded and offloading (Gerasimov & Sokolov, 2009). All other activities were classified as idling time. Specific work elements required to complete the studied forwarding cycle are shown in Figure 3.4.

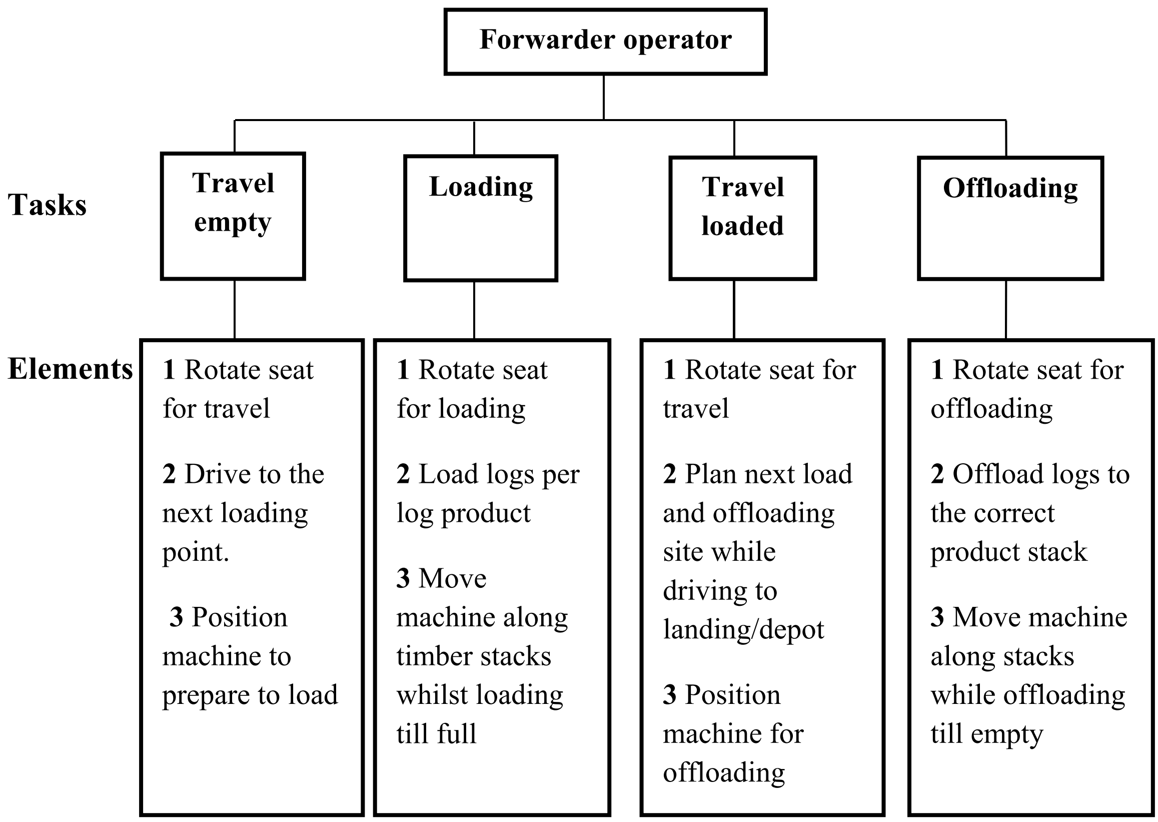


Figure 3.4: Tasks and elements of a forwarder operator

3.6 Data collection

In this section, data collection methods are described.

3.6.1 Work-Related Muscoloskeletal Disorder prevalence

Methods to assess exposure workplace risk factors for WMSDs can be categorised as self-reports, observational methods and direct measurements (David, 2005; Wilson, 2005a). Self-reporting using the modified standardised Nordic musculoskeletal discomfort questionnaire (Kuorinka et al., 1987; Corlett, 2005) (Appendix 2) was deemed an appropriate tool in the study owing to it being straightforward to use with limited resources (especially in developing countries such as South Africa). The standardised Nordic musculoskeletal discomfort questionnaire addresses psychological and work organisational factors, and is valid and reliable for the objectives of the study.

Survey

The reliability and validity of the questionnaire had been investigated by Kuorinka et al. (1987). Subject responses were compared with their clinical history, and the test-retest method was used to test reliability. They found that the questionnaires provided useful and reliable information on musculoskeletal symptoms. To assess localised musculoskeletal discomfort during the forwarding task, a perceived musculoskeletal discomfort rating scale (Appendix 4), together with a body part drawing (Appendix 3) were used.

The modified Nordic musculoskeletal questionnaire (Kuorinka et al., 1987; Corlett, 2005) was translated into isiZulu in order to assist operators to interpret the questionnaire. Although the risk of losing the original meaning of the questions through translation was apparent, this was minimised through interviews with the operators before and after completion of the questionnaire to clarify misinterpretations.

An initial meeting was held with all potential study participants. All operators that were approached consented to participating in the study. Operators were issued with invitation letters (Appendix 1) and questionnaires. The operators were requested not to undertake any strenuous activities during the test week. This was done to minimise the influence of external factors on the results. The researcher explained how to fill in the questionnaire and clarified it to each operator.

The operators were requested to fill in the questionnaire in their own time and return the completed questionnaire the following day. The researcher measured the individual operator's weight to the nearest 0.1 kg and height to the nearest 1 mm, using a digital bathroom scale and stature measuring tape measure. This was done with the operators in their work clothes without shoes and hard hats. The measurements were recorded on the operator's questionnaire.

Body discomfort scoring template

On the test day, the operators were issued with a perceived musculoskeletal discomfort scale (Corlett, 2005) (Appendix 4), together with a human body drawing from behind, which showed 27 human body parts with distinct body-part boundaries for precise identification Corlett, 2005) (Appendix 3). The operators were asked to record hourly the intensity of discomfort on a scale of 0–7 and location. For the purposes of the study, only the following upper body parts were further analysed: neck, upper back-a, upper back-b, lower back-a, lower back-b, and left and right shoulders (Appendix 3). This was mainly because operators reported some discomfort in these body areas (see Results page 44 for details).

3.6.2 Awkward head posture

On the test day, a Kodak ZM1 Mini Video Camera with a window suction mount was mounted on the right cab window of the forwarder, level with the seated operator's head (rear facing loading position). In this camera position, the operator's head and right hand (holding the joystick) were in full camera view. The operator was recorded during the first quarter of his shift for at least 40 minutes doing normal forwarding work (Gerasimov & Sokolov, 2009). This was done once for each participant. Owing to the nature of the shift systems, which overlap between day and night, the first quarter of the shift was selected in order to utilise daylight hours (video recording and direct observation) for two shifts per day. A parallel time study was also done alongside the video recording. A digital stopwatch was used to record the forwarding task cycle times in centi-minutes. Immediately after recording, the video footage was downloaded and stored on a laptop computer. The video recording was later used to assess operator head postures during the forwarding task. Only the frequency, and not the time spent in each of the awkward head postures that were adopted during each task (travel empty, loading, travel loaded and offloading) were assessed. Head flexion and extension (minor and extreme), lateral head rotation to the right and left (minor and extreme) (Appendix 6) postures were assessed. All video analysis and interpretation was done by the researcher and captured manually onto worksheets. Figure 3.5 (a–h) shows postures assessed in the study.

Figure 3.5(a–h): Postures assessed in study

a) Extreme lateral head rotation to the right (elr); b) Minor lateral head rotation to the right (mlr); c) Extreme lateral head rotation to the left (ell); d) Minor lateral head rotation to the left (mll); e) Extreme head flexion (ef); f) Minor head flexion (mf); g) Extreme head extension (ee); h) Minor head extension (me)

Preferred backrest inclination

Task demands have a significant effect on sitting position (Graf et al., 1995; ErgoWood & EC, 2006; Magnusson & Pope, 1998; Jack & Oliver, 2008). The seated posture is determined by both the design of the seat and the task to be performed. The height and inclination of the seat, position and shape of backrest and presence of armrests influence the sitting position (Graf et al., 1995; Magnusson & Pope 1998). Backrest inclination is an important factor, and several studies have found it has a major influence on myoelectric activity in the erector spinae and lumbar disk pressure (Magnusson & Pope 1998; Todd et al.., 2007). In the current study, the preferred backrest angles were measured to determine whether there was any relationship with the frequency of awkward head postures adopted. The operator's preferred seat backrest inclination angle was measured according to the method prescribed by (ErgoWood & EC, 2006) (Appendix 5). This was done once at the beginning of the shift, using a protractor and measuring tape.

3.6.3 Work organisation

Forwarding task time elements (weekly working hours, number of rest breaks, and length of rest breaks) and operator psychological profiles were regarded as the work organisation parameters. Both the forwarding time elements and psychological profiles were reported by the operators through the modified Nordic musculoskeletal questionnaire. The general health questions were administered at the same time with the WMSD prevalence questions (refer to 3.6.1). Actual machine hours worked were captured from the operator's daily production reports for the study period.

The operator psychological profile was based on the following 12 general health questions: 1) ability to concentrate; 2) losing sleep over worry; 3) feeling that you are playing a useful part in things; 4) decision making; 5) feeling constantly under strain; 6) overcoming difficulties;7) ability to enjoy normal day-to-day activities; 8) facing up to problems; 9) feeling unhappy or depressed; 10) losing confidence in yourself; 11) having been thinking of yourself as a worthless person; and 12) feeling reasonably happy, all things considered. The answers for the general health questions were scored on a scale of 1-4 (1 = better than normal condition, 2 = normal/usual, 3 = worse than normal and 4 = much worse than normal condition). The mean score for all the answers was used to reflect the general operator psychological profile.

3.6.4 Work-Related Musculoskeletal Disorder risk assessment

The forwarding task is complex, making it extremely difficult to observe and record all the musculoskeletal risk factors at the same time. The video camera captured and stored the forwarding activities. The recorded videos were later used to assess the forwarding task WMSD risk profile. The Health and Safety Excecutive (HSE) guidance tool was used to assess WMSD risks (HSE, 2002). A two-stage assessment was conducted.

The first stage involved the completion of a risk filter worksheet (HSE, 2002) (Appendix 7) to help identify hazards where a more detailed assessment would be necessary. The second stage involved the use of the more detailed assessment worksheets (HSE, 2002) (Appendix 8), for those tasks identified as hazards by the risk filter.

3.7 Data analysis

This section highlights the basic data-processing steps and statistics applied to the data. All analysis was done with the statistical software SAS® V9.3 under Windows XP (SP3) on a desktop computer at the Department of Statistics, University of Pretoria.

Basic data processing

i) Data were supplied in MS/Excel format. ii) Taken in SAS. iii) Printed and checked for errors and inconsistencies using PROC PRINT and PROC FREQ from SAS.

Statistics

i) PROC FREQ was employed for descriptive statistics for total data, and then ‘by processing’ for company, age group and experience group and combinations of these. ii) PROC MEAN was employed as above on total data as well as employing by processing for company, age group and experience group and combinations of these. iii) On inspection of the results from these procedures it was decided to perform non-parametric statistics using BMDP 7.01.2009 software and specifically the 3S program.

Non -parametric tests

Fisher’s exact test was used to test for significance between the mean neck, shoulders, elbows, wrists, upper-back and lower back discomfort frequency reported by the operators, during the last 12 months, 7 days and prevention from carrying out normal duties, for the two companies (NECF & KLF), age (20–30 years and >30 years) and experience (0–36 months,

>36-60 months and >60 months) groups. Owing to the small size of the data in the contingency tables, Fisher's exact test was regarded as suitable for the dataset.

Friedman's non-parametric test was performed with multiple comparisons for the following means of the variables: lower back, neck, shoulders and upper back operator discomfort during the last 12 months, 7 days, and prevention from carrying out normal duties. This was done to see whether further investigation of any relationships between the variables was warranted.

Kruskal-Wallis non-parametric test was used to determine significance between the means of:
i) the dependent variables: discomfort reported in the upper back, shoulders, neck and lower back during the last 12 months, 7 days, and prevention from carrying out normal duties; and the independent variables: company (NECF and KLF), age (20–30 years and >30 years) and experience (0–36 months, >36–60 months and >60 months)
ii) dependent variables: transformed mean head postures; and the independent variable: company
iii) dependent variables: transformed mean head postures; and the independent variable: preferred backrest inclination (<100°, 100° and >100°)
iv) dependent variables; shift length, number and length of rest breaks and the independent variable company
v) dependent variables: responses to psychological questions; and the independent variable: company, age and experience

Confidence level was set at 95% ($p<0.05$) for all the results that will be presented. The error bars that appear in all figures represent standard error.

CHAPTER 4 RESULTS

The main objective of this study was to do an ergonomic assessment on forwarding operations in South Africa. In this chapter the results of the study are presented. These include operator demography and anthropometric characteristics, WMSD prevalence and risk assessment, awkward head postures and work organisation.

4.1 Operator demography and anthropometric characteristics

The demographic and anthropometric characteristics for all NECF and KLF operators are shown in Table 4.1. The mean operator age was 33.85 years. The mean age for NECF and KLF operators was 27.5 years and 43.38 years, respectively, and the mean forwarding experience was 46.8 months. All operators sampled were right handed.

Table 4.1: Operator demography and anthropometric characteristics

Demography	N	Mean	Std dev	Std error	Range
Total sample	20				
Age		33.85	9.66	2.16	22 – 50
Weight (kg)		77.36	13.44	3.01	51.1 – 98
Height (cm)		172.70	8.56	1.91	154 – 185
Experience (months)		46.80	30.44	6.81	6 – 120
NECF	12				
Age		27.50	4.19	1.21	22 – 37
Weight (kg)		73.32	15.20	4.39	51.1– 98
Height (cm)		171.25	7.82	2.26	154 – 178
Experience (months)		42.40	20.38	5.88	11 – 61
KLF	8				
Age		43.38	7.27	2.57	28 – 50
Weight (kg)		83.49	7.52	2.69	75.6 – 96
Height (cm)		174.87	9.69	3.42	154 – 185
Experience (months)		53.40	42.20	14.92	6 – 120

All operators were right handed

Owing to the field nature of the study and the shortage of experienced forwarder operators in South Africa, only available operators were investigated and this resulted in the large age discrepancy between the two sample groups. However, an attempt was made to treat age and experience as co-variables.

4.2 Work-Related Musculoskeletal Disorder prevalence

Figures 4.1, 4.2 and 4.3 show the prevalence per body site of WMSDs experienced by all NECF and KLF operators, respectively, during the last 12 months, 7 days, and whether the discomfort experienced in the last 12 months had prevented them from carrying out normal activities. Operators reported having experienced discomfort during the last 12 months mainly in the lower back (12) (60%), neck (8) (40%), shoulder (6) (30%) and upper back (8) (40%). Lower back (4) (20%) and upper back (5) (25%) discomfort during the last 12 months were the main causes that prevented operators from carrying out normal duties (Figure 4.1).

Friedman's non-parametric test was performed with multiple comparisons for these variables: lower back, neck, shoulders and upper back operator discomfort during the last 12 months, 7 days, and prevention from carrying out normal duties (Appendix 9), to see whether further investigation was warranted. No significant relationships between the variables were found ($t = 14.99$, $p = 0.183$, 11 df, Kendall's W = 0.068).

NECF operators (Figure 4.2) reported significantly higher prevalence of neck ($t = 3.99$, $p = 0.046$, 1 df) and upper back ($t = 3.99$, $p = 0.046$, 1df) discomfort in the last 12 months than KLF operators (Figure 4.3). However, there was no significant difference in reporting shoulder, elbow, lower back and wrists between the operators of the two companies.

For musculoskeletal discomfort, there was a significant difference in reporting lower back discomfort during the last 12 months, 7 days, and prevention from carrying out duties by all operators (p = 0.009) and NECF (p = 0.025) operators with forwarding experience of >36-60 months. No significant difference was found among KLF operators. Of the total operators with >36–60 months experience, 75% reported experiencing lower back discomfort during the last 12 months, 37% in the last 7 days. In addition, none that experienced discomfort in the last 12 months were prevented from carrying out normal duties (Appendix 13). For the other experience and age groups, no significant differences were found for neck, shoulders, elbows, upper back and wrist discomfort reporting for other experience and age groups.

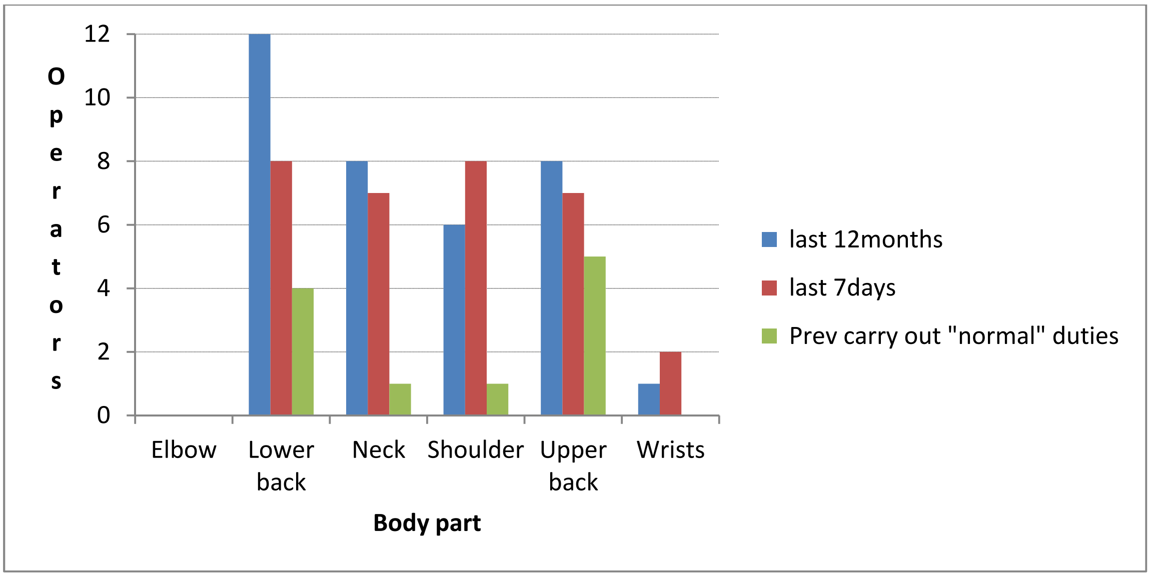


Figure 4.1: Number of operators reporting musculoskeletal discomfort and number of operators prevented from carrying out ‘normal duties’

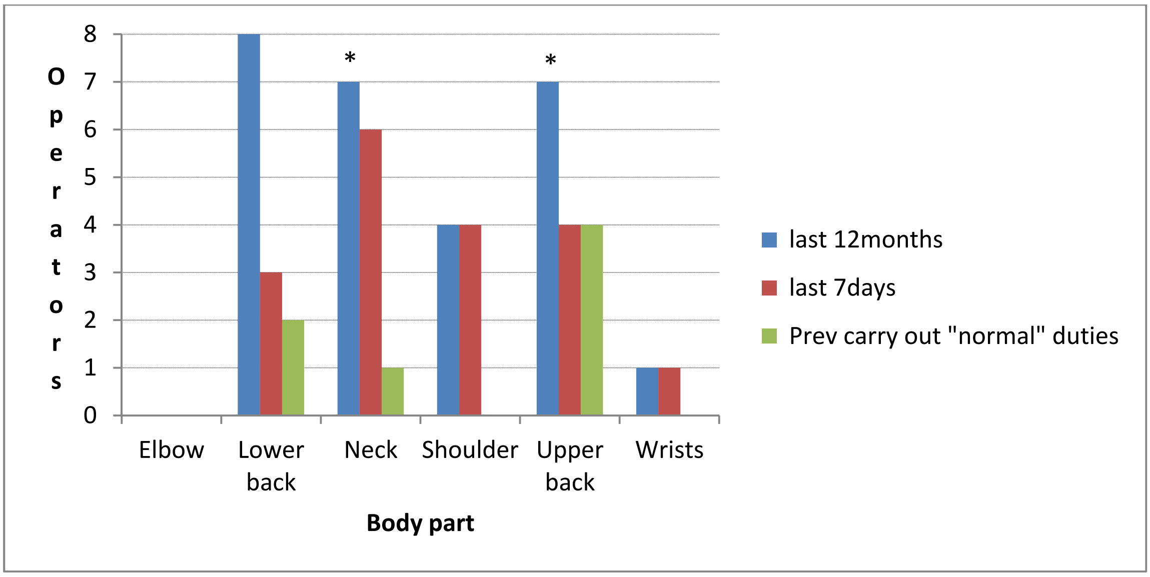


Figure 4.2: Number of NECF operators reporting musculoskeletal discomfort and number of NECF operators prevented from carrying out ‘normal duties’

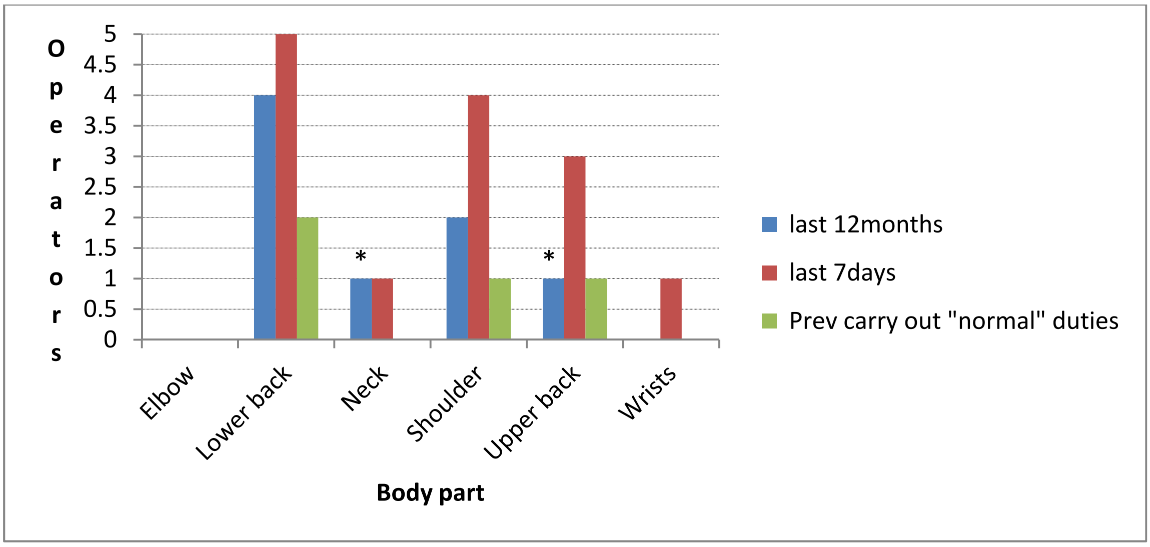


Figure 4.3: Number of KLF operators reporting musculoskeletal discomfort and number of KLF operators prevented from carrying out 'normal duties'

Duration

Most of the operators (all, NECF, and KLF) who reported having experienced discomfort in any body area in the last 12 months indicated that they experienced discomfort between 1 and 30 days (Figure 4.4)

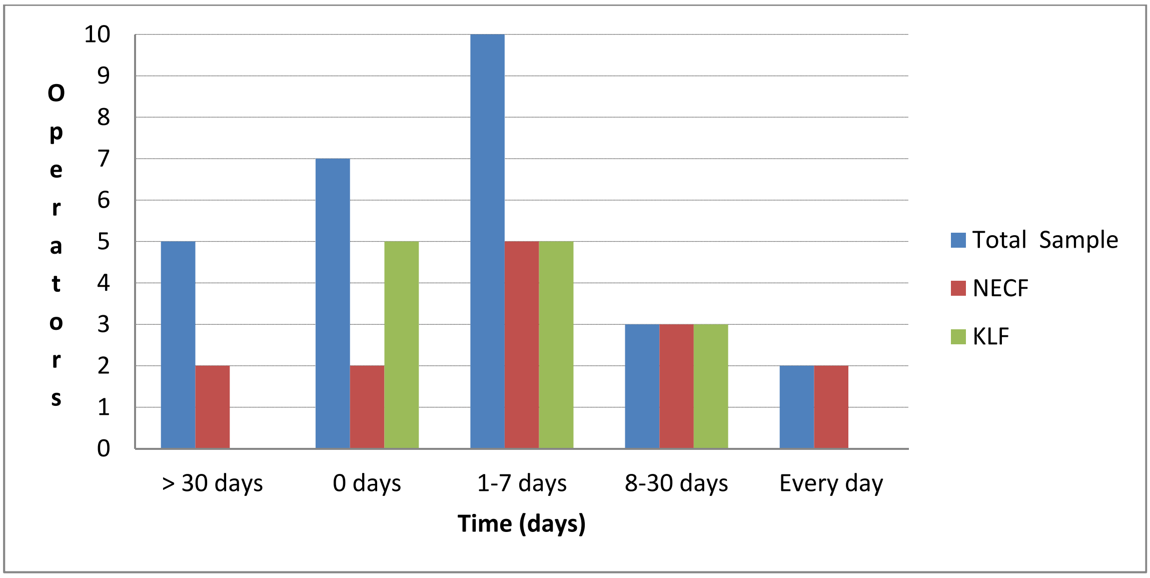


Figure 4.4: Number of operators reporting total time they experienced discomfort in any area in the last 12 months

Severity

Figures 4.5 show the frequency of reporting on the severity of musculoskeletal discomfort experienced during the worst episode by all operators. Sixteen (57%) of the responses by the operators for any area (Figure 4.5) indicate that operators experienced mild discomfort during their worst episode.

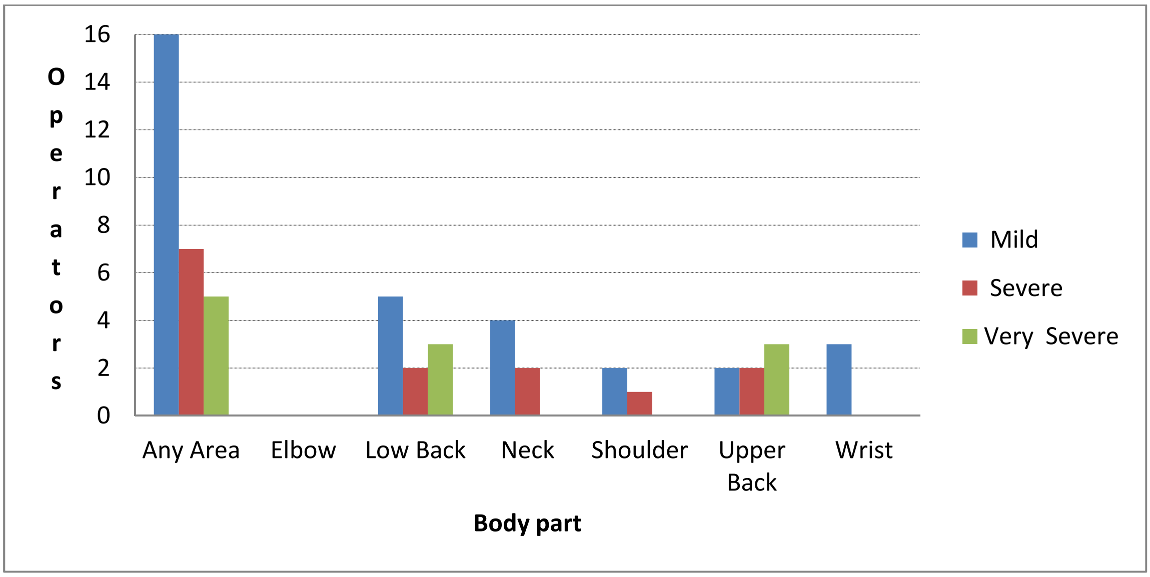


Figure 4.5: Number of all operators reporting severity of musculoskeletal discomfort experienced during the worst episode

4.2.1 Localised musculoskeletal discomfort during shift

Localised discomfort experienced during the shift was recorded hourly for the different body sites for a period of 8 hrs. The mean localised discomfort for the neck (Figure 4.6), lower back-a (Figure 4.7), lower back-b (Figure 4.8), upper back-a (Figure 4.9), upper back-b (Figure 4.10) right shoulder (Figure 4.11), and left shoulder (Figure 4.12) were recorded. The mean localised discomfort was recorded for the total sample of operators (all), and for those operators who reported some discomfort at least once during the shift (nonzero). The discomfort scale was from 0 to 7 (0 = no discomfort and 7 = extremely strong discomfort).

The majority of the operators did not report experiencing discomfort during the shift. Those who reported some discomfort experienced it mainly in the lower back (Figures 4.7 and 4.8).

Mean localised discomfort, recorded for all the body parts by the operators who reported some discomfort at least once during the shift (nonzero), was 0.3–2.6 (very weak to moderate) compared with all operators 0–1.1 (none to very weak). There was a general incremental trend in mean localised discomfort with time for all areas. There was a general decrease in mean localised discomfort during the 4th and 8th hour for the neck, lower back-a, lower back-b, and upper back-a. Operators experienced discomfort from the first hour of operating for the lower back-a, lower back-b, and upper back b. The highest peak mean discomfort was reported for the neck (Figure 4.6) and lower back-a (Figure 4.7).

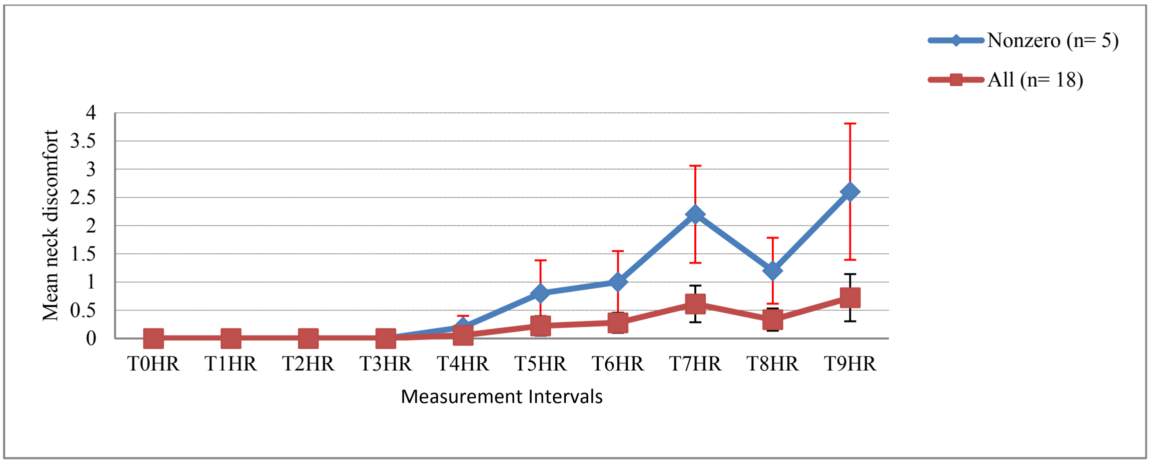


Figure 4.6: Mean neck discomfort reported by operators during a working day

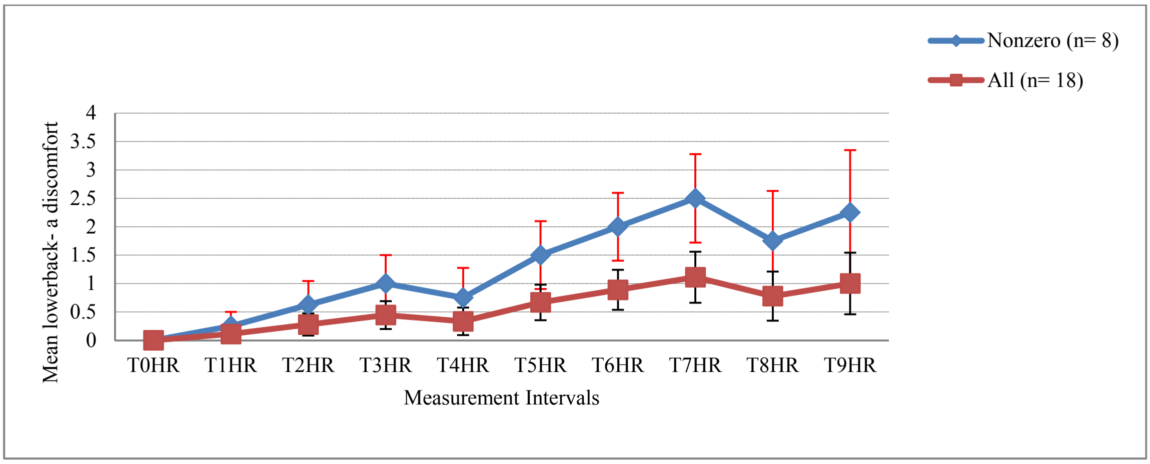


Figure 4.7: Mean lower back-a discomfort reported by operators during a working day

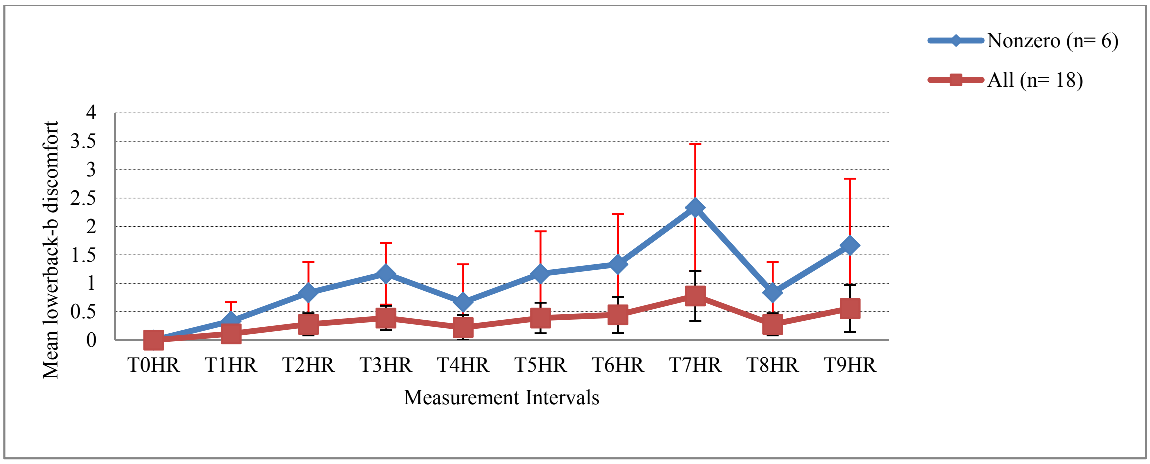


Figure 4.8: Mean lower back-b discomfort reported by operators during a working day

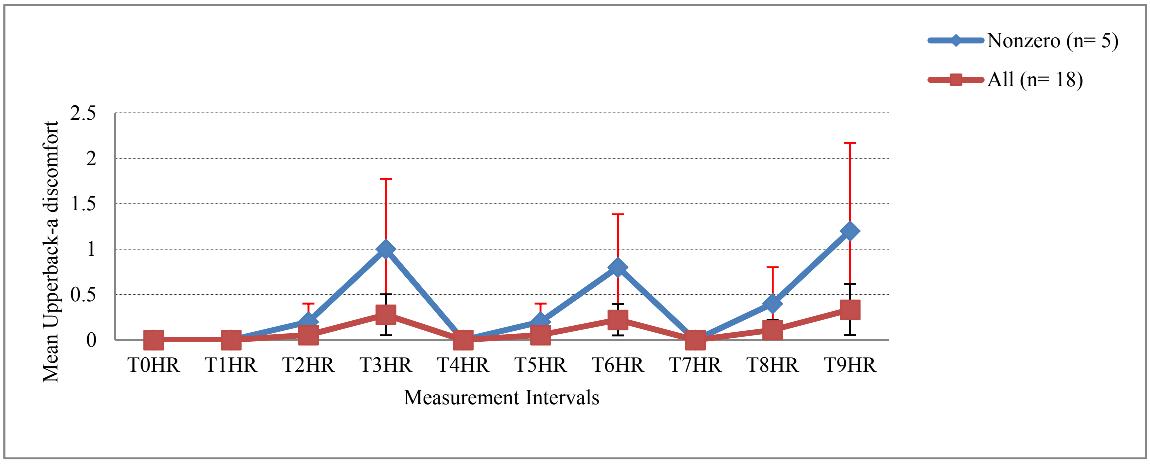


Figure 4.9: Mean upper back-a discomfort reported by operators during a working day

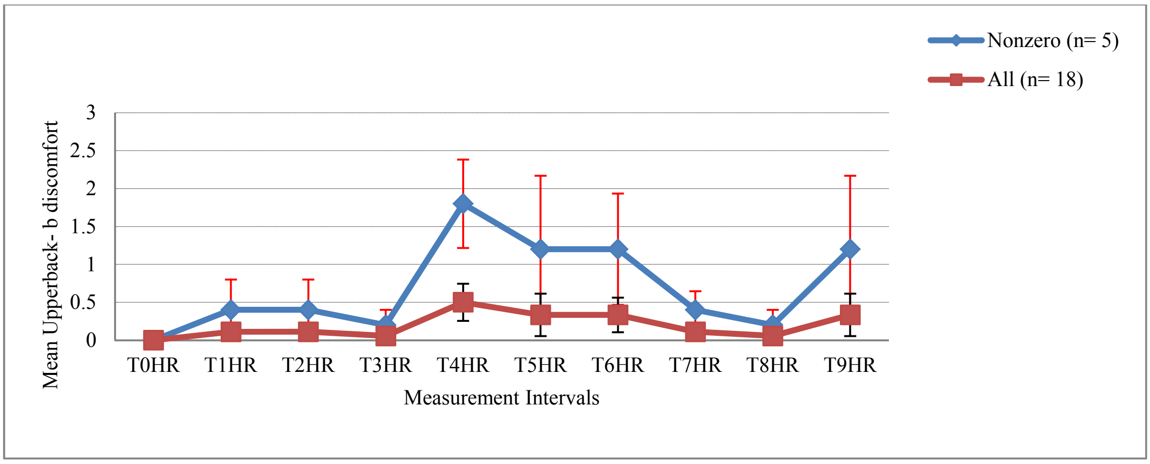


Figure 4.10: Mean upper back-b discomfort reported by operators during a working day

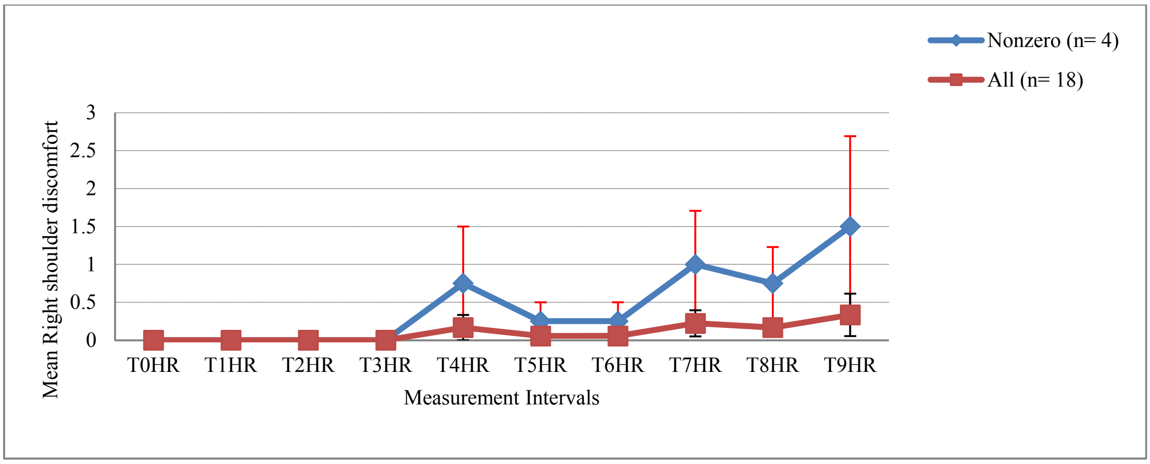


Figure 4.11: Mean right shoulder discomfort reported by operators during a working day

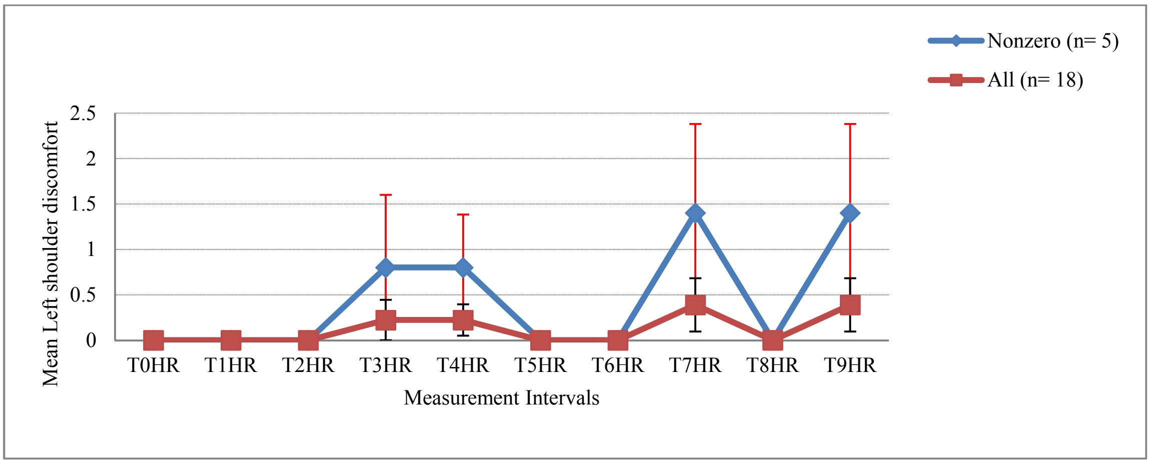


Figure 4.12: Mean left shoulder discomfort reported by workers during a working day

4.3 Awkward head posture

The average video-recording time per operator was 32.47 min (Appendix 11). Table 4.2 shows the average times for completing the forwarding task elements. Operators took on average 2.77 min (8.7%) travelling empty; 17.45 min (55%) loading; 2.47 min (7.8%) travelling loaded; and 9.05 min (28.5%) offloading (Table 4.2). There was no significant difference in task completion times between the companies.

Table 4.2: Mean forwarding task time

Task element	N	Mean	Std dev	Std error
Total sample	18			
Travel empty (min)		2.77	2.34	0.55
Loading (min)		17.45	6.44	1.52
Travel loaded (min)		2.47	1.13	0.26
Offloading (min)		9.05	5.03	1.19
NECF	10			
Travel empty (min)		3.47	2.78	0.55
Loading (min)		15.64	4.57	1.52
Travel loaded (min)		2.60	0.87	0.27
Offloading (min)		9.69	3.67	1.19
KLF	8			
Travel empty (min)		1.90	1.33	0.47
Loading (min)		19.71	7.96	2.81
Travel loaded (min)		2.30	1.44	0.51
Offloading (min)		8.25	6.54	2.31

The mean frequency of awkward head postures adopted during each task was recorded. Figures 4.13, 4.14 and 4.15 show mean head postures adopted in the sagittal plane for all, NECF, and KLF operators, respectively. Figures 4.16, 4.17 and 4.18 show mean head postures adopted in the transverse plane for all, NECF, and KLF operators, respectively. Most of the sagittal and transverse plane awkward head postures were adopted mainly during loading and offloading tasks. The observed operators assumed awkward head postures on average 180.6 times to complete the forwarding task (travel empty, loading, travel loaded and offloading) and 42.4 (23%) of these were extreme awkward postures (Appendix 11). For all operators observed, 3% (Figure 4.13) and 27% (Figure 4.16) of the postures adopted in the sagittal and transverse planes were extreme.

NECF operators adopted significantly more frequent extreme transverse plane lateral head rotation to the right during travelling empty (t = 4.66, p = 0.031, I df) than KLF operators (Figures 4.17 and 4.18). KLF operators adopted significantly more frequent extreme sagittal plane head flexion during loading (t = 4.21, p = 0.040, I df) (Figure 4.14 and 4.15) and minor transverse plane lateral head rotation to the right during travelling loaded (t = 4.95, p = 0.026, 1 df) (Figures 4.17 and 4.18) than NECF operators. There was no significant difference between the companies in the mean frequency of the other awkward postures assessed.

Sagittal plane

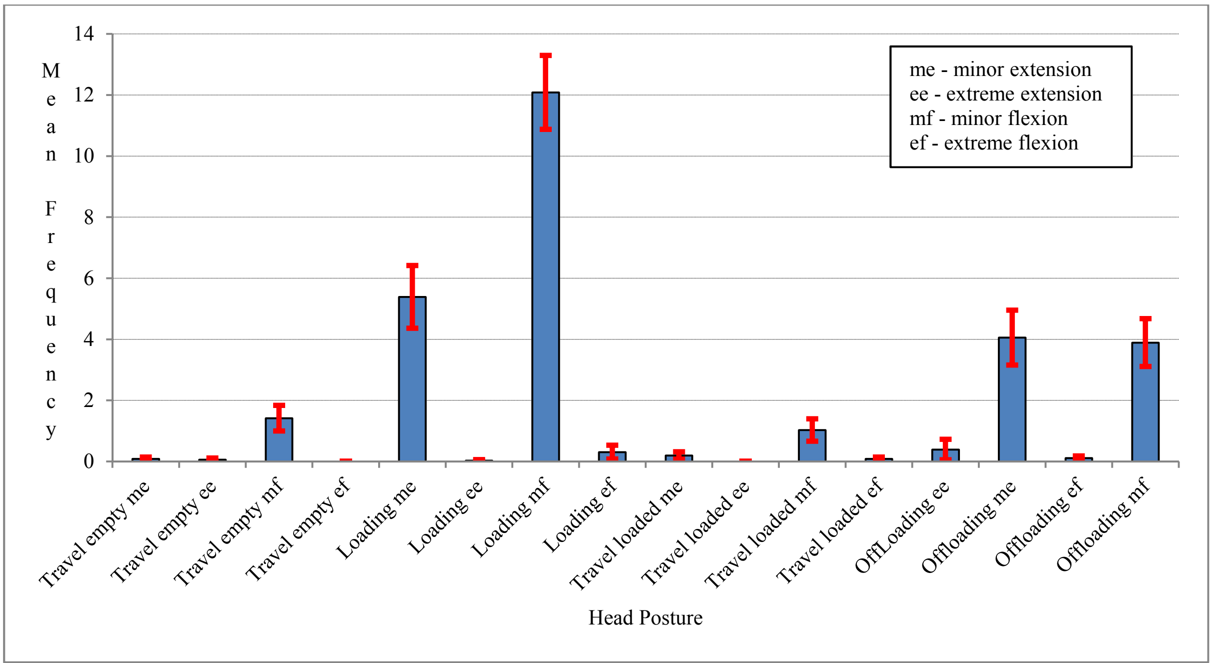


Figure 4.13: Mean sagittal plane head posture frequency adopted during forwarding tasks by all operators

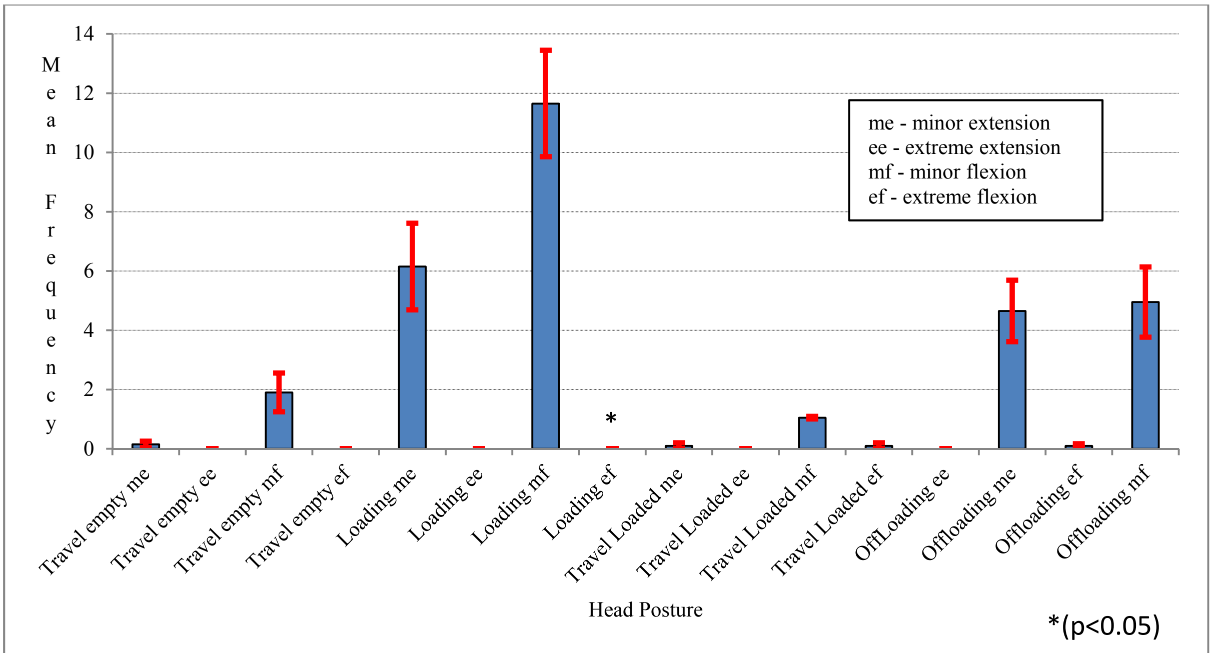


Figure 4.14: Mean sagittal plane head posture frequency adopted during forwarding tasks by NECF operators

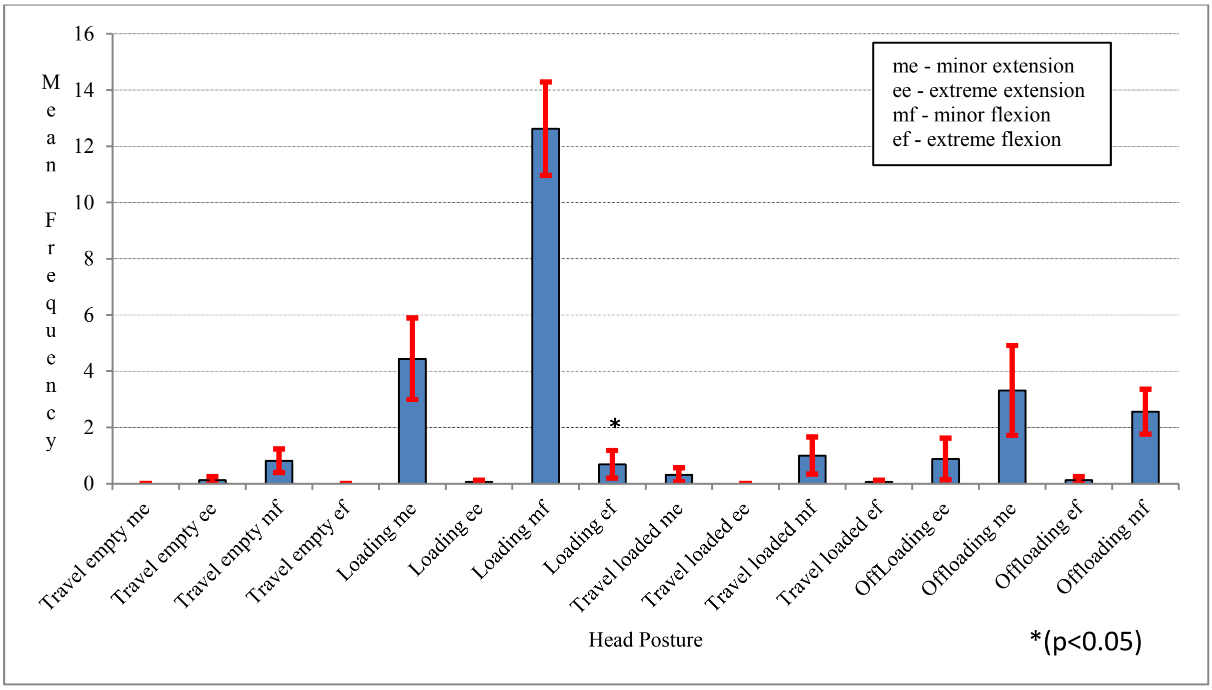


Figure 4.15: Mean sagittal plane head posture frequency adopted during forwarding tasks by KLF operators

Transverse plane

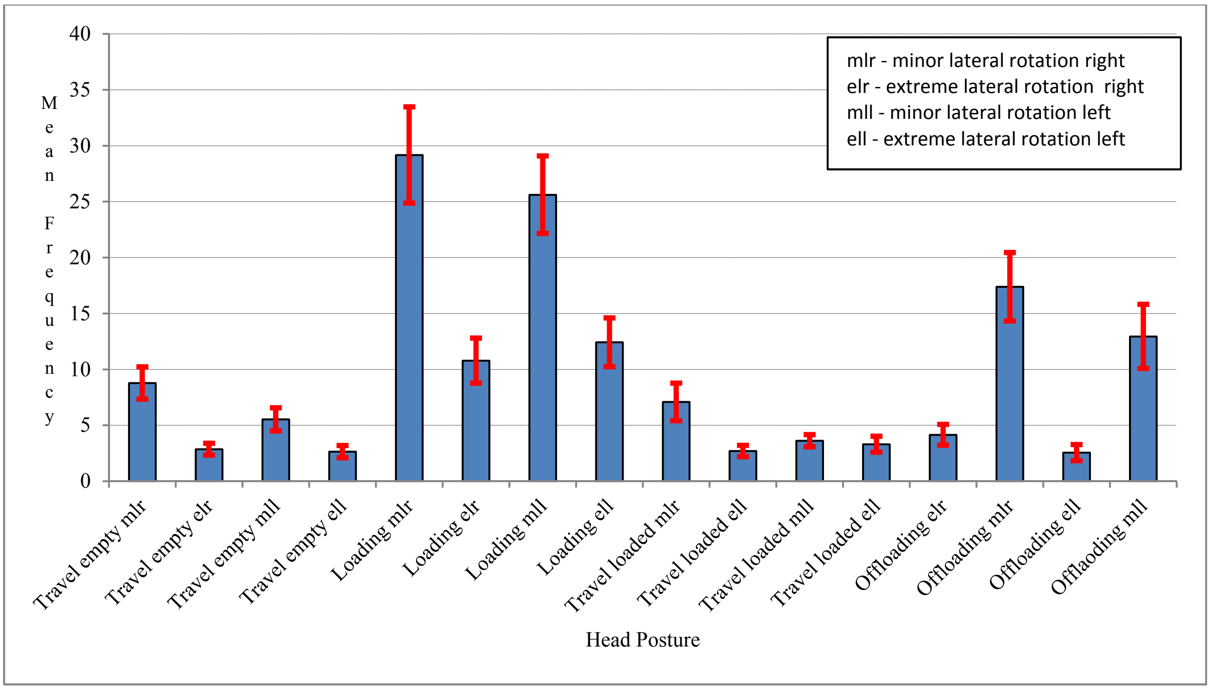


Figure 4.16: Mean transverse plane head posture frequency adopted during forwarding tasks by all operators

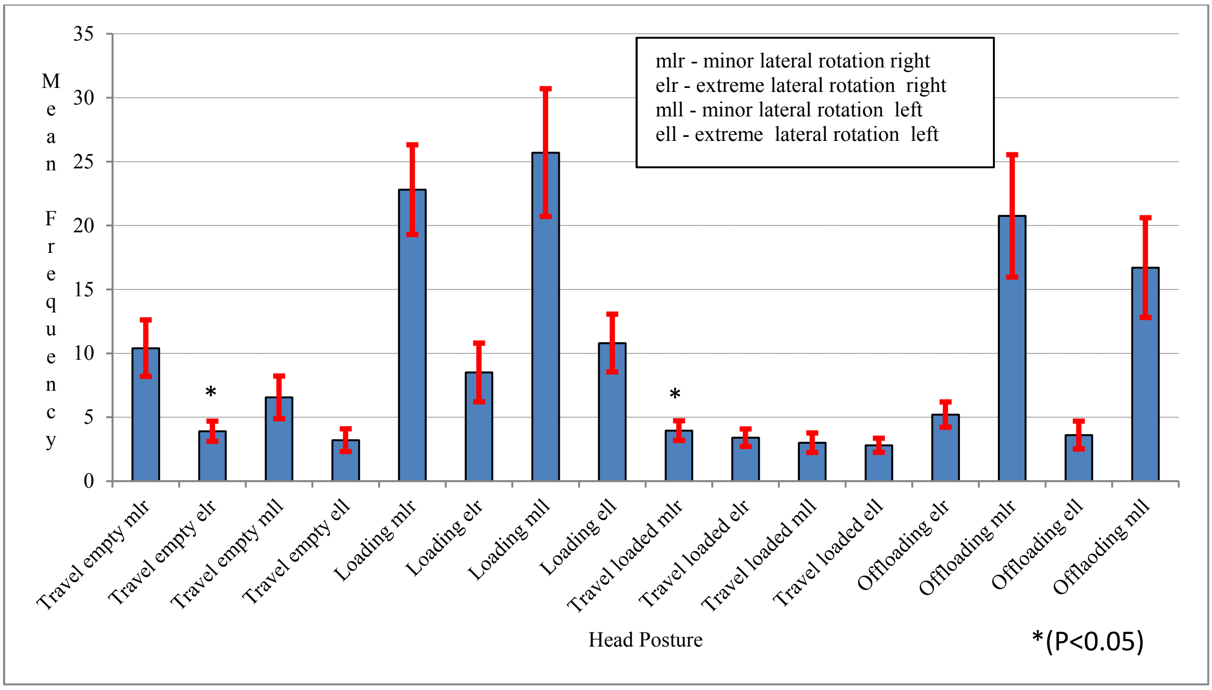


Figure 4.17: Mean transverse plane head posture frequency adopted during forwarding tasks by NECF operators

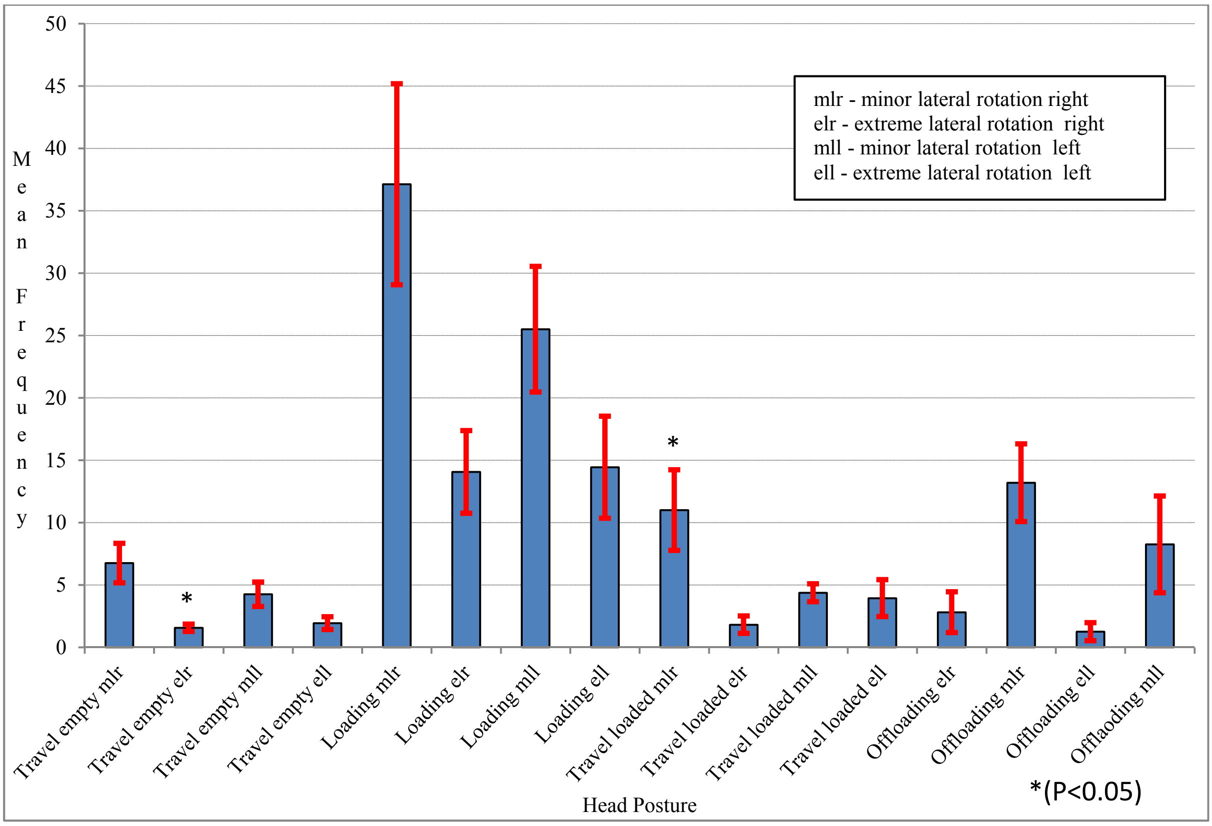


Figure 4.18: Mean transverse plane head posture frequency adopted during the forwarding tasks by KLF operators

The mean frequency of awkward head postures was recorded according to the operator's preferred backrest inclination. The preferred backrest inclination angles were stratified into three groups, <100°, 100° and >100°, for further statistical analysis (Appendix 12). Operators preferring backrest inclination of <100° had adopted a significant higher mean frequency of minor head rotation to the right posture during traveling loaded than those preferring an inclination of >100° (t=8.32, p=0.016, 2 df) (Figures 4.19 and 4.20).

There were no significant differences in the mean frequencies for all the other postures investigated between the preferred backrest inclination groups for all operators. Although not significant, operators preferring inclinations of <100° had adopted higher mean frequencies for the extreme lateral head rotation to the right posture during loading and extreme head extension during offloading than those preferring inclinations of >100°.

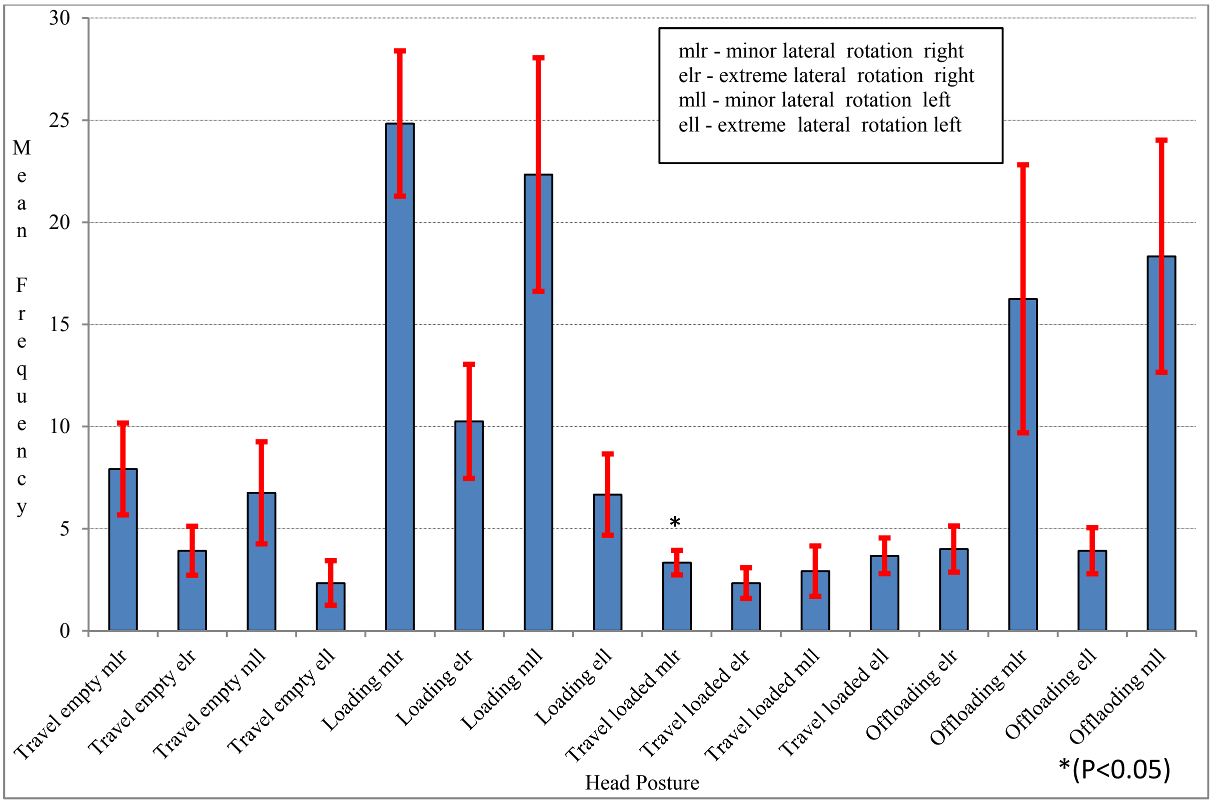


Figure 4.19: Mean transverse plane head posture frequency adopted during forwarding tasks by all operators preferring backrest inclination >100°

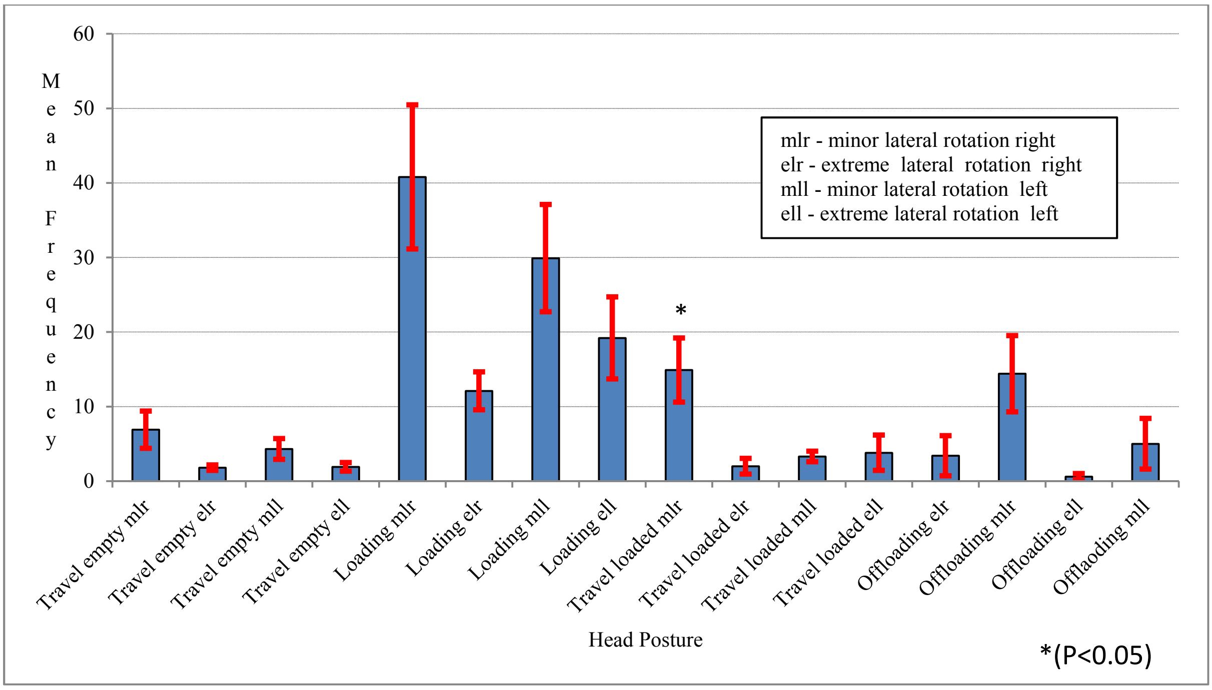


Figure 4.20: Mean transverse plane head posture frequency adopted during forwarding tasks by all operators preferring backrest inclination < 100°

4.4 Work organisation

Operators reported working on average 50 hours per week (including overtime, but excluding the main meal breaks). They took 2.15 breaks on a working day and, ignoring the lunch break, each break was 12.25 minutes long (Table 4.3). KLF operators reported working significantly more hours per week ($t = 9.60$, $p = 0.002$, 1 df) than NECF operators. There was no significant difference between the companies in the number and length of breaks per working day. Based on actual production reports for the test days, the operators spent on average 5.83 machine hours per shift.

The answers to the general health questions in the WMSD questionnaire were scored on a scale of 1–4 (1 = better than normal condition, 2 = normal/usual, 3 = worse than normal and 4 = much worse than normal condition). All operators had a worse than normal mean psychological profile of 3.34 (Table 4.4) during the past few weeks before the study was conducted. There was no significant difference between the two companies on psychological profiles. There was no significant difference on the age and experience groups for the psychological profiles.

Table 4.3: Work organisation time elements

Work variable	N	Mean	Std dev	Std error
Total sample	20			
Weekly working (hrs)		50.00	7.66	1.81
Number of breaks/day		2.15	1.23	0.27
Length of break(min)		12.25	13.95	3.12
Actual machine (hrs)/shift		5.83	1.49	1.02
NECF	12			
Weekly working (hrs)		44.80	5.99	1.90
Number of breaks/day		1.92	1.38	0.40
Length of break(min)		14.58	17.35	5.01
Actual machine (hrs)/shift		5.30	1.68	1.24
KLF	8			
Weekly working (hrs)		56.50	3.07	1.09
Number of breaks/day		2.50	0.93	0.33
Length of break (min)		8.75	5.68	2.01
Actual machine (hrs)/shift		6.50	0.83	0.75

Table 4.4: Mean operator psychological profile score

Operator sample	N	Mean	Std dev	Std error
All	20	3.34	0.35	0.08
NECF	12	3.24	0.25	0.07
KLF	8	3.48	0.44	0.15

4.5 Work-Relared Musculoskeletal Disorder risk assessment

Table 4.5 shows the summary of the forwarding work upper limb WMSD risk assessment (HSE, 2002). Repetition, working head/neck posture, duration of exposure, psychological factors and individual differences were identified as the main WMSD risk factors of the local forwarding job. The duration of awkward posture exposure was highest during the loading task (Table 4.2).

Table 4.5: Upper limb Work-Related Musculoskeletal Disorder risks of the local forwarding tasks assessed

Task-related factors	
Repetition	Loading and offloading involved repetitive shoulder, arm, and finger/thumb action. More than 50% of the task involved performing a repetitive sequence of motions
Working posture	All forwarding tasks involved repetitive twisting of the neck. Visual demands of the task result in operators adopting awkward head and neck postures
Duration of exposure	Operators worked on the machine for prolonged periods, greater than 2 hours without break. Loading constituted 55% of the work time on average 3.78hrs per day
Environment-related factors	
Vibration	Operators were exposed to low-level whole body vibration and jerky actions. The jerks and shocks were mainly experienced as the operator drove over stumps and uneven ground conditions in the compartment
Psychological factors	The forwarding work was characterised by shift systems, and task work was usually common. Operators tended to skip breaks in order to meet targets. Occasional unplanned overtime was worked. This was mostly owing to the tight mill volume demands. In general, forwarding work required high levels of concentration
Individual differences	Operators of different competencies and skill sets were often required to work together within a harvesting system

CHAPTER 5 DISCUSSION

The main objective of the study was to do an ergonomic assessment of local forwarding work systems. In this chapter results on WMSD prevalence and risk factors, awkward head postures and work organisation are discussed.

5.1 Work-Related Musculoskeletal Disorder prevalence

This study assessed the prevalence of WMSDs among local forwarder operators. Operators reported having experienced WMSDs during the last 12 months, predominantly in the lower back, neck, shoulders and upper back (Figure 4.1). This is consistent with the location of WMSD symptoms reported by forestry machine operators in previous studies (Hansson, 1990; Axelsson & Pontén, 1990; Jack & Oliver, 2006; Gerasimov & Sokolov, 2009; Hagen et al., 1998; Hanse & Winkel, 2008).

However, the studied operators reported higher 12-month WMSD prevalence in the back and lower prevalence in the neck, shoulder, wrist and elbow than that reported by operators in previous studies (Hanse & Winkel, 2008; Jack & Oliver, 2006; Hansson, 1990 Axelsson & Pòten, 1990; Hagen et al., 1998). No significant relationships were found between WMSD reported for the lower back, neck, upper back shoulders, and wrists by all operators during the past 12 months, 7 days, and prevention from carrying out normal duties. Back pain is a common symptom related to occupational driving (Rob & Mansfield, 2007; Bridger, 2003; Hanse & Winkel, 2008; Magnusson & Pope, 1998; Hansson, 1990). According to Scott et al (2010), back pain is the most common form of WMSD, usually associated with manual handling of loads, awkward or static postures, or arising from vibration.

Nonetheless, there is evidence in literature that lower back problems (LBPs) are highly interdependent and systemic (Marras, 2012; Kumar, 2001). Therefore the causal pathways of LBPs cannot be limited to controlling the physical world to which the worker is exposed, but must consider the worker's perception of his or her environment, in a systems manner to mediate his or her biomechanical and biochemical responses (Marras, 2012). The present study results support the assertion that causal pathways of WMSDs are complex and multifactorial. Task-related physical factors (awkward head and neck posture, time spent seated on a machine without a break, repetitive shoulder, arm and finger action in a vibration environment), and psychological and individual operator differences (Table 4.5) were identified in the present study as the main WMSD risk factors. While acknowledging the complex multifactorial interaction of musculoskeletal risk factors to injuries (Kee & Karwowski, 2007; Kumar, 2001), the higher incidence of lower back pain observed in the current study (Tables 4.1, 4.2, 4.3) might suggest higher postural and/or vibration exposure within these work systems than in previous reports.

NECF operators reported significantly higher neck and upper back WMSD during the last 12 months than KLF operators. The higher WMSD prevalence and severity for the neck and upper back by the younger NECF operators is a rather unexpected trend compared to previous studies (Hagen et al., 1998; Axelsson and Potén, 1990) where WMSD prevalence increased with age. This may be a result of biomechanical factors being more dominant than individual operator factors, including age and experience, in contributing to WMSD in the two work systems. Kumar (2001) argued that biomechanical factors are the main hazards of musculoskeletal injury to the upper extremities, whereas morphological factors influence the individual's vulnerability to injury. One would also have expected the more experienced and older (Table 4.1) KLF operators to have increased pain sensitisation owing to a centralised biochemical response (Marras, 2012) and therefore being more susceptible to this type of discomfort.

However, Marras (2012) argues that the multidimensional nature of work factors, both physical and mental, can greatly influence the loading of spine tissue; therefore it is difficult to pattern the exact causal pathways of LBPs. Marras (2012) stresses that tolerance limits vary throughout the lifespan of the worker because of controllable (exposure) and uncontrollable (genetic) factors. These factors of tissue loading and tolerance exist in a fine balance that is different between individuals. Consequently, the unexpected age trend observed in the present study emphasises the difficult and complex process of trying to establish the causal process of WMSDs. At best there is need to seek a balance that minimises the tissue load, as well as optimising the tissue tolerance and the resulting risk of WMSD for an individual (Marras, 2012).

The effect of age and experience on the WMSD trends observed in the study may not have been fully portrayed owing to the small operator sample, therefore it would be useful to interpret the results with caution. An attempt was made to use operator self-reports and observation techniques to adequately capture the complex work systems in the field.

The majority of the operators with >36 to 60 months' experience reported lower back WMSD during the past 12 months, but none said that their normal duties had been affected. In a related study, Hanse and Winkle (2008) found that many active years in forestry contributed to an increase in musculoskeletal symptoms among forest machine operators. Nevertheless, Harstella (1990) cautions that though some WMSDs may not have an immediate impact on workers' behaviour or injury rates, they must surely have long-term far-reaching effects. There is also a possibility that though operators reported that their normal duties were not affected, their efficiency in carrying out these duties while experiencing WMSD might have been impaired. The ErgoWood & EC (2005) reported high financial implications when forest machine operators worked while ill.

To further explain the prevalence of WMSD during forwarding, the study assessed the trends of localised WMSD experienced by forwarder operators during a shift. Most of the operators reported that they had not experienced WMSD during the shift. However, those who did experience some discomfort reported low-level discomfort (range 0–2.6 on a 7-point scale; 7 being very severe discomfort) for all body parts assessed during the shift. This is consistent with the results of a previous study by Østensvick et al. (2008), which found that 29 (n = 17 French, n = 12 Norwegians) forest machine operators reported low-level mean right neck and right forearm discomfort (0–1.5), recorded three times during the shift (morning, noon and afternoon). The current study operators who reported localised discomfort generally experienced an increase of WMSD with time. This trend is in contrast with a study by Østensvick et al. (2008) in which they found that mean right neck discomfort reported by the Norwegian operators peaked at noon and decreased as the shift progressed. The incremental trend of discomfort with time observed in the current study may be the result of inadequate recovery time during the shifts.

Based on the actual machine hours recorded during the test days, studied operators spent less time on the machines than they reported in the survey (Table 4.3). However, owing to the small timeframe in which the observations were made, these results may not accurately reflect the entire dynamics of the operations; therefore they must be interpreted with caution. Nonetheless, non-machine time constituted mainly machine breakdowns and other operational delays. These unplanned operational delays could have created more production pressure in that when the machines were operational, operators tended to work overtime or to skip mandatory breaks in order to catch up on lost production. The lack of adequate breaks may explain the general incremental work-related discomfort trend observed during the shift by the operators who reported experiencing some discomfort (Figures 4.6–4.12).

These ‘unplanned breaks’ may have reduced the exposure time and increased the variation of activities for the operators. Similarly, Attebrant et al (1997) argued that in the past, machines were less durable, therefore more breakdowns were experienced, resulting in such breaks offering variability and less exposure time. Today machines are more durable and hence operators are working longer hours, thus WMSD risks are more prevalent. This might not have been the case in the present study; operators were using modern durable machines, but may not necessarily have worked long machine hours per shift owing to the unplanned breaks. This may be the result of sub-optimal application of these systems in South Africa compared with the more experienced and developed regions.

The general limitations associated with questionnaires are applicable to the standardised Nordic questionnaire (Kuorinka et al., 1987). There is a possibility that recent and more serious WMSDs are prone to being remembered more than older and less serious ones. The environment and filling-out situation at the time of questioning may also have affected the result. The methodological initiatives of the current study to restrict the effect of the limitations included translation of the questionnaire into a vernacular language and ensuring that all participants completed the questionnaire within the same period.

5.2 Awkward head postures

Adoption of awkward postures during work is one of the major WMSD risk factors. The study also investigated the frequency of awkward head postures adopted by operators and how these are influenced by preferred backrest inclination. Operators spent most of their working time loading and offloading, which constituted 55% and 28%, respectively, of the mean forwarding cycle time (Table 4.2). On average, the operators spent more time (83%) loading and offloading and less time travelling compared with a related study in which Gerasimov and Sokolov (2009) reported that operators spent 73% loading and offloading. Time consumption and productivity of harvesting are dependent on stand conditions, the operators’ skills, working techniques and the characteristics of forestry machines (Nurminen et al., 2006).

Operators also assumed the highest number of awkward head postures during loading and offloading (Figures 4.1, 4.2, 4.3). Of the postures adopted during the forwarding cycle, 23% were extreme. Comparable findings were recorded by Gerasimov and Sokolov (2009) who reported that forwarder operators spent 23% of the average working time in uncomfortable work postures that involved turning the head through large angles during loading and moving the machine. Although little is known of which postures are optimal, the ErgoWood & EC (2006) stipulates that the head should not be turned more than 30° to the side or tilted more than 5° up or 25° down. Therefore forwarder operators who spend 23% of their working time adopting extreme postures, might run the risk of WMSDs.

Field observations showed that extreme head postures were adopted mainly in the transverse plane (27%, Figure 4.16). This was owing to the visual demands of the forwarding task in this plane, as operators were trying to view the operating zone and follow the boom and attachment movements. Ideally, the operators should have free view of the operating zone without having to adjust their posture. Mirrors and video camera assistance normally improve visibility (ErgoWood & EC, 2006). Any intervention that reduces the amount of time spent by operators adopting these extreme postures is likely to reduce the risk of WMSDs (Kumar, 2001). Previous studies reported that rotatable and movable driver cabins improved head postures and viewing angles substantially (Gellerstedt, 1998; Eklund et al., 1994; Gerasimov & Sokolov, 2009). The present study forwarders had fixed driver cabins with a rotating seat. This demonstrates that cab design and/or machine selection might have an influence on improving operator visibility.

There were no significant ‘company differences’ in the mean frequency of most of the awkward head postures that were assessed, with the exception of extreme lateral head rotation to the right during travel empty, extreme head flexion during loading and minor lateral head rotation to the right during travel loaded. Company differences in the present study would imply differences between the two group observations (NECF and KLF), and these could have been owing to terrain, work organisation and/or operator conditions. Therefore it may be possible that the awkward head postures were adopted mainly as a result of the visual requirements of the tasks. Despite the company differences, the forwarding task visual demands were comparable. However, the present study was a once-off approach and the observed significant differences might indicate that other factors played an important role towards determining the frequency of awkward head postures during the forwarding task.

There were no significant differences for most of the postures assessed between the preferred backrest inclination groups, with the exception of minor head rotation to the right during travelling loaded. But owing to the small sample size, the effect of backrest inclinations may not have been adequately shown in the present study. Although not significant, this is reflected by the operators who preferred backrest inclinations < 100° adopting higher extreme lateral head rotation to the right and extreme head extension during offloading than operators who preferred >100°. There is a possibility therefore that operators who preferred a backrest inclination of >100° could have adopted less frequent transverse plane head rotation to the right. This does present an opportunity for further research in the future. Postures adopted by forwarder operators are influenced mainly by visibility requirements of the task (Gerasimov & Sokolov, 2009; Jack & Oliver, 2006; Bridger 2003; Graf et al., 1995; ErgoWood & EC, 2006). Although no single posture has been found to be ideal, many studies of seated postures indicate that backrest inclinations greater than 100° and lumber support reduce disk pressure and muscle activity (Magnusson & Pope, 1998; ErgoWood & EC, 2006; Scott et al., 2010). This, coupled with the possible reduction of the frequency of awkward transverse plane head rotation postures adopted during forwarding tasks for preferred backrest inclinations >100°, may facilitate reduction of WMSD risk.

5.3 Work organisation

The study evaluated work organisation factors, in particular time elements and psychological aspects of forwarding work in South Africa. The time elements that were evaluated were shift length, number of rest breaks, and the length of rest breaks. The study further sought to establish whether there were company differences in the time elements and operator psychological profiles.

Although the operators reported working 50 hours a week, actual hours on the machines were observed to be much lower (Table 4.3) owing to a variety of factors, including machine breakdowns and shift-change delays. The operators' work pace was generally driven by production needs, and the tendency was to work intensively for four to six hours without breaks during the delay-free time of the shift (Table 4.5). This is consistent with findings from a previous study in which Steyn et al. (2010) reported that in South Africa, although most managers say rest breaks are mandatory, this is not always the case because of production targets and incentive schemes.

The reasons for operators not taking the mandatory breaks are complex and may be driven by the enormous production pressure placed on the operators. This production pressure may have been escalated by unplanned breaks owing to breakdowns and/or other operational delays in the systems. This is consistent with Attebrant et al (2007)'s observation that work organisation in forestry machine work is generally guided by production needs and only to a minor extent by ergonomics. The incremental mean localised WMSD trend for all body sites (Figures 4.6-4.12) might be explained by the lack of adequate recovery time during intensive machine work.

The non-significant company differences found in the number and length of breaks may indicate comparable operator work patterns despite the companies deploying different shift systems. This is in agreement with findings in the literature that there is no evidence of a single universal shift scheduling process that is applicable across the spectrum of mechanised harvesting operations (Lebel et al., 2010; Steyn et al., 2010; Murphy & Vanderburg, 2007).

All operators had a worse than normal mean psychological profile (3.34) (Table 4.4). The increased incidence of back pain reported by operators in this study may be related, among many other factors, to this. This is consistent with reports from a previous study in which Hagen et al. (1998) found that increasing levels of psychological demands were significantly associated with increased prevalence of lower back disorders. Marras (2012) concurred that physical and mental work factors can greatly influence the loading of spine tissues. There was no significant company, age and experience difference in the mean psychological profile. It is possible that operators faced similar work demands, and despite differences in experience, age and company, all the operators may have found it increasingly difficult to cope with the demands.

5.4 Work-Related Musculoskeletal Disorder risk assessment

Following the assessment of the major hazards of the local forwarding task, the study evaluated associated WMSD risks. The risk factors identified were repetitive shoulder, arm and finger/thumb action, especially during loading and offloading tasks, operators adopting awkward head and neck postures, duration of exposure, especially when loading, psychological pressure, and individual operator differences (Table 4.5).

This is consistent with forwarding work risks identified in the literature (Attebrant et al., 1997; Jack & Oliver, 2006; ErgoWood & EC, 2006; Axelsson & Potèn, 1990; Harstella, 1990; Østensvick et al., 2008).

Linking the risks to particular actions or tasks enables easier developing of solutions to mitigate the risks (HSG, 2002). The main risks identified in the systems may be classified as task, environment and worker related. The main forwarding risks were task related, in particular shoulder, arm, hand and fingers repetition, awkward head and neck postures, and duration of exposure to the risk factors.

Owing to the complex nature of human work systems, the causation of musculoskeletal conditions is multifactorial (Kee and Karwowski, 2007; Bridger, 2003; Kumar, 2001; Marras, 2012). Duration of exposure has been identified as an important concept in the assessment of WMSD risk factors (HSG, 2002). This was observed in the two systems. Although all forwarding tasks involved some shoulder, arm, hand and finger repetition and head and neck awkward postures, it was the duration of exposure that was likely to increase the WMSD risk. The cumulative time spent without a rest break for offloading, travelling empty, travelling loaded during the forwarding cycle was less than two hours for the operations. However, the cumulative time spent loading without a rest break was more than two hours for loading. Therefore, according to the HSG (2002), the loading task most likely elevated, shoulder, arm, hand and finger repetition and awkward head and neck posture risks of local forwarding work. Results of the localised discomfort assessment showed a cumulative increase in mean discomfort (Figures 4.6-4.12). This may be the result of insufficient recovery time owing to continuous working without rest. Reduction of duration and repetition might be achieved through monitoring and reducing piecework schemes; monitoring mandatory breaks and ensuring that adequate periodic breaks are taken, and managing overtime. The unplanned breaks resulting from breakdowns and other operational delays might have resulted in lower duration of exposure to WMSD risk and therefore some of the operators did not experience discomfort during the shift.

Although whole-body vibrations and bumps were not focus areas of the current study, they were identified as important WMSD risk factors for these work systems. Even though modern forestry machines are more sophisticated and engineered to reduce whole body vibrations to within acceptable limits, it was observed that the maintenance of the operator's workstation, in particular the operator seat, was a risk factor. A large body of previous work highlights the importance of the operator's seat in cushioning the operator from whole body vibration and reducing postural stress (ErgoWood & EC, 2006; Jack & Oliver, 2006; Magnusson & Pope, 1998 Rhen et al., 2005b; Bridger, 2003; Rob & Mansfield, 2007). The high incidence of lower back WMSDs observed in the current study may also be a result of biomechanical operator workloads, especially adopting awkward postures for long hours in an environment with whole-body vibration and bumps. The level of lower back WMSD risk might have been elevated in these work systems owing to lack of operator knowledge on the ergonomic importance of proper seat adjustment and/or lack of proper seat maintenance.

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

This chapter summarises the important findings on WMSD prevalence, awkward head postures, work organisation factors and WMSD risk assessment of the forwarding operations in South Africa. Recommendations are highlighted.

6.1 Conclusion

The study showed that back problems were the most prevalent WMSDs among the forwarder operators. The operators also reported shoulder, neck and wrist problems. Most of the operators who reported discomfort during the last 12 months had mild discomfort during the worst episode and experienced it for 1 to 30 days. Owing to the small operator sample, the effects of age and experience on WMSD prevalence may not have been fully portrayed in the present study. However, an unexpected trend was observed: the younger NECF operators reported significantly higher neck and upper back WMSD prevalence than KLF operators. This showed the complexity and difficulty of the process of trying to determine WMSD casualty. Body areas reported by operators in the localised discomfort study complemented those reported in the WMSD survey. Most of the operators stated that they did not experience discomfort during the shift. However, those that reported some WMSD during the shift had low-level discomfort. The study showed that WMSD for the neck, shoulders, lower back and upper back generally increased with time during the shift.

The study revealed that 23% of the awkward head postures adopted by operators were extreme, with the majority observed in the transverse plane. The operators spent most the forwarding cycle loading and offloading. Operators adopted awkward postures mainly for better visibility of the working area and the loading crane. There were no significant differences between preferred seat inclination and frequency of the most awkward head postures. Operators that preferred a backrest inclination of < 100° adopted a significantly higher minor lateral head rotation frequency to the right during travelling loaded than those who preferred >100°. There is a possibility therefore that operators who preferred a backrest inclination of >100° could have adopted less frequent transverse plane head rotation to the right. Owing to the small sample size in the present study, the impact of preferred backrest inclination may not have been adequately captured, therefore there may be a need to look in to it.

Operators reported spending on average 50 hours per week (including overtime and excluding main meal breaks) on the machines. KLF operators reported spending significantly more hours on the machine than NECF operators. However, operators from both companies worked fewer hours on the machine than they reported, owing to breakdowns and other delays. There were no significant company differences in the number and length of breaks. The operators reported a worse-than-usual psychological profile during the weeks leading to the study. No psychological differences were found among the two companies' operators.

The study shows the main WMSD risk factors associated with the local forwarding tasks are duration of exposure, psychological strain and working in a low-level whole-body vibration environment with jerky actions. The high prevalence of lower back pain reported in the present study may be related to the worse-than-usual operator psychological experiences. This might have reflected that the operators were not coping well with the increasing job demands.

This study was an ergonomic assessment of the local forwarding tasks. It has shown that local operators experienced WMSDs; operators were affected mainly by back problems. The study results support the proclamation that causal pathways of WMSDs are complex and multifactorial, therefore any interventions to mitigate them must address physical and mental risk factors and are dependent on individual operator tolerances.

6.2 Recommendations

Forwarder operating is a complex multistress profession. Operators are simultaneously exposed to a number of WMSD risks and to varying magnitudes. Therefore it is recommended that WMSD risk management should be incorporated into existing health and safety 'wellness' programmes to ensure early detection and continuous mitigation of WMSD risks.

It is recommended that operator consultation should be considered when replacing machines and that ergonomic considerations of the cab design should be among the priority decision drivers. These may include visibility-enhancing features (such as rotating cabs and rear-view camera assistance) and the operator seat.

Irrespective of the shift systems in place, continuous monitoring and management of operator machine time is recommended, particularly where breakdowns and operational delays result in the disruption of normal scheduled work. In such cases the operator workload balancing is critical and may be achieved through;

- Monitoring and reducing piecework schemes
- Ensuring that mandatory breaks and adequate periodic breaks are taken when they are most beneficial
- Managing overtime effectively

Owners of forwarders in South Africa are encouraged to incorporate periodic lower back medical check-ups in existing operator health and safety programmes

Training of operators and other support personnel in critical skills is recommended. These include proper operator workstation maintenance and adjustment, continuous development of operating skill sets, teamwork and communication.

Further study on the psychological stress encountered by machine operators and the search for locally adapted stress control initiatives is recommended.

A long-term longitudinal study on WMSD prevalence and risk factors in South Africa is recommended.

The influence that the operator's preferred backrest inclination has on the frequency of awkward posture may require further study, particularly with a larger operator sample.

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APPENDICES

Appendix 1: Cover Letter

UNIVERSITY OF PRETORIA

FACULTY OF NATURAL AND AGRICULTURAL SCIENCES

MSc FOREST SCIENCE: Student No 11352002

INVITATION LETTER

July 2012

RE: PARTICIPATION IN ERGONOMICS STUDY

Dear Sir

My name is Kuda Phairah. I am a forestry science graduate student at the University of Pretoria. I am conducting a study as part of the requirements of my degree in Forest science and would like to invite you to participate.

I am studying work-related musculoskeletal discomfort during forwarding work in South Africa. Participation is anonymous. The researcher will however allocate you a random reference number only to be used by the researcher for data analyses later on.

Thank you for your consideration. If you would like to participate, you will be requested to refrain from strenuous activities after working hours for the duration of the field study to avoid external factors affecting the research results.

You will be requested to: fill in a questionnaire on your experiences with work related discomfort, researcher will measure your weight and height, the researcher will at hourly intervals on the test day ask you to rate any discomfort during your shift, the researcher will record your work postures for an hour on the test day using a video camera mounted in your cab. The video footage will only be used for postural analysis by the researcher.

Thank you for participating

With Kind regards

Signature:______________________

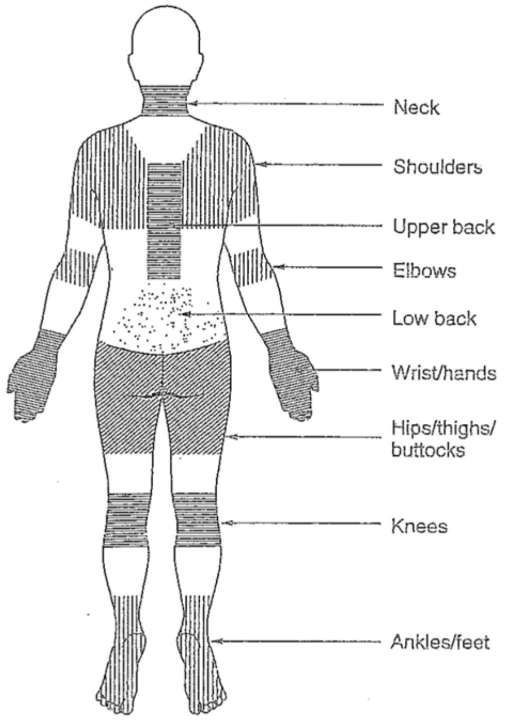
Address: 3 Engelhard Park Sabie, 1260

Tel: 0027137649200

Email Address: kphairah@york.co.za

Appendix 2: Modified Nordic Musculoskeletal Questionnaire.

BODY MAP – IZITHO ZOMZIMBA



This picture shows how the body has been divided. Please answer the questions shown on the next page for each body area. Body sections are not sharply defined and certain parts overlap. You decide for yourself which part (If any) is or has been affected.

Lesithombe sikhombisa ukuthi umzimba uhlukaniswe kanjani. Sicela uphendule imibuzo kwi hasi elilandelayo kwingxenye yomzimba ngayinye. Izingenye zomuzimba azichaziwe ngqo futhi ezinye izingxenye ziyamanxile. Kufanele uzibomele igokwakho ukuthi iyiphi ingenye yomzimba ethintekayo.

UNIVERSITY OF PRETORIA

FACULTY OF NATURAL AND AGRICULTURAL SCIENCES

MSc. Forest science: Student No 11352002

MACHINE OPERATOR MUSCULOSKELETAL QUESTIONNAIRE

INHLOLO-MBUZO YOMUZIMBA NAMATAMBO KAMSHAYELI WOMUSHINI

Nordic Musculoskeletal questionnaire as modified by UK Health and Safety (Corlett, 2005)

HOW TO ANSWER THE QUESTIONNAIRE ***(IPENDULWA KANJANI LENLOLO-MIBUZO)***

Please complete this questionnaire by answering **ALL** questions as fully as possible. Some of the questions require a written answer, and others need only a tick in the appropriate box.

(Sicela ugcwalise lenholo-mibuzo ngoku phendula yonke imibuzo ngoku phelele. Eminye imibuzo idinga impendulo ebhalwayo, eminye idinga umake impendulo okuyiyo ebhokisini elifanele)

PERSONAL DETAILS***IMININGWANE EQONDENE NAWE***

1. **Today's date** *Usuku lwanamuhla* ☐☐☐☐☐☐☐☐
2. **Sex** *ubulili* **M** *Owesilisa* 1 ☐ **F** *O[...]fazane* 2 ☐
3. **Date of Birth** *usuku lokuzalwa* ☐☐☐☐☐☐☐☐
4. **What is your weight** *Singakanani isisindo sakho* kg ☐☐☐
5. **What is your height** *Bungakanani ubude bakho* cm ☐☐☐
6. **Are you right or left handed** *Uyisikudla noma isinxele*

Right left able to use both hands equally
(Kwesokudla kwesobunxele (Ukusebenzisa izandla zombili ngokufana)
1 ☐ 2 3 ☐ ☐

MUSCULOSKELETAL DISCOMFORT***UKUNGAPHATHEKI KAHLE KOMUZIMBA-NAMATAMBO***

Please answer by using the boxes – one tick for each question please note this part of the questionnaire should be answered even if you never had trouble in any parts of our body. *Phendula ngokumaka emabhokisini – imaki elilodwa kumubuzo ngamunye, qaphela ukuthi kungxenge yenhlolo – mbuzo ingaphendulwa noma ngisho ungakaze ube nenkinga kunoma iyipi ingxenye yomuzimba*

Have you at any time during the last 12 months had trouble such as ache ,pain, discomfort, numbness in*: kulezinganya eziyishumi nambili ezedlule ngabe uke waphathwa ubuhlungu,ukungazizwa kahle,izinkwantshu kwi:*	Have you had trouble during the last 7 days: *Ngabe uke waba nezinkinga kulezinsuku eziyisikhombisa ezedlule*	During the last 12 months have you been prevented from carrying out normal activities e.g job, house work, hobbies because of this trouble *Kulezinyanga eziyishumi nambili ezedlule ngabe uke wanqatshelwa ukwenza izinto ezifana nomsebenzi,imisebenzi yasendlini, izinto zokuchitha isizungu ngenxa yalenkinga*
1 *Neck Intamo* No *Cha* Yes *Yebo* 1 ☐ 2 ☐	**2** *Neck Intamo* No *Cha* Yes *Yebo* 1 ☐ 2 ☐	**3** *Neck Intamo* No *Cha* Yes *Yebo* 1 ☐ 2 ☐

4 *Shoulders Amahlombe* No *Cha* Yes *Yebo* 1 ☐ 2 in rig☐ *Ehlombe lakwesokudla* 3 in left☐lder *Ehlombe Lakwesobunxele* 4 in bot☐ *Kokubili*	**5** *Shoulders Amahlombe* No *Cha* Yes *Yebo* 1 ☐ 2 in rig☐ *Ehlombe lakwesokudla* 3 in left☐lder *Ehlombe Lakwesobunxele* 4 in bot☐ *Kokubili*	**6** *Shoulders(both/either) Amahlombe (kokubili)* No *Cha* Yes *Yebo* 1 ☐ 2 ☐
7 *Elbows Izindololwane* No *Cha* Yes *Yebo* 1 ☐ 2 in rig☐bow *Endololwaneni Yakwesokudla* 3 in left☐w *Endololwaneni yakwesobunxele* 4 in bot☐ *Kokubili*	**8** *Elbows Izindololwane* No *Cha* Yes *Yebo* 1 ☐ 2 in rig☐bow *Endololwaneni Yakwesokudla* 3 in left☐w *Endololwaneni yakwesobunxele* 4 in bot☐ *Kokubili*	**9** *Elbows (both/either) Izindololowane(kokubili* No *Cha* Yes *Yebo* 1 ☐ 2 ☐
10 *Wrists/Hands* Izihlakala/Izandla No *Cha* Yes *Yebo* 1 ☐ 2 in rig☐ist/h Esihlakaleni sakwesokudla/Esandleni sakwesokudla 3 in left☐t/h Esihlakaleni sakwesobunxele/esandleni sakwesobunxele 4 in bot☐ *(kokubili)*	**11** *Wrists/Hands* Izihlakala/Izandla No *Cha* Yes *Yebo* 1 ☐ 2 in ☐ wrist/h Esihlakaleni sakwesokudla/Esandleni sakwesokudla 3 in l☐rist/h Esihlakaleni sakwesobunxele/esandleni sakwesobunxele 4 in b☐ *(kokubili)*	**12** *Wrists/Hands (both/either)* Izihlakala/Izandla Izihlakala/Izandla No *Cha* Yes *Yebo* 1 ☐ 2 ☐
13 *Upper back Emhlane* No *Cha* Yes *Yebo* 1 ☐ 2 ☐	**14** *Upper back Emhlane* No *Cha* Yes *Yebo* 1 ☐ 2 ☐	**15** *Upper back Emhlane* No *Cha* Yes *Yebo* 1 ☐ 2 ☐
16 *lower back(small of the back) Eqolo* No *Cha* Yes *Yebo* 1 ☐ 2 ☐	17 *lower back Eqolo* No *Cha* Yes *Yebo* 1 ☐ 2 ☐	18 *lower back Eqolo* No *Cha* Yes *Yebo* 1 ☐ 2 ☐

NECK TROUBLE *(UKUHLUSHWA INTAMO)*

How to answer the questionnaire *(iphendulwa kanjani imibuzo)* :

By neck trouble we mean pain ache or discomfort in the shaded area only. *(Inkinga yentamo isho ubuhlungu noma ukungazizwa kahle kulendawo ekhonjisiwe kuphela)*

Please answer by ticking one box for each answer. *(Sicela uphendule ngoku-maka ibhokisi elilodwa kwimpendulo ngayinye)*

1 Have you ever had any neck trouble (ache, pain numbness or discomfort)? *wake waba nenkinga entanyeni (ubuhlungu,ukungazizwa kahle,izinkwantshu)*

Yes *Yebo* No *Cha*
1 2

If you have answered NO to this question, do not answer questions 2-12 but, please go to the next on section shoulder page 8.
Uma uphendule mbuzo wathi 'Cha' unga wuphenduli umbuzo 2-12 kodwa sicela uqhubeke kwi sahluko samahlombe kwi – khasi lesishiyagalombili

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2 Have **you ever hurt your neck in an accident** *Wake walimala entanyeni ngenxa yengozi* ?

Yes *Yebo* No *Cha*

1 2

IF the answer is NO, please go to Question 3 *Uma uphendule wathi cha, qhubekela kumbuzo wesithathu*

IF YES: *uma kunjalo:*

2a was the accident at work? *Ngabe isehlakalo sasisemisebenzini?*

Yes *Yebo* No *Cha*

1 2

2b what was the approximate date of the accident *Lwalunini umhlambe usuku lwengozi?*

---

3 Have you ever had to change duties or jobs because of neck trouble *Wake washintsha imisebenzi ngenxa yokuhlushwa intamo?*

Yes *Yebo* No *Cha*

1 2

4 What do you think brought on this problem with your neck *Ucabanga ukuthi yini edala uhlushwe intamo?*

1 Accident *Ingozi* 2 Sporting Activity *Ezemidlalo* 3 Activity at home *Okwenziwa ekhaya*

4 Activity at work *Okwenziwa emsebenzini*

5 Other Okunye

(Please Specify) *Ngicela ucacise*

5a What year did you first have neck trouble? *Imuphi unyaka owaqala ukuhlushwa intamo ngawo?*

5b What year did you have your worst neck trouble? *Imuphi unyaka owahlushwa kakhulu intamo ngawo?*

---

6 How bad was the pain during the worst episode? *Babunjani ubuhlungu ngesikhathi ikuhlupha kakhulu intamo?*

1 Mild *Phakathi nendawo* 2 Severe *Kakhulu* 3 Very Severe *Kakhulu ngokweqile*

7 Have you ever been absent from work because of neck problem? *Wake walova emsebenzini ngenxa yokuhlushwa intamo?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is NO, please go on to Question 8 *Uma uphendule wathi cha, qhubekela kumbuzo wesishiyagalombili*

If YES: *uma kunjalo*:

How many Times *Kangaki*?

7a ☐☐

How many days have you been absent from work with neck trouble in Total *Zingaki izinsuku owazilova seziphelele ngenxa yokuhlushwa intamo?*

7b ☐☐ *suku*

How many days have you been absent from work with neck trouble in the last 12 months *Zingaki izinsuku ozilovile kulezinyanga eziyishumi nambili ezedlule ngenxa yokuhlushwa intamo?*

7c ☐☐ *suku*

---

8 How often do you get or have you had neck trouble*? Ikuhlupha kangaki intamo?*

1 Daily *Nsukuzonke* ☐ One or more times a week *kanye noma kaningi ngesonto* ☐

3 One or more times a month *kanye noma kaningi enyangeni* ☐

4 One or more times a year *kanye noma kaningi enyakeni*? ☐

5 One or more times every few years *kanye noma kaningi emva kweminyaka embalwa* ☐

6 One episode of trouble *Isiqutshana sobunzima* ☐

9 What is the total length of time that you had neck trouble during the last 12 months? *Singakananai isikhathi upehethwe intamo kulezinyanga ezishumi nambili ezedlule*

1. 0 days *Akunazinsuku* ☐ 2. 1 – 7 days *Usuku kuya kweziyisikhombisa* ☐

3. 8 – 30 days *Izinsuku eziyishiyagalombili kuya kwezingamashumi amathathu* ☐

4. More than 30days,but not every day *Ngaphezu kwezinsuku ezingamashumi amathathu kodwa hhayi nsukuzonke* ☐

5 Every day *Nsukuzonke* ☐

10 Has the neck trouble caused you to reduce your activity during the last 12 months? *Ngabe intamo isake yakuhlupha kangangoba waze wanciphisa izinto ozenzayo kulezinyanga eziyishumi nambili ezedlule?*

10a Work Activity *Okwenzayo* (at home or away from home) *ekhaya noma ungekho ekhaya*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

10b Leisure Activity *Into yokuchitha isizungu oyenzayo*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

---

11 What is the total length of time that the neck trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months? *Singakanani isikhathi lapho ungakwazanga ukwenza imisebenzi ejwayelekile ngenxa yokuhlushwa intamo*?

1. 0 days ☐ 1- 7 days 3. ☐30 days 4. M☐han 30 days ☐

12 Have you been seen by the doctor, physiotherapist, chiropractor, or other such person because of neck trouble during the last 12 months *Usake wabonana nabodokotela ngenza yokuhlushwa intamo kulezinyanga eziyishumi nambili ezedlule* ?

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is No go to the next section. *uma impendulo ithi 'Cha', iya kwi isahluko elandelayo.*

If YES: *uma kunjalo:*

Where? ipi ndawo?(More than one box can be ticked)*(Lapho ungakhetha amabhokisi angaphezulu kwelilodwa)*

1 Medical centre at work *Emtholampilo wasemusebenzini* ☐ GP *Kadokotela* ☐

3 Hospital *Esibhedlela* ☐ 4 Private Doctor *Udokotela wangasese* ☐

5 Other *Okunye* ☐lease specify) *Ngicela ucacise* ☐

SHOULDER TROUBLE *INKINGA YAMAHLOMBE*

How to answer the questionnaire *(iphendulwa kanjani imibuzo) :*

By shoulder trouble we mean pain ache or discomfort in the shaded area only.*(Inkinga yemahlombe isho ubuhlungu noma ukungazizwa kahle kulendawo ekhonjisiwe kuphela.)*

Please answer by ticking one box for each answer. *(Sicela uphendule ngoku-maka ibhokisi elilodwa kwimpendulo ngayinye)*

1 Have you ever had any shoulder trouble (ache, pain numbness or discomfort)?
wake waba nenkinga yemahlombe (ubuhlungu,ukungazizwa kahle,izinkwantshu)
Yes *Yebo* No *Cha*
1 ☐ 2 ☐
If you have answered NO to this question, do not answer questions 2-12 but, please go to the next on section upper back page 12.
Uma uphendulo mbuzo wathi 'Cha' ungapwuphenduli umbuzo 2-12 kodwa sicela uqhubeke kwi sahluko samalhombe kwi – khasi leshumi nambili

2 Have **you ever hurt your shoulder in an accident** *Wake walimala amahlombe ngenxa yengozi?*

Yes *Yebo* No *Cha*

1 ☐2 ☐

IF the answer is NO, please go to Question 3 *Uma uphendule wathi cha, qhubekela kumbuzo wesithathu*

IF YES: *uma kunjalo:*

2a was the accident at work? *ngabe isehlakalo sasisemisebenzini?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

2b what was the approximate date of the accident ?*Lwalunini umhlambe usuku lwengozi ?*

☐☐☐☐☐☐☐☐

---

3 Have you ever had to change duties or jobs because of shoulder trouble? *Wake washintsha imisebenzi ngenxa yokuhlushwa amahlombe?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

4 What do you think brought on this problem with your shoulder? *Ucabanga ukuthi yini edala uhlushwe amahlombe?*

1 Accident *Ingozi* ☐ Sporting Activity *Ezemidlalo* ☐ ctivity at home *Okwenziwa ekhaya* ☐

4 Activity at work *Okwenziwa emsebenzini* ☐ ☐

5 Other *Okunye* ☐

(Please Specify) *Ngicela ucacise* ☐

5a What year did you first have shoulder trouble? *Imuphi unyaka owaqala ukuhlushwa amahlombe ngawo?*

☐☐☐☐

5b What year was your worst shoulder trouble? *Imuphi unyaka owahlushwa kakhulu amahlombe ngawo?*

☐☐☐☐

---

6 How bad was the pain during the worst episode? *Babunjani ubuhlungu ngesikhathi ikuhlupha kakhulu amahlombe?*

1 Mild *Phakathi nendawo* ☐ 2 Severe *Kakhulu* 3 ☐ Severe *Kakhulu ngokweqile* ☐

---

7 Have you ever been absent from work because of shoulder problem? *Wake walova emsebenzini ngenxa yokuhlushwa amahlombe?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is NO, please go on to Question 8 *Uma uphendule wathi cha, qhubekela kumbuzo wesishiyagalombili*

If YES: *uma kunjalo*:

How many times *Kangaki* ?

7a ☐☐

How many days have you been absent from work with shoulder trouble in total *Zingaki izinsuku owazilova seziphelele ngenxa yokuhlushwa amahlombe?*

7b ☐☐ *insuku*

How many days have you been absent from work with shoulder trouble in the last 12 months *Zingaki izinsuku ozilovile kulezinyanga eziyishumi nambili ezedlule ngenxa yokuhlushwa amahlombe?*

7c *insuku*

---

8 How often do you get or have you had shoulder trouble? *akuhlupha kangaki amahlombe* ?

1 Daily *Nsukuzonke* 2 One or more times a week *kanye noma kaningi ngesonto*

3 One or more times a month *kanye noma kaningi enyangeni*

4 One or more times a year *kanye noma kaningi enyakeni*?

5 One or more times every few years *kanye noma kaningi emva kweminyaka embalwa*

6 One episode of trouble *Isiqutshana sobunzima*

9 What is the total length of time that you had shoulder trouble during the last 12 months?

1. 0 days*Akunazinsuku* 2. 1 – 7 days *Usuku kuya kweziyisikhombisa*

3. 8 – 30 days *Izinsuku eziyishiyagalombili kuya kwezingamashumi amathathu*

4. More than 30 days,but not every day *Ngaphezu kwezinsuku ezingamashumi amathathu kodwa hhayi nsukuzonke*

5 Every day *Nsukuzonke*

10 Has the shoulder trouble caused you to reduce your activity during the last 12 months? *Ngabe amahlombe asake akuhlupha kangangoba waze wanciphisa izinto ozenzayo kulezinyanga eziyishumi nambili ezedlule*?

10a Work Activity *Okwenzayo* (at home or away from home) *ekhaya noma ungekho ekhaya*

Yes *Yebo* No *Cha*

1 2

10b Leisure Activity *Into yokuchitha isizungu oyenzayo*

Yes *Yebo* No *Cha*

1 2

---

11 What is the total length of time that the shoulder trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months? *Singakanani isikhathi lapho ungakwazanga ukwenza imisebenzi ejwayelekile ngenxa yokuhlushwa amahlombe?*

1. 0 days . 1- 7 days 3. 30 days 4. M han 30 days

---

12 Have you been seen by the doctor, physiotherapist, chiropractor, or other such person because of shoulder trouble during the last 12 months *Usake wabonana nabodokotela ngenza yokuhlushwa amahlombe kulezinyanga eziyishumi nambili ezedlule* ?

Yes *Yebo* No *Cha*

1 2

If the answer is No go to the next section. *uma impendulo ithi 'Cha', iya kwi isahluko elandelayo.*

If YES :*uma kunjalo :*

Where? ipi ndawo?(More than one box can be ticked)*(Lapho ungakhetha amabhokisi angaphezulu kwelilodwa)*

1 Medical centre at work *Emtholampilo wasemusebenzini* ☐ 2 GP *Kadokotela* ☐

3 Hospital *Esibhedlela* ☐ 4 Private Doctor *Udokotela wangasese* ☐

5 Other *Okunye* ☐ (please specify) *Ngicela ucacise* ☐

UPPER BACK TROUBLE *INKINGA EMHLANE*

How to answer the questionnaire *(iphendulwa kanjani imibuzo)*:

By upper back trouble we mean pain ache or discomfort in the shaded area only. *(Inkinga emhlane isho ubuhlungu noma ukungazizwa kahle kulendawo ekhonjisiwe kuphela.)*

Please answer by ticking one box for each answer. *(Sicela uphendule ngoku-maka ibhokisi elilodwa kwimpendulo ngayinye)*

1 Have you ever had any upper back trouble (ache, pain numbness or discomfort)?
wake waba nenkinga emhlane (ubuhlungu,ukungazizwa kahle,izinkwantshu)
Yes *Yebo* No *Cha*
1 ☐ 2 ☐
If you have answered NO to this question, do not answer questions 2-12 but, please go to the next on section elbow page 16. *Uma uphendulo mbuzo wathi 'Cha' ungapwuphenduli umbuzo 2-12 kodwa sicela uqhubeke kwi sahluko samalhombe kwi – khasi lesishumi nesithupa*

2 Have you ever hurt your upper back in an accident? *Wake walimala emhlane ngenxa yengozi?*

Yes *Yebo* No *Xa*

1 ☐ 2 ☐

IF the answer is NO, please go to Question 3 *Uma uphendule wathi cha, qhubekela kumbuzo wesithathu*

IF YES: *uma kunjalo:*

2a was the accident at work? *ngabe isehlakalo sasisemisebenzini?*

Yes *Yebo* No *Cha*

☐ 2 ☐
3

2b what was the approximate date of the accident? *Lwalunini umhlambe usuku lwengozi?*

☐☐☐☐☐☐☐☐

3 Have you ever had to change duties or jobs because of upper back trouble? *Wake washintsha imisebenzi ngenxa yokuhlushwa emhlane*?

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

4 What do you think brought on this problem with your upper back *Ucabanga ukuthi yini edala uhlushwe emhlane?*

1 Accident *Ingozi* ☐ Sporting Activity *Ezemidlalo* ☐ Activity at home *Okwenziwa ekhaya* ☐

4 Activity at work *Okwenziwa emsebenzini* ☐

5 Other *Okunye* ☐

(Please Specify) *Ngicela ucacise* ☐

5a what year did you first have upper back trouble? *Imuphi unyaka owaqala ukuhlushwa umhlane ngawo?*

☐☐☐☐

5b What year was your worst upper back trouble? *Imuphi unyaka owahlushwa kakhulu umhlane ngawo?*

☐☐☐☐

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6 How bad was the pain during the worst episode? *Babunjani ubuhlungu ngesikhathi ikuhlupha kakhulu umhlane?*

1 Mild *Phakathi nendawo* ☐ 2 Severe *Kakhulu* 3 ☐ y Severe *Kakhulu ngokweqile* ☐

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7 Have you ever been absent from work because of upper back problem? *Wake walova emsebenzini ngenxa yokuhlushwa umhlane?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is NO, please go on to Question 8 *Uma uphendule wathi cha, qhubekela kumbuzo wesishiyagalombili*

If YES: *uma kunjalo*:

How many Times *Kangaki*?

7a ☐☐

How many days have you been absent from work with upper back trouble in Total *Zingaki izinsuku owazilova seziphelele ngenxa yokuhlushwa umhlane?*

7b ☐☐ *nsuku*

How many days have you been absent from work with upper back trouble in the last 12 months *Zingaki izinsuku ozilovile kulezinyanga eziyishumi nambili ezedlule ngenxa yokuhlushwa umhlane?*

7c ☐☐ *nsuku*

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8 How often do you get or have you had upper back trouble*? Ikuhlupha kangaki umhlane?*

1 Daily *Nsukuzonke* ☐ 2 One or more times a week *kanye noma kaningi ngesonto* ☐

3 One or more times a month *kanye noma kaningi enyangeni* ☐

4 One or more times a year *kanye noma kaningi enyakeni*? ☐

5 One or more times every few years *kanye noma kaningi emva kweminyaka embalwa* ☐

6 One episode of trouble *Isiqutshana sobunzima* ☐

9 What is the total length of time that you had upper back trouble during the last 12 months? *Singakananai isikhathi upehethwe iqolo kulezinyanga ezishumi nambili ezedlule*

1. 0 days *Akunazinsuku* ☐ 1 – 7 days *Usuku kuya kweziyisikhombisa* ☐

3. 8 – 30 days *Izinsuku eziyishiyagalombili kuya kwezingamashumi amathathu* ☐

4. More than 30days, but not every day *Ngaphezu kwezinsuku ezingamashumi amathathu kodwa hhayi nsukuzonke* ☐

5 Every day *Nsukuzonke* ☐

10 Has the upper back trouble caused you to reduce your activity during the last 12 months? *Ngabe umhlane usake wakuhlupha kangangoba waze wanciphisa izinto ozenzayo kulezinyanga eziyishumi nambili ezedlule?*

10a Work Activity *Okwenzayo* (at home or away from home) *ekhaya noma ungekho ekhaya*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

10b Leisure Activity *Into yokuchitha isizungu oyenzayo*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

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11 What is the total length of time that the upper back trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months*? Singakanani isikhathi lapho ungakwazanga ukwenza imisebenzi ejwayelekile ngenxa yokuhlushwa umhlane?*

1. 0 days ☐ 1- 7 days 3. ☐30 days 4. M☐han 30 days ☐

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12 Have you been seen by the doctor, physiotherapist, chiropractor, or other such person because of upper back trouble during the last 12 months *Usake wabonana nabodokotela ngenza yokuhlushwa umhlane kulezinyanga eziyishumi nambili ezedlule?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is No go to the next section. *uma impendulo ithi 'Cha', iya kwi isahluko elandelayo.*

If YES :*uma kunjalo :*

Where? ipi ndawo?(More than one box can be ticked)*(Lapho ungakhetha amabhokisi angaphezulu kwelilodwa)*

1 Medical centre at work *Emtholampilo wasemusebenzini* ☐ 2 GP *Kadokotela* ☐

3 Hospital *Esibhedlela* ☐ 4 Private Doctor *Udokotela wangasese* ☐

5 Other *Okunye* ☐ease specify) *Ngicela ucacise* ☐

ELBOW TROUBLE ***INKINKA EZINDOLOLWANE***

How to answer the questionnaire *(iphendulwa kanjani imibuzo)*:

By elbow trouble we mean pain ache or discomfort in the shaded area only. *(Inkinga yezindololwane isho ubuhlungu noma ukungazizwa kahle kulendawo ekhonjisiwe kuphela.)*

Please answer by ticking one box for each answer. *(Sicela uphendule ngoku-maka ibhokisi elilodwa kwimpendulo ngayinye)*

1 Have you ever had any elbow trouble (ache, pain numbness or discomfort)?
wake waba nenkinga yezindololwane (ubuhlungu,ukungazizwa kahle,izinkwantshu)
Yes *Yebo* No *Cha*
1 ☐ 2 ☐
If you have answered NO to this question, do not answer questions 2-12 but, please go to the next on section lower back page 20.
Uma uphaendulo mbuzo wathi 'Cha' ungapwuphenduli umbuzo 2-12 kodwa sicela uqhubeke kwi sahluko ezidololwane kwi – khasi lemashumi amabili

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2 Have you ever hurt your elbow in an accident? *Wake walimala ezindololwaneni ngenxa yengozi?*

Yes *Yebo* No *Xa*

1 ☐ 2 ☐

IF the answer is NO, please go to Question 3 *Uma uphendule wathi cha, qhubekela kumbuzo wesithathu*

IF YES: *uma kunjalo:*

2a was the accident at work? *ngabe isehlakalo sasisemisebenzini?*

Yes *Yebo* No *Cha*

1 ☐ ☐

2b what was the approximate date of the accident *Lwalunini umhlambe usuku lwengozi?*

☐☐☐☐☐☐☐☐

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3 Have you ever had to change duties or jobs because of elbow trouble? *Wake washintsha imisebenzi ngenxa yokuhlushwa izindololwane?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

4 What do you think brought on this problem with your elbow? *Ucabanga ukuthi yini edala uhlushwe izindololwane?*

1 Accident *Ingozi* ☐ 2 Sporting Activity *Ezemidlalo* ☐ 3 Activity at home *Okwenziwa ekhaya* ☐

4 Activity at work *Okwenziwa emsebenzini* ☐

5 Other Okunye ☐

(Please Specify) *Ngicela ucacise* ☐

5a What year did you first have elbow trouble? *Imuphi unyaka owaqala ukuhlushwa izindololwane ngawo?*

☐☐☐☐

5b What year was your worst elbow trouble? *Imuphi unyaka owahlushwa kakhulu izindololwane ngawo?*

☐☐☐☐

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6 How bad was the pain during the worst episode? *Babunjani ubuhlungu ngesikhathi uhlushwa kakhulu izindololwane ?*

1 Mild *Phakathi nendawo* ☐ 2 Severe *Kakhulu* ☐ 3 Very Severe *Kakhulu ngokweqile* ☐

---

7 Have you ever been absent from work because of elbow problem? *Wake walova emsebenzini ngenxa yokuhlushwa izindololwane?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is NO, please go on to Question 8 *Uma uphendule wathi cha, qhubekela kumbuzo wesishiyagalombili*

If YES: *uma kunjalo*:

How many Times *Kangaki*?

7a ☐☐

How many days have you been absent from work with elbow trouble in Total *Zingaki izinsuku owazilova seziphelele ngenxa yokuhlushwa izindololwane ?*

7b ☐ days *Izinsuku*

How many days have you been absent from work with elbow trouble in the last 12 months *Zingaki izinsuku ozilovile kulezinyanga eziyishumi nambili ezedlule ngenxa yokuhlushwa izindololwane ?*

7c ☐ days *Izinsuku*

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8 How often do you get or have you had elbow trouble? *Zikuhlupha kangaki izindololwane?*

1 Daily *Nsukuzonke* ☐ 2 One or more times a week *kanye noma kaningi ngesonto* ☐

3 One or more times a month *kanye noma kaningi enyangeni* ☐

4 One or more times a year *kanye noma kaningi enyakeni?* ☐

5 One or more times every few years *kanye noma kaningi emva kweminyaka embalwa* ☐

6 One episode of trouble *Isiqutshana sobunzima* ☐

9 What is the total length of time that you had elbow trouble during the last 12 months? *Singakananai isikhathi upehethwe iqolo kulezinyanga ezishumi nambili ezedlule*

1. 0 days *Akunazinsuku* ☐ 2. 1 – 7 days *Usuku kuya kweziyisikhombisa* ☐

3. 8 – 30 days *Izinsuku eziyishiyagalombili kuya kwezingamashumi amathathu* ☐

4. More than 30days, but not every day *Ngaphezu kwezinsuku ezingamashumi amathathu kodwa hhayi nsukuzonke* ☐

5 Every day *Nsukuzonke* ☐

10 Has the elbow trouble caused you to reduce your activity during the last 12 months? *Ngabe indololwane isake yakuhlupha kangangoba waze wanciphisa izinto ozenzayo kulezinyanga eziyishumi nambili ezedlule?*

10a Work Activity *Okwenzayo* (at home or away from home) *ekhaya noma ungekho ekhaya*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

10b Leisure Activity *Into yokuchitha isizungu oyenzayo*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

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11 What is the total length of time that the elbow trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months? *Singakanani isikhathi lapho ungakwazanga ukwenza imisebenzi ejwayelekile ngenxa yokuhlushwa izindololwane?*

1. 0 days ☐ 2. 1- 7 days ☐ 3. 8 – 30 days ☐ 4. More than 30 days ☐

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12 Have you been seen by the doctor, physiotherapist, chiropractor, or other such person because of elbow trouble during the last 12 months *Usake wabonana nabodokotela ngenza yokuhlushwa izindololwane kulezinyanga eziyishumi nambili ezedlule* ?

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is No go to the next section. *Uma impendulo ithi 'Cha', iya kwi isahluko elandelayo.*

If YES: *uma kunjalo:*

Where? ipi ndawo?(More than one box can be ticked)*(Lapho ungakhetha amabhokisi angaphezulu kwelilodwa)*

1 Medical centre at work *Emtholampilo wasemusebenzini* ☐ 2 GP *Kadokotela* ☐

3 Hospital *Esibhedlela* ☐ 4 Private Doctor *Udokotela wangasese* ☐

5 Other *Okunye* ☐ (please specify) *Ngicela ucacise* ☐

LOW BACK TROUBLE *INKINGA YEQOLO*

How to answer the questionnaire *(iphendulwa kanjani imibuzo) :*

By low back trouble we mean pain ache or discomfort in the shaded area only.*(Inkinga yeqolo isho ubuhlungu noma ukungazizwa kahle kulendawo ekhonjisiwe kuphela.)*

Please answer by ticking one box for each answer.*(Sicela uphendule ngoku-maka ibhokisi elilodwa kwimpendulo ngayinye)*

1 Have you ever had any low back trouble (ache, pain numbness or discomfort)?
wake waba nenkinga yeqolo (ubuhlungu,ukungazizwa kahle,izinkwantshu)
Yes *Yebo* No *Cha*
1 ☐ 2 ☐
If you have answered NO to this question, do not answer questions 2-12 but, please go to the next on section wrist/hand page 24.
Uma uphendulo mbuzo wathi 'Cha' ungapwuphenduli umbuzo 2-12 kodwa sicela uqhubeke kwi sahluko yesihlakala noma isandla kwi –khasi lamashumi mabili nane

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2 Have **you ever hurt your low back in an accident** *Wake walimala eqolo ngenxa yengozi?*

Yes *Yebo* No *Xa*

1 ☐ 2 ☐

IF the answer is NO, please go to Question 3 *Uma uphendule wathi cha, qhubekela kumbuzo wesithathu*

IF YES: *uma kunjalo:*

2a was the accident at work? *ngabe isehlakalo sasisemisebenzini?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

2b what was the approximate date of the accident *Lwalunini umhlambe usuku lwengozi ?*

☐☐☐☐☐☐☐☐

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3 Have you ever had to change duties or jobs because of low back trouble *Wake washintsha imisebenzi ngenxa yokuhlushwa eqolo ?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

4 What do you think brought on this problem with your low back? *Ucabanga ukuthi yini edala uhlushwe eqolo?*

1 Accident *Ingozi* 2 ☐ ting Activity *Ezemidlalo* ☐ Activity at home *Okwenziwa ekhaya* ☐

4 Activity at work *Okwenziwa emsebenzini* ☐ ☐

5 Other *Okunye* ☐

(Please Specify) *Ngicela ucacise* ☐

5a What year did you first have low back trouble? *Imuphi unyaka owaqala ukuhlushwa iqolo ngawo?*

☐☐☐☐

5b What year was your worst low back trouble? *Imuphi unyaka owahlushwa kakhulu ngawo iqolo?*

☐☐☐☐

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6 How bad was the pain during the worst episode? *Babunjani ubuhlungu ngesikhathi uhlushwa kakhulu iqolo?*

1 Mild *Phakathi nendawo* ☐ 2 Severe *Kakhulu* ☐ 3 Very Severe *Kakhulu ngokweqile* ☐

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7 Have you ever been absent from work because of low back problem? *Wake walova emsebenzini ngenxa yokuhlushwa iqolo?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is NO, please go on to Question 8 *Uma uphendule wathi cha, qhubekela kumbuzo wesishiyagalombili*

If YES: *uma kunjalo*:

How many Times *Kangaki?*

☐☐

7a

How many days have you been absent from work with low back trouble in Total *Zingaki izinsuku owazilova seziphelele ngenxa yokuhlushwa eqolo?*

7b ☐ days *Izinsuku*

How many days have you been absent from work with low back trouble in the last 12 months *Zingaki izinsuku ozilovile kulezinyanga eziyishumi nambili ezedlule ngenxa yokuhlushwa eqolo?*

7c ☐ days *Izinsuku*

8 How often do you get or have you had low back trouble? *likuhlupha kangaki iqolo?*

1 Daily *Nsukuzonke* ☐ 2 One or more times a week *kanye noma kaningi ngesonto* ☐

3 One or more times a month *kanye noma kaningi enyangeni* ☐

4 One or more times a year *kanye noma kaningi enyakeni*? ☐

5 One or more times every few years *kanye noma kaningi emva kweminyaka embalwa* ☐

6 One episode of trouble *Isiqutshana senkinga* ☐

9 What is the total length of time that you had low back trouble during the last 12 months? *Singakananai isikhathi upehethwe iqolo kulezinyanga ezishumi nambili ezedlule*

1. 0 days *Akinazinsuku* ☐ 2. 1 – 7 days *Usuku kuya kweziyisikhombisa* ☐

3. 8 – 30 days *Izinsuku eziyishiyagalombili kuya kwezingamashumi amathathu* ☐

4. More than 30days, but not every day *Ngaphezu kwezinsuku ezingamashumi amathathu kodwa hhayi nsukuzonke* ☐

5 Every day *Nsukuzonke* ☐

10 Has the low back trouble caused you to reduce your activity during the last 12 months? *Ngabe iqololisake lakuhlupha kangangoba waze wanciphisa izinto ozenzayo kulezinyanga eziyishumi nambili ezedlule*?

10a Work Activity *Okwenzayo* (at home or away from home) *ekhaya noma ungekho ekhaya*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

10b Leisure Activity *Into yokuchitha isizungu oyenzayo*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

11 What is the total length of time that the low back trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months*? Singakanani isikhathi lapho ungakwazanga ukwenza imisebenzi ejwayelekile ngenxa yokuhlushwa eqolo*?

1. 0 days ☐ 1- 7 days ☐ 3. 8 – 30 days ☐ 4. More than 30 days ☐

12 Have you been seen by the doctor, physiotherapist, chiropractor, or other such person because of low back trouble during the last 12 months *Usake wabonana nabodokotela ngenza yokuhlushwa iqolo kulezinyanga eziyishumi nambili ezedlule?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is No go to the next section. *uma impendulo ithi 'Cha', iya kwi isahluko elandelayo.*

If YES: *uma kunjalo:*

Where? *Ipi ndawo?(*More than one box can be ticked)*(Lapho ungakhetha amabhokisi angaphezulu kwelilodwa)*

1 Medical centre at work *Emtholampilo wasemusebenzini* ☐ 2 GP *Kadokotela* ☐

3 Hospital *Esibhedlela* ☐ 4 Private Doctor *Udokotela wangasese* ☐

5 Other *Okunye* ☐ please specify) *Ngicela ucacise* ☐

WRIST OR HAND TROUBLE *INKINGA YESIHLAKALA NOMA ISANDLA*

How to answer the questionnaire *(iphendulwa kanjani imibuzo)*:

By wrist/ hand trouble we mean pain ache or discomfort in the shaded area only. *(Inkinga yesihlakala noma isandla isho ubuhlungu noma ukungazizwa kahle kulendawo ekhonjisiwe kuphela.)*

Please answer by ticking one box for each answer.*(Sicela uphendule ngoku-maka ibhokisi elilodwa kwimpendulo ngayinye)*

1 Have you ever had any wrist/hand trouble (ache, pain numbness or discomfort)?
wake waba nenkinga yesihlakala noma isandla (ubuhlungu,ukungazizwa kahle,izinkwantshu)
Yes *Yebo* ☐ No *Cha* ☐
1 2

If you have answered NO to this question, do not answer questions 2-12 but, please go to the next on section general health page 28.
Uma uphendulo mbuzo wathi 'Cha' ungapwuphenduli umbuzo 2-12 kodwa sicela uqhubeke kwi sahluko inhlolo-mibuzo yempilo ngokujwalekile kwi –khasi lemashumi namabili neshiyagalombili

2 Have you ever hurt your wrist/hand in an accident *Wake walimala izihlakala noma izandla ngenxa yengozi?*

Yes *Yebo* No *Xa*

1 ☐ 2 ☐

IF the answer is NO, please go to Question 3 *Uma uphendule wathi cha, qhubekela kumbuzo wesithathu*

IF YES: *uma kunjalo:*

2a was the accident at work? *ngabe isehlakalo sasisemisebenzini?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

2b what was the approximate date of the accident *Lwalunini umhlambe usuku lwengozi?*

☐☐☐☐☐☐☐☐

3 H[illegible] or jobs because of wrist/hand trouble *Wake washintsha imisebenzi ngenxa yokuhlushwa yesihlakala noma isandla?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

4 What do you think brought on this problem with your wrist/hand *Ucabanga ukuthi yini edala uhlushwe yisihlakala noma isandla?*

1 Accident *Ingozi* ☐ Sporting Activity *Ezemidlalo* ☐ ctivity at home *Okwenziwa ekhaya* ☐

4 Activity at work *Okwenziwa emsebenzini* ☐ ☐

5 Other Okunye ☐

(Please Specify) *Ngicela ucacise* ☐

5a What year did you first have wrist/hand trouble? *Imuphi unyaka owaqala ukuhlushwa izihlakala noma izandla ngawo?*

☐☐☐☐

5b What year was your worst wrist/hand trouble? *Imuphi unyaka owahlushwa kakhulu intamo ngawo?*

☐☐☐☐

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6 How bad was the pain during the worst episode? *Babunjani ubuhlungu ngesikhathi ikuhlupha kakhulu intamo?*

1 Mild *Phakathi nendawo* ☐ 2 Severe *Kakhulu* 3 ☐ y Severe *Kakhulu ngokweqile* ☐

---

7 Have you ever been absent from work because of wrist/hand problem? *Wake walova emsebenzini ngenxa yokuhlushwa yesihlakala noma isandla ?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is NO, please go on to Question 8 *Uma uphendule wathi cha, qhubekela kumbuzo wesishiyagalombili*

If YES: *uma kunjalo*:

How many Times *Kangaki ?*

7a ☐☐

How many days have you been absent from work with wrist/hand trouble in Total *Zingaki izinsuku owazilova seziphelele ngenxa yokuhlushwa yesihlakala noma isandla?*

7b ☐ days *Izinsuku*

How many days have you been absent from work with wrist/hand trouble in the last 12 months *Zingaki izinsuku ozilovile kulezinyanga eziyishumi nambili ezedlule ngenxa yokuhlushwa yesihlakala noma isandla?*

7c ☐ days *Izinsuku*

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8 How often do you get or have you had wrist/hand trouble*? Sikuhlupha kangaki isihlakala noma isandla?*

1 Daily *Nsukuzonke* ☐ 2 One or more times a week *kanye noma kaningi ngesonto* ☐

3 One or more times a month *kanye noma kaningi enyangeni* ☐

4 One or more times a year *kanye noma kaningi enyakeni*? ☐

5 One or more times every few years *kanye noma kaningi emva kweminyaka embalwa* ☐

6 One episode of trouble *Isiqutshana sobunzima* ☐

9 What is the total length of time that you had wrist/hand trouble during the last 12 months? *Singakananai isikhathi upehethwe isandla kulezinyanga ezishumi nambili ezedlule*

1. 0 days Akunazinsuku ☐ 2. 1 – 7 days *Usuku kuya kweziyisikhombisa* ☐

3. 8 – 30 days *Izinsuku eziyishiyagalombili kuya kwezingamashumi amathathu* ☐

4. More than 30days,but not every day *Ngaphezu kwezinsuku ezingamashumi amathathu kodwa hhayi nsukuzonke* ☐

5 Every day *Nsukuzonke* ☐

10 Has the wrist/hand trouble caused you to reduce your activity during the last 12 months? *Ngabe isihlakala noma isandla sisake sakuhlupha kangangoba waze wanciphisa izinto ozenzayo kulezinyanga eziyishumi nambili ezedlule?*

10a Work Activity *Okwenzayo* (at home or away from home) *ekhaya noma ungekho ekhaya*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

10b Leisure Activity *Into yokuchitha isizungu oyenzayo*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

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11 What is the total length of time that the wrist/hand trouble has prevented you from doing your normal work (at home or away from home) during the last 12 months*? Singakanani isikhathi lapho ungakwazanga ukwenza imisebenzi ejwayelekile ngenxa yokuhlushwa?*

1. 0 days ☐ 2. 1- 7 days ☐ 3. 8 – 30 days ☐ 4. More than 30 days ☐

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12 Have you been seen by the doctor, physiotherapist, chiropractor, or other such person because of wrist/hand trouble during the last 12 months *Usake wabonana nabodokotela ngenza yokuhlushwa isihlakala noma isandla kulezinyanga eziyishumi nambili ezedlule* ?

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

If the answer is No go to the next section. *Uma impendulo ithi 'Cha', iya kwi isahluko elandelayo.*

If YES :*uma kunjalo :*

Where? ipi ndawo?(More than one box can be ticked)*(Lapho ungakhetha amabhokisi angaphezulu kwelilodwa)*

1 Medical centre at work *Emtholampilo wasemusebenzini* ☐ 2 GP *Kadokotela* ☐

3 Hospital *Esibhedlela* 4 ☐ Private Doctor *Udokotela wangasese* ☐

5 Other *Okunye* ☐ (please specify) *Ngicela ucacise* ☐

GENERAL HEALTH QUESTIONNAIRE**(INHLOLO-MIBUZO YEMPILO NGOKUJWALEKILE)*

We would like to know how your health has been in general **OVER THE PAST FEW WEEKS**. *(Sithanda ukwazi ukuthi impilo yakho ngokujwalekile ibe njani kulamasonto amabalwa adlule)*

Please circle the answer which you think most nearly applies to you. *(Sicela uzingelezele impendulo ocabanga ukuthi icishe yenzeke kuwe)*

HAVE YOU RECENTLY: *(kusanda kwenzeka ukuthi)*

	1	2	3	4
1. Been able to concentrate on whatever you are doing? *Ngabe uke wakwazi ugxila entweni oyenzayo?*	Better than usual *Kungcono kunokujwayelekile*	Same as usual *Kuyafana nokujwayelekil-e*	Less than usual *Kwehlile kokujwayelekil-e*	Much less than usual *Kwehle kakhulu kunalokhu okujwayelekile*
2. Lost much sleep over worry? *Ngabe uke wangalala ngenxa yokukhathazeka?*	Not at all *Akwenzeki*	No more than usual. *Akudlulile kulokho okujwayelekile*	Rather more than usual. *kungathi kungaphezulu kwalokho okujwayelekile*	Much more than usual. *Kweqe kakhulu lulokhu okujwayelekile*
3. Felt that you are playing a useful part in things? *Ngabe uke wazizwa wenza izinto kangcono?*	More so than usual. *Kungcono kunokujwayelekile*	Same as usual *Kuyafana nokujwayelekil-e*	Less useful than usual *Kusiza kancane kunalokho okujwayelekile*	Much less useful *Akusizi nakancane*
4. Felt capable of making decisions about things? *Ngabe uke wazizwa ukwazi ukuthatha izinqumo ezintweni?*	More so than usual *Kungcono kunokujwayelekile*	Same as usual *Kuyafana nokujwayelekil-e*	Less useful than usual *Kusiza kancane kunalokho okujwayelekile*	Much less useful *Akusizi nakancane*
5. Felt constantly under strain? *Ngabe uke wangaphansi kobunzima isikhathi eside*	Not at all *Akwenzeki*	No more than usual. *Akudlulile kulokho okujwayelekile*	Rather more than usual. *kungathi kungaphezulu kwalokho okujwayelekile*	Much more than usual. *Kweqe kakhulu lulokhu okujwayelekile*
6. Felt that you couldn't overcome your difficulties? *Ngabe uke wazizwa sengathi ngeke uphumelele ebunzimeni*	Not at all *Akwenzeki*	No more than usual. *Akudlulile kulokho okujwayelekile*	Rather more than usual. *kungathi kungaphezulu kwalokho okujwayelekile*	Much more than usual. *Kweqe kakhulu lulokhu okujwayelekile*
7. Been able to enjoy your normal day to day activities?Ukukwazi ukujabulela lokho okwenza nsukuzonke?	More so than usual*(Kungcono kunokujwayelekile*	Same as usual *Kuyafana nokujwayelekile*	Less so than usual.	Much less than usual *Kwehle kakhulu kunalokhu okujwayelekile*
8. Been able to face up to your problems? *Ukukwazi ukubhekana nezinkinga zakho?*	More so than usual *Kungcono kunokujwayelekile*	Same as Usual *uyafana nokujwayelekile*	Less able than usual	Much less able *Kwenzeka kancane kakhulu*
9. Been feeling unhappy and depressed? *ukuzizwa ungajabule futhi ugcindezelekile emphefumulweni?*	Not at all *Akwenzeki*	No more than usual. *Akudlulile kulokho okujwayelekile*	Rather more than usual. *kungathi kungaphezulu kwalokho okujwayelekile*	Much more than usual. *Kweqe kakhulu lulokhu okujwayelekile*
10. Been losing Confidence in yourself(Ukungazethembi?	Not at all *Akwenzeki*	No more than usual. *Akudlulile kulokho okujwayelekile*	Rather more than usual. *kungathi kungaphezulu kwalokho okujwayelekile*	Much more than usual. *Kweqe kakhulu lulokhu okujwayelekile*
11. Been thinking yourself as a worthless person ?(Ukuzithatha njengomuntu ongelutho?	Not at all *Akwenzeki*	No more than usual. *Akudlulile kulokho okujwayelekile*	Rather more than usual. *kungathi kungaphezulu kwalokho okujwayelekile*	Much more than usual. *Kweqe kakhulu lulokhu okujwayelekile*
12. Been feeling reasonably	More so than	About same as	Less so than usual	Much less than

happy all things considered?*(Ukuzizwa uthokozile ezintweni zonke?)*	usual*(Kungcono kunokujwayelekile*	usual		usual*(Kwehle kakhulu kunalokhu okujwayelekile)*

13 How often do you experience any of the following symptoms during or after work? For each symptom, put a tick in the appropriate box. *Kukangaki lapho uhlangabezana nalezinkomba ngesikhathi somsebenzi noma ungasebenzi, beka ebhokisini okuyilona*

1 Frequently *(Kaningi)*	**2** Sometimes *(Kwezinye izikhathi)*	**3** Rarely*(Akuvamile)*	**4**Never *(Akwenzeki)*	
Fatigue *ukukathala ngokwejile*	1 ☐	2 ☐	3 ☐	4 ☐
Headaches *ubuhlungu bekhanda*	1 ☐	2 ☐	3 ☐	4 ☐
Distributed vision *ukungaboni kahle*	1 ☐	2 ☐	3 ☐	4 ☐

14 Do you wear spectacles or contact lenses while working in the machine(Uyazifaka yini izibuko uma usebenzisa umshini)?

Yes *(Yebo)* No *(Cha)*

1 ☐ 2 ☐

INFORMATION ABOUT YOUR JOB *ULWAZI MAYELANA NOMSEBENZI WAKHO*

1 How many years and months have you been doing your present type of work? *Mingaki iminyaka nezinyanga wenza lomsebenzi owenzayo ngengamanje?*

Years Iminyaka Months Izinyanga

☐ ☐

If less than one month, how many weeks (Uma kungaphansi kwenyanga, mangaki amasonto)?

☐

2 Have you worked at other harvesting Operations? *Usake wasebenza kunoma kuyipi ingxenye yokuwiswa kwamahlathi?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

2.1 if yes, what is the total length of time you worked in the harvester or forwarder elswere, befor working here? *Uma impedulo ithi 'Yebo', singakanani isikhathi owasisebenza, kwi- Harvester noma kwi Forwarder ngapambi kokusebenza lapha?*

Years *Ininyaka* Months *Izinyanga*

☐ ☐

If less than one month, how many weeks? *Uma kungapansi kwenyanga, mangaki amasonto?*

☐

3. Do you have any other paid job other than here *Ngabe ukhona yini umsebenzi owenzayo okukhokhelayo ngaphandle kwalapha?*

Yes *(Yebo)* No *(Cha)*

1 ☐ 2 ☐

4. On average how many hours a week do you work on the machine? (Including overtime but excluding the main meal breaks).

Hours Amahora ☐

5. Do you rotate or change your duties regularly during the day*? Ngabe uyashintsha imisebenzi ngosuku?*

Yes *Yebo* No *Cha*

1 ☐ 2 ☐

6. If yes how often *(Uma uthi yebo, kukangaki)*?

Changing once every hour *(kuyashintsha kanye ngehora)* 1 ☐

Changing once every 2 hours *(Kuyashintsha kanye emva kwamahora ambili)* 2 ☐

Changing once every 2 -4 hours *(kuyashintsha kanye emva kwamahora amabili noma amane)* 3 ☐

Other Okunye 4 ☐

If you have ticked other say how often. *uma umake okunye, isho ukuthi kubakangaki obanaso ngosuku lomusebenzi* ☐

7 On average how many breaks do you have each working day? *Ngokwesinganiso esiphakathi nendawo, singakanani isikathi sokuphumula* ☐

8 Ignoring lunch – break how long is each of your breaks on average? *Ngapandle kwesikhathi sokudla – sibangakanani isikhati sokupumla uma ulinganisa ngokumaphakathi nendawo*

☐ es

THANK YOU

NGIYABONGA

Appendix 3: Body template

(Adapted from: Corlett, 2005, pp 473-474)

0= Neck

1= Upper back-a

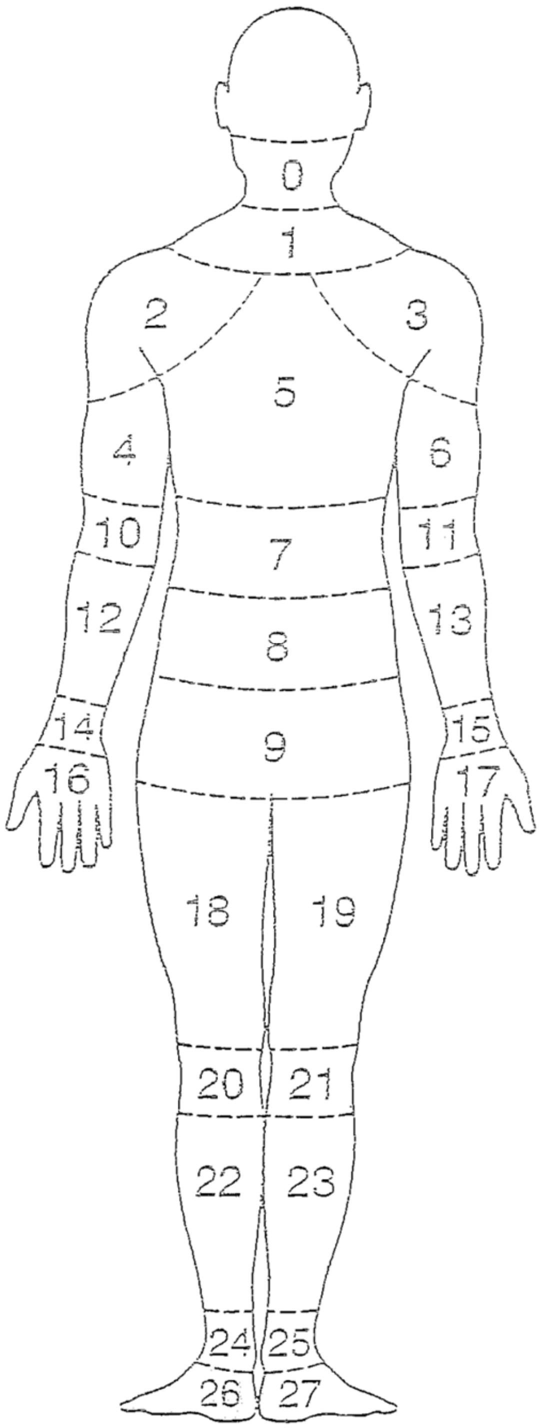
2= Left Shoulder

3= Right Shoulder

5= Upper back- b

7= Lower back- a

8= Lower back- b



Appendix 4: Ratings of perceived musculoskeletal discomfort

(Adapted from: Corlett, 2005, pp 473-474)

RATING SCALE

0. **No discomfort** *(Akuna buhlungu)*
1. **Very weak discomfort** *(Ubuhlungu obuncane kakhulu)*
2. **Weak discomfort** *(Ubuhlungu obuncane)*
3. **Moderate discomfort** *(Ubuhlungu ubuphakhathi nendawo)*
4. **Somewhat strong discomfort** *(Kucishe kube buhlungu kakhulu)*
5. **Strong discomfort** *(Kubuhlungu kakhulu)*
6. **Very strong Discomfort** *(Kubuhlungu ngokweqile)*
7. **Extremely strong discomfort** *(Kubuhlungu ngoqile kakhulu)*

The participants were asked to use the rating scale to rate their perceived musculoskeletal discomfort (per body site) every hour during the 9 hour shift.

Appendix 5: Backrest angle measurement

Seat backrest inclination was measured at the beginning of the shift using the EC (2006) guidelines. A protractor and measuring tape was used.

Assessment

Make, model, and year of manufacture of seat and armrests:

New ☐ Second hand ☐

Additional equipment etc.: ______________________________

Repairs/overhauls carried out: ______________________________

Establish the Seat Reference Point (SRP). The SRP is situated in the centre of the seat in the intersection between the seat cushion and the backrest from which the measurements are taken. The SRP is 97 mm below and 130 mm behind the Seat Index Point (SIP) (see ISO 5353).

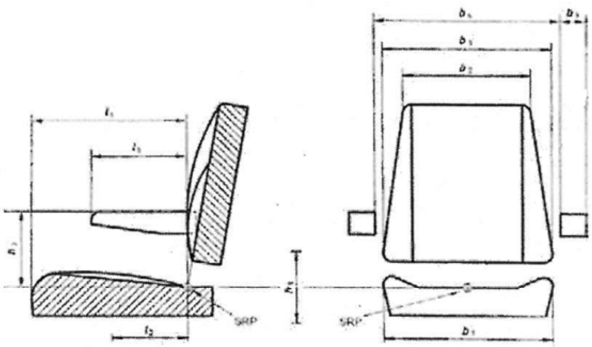


Figure 5. Measurement points on operator's seat and armrests.

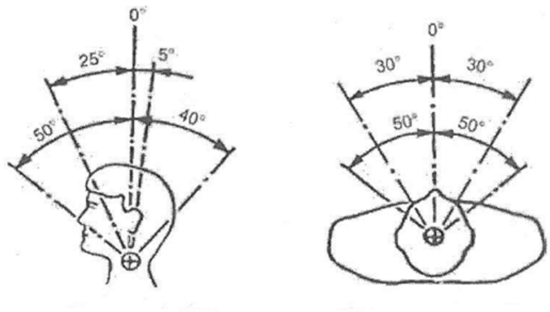
Operator's seat

Legroom ± 240	Height 400-650 1)	Damping	Backrest angle - 5-30°	Seat pitch Up 8° Down15°	Lumbar-support convexity > 80	
Lumbar-support height 150-230	Seat depth 370-480	Fore-and-aft tilt 2) > ± 20°	Lateral tilt 2) ±10-15°	Seat swivel 3) 220°/270°	Seat width 460-510	Backrest width b_2: 310-360 b_3: 430-510

1) The height of the seat cushion above the floor should be measured with a load of 750 N on the seat.
2) Depending on whether the operator's seat or cab can be levelled.
3) Depending on whether the cab is rotateable.

Figure 6. Range of seat adjustments (mm or °).

Appendix 6: Description of head postures investigated



Optimum and maximum ranges of movement for the head and neck. Maximum range should be only for short periods on isolated occasions during a work cycle (EC, 2006)

POSTURE	DESCRIPTION
Minor head flexion (MF)	Head and neck movement down within optimal range of 25° visually estimated Fig 3.4(f).
Extreme head flexion (EF)	Head and neck movement to the bottom within maximum range greater than 25° estimated visually Fig 3.4(e).
Minor head extension (ME)	Head and neck movement to the top within optimal range of 5° visually estimated Fig 3.4(h).
Extreme head extension (EE)	Head and neck movement to the top within maximum range greater than 5° visually estimated Fig 3.4(g).
Minor lateral head rotation to the right (MLR)	Lateral head and neck movement to the right within optimal range of 30° visually estimated Fig 3.4(b).
Extreme lateral head rotation to the right (ELR)	Lateral head and neck movement to the right within maximum range greater than 30° Fig 3.4(a).
Minor lateral head rotation to the left (MLL)	Lateral head and neck movement to the left within optimal range of 30° visually estimated Fig 3.4(d).
Extreme lateral head rotation to the left (ELL)	Lateral head and neck movement to the left within maximum range greater than 30° visually estimated Fig 3.4(c).

Appendix 7: Risk Filter

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RISK FILTER

Task: ______________________________
Assessor: ______________________________
Date: ______________ Location/work area: ______________

IF YOU ANSWER YES TO ANY OF THE STEPS, YOU SHOULD THEN MAKE A FULL RISK ASSESSMENT OF THE TASK. REMEMBER TO CONSIDER ALL OF THE BODY PARTS OF THE UPPER LIMBS (FINGERS, HANDS, WRISTS, ARMS, SHOULDERS AND NECK). ANSWER **ALL** QUESTIONS

Step 1: Signs and symptoms			
Are there any: ☐ Medically diagnosed cases of ULDs in this work? ☐ Complaints of aches and pains? ☐ Improvised changes to work equipment, furniture or tools?	Are any of these present?	YES ☐ NO ☐	Move on to Step 2
Step 2: Repetition			
Are there repetitive elements such as: ☐ Repeating the same motions every few seconds? ☐ A sequence of movements repeated more than twice per minute? ☐ More than 50% of the cycle time involved in performing the same sequence of motions?	For more than 2 hours total per shift?	YES ☐ NO ☐	Move on to Step 3
Step 3: Working postures			
Are there any working postures such as: ☐ Large range of joint movement such as side to side or up and down? ☐ Awkward or extreme joint positions? ☐ Joints held in fixed positions? ☐ Stretching to reach items or controls? ☐ Twisting or rotating items or controls? ☐ Working overhead?	For more than 2 hours total per shift?	YES ☐ NO ☐	Move on to Step 4
Step 4: Force			
Are there any forces applied such as: ☐ Pushing, pulling, moving things (including with the fingers or thumb)? ☐ Grasping/gripping? ☐ Pinch grips ie holding or grasping objects between thumb and finger? ☐ Steadying or supporting items or work pieces? ☐ Shock and/or impact being transmitted to the body from tools or equipment? ☐ Objects creating localised pressure on any part of the upper limb?	Sustained or repeated application of force for more than 2 hours total per shift?	YES ☐ NO ☐	Move on to Step 5
Step 5: Vibration			
☐ Do workers use any powered hand-held or hand-guided tools or equipment or do they hand-feed work pieces to vibrating equipment?	Regularly (ie at some point during most shifts)?	YES ☐ NO ☐	

If you answer yes to any of the steps, you should make a full risk assessment of the task.

Upper limb disorders in the workplace

Appendix 8: Risk assessment worksheet

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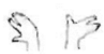
RISK ASSESSMENT WORKSHEETS

Worksheet Reference Number [ ]

Date:______ Name of assessor:______ Task:______ No. of employees that conduct this task____ How long is the task typically undertaken for: a) without a break______ b) in a typical shift (excluding breaks)______	How frequently is the task undertaken (eg. daily, weekly):______ Other tasks undertaken by worker that may pose risk of ULDs *(include worksheet reference numbers)*: ______ What hand tools are used in the task:______	Task description:

1 Repetition **For 2 consecutive hours per work day:**		Yes	No	**Describe any problem(s) and probable cause(s):** *Describe what the person is doing eg. hand operation of drill 10 times per minute. Performed 3 hours per day, five days per week.*	**Describe any risk control options you have identified**	**Control options** *(not exhaustive list)*
1.1 Does the task involve repeating the same movements every few seconds?	*A '**Cycle**' is a sequence of actions of relatively short duration that is repeated over and over, and is almost always the same. A cycle is not necessarily associated with one single joint movement, but also with complex movements of one or more parts of the body.*	☐	☐			**Reduce repetition:** ■ Mechanise or automate repetitive functions ■ Use power ratchet tools ■ Remove machine or other pacing ■ Restructure task (Job design) ■ Remove or monitor piecework schemes **Reduce duration:** ■ Implement job enlargement ■ Ensure adequate breaks ■ Implement job rotation ■ Limit/control overtime
1.2 Is there a cycle or sequence of movements that is repeated twice per minute or more OR More than 50% of the task involves performing a repetitive sequence of motions?		☐	☐			
1.3 Are the wrists/hands/fingers used intensively?		☐	☐			
1.4 Is there repetitive shoulder/arm movement (ie regular arm movement with some pauses or almost continuous arm movement?)		☐	☐			
1.5 Are tools used that require **repetitive** finger or thumb action?		☐	☐			

Upper limb disorders in the workplace

2 Working posture **Fingers, hands and wrist**		Yes	No	**Describe any problem(s) and probable cause(s):** *Note problem postures and identify parts of the upper limb involved. eg. Static gripping posture used for up to 2 hours at a time, wrists repetitively bent sideways when drilling objects.*	**Describe any risk control options you have identified**	**Control options** *(not exhaustive list)*
2.1 Is the wrist bent **repetitively** up and/or down?	*Remember: the greater the deviation from a neutral position, the greater the risk.* 	☐	☐			**Optimise working posture:** ■ Modify operation or production method ■ Relocate equipment or items ■ Present work items differently ■ Reduce amount of manipulation required ■ Ensure equipment accounts for differences in worker size, shape and strength ■ Ensure working heights are appropriate ■ Ensure items are within reach distances ■ Provide suitable (and adjustable) seating ■ Use fixtures/jigs After tools or controls ■ Ensure tools are suitable for task ■ Ensure tools do not require awkward postures
2.2 Is the wrist **held** in a position that is bent upwards or downwards?		☐	☐			
2.3 Are the fingers gripping or used while the wrists are bent?		☐	☐			
2.4 Is the wrist bent **repetitively** to either side?		☐	☐			
2.5 Is the wrist **held** bent to either side?		☐	☐			
2.6 Are the hands **repetitively** turned or twisted so that the palm is facing up or downwards?		☐	☐			
2.7 Are the **hands** held with the palms facing up or down?		☐	☐			
2.8 is a wide finger and/ or hand span needed to grip, hold or manipulate items?		☐	☐			
2.9 Do static postures of the fingers, hand or wrist occur, for more than two consecutive hours per working day?		☐	☐			
2.10 Are there tools, equipment and/or work pieces that are poorly shaped and/or do not fit the hand comfortably?		☐	☐			
2.11 Are there any tools, hand held equipment or work pieces that are too large or small to be gripped easily?		☐	☐			
2.12 Are tools designed for right handed use only?		☐	☐			

3 Working posture **Arms and shoulders**		Yes	No	**Describe any problem(s) and probable cause(s):** *Note problem postures and identify parts of the upper limb involved. eg. Shoulder held in fixed position with elbow out to the side for up to 2 hours at a time. This is due to the work height.*	**Describe any risk control options you have identified**	**Control options** *(not exhaustive list)*
3.1 Is work performed above the head or with the elbows above the shoulders for more than 2 hours total in a working day?	*Remember: the greater the deviation from a neutral position, the greater the risk.* 	☐	☐			**Optimise working posture:** ■ Automate or mechanise ■ Modify operation or production method ■ Relocate equipment or items ■ Present work items differently ■ Reduce amount of manipulation required ■ Ensure workplaces and equipment account for differences in worker size, shape and strength ■ Ensure working heights are appropriate ■ Ensure items are within reach distances ■ Provide suitable (and adjustable) seating ■ Use fixtures/jigs Alter tools or controls ■ Ensure tools are suitable for task ■ Ensure tools do not require awkward postures ■ Provide arm support for precision work
3.2 Does the task involve **repetitively** moving the upper arms out to the side of the body?		☐	☐			
3.3 Does the task involve **holding** the upper arms out to the side of the body without support?		☐	☐			
3.4 Do static postures of the shoulder or elbow occur, for more than two consecutive hours per work day?		☐	☐			
3.5 Does the work involve any other postures such as: ☐ Awkward forward or sideways reaching? ☐ Awkward reaching behind the body? ☐ Awkward reaching across the body?	  *Workstation layout and working height can be a major influence on working postures*	☐	☐			

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4 Working posture **Head and neck**		Yes	No	**Describe any problem(s) and probable cause(s):** *Note problem postures and identify parts of the upper limb involved. eg. neck held in fixed bending position to see screw holes.*	**Describe any risk control options you have identified**	**Control options** *(not exhaustive list)*
4.1 Does the task involve **repetitively** bending or twisting the neck?	*Remember: the greater the deviation from a neutral position, the greater the risk.*	☐	☐			**Optimise working posture:** ■ Ensure visual requirements are not too demanding ■ Provide visual aids ■ Ensure lighting is suitable ■ Reposition items that workers are required to look at
4.2 Does the task involve **holding** the neck bent and/or twisted for more than 2 hours total per working day?		☐	☐			
4.3 Do the visual demands of the task require the worker to view fine details and adopt awkward positions?		☐	☐			
4.4 Do aspects of lighting such as dim light, shadow, flickering light, glare and/or reflections cause the worker to adopt awkward postures?		☐	☐			

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5 Force		Yes	No	**Describe any problem(s) and probable cause(s):** *eg. Drill handle is too small resulting in increased gripping force for up to 4 hours per day. Also high force applied to screws*	**Describe any risk control options you have identified**	**Control options** *(not exhaustive list)*
5.1 Does the task require **repetitive** or **static** application of force?	*For the hand/ wrist, high-force tasks are those with estimated average individual hand force requirements of 4 kg or above.*	☐	☐			**Optimise working posture:** ■ Reduce forces necessary ■ Use power tools ■ Can the function be achieved differently? ■ Use jigs to hold items ■ Reduce weight of items ■ Present items differently ■ Increase mechanical advantage ■ After task to use stronger muscles ■ Use foot pedals ■ If gloves used check that they are appropriate ■ Maintain tools ■ Ensure tools are suitable for task ■ Improve handles ■ Use light weight tools ■ Use tool counterbalances ■ Ensure tool handles fit workers comfortably
5.2 Is it a pinch grip being used **repetitively** or **statically** for more than two hours total per work day?	*For example, pinching an unsupported object weighing 0.9 kg (2 lbs) or more per hand, or using a similar pinching force (eg holding a small binder clip open).* 	☐	☐			
5.3 Does the worker use the grip of the finger, thumb or hand as a pressing tool?		☐	☐			
5.4 Do tools require the application of pressure on a trigger or button?		☐	☐			
5.5 Does the hand apply force by twisting objects/ tools or squeezing items?		☐	☐			
5.6 Is the hand or wrist used as a hammer?		☐	☐			
5.7 Is force being applied when the wrists are bent and/or with the arms raised?		☐	☐			
5.8 Does the task require the wearing of gloves which affect gripping?		☐	☐			
5.9 Do any objects, work pieces, tools or parts of the workstation impinge or create localised pressure on any part of the body?		☐	☐			

6 Working environment		Yes	No	**Describe any problem(s) and probable cause(s):** *eg. Workers exposed to hand vibration from drill up to 4 hours per day. Workers have cold air blowing on hands from exhaust.*	**Describe any risk control options you have identified**	**Control options** *(not exhaustive list)*
6.1 Are vibration exposures likely to regularly exceed HSE's recommended action level of 2.8 m/s² A(8)? - impulsive tools (chipping hammmers, needle guns, hammer drills, etc) may exceed HSE's recommended action level after only a few seconds use per day and are highly likely to exceed the action level after 30 minutes use per day - Rotary tools (grinders, sanders, etc may exceed HSE's recommended action level after only a few minutes use per day and are highly likely to exceed the action level after 2 hours use per day		☐	☐			**Improve the working environment:** ■ Use alternative process(es) ■ Select alternative lower vibration equipment ■ Use balancers/ tensioners ■ Maintain equipment ■ Reduce exposure time to vibration ■ Provide information and training ■ Conduct health surveillance ■ Avoid working in cold ■ Avoid handling or insulate cold items or tools ■ Redirect blowing air ■ Use warm clothing
6.2 Do tools create or transmit jerky actions, shock or torque (twisting)?		☐	☐			
6.3 Does the task involve working in cold or in draughts, particularly with cold air blowing over the hands?		☐	☐			
6.4 Does the task involve holding cold tool handles, work items or other cold objects?		☐	☐			

7 Psychosocial factors *(These factors are best dealt with through discussion with workers. Sensitivity may be required)*	Yes	No	**Describe any problem(s) and probable cause(s):** *eg. Workers are on piecework system. Support from supervision and co-workers is low.*	**Describe any risk control options you have identified**	**Control options** *(not exhaustive list)*
7.1 Is the work placed? ie machine or team sets the pace, or the work rate is otherwise not under the worker's control?	☐	☐			**Reduce force:** ■ Reduce monotony ■ Ensure reasonable workload and deadlines ■ Ensure good communication and reporting of problems ■ Encourage teamwork ■ Monitor and control overtime and shiftwork ■ Reduce or monitor productivity relatedness of pay systems ■ Provide appropriate training
7.2 Is there a system of work, or piecework, which encourages workers to skip breaks or to finish early?	☐	☐			
7.3 Do workers find it difficult to keep up with their work?	☐	☐			
7.4 Do workers feel that there is a lack of support from supervisors or co-workers?	☐	☐			
7.5 Is there overtime/shiftwork that is unplanned, unmonitored and/or not organised to minimise risk of ULDs?	☐	☐			
7.6 Do the tasks require high levels of attention and concentration?	☐	☐			
7.7 Do the workers have little or no control over the way they do their work?	☐	☐			
7.8 Are there frequent tight deadlines to meet?	☐	☐			
7.9 Are there sudden changes in workload, or seasonal changes in volume without any mechanisms for dealing with the change	☐	☐			
7.10 Do workers feel that they have been given sufficient training and information in order to carry out their job successfully?	☐	☐			

8 Individual differences	Yes	No	**Describe any problem(s) and probable cause(s):** *eg. No system for gradual return to work*	**Describe any risk control options you have identified**	**Control options** *(not exhaustive list)*
8.1 Are any workers potentially at increased risk of ULS due to: ☐ being new employees or returning to work after a long break; ☐ differences in competence and skills; ☐ being part of vulnerable groups such as older, younger workers, new or expectant mothers; ☐ disability and health status.	☐	☐			**Improve the working environment:** ■ Allow for a gradual build up to full production speed ■ Provide suitable training to develop the skills required ■ Seek advice on special requirements

Appendix 9: Non-Significant result of the multiple comparisons between the variables neck, shoulder upper back and lower back WMSD reporting by operators

Variables tested

Body Site	Discomfort last 12 months	Discomfort last 7 days	Prevention 'Normal Duties'
Neck	V10	V11	V12
Shoulders	VV13	VV14	V15
Upper back	V22	V23	V24
Lower back	V25	V26	V27

```
FRIEDMAN TWO-WAY ANALYSIS OF VARIANCE TEST RESULTS

  VARIABLE      RANK
  NO. NAME      SUM
   2 V22      140.5
   3 V23      134.5
   4 V24      122.5
   5 VV13     128.5
   6 VV14     140.5
   7 V15      98.5
   8 V10      140.5
   9 V11      134.5
  10 V12      98.5
  11 V25      164.5
  12 V26      140.5
  13 V27      116.5

 FRIEDMAN TEST STATISTIC =   14.99. P-VALUE = 0.1830
 ASSUMING CHI-SQUARE DISTRIBUTION WITH  11 DEGREES OF FREEDOM

 KENDALL COEFFICIENT OF CONCORDANCE = 0.0681


     MULTIPLE COMPARISONS

 THE NULL HYPOTHESIS IS REJECTED IF ZSTAT IS LARGER THAN
 THE CRITICAL VALUE ZC, WHERE 1-PHI(ZC)= ALPHA/(K(K-1)),
 PHI IS THE CUMULATIVE STANDARD NORMAL DISTRIBUTION FUNCTION,
 ALPHA IS THE DESIRED OVERALL SIGNIFICANCE LEVEL, AND
 K IS THE NUMBER OF GROUPS COMPARED.

WITH 12 GROUPS , THE CRITICAL Z VALUES ARE:
    3.17 FOR OVERALL ALPHA OF .10 (*)
    3.37 FOR OVERALL ALPHA OF .05 (**)

  COMPARISONS      ZSTAT   DIF     SE
 V22    - V23     0.26   6.00   22.80
 V22    - V24     0.79   18.00   22.80
 V22    - VV13     0.53   12.00   22.80
 V22    - VV14     0.00   0.00   22.80
 V22    - V15     1.84   42.00   22.80
 V22    - V10     0.00   0.00   22.80
 V22    - V11     0.26   6.00   22.80
 V22    - V12     1.84   42.00   22.80
 V22    - V25     1.05  -24.00   22.80
 V22    - V26     0.00   0.00   22.80
 V22    - V27     1.05   24.00   22.80
 V23    - V24     0.53   12.00   22.80
 V23    - VV13     0.26   6.00   22.80
 V23    - VV14     0.26   -6.00   22.80
 V23    - V15     1.58   36.00   22.80
 V23    - V10     0.26   -6.00   22.80
 V23    - V11     0.00   0.00   22.80
 V23    - V12     1.58   36.00   22.80
 V23    - V25     1.32  -30.00   22.80
 V23    - V26     0.26   -6.00   22.80
 V23    - V27     0.79   18.00   22.80
 V24    - VV13     0.26   -6.00   22.80
 V24    - VV14     0.79  -18.00   22.80
 V24    - V15     1.05   24.00   22.80
 V24    - V10     0.79  -18.00   22.80
```

```
V24   - V11    0.53  -12.00   22.80
V24   - V12    1.05   24.00   22.80
V24   - V25    1.84  -42.00   22.80
V24   - V26    0.79  -18.00   22.80
V24   - V27    0.26   6.00   22.80
VV13   - VV14    0.53  -12.00   22.80
VV13   - V15    1.32   30.00   22.80
VV13   - V10    0.53  -12.00   22.80
VV13   - V11    0.26   -6.00   22.80
VV13   - V12    1.32   30.00   22.80
VV13   - V25    1.58  -36.00   22.80
VV13   - V26    0.53  -12.00   22.80
VV13   - V27    0.53   12.00   22.80
VV14   - V15    1.84   42.00   22.80
VV14   - V10    0.00   0.00   22.80
VV14   - V11    0.26   6.00   22.80
VV14   - V12    1.84   42.00   22.80
VV14   - V25    1.05  -24.00   22.80
VV14   - V26    0.00   0.00   22.80
VV14   - V27    1.05   24.00   22.80
V15   - V10    1.84  -42.00   22.80
V15   - V11    1.58  -36.00   22.80
V15   - V12    0.00   0.00   22.80
V15   - V25    2.89  -66.00   22.80
V15   - V26    1.84  -42.00   22.80
V15   - V27    0.79  -18.00   22.80
V10   - V11    0.26   6.00   22.80
V10   - V12    1.84   42.00   22.80
V10   - V25    1.05  -24.00   22.80
V10   - V26    0.00   0.00   22.80
V10   - V27    1.05   24.00   22.80
V11   - V12    1.58   36.00   22.80
V11   - V25    1.32  -30.00   22.80
V11   - V26    0.26   -6.00   22.80
V11   - V27    0.79   18.00   22.80
V12   - V25    2.89  -66.00   22.80
V12   - V26    1.84  -42.00   22.80
V12   - V27    0.79  -18.00   22.80
V25   - V26    1.05   24.00   22.80
V25   - V27    2.10   48.00   22.80
V26   - V27    1.05   24.00   22.80
```

NUMBER OF INTEGER WORDS USED IN PRECEDING PROBLEM 1374

BMDP3S - NONPARAMETRIC STATISTICS

Appendix 10: Non-significant result of neck WMSD reported by 20–30-year-old operators

```
Mr Kudak Phairah - Research Project - T13003     08:50 Monday, November 11, 2013  5
K01-R8c) : n-Way PROC FREQ of varbs DISCOMFORT*ANSWER by VV6 for NECK from data set NECK

------------------------------------- VV6=20 to 30yrs ----------------------------------------

         The FREQ Procedure

      Table of DISCOMFORT by ANSWER

   DISCOMFORT    ANSWER

   Frequency  |
   Percent    |
   Row Pct    |
   Col Pct    |No     |Yes    | Total
   -------------+--------+--------+
   Neck-12m-V10 |    4 |    6 |    10
          | 13.33 | 20.00 | 33.33
          | 40.00 | 60.00 |
          | 22.22 | 50.00 |
   -------------+--------+--------+
   Neck-7d-V11 |    5 |    5 |    10
          | 16.67 | 16.67 | 33.33
          | 50.00 | 50.00 |
          | 27.78 | 41.67 |
   -------------+--------+--------+
   Neck-DP-V12 |    9 |    1 |    10
          | 30.00 |  3.33 | 33.33
          | 90.00 | 10.00 |
          | 50.00 |  8.33 |
   -------------+--------+--------+
   Total       18     12     30
           60.00  40.00  100.00


  Statistics for Table of DISCOMFORT by ANSWER

Statistic           DF     Value    Prob
------------------------------------------------------
Chi-Square           2    5.8333   0.0541
Likelihood Ratio Chi-Square  2    6.5559   0.0377
Mantel-Haenszel Chi-Square   1    5.0347   0.0248
Phi Coefficient             0.4410
Contingency Coefficient         0.4035
Cramer's V               0.4410

WARNING: 50% of the cells have expected counts less
     than 5. Chi-Square may not be a valid test.


        Fisher's Exact Test
     ----------------------------------
     Table Probability (P)     0.0061
     Pr <= P              0.0658

         Sample Size = 30
```

Appendix 11: Mean forwarding task time and awkward head posture frequencies

Mr Kudak Phairah - Research Project - T13003 16:12 Monday, November 25, 2013 15

(K03-R5a) : PROC FREQ of varbs from data set MPOSTURE

The MEANS Procedure

Variable	N	Mean	Std Dev	Std Error	Median	Variance	Minimum	Maximum
MTEMPTY	18	2.7704167	2.3345385	0.5502560	2.3722500	5.4500699	0.4380000	10.3530000
MLOADING	18	17.4517222	6.4370086	1.5172175	14.8612500	41.4350798	9.3620000	30.5400000
MTLOADED	18	2.4680000	1.1283197	0.2659475	2.1157500	1.2731053	1.0710000	5.2370000
MOFFLOAD	18	9.0528333	5.0262996	1.1847102	8.2475000	25.2636880	3.4510000	23.1300000
MIDLE	2	1.0132500	0.9309061	0.6582500	1.0132500	0.8665861	0.3550000	1.6715000
MTRECTIME	18	32.4760000	11.4476759	2.6982431	29.3757500	131.0492840	16.1690000	55.1000000
MTEMLR	18	8.7777778	6.1314575	1.4451984	7.5000000	37.5947712	1.5000000	22.0000000
MTEELR	18	2.8611111	2.2413596	0.5282935	2.0000000	5.0236928	0.5000000	9.0000000
MTEMLL	18	5.5277778	4.4007761	1.0372729	4.2500000	19.3668301	0	18.5000000
MTEELL	18	2.6388889	2.3439883	0.5524833	2.0000000	5.4942810	0	9.0000000
MTEME	18	0.0833333	0.2572479	0.0606339	0	0.0661765	0	1.0000000
MTEEE	18	0.0555556	0.2357023	0.0555556	0	0.0555556	0	1.0000000
MTEMF	18	1.4166667	1.7760664	0.4186229	0.7500000	3.1544118	0	6.0000000
MTEEF	18	0	0	0	0	0	0	0
MLMLR	18	29.1666667	18.2353890	4.2981224	27.5000000	332.5294118	5.0000000	63.0000000
MLELR	18	10.7777778	8.5650147	2.0187933	9.7500000	73.3594771	0	34.0000000
MLMLL	18	25.6111111	14.6914897	3.4628173	26.0000000	215.8398693	1.0000000	45.0000000
MLELL	18	12.4166667	9.2454281	2.1791683	12.0000000	85.4779412	0	35.0000000
MLME	18	5.3888889	4.3573992	1.0270488	5.0000000	18.9869281	0	13.0000000
MLEE	18	0.0277778	0.1178511	0.0277778	0	0.0138889	0	0.5000000
MLMF	18	12.0833333	5.1370912	1.2108240	12.0000000	26.3897059	3.5000000	20.0000000
MLEF	18	0.3055556	0.9570004	0.2255671	0	0.9158497	0	4.0000000
MTLMLR	18	7.0833333	7.1089215	1.6755889	4.7500000	50.5367647	1.0000000	28.0000000
MTLELR	18	2.6944444	2.1702459	0.5115319	2.0000000	4.7099673	0	7.0000000
MTLMLL	18	3.6111111	2.2980526	0.5416562	3.2500000	5.2810458	0	8.0000000
MTLELL	18	3.3055556	3.0250857	0.7130195	2.5000000	9.1511438	0	13.0000000
MTLME	18	0.1944444	0.5184504	0.1221999	0	0.2687908	0	2.0000000
MTLEE	18	0	0	0	0	0	0	0
MTLMF	18	1.0277778	1.5479799	0.3648624	0.2500000	2.3962418	0	5.5000000
MTLEF	18	0.0833333	0.2572479	0.0606339	0	0.0661765	0	1.0000000
MOLELR	18	4.1388889	3.9400118	0.9286697	2.7500000	15.5236928	0	14.0000000
MOLMLR	18	17.3888889	12.9745855	3.0581391	17.0000000	168.3398693	0	46.0000000
MOLELL	18	2.5555556	3.0673273	0.7229760	1.2500000	9.4084967	0	10.0000000
MOLMLL	18	12.9444444	12.1883369	2.8728185	9.0000000	148.5555556	0	36.0000000
MOLEE	18	0.3888889	1.4199788	0.3346922	0	2.0163399	0	6.0000000
MOLME	18	4.0555556	3.8113179	0.8983362	3.5000000	14.5261438	0	12.0000000
MOLEF	18	0.1111111	0.2741594	0.0646200	0	0.0751634	0	1.0000000
MOLMF	18	3.8888889	3.3235150	0.7833600	2.2500000	11.0457516	0	10.0000000

Appendix 12: Mean frequencies of head postures by the preferred backrest inclination groups (<100°, 100 and >100)

Mr Kudak Phairah - Research Project - T13003 16:12 Monday, November 25, 2013 18
(K03-R5c) : PROC FREQ of varbs by CMPBRA from data set MPOSTURE

--- CMPBRA=< 100 ---

The MEANS Procedure

Variable	N	Mean	Std Dev	Std Error	Median	Variance	Minimum	Maximum
MTEMPTY	5	2.2455000	1.6395587	0.7332329	1.3590000	2.6881527	0.5220000	4.1850000
MLOADING	5	21.1238000	6.8165024	3.0484326	20.1040000	46.4647052	12.2700000	30.5400000
MTLOADED	5	2.9114000	1.5347673	0.6863688	2.2865000	2.3555107	1.2765000	5.2370000
MOFFLOAD	5	7.0367000	2.8127525	1.2579012	5.5090000	7.9115767	4.2705000	10.8260000
MIDLE	0	.	.	.	.	.	.	.
MTRECTIME	5	33.7859000	11.4994668	5.1427179	30.5150000	132.2377373	19.7610000	49.0690000
MTEMLR	5	6.9000000	5.5834577	2.4969982	5.5000000	31.1750000	1.5000000	13.5000000
MTEELR	5	1.8000000	0.8366600	0.3741657	2.0000000	0.7000000	1.0000000	3.0000000
MTEMLL	5	4.3000000	3.1144823	1.3928388	4.5000000	9.7000000	1.0000000	9.0000000
MTEELL	5	1.9000000	1.2942179	0.5787918	2.0000000	1.6750000	0	3.5000000
MTEME	5	0	0	0	0	0	0	0
MTEEE	5	0	0	0	0	0	0	0
MTEMF	5	1.3000000	1.3038405	0.5830952	1.5000000	1.7000000	0	3.0000000
MTEEF	5	0	0	0	0	0	0	0
MLMLR	5	40.8000000	21.6119180	9.6651436	45.5000000	467.0750000	5.0000000	62.0000000
MLELR	5	12.1000000	5.6833089	2.5416530	12.0000000	32.3000000	6.0000000	20.0000000
MLMLL	5	29.9000000	16.0794900	7.1909666	28.0000000	258.5500000	5.5000000	45.0000000
MLELL	5	19.2000000	12.2912571	5.4968173	20.5000000	151.0750000	0.5000000	35.0000000
MLME	5	5.2000000	4.3243497	1.9339080	5.0000000	18.7000000	1.0000000	12.0000000
MLEE	5	0	0	0	0	0	0	0
MLMF	5	14.0000000	4.7037219	2.1035684	13.0000000	22.1250000	8.5000000	20.0000000
MLEF	5	1.0000000	1.7320508	0.7745967	0	3.0000000	0	4.0000000
MTLMLR	5	14.9000000	9.6137922	4.2994186	13.5000000	92.4250000	5.5000000	28.0000000
MTLELR	5	2.0000000	2.3452079	1.0488088	1.0000000	5.5000000	0	6.0000000
MTLMLL	5	3.3000000	1.6046807	0.7176350	3.5000000	2.5750000	1.5000000	5.5000000
MTLELL	5	3.8000000	5.2985847	2.3695991	1.5000000	28.0750000	0	13.0000000
MTLME	5	0.5000000	0.8660254	0.3872983	0	0.7500000	0	2.0000000
MTLEE	5	0	0	0	0	0	0	0
MTLMF	5	1.6000000	2.2192341	0.9924717	1.0000000	4.9250000	0	5.5000000
MTLEF	5	0.1000000	0.2236068	0.1000000	0	0.0500000	0	0.5000000
MOLELR	5	3.4000000	6.0145657	2.6897955	0.5000000	36.1750000	0	14.0000000
MOLMLR	5	14.4000000	11.4149025	5.1048996	19.0000000	130.3000000	2.0000000	28.0000000
MOLELL	5	0.6000000	0.8944272	0.4000000	0	0.8000000	0	2.0000000
MOLMLL	5	5.0000000	7.5911132	3.3948490	1.0000000	57.6250000	0	18.0000000
MOLEE	5	1.4000000	2.6076810	1.1661904	0	6.8000000	0	6.0000000
MOLME	5	2.9000000	3.3241540	1.4866069	2.5000000	11.0500000	0	8.0000000
MOLEF	5	0.2000000	0.4472136	0.2000000	0	0.2000000	0	1.0000000
MOLMF	5	2.3000000	2.2803509	1.0198039	2.0000000	5.2000000	0	6.0000000

(K03-R5c) : PROC FREQ of varbs by CMPBRA from data set MPOSTURE

--- CMPBRA=100 ---

The MEANS Procedure

Variable	N	Mean	Std Dev	Std Error	Median	Variance	Minimum	Maximum
MTEMPTY	7	3.1079286	3.3575015	1.2690163	1.9745000	11.2728162	0.4380000	10.3530000
MLOADING	7	17.8523571	7.3819319	2.7901080	14.8105000	54.4929192	9.3620000	29.5700000
MTLOADED	7	2.3300000	1.0864370	0.4106346	2.0415000	1.1803454	1.0710000	4.2140000
MOFFLOAD	7	10.5365000	6.4859622	2.4514633	8.4560000	42.0677051	3.4510000	23.1300000
MIDLE	1	1.6715000	.	.	1.6715000	.	1.6715000	1.6715000
MTRECTIME	7	34.6740000	13.6207408	5.1481561	33.6065000	185.5245791	16.1690000	55.1000000
MTEMLR	7	10.8571429	7.1920922	2.7183553	7.5000000	51.7261905	3.0000000	22.0000000
MTEELR	7	2.7142857	2.1185125	0.8007225	2.0000000	4.4880952	0.5000000	6.0000000
MTEMLL	7	5.3571429	3.7937919	1.4339186	4.0000000	14.3928571	0	10.0000000
MTEELL	7	3.4285714	2.6837252	1.0143528	3.0000000	7.2023810	1.0000000	9.0000000
MTEME	7	0.1428571	0.3779645	0.1428571	0	0.1428571	0	1.0000000
MTEEE	7	0.1428571	0.3779645	0.1428571	0	0.1428571	0	1.0000000
MTEMF	7	1.0000000	2.2360680	0.8451543	0	5.0000000	0	6.0000000
MTEEF	7	0	0	0	0	0	0	0
MLMLR	7	24.5714286	20.2822348	7.6659642	14.0000000	411.3690476	6.0000000	63.0000000
MLELR	7	10.2857143	12.0549338	4.5563367	5.5000000	145.3214286	0	34.0000000
MLMLL	7	25.3571429	15.7921771	5.9688819	24.5000000	249.3928571	1.0000000	43.0000000
MLELL	7	12.5000000	7.0887234	2.6792856	15.0000000	50.2500000	0.5000000	21.0000000
MLME	7	7.3571429	4.1504446	1.5687206	7.0000000	17.2261905	1.0000000	13.0000000
MLEE	7	0	0	0	0	0	0	0
MLMF	7	9.5000000	4.7169906	1.7828549	10.0000000	22.2500000	3.5000000	18.0000000
MLEF	7	0	0	0	0	0	0	0
MTLMLR	7	4.7142857	2.8702082	1.0848367	5.0000000	8.2380952	1.0000000	9.0000000
MTLELR	7	3.5000000	2.3629078	0.8930952	3.0000000	5.5833333	0	7.0000000
MTLMLL	7	4.4285714	2.0701967	0.7824608	4.0000000	4.2857143	2.0000000	8.0000000
MTLELL	7	2.6428571	1.5998512	0.6046869	2.5000000	2.5595238	0	5.0000000
MTLME	7	0	0	0	0	0	0	0
MTLEE	7	0	0	0	0	0	0	0
MTLMF	7	1.0000000	1.1547005	0.4364358	1.0000000	1.3333333	0	3.0000000
MTLEF	7	0	0	0	0	0	0	0
MOLELR	7	4.7857143	3.5338499	1.3356697	6.0000000	12.4880952	0.5000000	9.0000000
MOLMLR	7	20.5000000	12.4331546	4.6992907	22.5000000	154.5833333	4.0000000	38.0000000
MOLELL	7	2.7857143	3.8281539	1.4469062	1.5000000	14.6547619	0	10.0000000
MOLMLL	7	14.0000000	11.7473401	4.4400772	10.0000000	138.0000000	0	31.0000000
MOLEE	7	0	0	0	0	0	0	0
MOLME	7	6.5714286	4.1274343	1.5600235	6.0000000	17.0357143	0	12.0000000
MOLEF	7	0.0714286	0.1889822	0.0714286	0	0.0357143	0	0.5000000
MOLMF	7	4.7142857	3.5807022	1.3533782	6.0000000	12.8214286	1.0000000	10.0000000

(K03-R5c) : PROC FREQ of varbs by CMPBRA from data set MPOSTURE

-- CMPBRA=> 100 --

The MEANS Procedure

Variable	N	Mean	Std Dev	Std Error	Median	Variance	Minimum	Maximum
MTEMPTY	6	2.8140833	1.5540368	0.6344329	2.7892500	2.4150304	1.2920000	5.5920000
MLOADING	6	13.9242500	3.1105409	1.2698730	13.4685000	9.6754650	9.5345000	19.0990000
MTLOADED	6	2.2595000	0.8673540	0.3540958	1.9692500	0.7523030	1.4810000	3.5550000
MOFFLOAD	6	9.0020000	4.6836272	1.9120828	8.4402500	21.9363637	4.2705000	17.3860000
MIDLE	1	0.3550000	.	.	0.3550000	.	0.3550000	0.3550000
MTRECTIME	6	28.8200833	9.6244213	3.9291535	27.6095000	92.6294852	20.2305000	46.4330000
MTEMLR	6	7.9166667	5.5083270	2.2487651	5.7500000	30.3416667	3.5000000	17.5000000
MTEELR	6	3.9166667	2.9396712	1.2001157	3.5000000	8.6416667	0.5000000	9.0000000
MTEMLL	6	6.7500000	6.1216828	2.4991665	5.2500000	37.4750000	1.5000000	18.5000000
MTEELL	6	2.3333333	2.6770631	1.0929064	1.5000000	7.1666667	0	7.5000000
MTEME	6	0.0833333	0.2041241	0.0833333	0	0.0416667	0	0.5000000
MTEEE	6	0	0	0	0	0	0	0
MTEMF	6	2.0000000	1.6431677	0.6708204	2.0000000	2.7000000	0	4.5000000
MTEEF	6	0	0	0	0	0	0	0
MLMLR	6	24.8333333	8.7101473	3.5559028	24.0000000	75.8666667	13.5000000	36.0000000
MLELR	6	10.2500000	6.8392251	2.7921020	9.7500000	46.7750000	2.0000000	19.0000000
MLMLL	6	22.3333333	14.0130891	5.7208197	23.2500000	196.3666667	4.0000000	40.0000000
MLELL	6	6.6666667	4.8751068	1.9902540	6.7500000	23.7666667	0	12.0000000
MLME	6	3.2500000	4.2396934	1.7308476	2.2500000	17.9750000	0	11.0000000
MLEE	6	0.0833333	0.2041241	0.0833333	0	0.0416667	0	0.5000000
MLMF	6	13.5000000	5.4680892	2.2323381	14.0000000	29.9000000	4.0000000	20.0000000
MLEF	6	0.0833333	0.2041241	0.0833333	0	0.0416667	0	0.5000000
MTLMLR	6	3.3333333	1.4719601	0.6009252	4.0000000	2.1666667	1.0000000	4.5000000
MTLELR	6	2.3333333	1.8348479	0.7490735	1.7500000	3.3666667	0	5.0000000
MTLMLL	6	2.9166667	3.0235189	1.2343464	2.0000000	9.1416667	0	7.5000000
MTLELL	6	3.6666667	2.1369761	0.8724168	3.7500000	4.5666667	1.0000000	6.5000000
MTLME	6	0.1666667	0.4082483	0.1666667	0	0.1666667	0	1.0000000
MTLEE	6	0	0	0	0	0	0	0
MTLMF	6	0.5833333	1.4288690	0.5833333	0	2.0416667	0	3.5000000
MTLEF	6	0.1666667	0.4082483	0.1666667	0	0.1666667	0	1.0000000
MOLELR	6	4.0000000	2.7748874	1.1328430	4.0000000	7.7000000	0	8.0000000
MOLMLR	6	16.2500000	16.0802674	6.5647417	14.2500000	258.5750000	0	46.0000000
MOLELL	6	3.9166667	2.7643565	1.1285438	3.7500000	7.6416667	1.0000000	8.0000000
MOLMLL	6	18.3333333	13.9236011	5.6842863	20.5000000	193.8666667	2.0000000	36.0000000
MOLEE	6	0	0	0	0	0	0	0
MOLME	6	2.0833333	2.2894686	0.9346717	1.7500000	5.2416667	0	6.0000000
MOLEF	6	0.0833333	0.2041241	0.0833333	0	0.0416667	0	0.5000000
MOLMF	6	4.2500000	3.7914377	1.5478480	3.0000000	14.3750000	0	10.0000000

Appendix 13: Significant result of lower back WMSD reported by operators with >36 to 60 months experience

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K01-R13d) : n-Way PROC FREQ of varbs DISCOMFORT*ANSWER by VV148 for LOWER BACK from data set
LOWBACK

------------------------------------ VV148=>36 to 60mn ------------------------------------

         The FREQ Procedure

      Table of DISCOMFORT by ANSWER

   DISCOMFORT    ANSWER

   Frequency    |
   Percent      |
   Row Pct      |
   Col Pct      |No     |Yes     | Total
   ---------------+--------+--------+
   L-Back-12m-V25 |    2 |    6 |    8
         |  8.33 | 25.00 | 33.33
         | 25.00 | 75.00 |
         | 13.33 | 66.67 |
   ---------------+--------+--------+
   L-Back-7d-V26 |    5 |    3 |    8
         | 20.83 | 12.50 | 33.33
         | 62.50 | 37.50 |
         | 33.33 | 33.33 |
   ---------------+--------+--------+
   L-Back-DP-V27 |    8 |    0 |    8
         | 33.33 |  0.00 | 33.33
         | 100.00 |  0.00 |
         | 53.33 |  0.00 |
   ---------------+--------+--------+
   Total        15     9     24
         62.50  37.50  100.00


  Statistics for Table of DISCOMFORT by ANSWER

Statistic            DF     Value    Prob
------------------------------------------------------
Chi-Square            2    9.6000   0.0082
Likelihood Ratio Chi-Square  2   12.1727   0.0023
Mantel-Haenszel Chi-Square   1   9.2000   0.0024
Phi Coefficient            0.6325
Contingency Coefficient        0.5345
Cramer's V              0.6325

WARNING: 50% of the cells have expected counts less
     than 5. Chi-Square may not be a valid test.


        Fisher's Exact Test
     ----------------------------------
     Table Probability (P)     0.0012
     Pr <= P            0.0094

                   Sample Size = 24
```