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THE RELATIONSHIP BETWEEN AGE, GENDER, PHYSICAL WORK CAPACITY PROFILE AND A WORKSITE WELLNESS PROGRAM FOR WORKERS IN AN ELECTRICITY SUPPLY COMPANY

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ABSTRACT

The relationship between age, gender, physical work capacity profile and a worksite wellness program for workers in an electricity supply company

Keywords: physical work capacity, age, gender, worksite wellness program, pre-employment evaluation, electricity utility industry

1. The problem and objective of study

Workers in physically demanding jobs have, over the last decade, shown a high incidence of work-related injuries as well as other related physical disorders (Dempsey & Hashemi, 1999:183; Mital & Ramakrishnan, 1999:74; WHO, 1999:1; Weir & Nielson, 2001:128; Cox *et al.*, 2003:6). This has been shown to lead to absenteeism, lost work time and poor work quality which in turn give rise to increased costs of yearly worker compensation claims, medical treatment and general loss of production (Ciriello & Snook, 1999:149; Mital, 1999:246-247; Cox *et al.*, 2003:6). For example, the World Health Organization indicates that work related injuries and illness kill an estimated 1.1 million people worldwide every year. This is roughly equal to the number of worldwide deaths due to malaria each year (WHO, 1999:1). Research indicates that these types of injuries and/or work disability usually occur when the physical demands of the work tasks exceed the physical work capacity of the worker (Chaffin, 1974:251-254; Fraser, 1992:24; Shrey, 1997a:8). Two types of workers are usually pointed out by management in this regard, namely the older workers and females that are exposed to tasks with a high physical demand (Ayoub & Mital, 1989:9; Smith & Mustard, 2004:755; Sluiter, 2006:438).

The above-mentioned problem seems to be a global concern (Mital, 1999:246; WHO, 1999:1) and forces companies to better manage the physical incapacity of workers in physical demanding jobs. The management of the electricity supply company in South Africa (hereafter the company) who realised that this problem was also prevalent in their workforce, developed minimum physical ability task requirements, that represent the physical work demands, for all the physically demanding jobs (Lubbe, 2003b:4). These minimum requirements enable the company to determine which workers do not have the physical work capacity to perform their physical

work demands and to implement the necessary management process, such as a worksite wellness program, to address the problem.

Hence the objective of the study were to determine the:

a) role of gender on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
b) role of age on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
c) effect of a worksite wellness program on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

2. Summary of results

a) The physical work capacity of male workers in this population are practically significant greater than that of female workers with the same job-related minimum physical ability task requirements.
b) Practically significant more female workers do not have the minimum physical work capacity required by their job, than male workers.
c) The physical work capacity of workers in physically demanding jobs within this company declines with aging.
d) The age-related decline in physical work capacity for male workers is to such an extent that from the age of 60, the physical work demands of their job exceed their physical work capacity.
e) The age-related decline in physical work capacity for female workers is to such an extent that, in general, the indication is that they will never have the required physical work capacity based on the minimum physical ability task requirements of their job, for it is predicted that from the age of 18, the physical work demands of their job exceed their physical work capacity.

f) A worksite wellness program assists workers whose physical work capacity profile does not meet the minimum physical ability task requirements of their job, to regain the required physical work capacity.

g) A worksite wellness program provide an alternative option to managing the physical work capacity of their workers, other than ill-health retirement, retrenchments or prolonged sick-leave.

UITTREKSEL

Die verband tussen ouderdom, geslag, fisieke werksvermoëprofiel en `n beroepsgerigte welstandsprogram vir werkers in `n elektrisiteitsvoorsieningsmaatskappy

Sleutelwoorde: fisieke werksvermoë, ouderdom, geslag, beroepsgerigte welstandsprogram, voorindiensnemingevaluasie, elektrisiteitvoorsieningsindustrie

3. Probleem en doel van die studie

Werkers wat fisiek intensiewe werkstake verrig het in die afgelope dekade `n hoë voorkoms van werksverwante beserings en ander verwante fisieke afwykings getoon (Dempsey & Hashemi, 1999:183; Mital & Ramakrishnan, 1999:74; WHO, 1999:1; Weir & Nielson, 2001:128; Cox *et al.*, 2003:6). Dit het tot werksafwesigheid, verlore werkstyd en swak werkskwaliteit aanleiding gegee wat op hul beurt weer tot verhoogde kostes aan jaarlikse werker kompensasie-eise, mediese behandeling, en algemene produksieverliese gelei het (Ciriello & Snook, 1999:149; Mital, 1999:246-247; Cox *et al.*, 2003:6). Hierdie tipe beserings en/of werksongeskiktheid vind gewoonlik plaas wanneer die fisieke eise van die werkstake die fisieke vermoë van die werker oorskry (Chaffin, 1974:251-254; Fraser, 1992:24; Shrey, 1997a:8). Twee tipes werkers word algemeen in hierdie verband deur bestuur uitgewys, naamlik die ouer werkers en vrouens wat aan werkstake met `n hoë fisieke vereiste blootgestel word (Ayoub & Mital, 1989:9; Smith & Mustard, 2004:755; Sluiter, 2006:438).

Bogenoemde probleem blyk `n wêreldwye bekommernis te wees (Mital, 1999:246; WHO, 1999:1) wat meebring dat bestuur van maatskappye genoodsaak word om die fisieke onvermoë van hul werkerskorps in fisiek intensiewe werkomgewings beter te bestuur. Die bestuur van `n elektrisiteitsvoorsieningsmaatskappy in Suid-Afrika (hierna verwys as EVM) het op grond van hierdie tendens wat ook sigbaar in hul eie werkerskorps was, minimum fisieke werksvermoë profiele ontwikkel vir werke met inherente fisieke taak vereistes (Lubbe, 2003b:4). Hierdie profiele stel die EVM in staat om die fisieke werksvermoë van hul werkers beter te bestuur deur te bepaal watter werkers nie oor die fisieke vermoë beskik om hul fisiek intensiewe werkstake te verrig nie en die nodige bestuursproses, soos `n beroepsgerigte welstandsprogram, in te stel om die probleem aan te spreek.

Gevolglik was die doel van die studie om te bepaal wat die:

a) rol is van geslag op die fisieke werksvermoë van werkers in die EVM op grond van die minimum fisieke taakvereistes van hul werk;
b) rol is van ouderdom op die fisieke werksvermoë van werkers in die EVM op grond van die minimum fisieke taakvereistes van hul werk;
c) effek is van `n beroepsgerigte welstandsprogram op die fisieke werksvermoë van werkers in die EVM op grond van die minimum fisieke taakvereistes van hul werk.

4. Kern van die bevindings

a) Die fisieke werksvermoë van manlike werkers is praktiese betekenisvol groter as die van vroulike werkers op grond van die minimum fisieke taakvereistes van hul werk.
b) Prakties betekenisvol meer vroulike werkers as manlike werkers, voldoen nie aan die minimum fisieke taakvereistes van hul werk nie.
c) Die fisieke werksvermoë van werkers met fisiek intensiewe werkstake neem af, met `n toename in ouderdom.
d) Die ouderdomverwante afname in fisieke werksvermoë van manlike werkers is tot so `n mate dat vanaf die ouderdom van 60 jaar, die fisieke taakvereistes van hul werk hul fisieke werksvermoë oorskry.
e) Die ouderdomverwante afname in fisieke werksvermoë van vroulike werkers is tot so `n mate dat oor die algemeen hul nooit die vereiste fisieke werksvermoë het nie, omrede die beraamde ouderdom waarop die fisieke taakvereistes van hul werk hul fisieke werksvermoë oorskry, 18 jaar is.
f) `n Beroepsgerigte welstandsprogram ondersteun werkers wie se fisieke werksvermoë profiel nie aan die minimum fisieke taakvereistes van hul werk voldoen nie, om die vereiste fisieke werksvermoë te verkry.

g) `n Beroepsgerigte welstandsprogram verleen `n alternatief vir die bestuur van werkers met onvoldoende fisieke werksvermoë anders as ongeskiktheidsaftrede, voortdurende siekeverlof of afdanking.

DECLARATION

The co-authors of the articles, which form part of this thesis, Prof. D.D.J. Malan and Prof. C.J. Wilders, hereby give permission to the candidate, Mr. J.P.H. Lubbe to include the three articles as part of this thesis submitted for the degree Philosophiae Doctor. The contribution of these co-authors was kept within reasonable limits, thereby enabling the candidate to submit this thesis for examination purposes. This thesis is therefore submitted for the degree Philosophiae Doctor in Human Movement Science at the North-West University (Potchefstroom campus).

Prof. D.D.J. Malan **Promoter and co-author**	**Prof. C.J. Wilders** **Co-promoter and co-author**

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LIST OF ABBREVIATIONS

ACOEM	=	American College of Occupational and Environmental Medicine
ACSM	=	American College of Sport Medicine
AIDS	=	Acquired immunodeficiency syndrome
BP	=	Blood Pressure
CEO	=	Chief Executive Officer
CHAA	=	Corporate Health Achievement Award
CI	=	Confidence Interval
ESC	=	Electricity Supply Company
et al.	=	Latin phrase et alia, which means "and others."
etc.	=	et cetera
e.g.	=	example
EVM	=	Elektrisiteitsvoorsieningsmaatskappy
HIV	=	Human immunodeficiency virus
kg.	=	Kilogram

ILO = International Labour Organization

min. = Minimum

PWC = Physical work capacity

PWD = Physical work demands

RPE = Rate of perceived effort

US = United States

VO_2-max = Maximal oxygen consumption

WELCOA = Wellness Council of America

WHO = World Health Organization

E_1 = Pre-test for experimental group

E_2 = Post-test for experimental group

C_1 = Pre-test for control group

C_2 = Post-test for control group

T_e = Worksite wellness program intervention for experimental group

X' = Predicted variable represented on the abscissa (x-axis)

R^2 = Determination coefficient

ω = Effect size for variables

$\overline{x}_K$ = Mean for the control group

$\overline{x}_E$ = Mean for the experimental group

Y' = Predicted values of physical work capacity for the various values of age

π_F = Proportion of female workers approved

π_M = Proportion of male workers approved

π_C = Proportion of workers approved for control groups

π_E = Proportion of workers approved for experimental control

s_K = Standard deviation for the control group

$\overline{X}$, = X-axis calibration line

$\overline{Y}$ = Y-axis calibration line

% = Percentage

A = physical work capacity intercept

b = Slope of the regression line

d = Effect size for averages

p = Percentage mean for male and female workers

p_1 = Percentage mean for male workers

p_2 = Percentage mean for female workers

X = variable represented on the abscissa (x-axis)

CHAPTER 1

The problem and objective of study

1.1 Background

Workers in physically demanding jobs have, over the last decade, shown a high incidence of work-related injuries as well as other related physical disorders (Dempsey & Hashemi, 1999:183; Mital & Ramakrishnan, 1999:74; WHO, 1999:1; Weir & Nielson, 2001:128; Cox *et al.*, 2003:6). This has been shown to lead to absenteeism, lost work time and poor work quality which in turn give rise to increased costs of yearly worker compensation claims, medical treatment and general loss of production (Ciriello & Snook, 1999:149; Mital, 1999:246-247; Cox *et al.*, 2003:6). For example, the World Health Organization indicates that work related injuries and illness kill an estimated 1.1 million people worldwide every year. This is roughly equal to the number of worldwide deaths due to malaria each year (WHO, 1999:1). Research indicates that these types of injuries and/or work disability usually occur when the physical demands of the work tasks exceed the physical work capacity of the worker (Chaffin, 1974:251-254; Fraser, 1992:24; Shrey, 1997a:8). Two types of workers are usually pointed out by management in this regard, namely the older workers and females that are exposed to tasks with a high physical demand (Ayoub & Mital, 1989:9; Smith & Mustard, 2004:755; Sluiter, 2006:438).

Certain industries in South Africa, such as the electricity supply industry and mining industry, have realized for quite some time the importance of managing the physical capacity of workers (Morrison *et al.*, 1968:185; Lubbe, 2003b:4). One such method used by employers as described by Fraser (1992:67-79), deals with the assessment of the physical abilities of the workers according to the demands of their work tasks. This method deals with the development of minimum physical ability task requirements for these jobs. The worker or potential worker's physical work capacity is then measured against the inherent physical demands of the work tasks. This physical work capacity profile that is drawn up for the worker will then help the employer to safely provide, select, train and place the worker in the workplace.

1.2 Problem statement

Due to factors such as the worldwide ageing population effect (WHO, 1993:1-49; De Zwart *et al.*, 1995:1; Ilmarinen *et al.*, 1997:49; Sluiter, 2006:429-432) and the high unemployment rate in South Africa (Statistics South Africa, 2002:169), companies are experiencing an increasingly ageing working community. This has the effect that workers remain in their existing jobs for longer, simply just to have work (Lubbe, 2003b:77). This increase in the number of ageing workers in the working environment leads to, amongst others, an increase in physical injuries that usually occurs as a result of these worker's inability to handle the physical demands of the work (De Zwart *et al.*, 1995:8; WHO, 1999; Ilmarinen, 2001:546; Sluiter, 2006:429-440). Researchers agree that ageing goes hand in hand with a decline in physical work capacity and is characterized by a diminished aerobic capacity and muscular capacity (Shephard, 1999:337-338; Ilmarinen, 2001:547-548; Lubbe, 2003b:105-106; Sluiter, 2006:434-436). The research, however, that investigates the relationship between the ageing worker's physical work capacity and his/her physically demanding tasks based on the minimum physical ability task requirements, is limited.

Furthermore, due to the inception of human rights legislation in South Africa, such as the Employment Equality Act 55 of 1998 and the Promotion of Equality and Prevention of Unreasonable Discrimination Act 4 of 2000 (South Africa, 1998 & 2000), together with high poverty prevalence (ILO, 2000:1-57; Messing & Őstlin, 2006:vi), females are increasingly being employed in the labour industry, without taking into account all the aspects of the physical demands of the work tasks (Kelsh & Sahl, 1996:1050; WHO, 1999:4). This forces companies to favour the employment of females, even in jobs with physically demanding tasks that were previously only carried out by males. The consequence of this is that increasingly more females are exposed to tasks that, due to the physically demanding nature of the job, historically had a higher incidence of injury and were mainly designed with the male physique in mind (Kelsh & Sahl, 1996:1050; Mac Duff *et al.*, 2005:25). The above-mentioned problem is a worldwide concern (Mital, 1999:246; WHO, 1999:1), which means that management of companies should be urged to better manage the physical shortcomings of their staff in physically demanding jobs.

The management of an electricity supply company in South Africa (hereafter the company) who realised that this trend was also prevalent in their workforce, developed minimum physical ability task requirements, that represent the physical work demands, for all the physically demanding jobs (Lubbe, 2003b:4). These minimum requirements enable the company to determine which workers do not have the physical work capacity to perform their physical work demands effectively regardless of gender or age, and are thus at risk for work related injury or disability (Matheson, 1996:168-188; Lubbe, 2003b:4). It also allows the implementation of the necessary management program, such as a worksite wellness program, to address the problem.

The literature on worksite wellness programs seems to indicate that the worksite is ideal for wellness programs, and these programs lead to substantial benefit to the employee and employer alike (Aldana, 2001:296; Golaszewski, 2001:332; O'Donnell, 2002:xv; Serxner *et al.*, 2006:1). However, the literature on worksite wellness programs for workers in physically demanding jobs is limited and therefore requires more research to determine the effect on their physical work capacity based on the minimum physical ability task requirement of their job, and if such a program could assist those workers whose physical work capacity does not meet the minimum physical work capacity of their job, to attain those requirements.

The resulting questions that this research aims to answer are as follows:

a) what the role of gender is on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
b) what the role of age is on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
c) what the effect of a worksite wellness program is on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

The answers to these questions can give management of the company clarity concerning the effect that older workers and an increasingly female work force, has on their physical work capacity to perform their physically demanding tasks. It can further be determined whether a worksite wellness program can improve the workers' physical work capacity to perform their work and maintain it above the minimum physical ability task requirements of their job.

1.3 Objectives

The objectives of this study are to determine the:

a) role of gender on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
b) role of age on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
c) effect of a worksite wellness program on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

1.4 Hypothesis

This research is based in the following hypothesis:

a) The physical work capacity profile of females in the company do not meet the minimum physical ability task requirements of their job;
b) The physical work capacity profile of the ageing workers in the company do not meet the minimum physical ability task requirements of their job;
c) A worksite wellness program can improve the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

1.5 Structure of the thesis

The structure of the thesis was prepared according to the guidelines provided by the North West University. Chapter one gives a layout of the background and problem statement that lead to the undertaking of this research project. The objectives and hypotheses of the research are included in this chapter.

Chapter two gives the result of a literature review done on the physical work capacity of workers in physically demanding jobs based on the role of age, gender and a worksite wellness program thereon. Therefore, the main objectives of this literature review are firstly to research the use of physical work capacity assessments in the workplace. Secondly to examine the role of ageing and gender on the physical work capacity of workers in physically demanding jobs and thirdly to determine the impact of a worksite wellness programs on the physical work capacity of workers in physically demanding jobs.

The following three chapters are all empirical research studies and are prepared for submission as articles to the Journal of Occupational Health South Africa. The main aim of these articles is to discuss the research methodology and results of the three objectives of this thesis. Chapter three researches the relationship between gender and the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job. The title of the article is **"The role of gender on the physical work capacity profile of workers in an electricity supply company"**. Chapter four researches the relationship between age and the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job. The title of the article is **"The role of ageing on the physical work capacity profile of workers in an electricity supply company"**. Chapter five researches the relationship between a worksite wellness program and the physical work capacity profile of workers in the company based on the minimum physical task requirements of their job. The title of this article is **"The effect of a worksite wellness program on the physical work capacity profile of workers in an electricity supply company"**.

Chapter six closes the research project off with a summary of the study results, together with conclusions reached in terms of the set hypotheses and objectives. Furthermore, this chapter provides recommendations resulting from this study for further research as well as practical applicability for management of businesses, professional persons and practitioners in the field of physical work capacity.

The literature referrals in the text are supported by a Bibliography in which complete bibliographic references are supplied, as well as studied sources that are not directly referred to, but contributed to the study and could be located after Chapter 6. The Harvard writing style of bibliographic referrals was used in the Bibliography, according to the specifications outlined by the Northwest University (Van der Walt, 2006:1-48). For each of the article chapters prepared, a reference list was included according to the Vancouver bibliographic style, as determined by the publishers of the journal. The guidelines of this style are set out in Appendix B.

Appendices that support the research done in this thesis are added. Appendix A supplies the general information about the collection of data and specifically highlights the list of equipment, informed consent with confidentiality agreement collected as well as the physical activity readiness evaluation done. Appendix B supplies the guidelines for authors from the Journal of Occupational Health South Africa for the preparation of an article publication. Furthermore, information is supplied about the "Vancouver" bibliographic style used as required by the publishers of the journal.

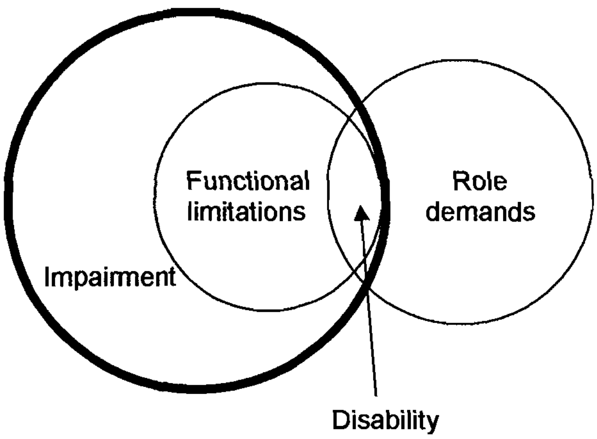
CHAPTER 2

Physical work capacity of workers in physically demanding jobs - the role of age, gender and a worksite wellness program (literature review)

2.1 Introduction

Despite increased automation in the workplace and a general reduction in the physical demands of many occupations, the majority of jobs still include physically demanding aspects (Rayson, 2000:434, Weir & Nielson, 2001:128; Cox *et al.*, 2003:6). Some jobs such as those in the armed service, the civilian emergency service, electricity utility industry and many others seem to be physically strenuous, demanding high levels of cardiovascular fitness, muscular strength and muscle endurance (Shephard, 1990:89; Rayson, 2000:434; Cox *et al.*, 2003:6; Lubbe, 2003b:50). Rayson (2000:434) emphasises that for occupations such as these mentioned where the lives and safety of the public and their colleagues may be at risk, the operational efficiency, health and safety of the workforce is of importance. Researchers agree that operational efficiency, health and safety are ultimately dependant upon the ability of each employee to perform the necessary tasks to the required standards (Fraser, 1992:67-79; Rayson, 2000:434; Cox *et al.*, 2003:10-20).

Matheson (1996:168) indicates that the effect of the worker's impairment on his or her ability to perform meaningful tasks is the focus of physical work capacity assessments. As such, the physical work capacity of workers in physically demanding jobs is important to measure because it translates the effect that the impairment of the worker has on his or her inability (or as he terms it "disability") to perform the task demands.



Source: Matheson, (1996:168)

Figure 2.1: Interface between impairment, functional limitations, role demands, and disability (inability)

Matheson (1996:168) describes this disability as the employee's uncompensated shortfalls in responding to role demands and through Figure 2.1 explains the effect that this functional limitations of these workers have on task demands (or as he terms it "role demands" in Figure 2.1). According to Matheson's model, an individual has a certain impairment resulting from environmental and personal resources for example, the state of aerobic fitness of the worker will directly influence his/her cardiovascular endurance required to do a task. If the impairment is sufficiently severe, functional limitation can result. If the functional limitations are sufficiently severe and pertinent to role demands, disabilities with regard to those tasks can result.

Therefore, it seems that by ensuring people are physically fit-for-work, by matching their capabilities with the physical requirements of their job could be an important factor in reducing the workers' compensation claims, absenteeism, lost work time and poor quality of work reported by several researchers in the previous chapter (Dempsey & Hashemi, 1999:183; Mital & Ramakrishnan, 1999:74; WHO, 1999:1; Weir & Nielson, 2001:128; Cox *et al.*, 2003:6). Two types of workers are usually pointed out by management as not having the required physical work capacity to perform their physically demanding tasks, namely the older workers and females that are exposed to tasks with a high physical demand (Ayoub & Mital, 1989:9; Smith & Mustard, 2004:755; Sluiter, 2006:438). The objective of this literature review is threefold; firstly to research the use of physical work capacity assessments in the workplace. Secondly, to examine the role of ageing and gender on the physical work capacity of workers in physically demanding jobs and thirdly to discuss the impact of worksite wellness programs on the physical work capacity of workers physically demanding jobs.

2.2 The use of physical work capacity assessments in the workplace

The primary reason for assessing the physical work capacity of workers in physically demanding jobs is to ensure that an individual is fit to perform the tasks involved effectively and without risk to his/her own or other worker's health and safety (Cox *et al.*, 2003:7). Much of the early fit-for-work assessments focused on cognitive abilities, but due to the change in legislation, and the increase in manual labour related injuries, the need for pre-employment physical work capacity tests became imperative (Jackson, 1994:53). In 1982, Campion (1983:528) suggested that there was a need for better methods of selecting personnel for physically demanding jobs for at least three reasons. First, equal employment opportunities legislation resulted in greater number of females and handicapped individuals seeking employment in jobs requiring high levels of physical ability. Second, there was evidence suggesting that physically unfit workers had higher incidences of lower back injuries. Lastly, pre-employment medical evaluations used alone were inadequate for personnel selection in physically demanding jobs.

According to Myers *et al.* (1993:311) research has generally taken two different approaches in determining the physical work capacity of workers in physically demanding jobs. One approach involves efforts to identify the physiological components that underline physical work capacity. In this literature, physical work capacity is described as a function of the combination of strength, cardiovascular endurance, utilization of energy pathways, and range of motion at joints (Myers *et al.*, 1993:311). The second approach examined individual differences in physical work capacity and the empirical correlations among these abilities such as static strength, dynamic strength, explosive strength, trunk strength, flexibility and cardiovascular endurance (Myers *et al.*, 1993.311). This is also the approach adopted by the company in the current study when developing minimum physical ability task requirements for their workers performing physically demanding tasks. Some of the researchers that made significant contributions to this field of study include Fleishman (1964), Baumgartner and Zuideman (1972), Meyers *et al.* (1993), and Jackson (1994). The physical abilities required according to the second approach, will be examined in more detail in the next section for it has relevance to the study population in this thesis.

2.2.1 Physical abilities required by workers to perform physically demanding tasks

Fleishman (1979:83) indicated that there is often confusion about the term "ability" and "skill". According to him "ability" refers to a more general characteristic of the individual and is quite lasting and difficult to change. Most of these abilities, according to Fleishman (1979:83), are a product of what is learnt. These abilities are related to the performance of a variety of human tasks and the individuals bring these characteristics with them to work. On the other hand the term "skill" refers to the level of proficiency to complete a specific task. The assumption is that "skills" involved in complex activities, can be described in terms of the more basic abilities that are needed (Fleishman 1979:83). Fleishman (1964); Baumgartner and Zuideman (1972); Meyers *et al.* (1993) and Jackson (1994) in their research describe these basic abilities required. There are four major physical ability components described by these researchers out of which most of the physical work capacity tests are derived namely: cardiovascular endurance, muscle strength, muscle endurance, flexibility and balance. Each will be briefly discussed.

2.2.1.1 Cardiovascular endurance

Fleishman (1979:87) indicates that the cardiovascular system plays an important role during endurance tasks. Cardiovascular endurance is regards as one of the most important physiological factors of physical work capacity, and is required by workers in physically demanding jobs to endure relatively strenuous activities for a sizeable time period (Baumgartner & Jackson, 1995:225; Shephard, 1997:337).

Over the last few decades, maximal oxygen consumption (VO_2-max) was considered as a valid measurement of overall cardiovascular endurance with the objective of placing workers in determined areas of work (De Vries *et al.*, 1987:1195-1204; De Zwart *et al.*, 1995:3; Ilmarinen, 2001:547). During most types of activities that require intensive muscle action, there is a relationship between the increase in oxygen consumption and the increase in work intensity (Astrand & Rhyming, 1954:218; Wilson & Corlettt, 2005:643). According to these researchers, a person's maximal oxygen consumption is therefore an indication of his/her maximal work capacity.

Scott and Christie (2004:698) concluded that, when assessing workers for tasks demanding a high level of physical effort, the workers whose maximal oxygen consumption is stretched beyond their capability should not be exploited, in order to enable them to complete the tasks safely. It is generally accepted that, during a normal eight hour work shift with the normal interruptions and resting periods, a task should not exceed more than 30-40 percent of a person's maximal oxygen consumption (Legg & Myles, 1985:340; Wilson & Corlett, 2005:77).

2.2.1.2 Muscle strength

Muscle strength refers to the maximal weight (expressed in Newton or kg.) that can be lifted, moved or pressed by a specific muscle group in one attempt (ACSM, 1995:80). Fleishman (1979:85) indicates that muscle strength consists mainly out of two components, namely static strength and explosive strength. According to Fleishman (1979:85), explosive strength is the ability to generate maximal energy in one or more quick actions over a relatively short period of time. It is applied in work tasks where the body must be effectively mobilized in a very short period of time. Static strength on the other hand represents the maximal strength that a person can exert over a short period of time without movement taking place (Fleishman, 1979:86). In contrast with explosive strength, Fleishman (1979:86) refers to static strength as the force that is exerted in order to pick up or push heavy objects. Baumgartner and Jackson (1995:203) report that the muscle strength test is one of the most common used pre-employment tests to relate strength performance to job success.

2.2.1.3 Muscle endurance

Muscle endurance is known as the ability to exert physical muscle force continuously for a reasonable period of time (Wilson & Corlett, 2005:77). According to Fleishman (1979:85), it represents the resistance of muscles to exhaustion. Bridger (2003:77) reports that muscles fatigue rapidly under conditions of static loading, which could be found in several physically demanding tasks, even at low workload. Therefore, even though a static exertion such as standing with the arm fully extended at 90 degrees to the torso only requires 10% of maximum, musculoskeletal complaints will occur if the action has to be sustained all day at work (Parenmark *et al.* quoted by Bridger, 2003:77). Baumgartner and Jackson (1995:225) identified two basic muscle groups important to perform physically demanding tasks that require muscle endurance, namely: muscle endurance of the arm and shoulder girth and muscle endurance of the abdominal muscles.

2.2.1.4 Flexibility

Flexibility refers to the range of movement of the different body joints that are determined by the muscle and tendon length, as well as the ligaments that are attached to the different joints (ACSM, 1991:50). Fleishman (1979:86) identifies two different flexibility factors, namely

a) reach flexibility which is the ability to stretch the waist and back muscles as far forward, backward and laterally, and
b) dynamic flexibility that refers to the ability of muscles to carry out quick, repetitive bending and stretching actions. This includes numerous lifting actions that occur during the execution of work tasks.

In the workplace for example, Grenier *et al.* (2003:166) indicates that low back flexibility is used as a surrogate indicator of low back health, which according to Punnett and Wegman (2004:14) is the body part with the highest prevalence of work-related injury rates in physically demanding jobs. However, according to Waddell and Burton (2001:128) and Grenier *et al.* (2003:172-175) researchers are still divided in their view of the effectiveness of low back flexibility in determining risk for low back injury. The fact remains that flexibility tests still often form part of the physical work capacity assessment of workers in physically demanding jobs as a means to determine risk for work-related injury (Grenier, 2003:172-175).

2.2.1.5 Balance

Balance is the ability to hold a body position despite forces pulling a person off balance (Fleishman, 1979:87). Balance must therefore be maintained while the body is static or in movement. Good balance abilities form one important factor with respect to efficient and safe performance in physically demanding jobs (Punakallio, 2003:33). Work actions that require this ability include work from heights, walking on narrow surfaces or climbing ladders, (Fleishman, 1979:87). Jobs like construction, fire fighting and rescue work, for example, demand intense control of balance when climbing and working on scaffolding or slippery roofs (Punakallio, 2003:33).

In conclusion, from the literature on the use of physical work capacity assessments in the workplace, it appears that the execution of physically intensive work tasks requires the identification of specific physical ability components that determines an individual's physical work capacity. These physical ability components, according to Cox *et al.* (2003:12) should relate to the task demands of the worker's job. They suggest that when selecting minimum physical ability task requirements, factors such as work demands, work environment, organizational aspects etc. should be considered when assessing workers for the workplace. Accordingly, there will be a short discussion on the development procedure for setting minimum physical ability task requirements for testing the physical work capacity of workers in the work place.

2.2.2 Development procedure for setting minimum physical ability task requirements

Alexander *et al.* (1975:687) indicates that the purpose for developing minimum physical ability task requirements is exclusively for selecting, conditioning or the correct placement of the right person for the job. Several researchers (Fleishman, 1964, 1975, 1979; Chaffin *et al.*, 1977a, 1977b & 1978; Hogan, 1980a & 1980b; Ayoub, 1982 & 1991; Fraser, 1992; Baumgartner & Jackson, 1995; Mital, 1999; Cox *et al.*, 2003) have done extensive research in this field to ensure that employers can compile such minimum requirements with confidence. Most of these researchers agree that there are generally three stages that must be followed to compile minimum physical ability task requirements. Firstly, by following thorough job analysis techniques, it must be determined what the tasks of the job are and what physical abilities will be required to carry out these tasks effectively. The next step is to select the appropriate and validated tests that can be used to determine workers' task related physical work capacity. Lastly, a task related profile must be compiled with a reasonable minimum standard to which the worker's physical work capacity must comply in terms of the physical demands of the job (Matheson, 1996:183-184).

2.2.3 The application of physical work capacity assessments in the workplace

According to a review of the literature, the application of physical work capacity assessments in the workplace could be summarized as follows:

a) placement of employees in suitable jobs (Morrison *et al.*, 1968:185; Shephard, 1990; Fordyce, 1995:39; Botha *et al.*, 1998:24; Cox *et al.*, 2003:18),

b) periodic surveillance of workforce to ensure early identification of high risk employees (Campion, 1983:546; Rorke & Rorke, 2002:31, Cox *et al.*, 2003:21-22),

c) monitor the vocational rehabilitation progress of an injured or occupationally disabled worker (Fordyce, 1995:39; Shrey, 1997a:38-39; O'Halloran, 2002:216),

d) ergonomic redesigning of workplace (Mital, 1999:240-257; Wilson & Corlett, 2005),

e) screen applications for job disability benefits (Matheson, 1996:168-188; Shrey, 1997a:3-53; Cox *et al.*, 2003:7),

f) accommodating impaired workers in physically demanding jobs (Rumrill, 1999:135-136; Schneider, 1999:159-164; Langton, 2001:27-37),

g) determine the occupational fitness of an individual to carry out the work without being a danger to themselves or others (Hogan & Bernacki, 1981:469; Fraser, 1992:1),

h) help individuals with the maintenance and improvement of their work-related health (De Kort & Van Dijk, 1997:1; Lubbe, 2006a:51-60),

i) determine the effect of dangerous work circumstances and to give correct application advice accordingly (De Kort & Van Dijk, 1997:1), and

j) provide written records in relation to the condition of the individual's physical work capacity (Fraser, 1992:2).

It is clear from this literature review that the application possibilities for physical work capacity assessments are comprehensive. However, if the amount of research in the South African context is taken as a barometer, it seems that our industries with physically demanding jobs have not fully applied physical work capacity assessments as suggested by the research literature, except for the electricity utility (Lubbe, 2006a:51-60) and mining (Morrison *et al.*, 1968:185; Malan, 2007) industries. Some organizations might argue that human rights legislation in South Africa hinders or restricts the use of physical work capacity assessments and, therefore, it will be reviewed in more detail in the next section.

2.2.4 The effect of human rights legislation on physical work capacity assessments

According to Shephard (1990:90), the use of formal assessments of physical work capacity, or as he termed it "occupational fitness", has been greatly influenced by the human rights legislation in Canada, and by parallel activities in the Equal Employment Opportunities Commission in the United States. For example, the Ontario Human Rights Code of 1981 states that every person has the right to freedom from discrimination in employment on the basis of gender, age or disability. The "equal treatment" that is required under this legislation covers such items as recruitment, training, transfer, promotion, dismissal and layoffs of employees. However, it does not preclude a difference of treatment if an employer can demonstrate that gender, age or disability make it impossible for a specific category of worker to perform the essential duties of a given job (Shephard, 1990:90). Hogan and Quigley (1986:1193-1217) and Cox *et al.*, (2003:26-41) emphasize the importance of testing precedents and proofs to demonstrate and rebut prima facie discrimination as required by the courts.

South African legislation followed the international trend with the inception of the Occupational Health and Safety Act 85 of 1993 (South Africa, 1993), followed by the Employment Equity Act 66 of 1998 (South Africa, 1998) and the Promotion of Equality and Prevention of Unfair Discrimination Act 4 of 2000 (South Africa, 2000). The effect of these three acts on physical work capacity assessments, will be briefly discussed, especially the impact it has on age and gender discrimination as well as on the electricity utility industry (study population of this thesis).

2.2.4.1 Employment Equity Act 66 of 1998

The Employment Equity Act, Section 6, prohibits discrimination as follows:

- **Section 6(1):**

"No person may unfairly discriminate, directly or indirectly, against an employee in any employment policy or practice, on one or more grounds, including race, gender, sex, pregnancy, marital status, family responsibility, ethnic or social origin, colour, sexual orientation, age, disability, religion, HIV status, conscience, belief, political opinion, culture, language and birth"

- **Section 6(2)(b):**

"It is not unfair discrimination to -

Distinguish, exclude or prefer any person on the basis of an inherent requirement of a job"

The Act thus allows discriminating under the above mentioned conditions and sets out boundaries for medical testing in section 7(1) of the Act.

- **Section 7(1):**

"Medical testing of an employee is prohibited, unless-

(a) Legislation permits or requires the testing; or

(b) It is justifiable in the light of medical facts, employment conditions, social policy, and the fair distribution of employee benefits or the inherent requirements of a job."

Botha and Heyser (2004:27) interpret the Act by suggesting that medical testing includes tests, questions, inquiry or other means designed to ascertain, or other means, which have the effect of enabling the employer to ascertain whether an employee has any medical condition. According to them, it is logical that an electrician, for instance should not be colour-blind and, therefore, it would be permissible in terms of the inherent requirements of the job to test electricians for colour-blindness. They further suggest that it might be justifiable in the light of the medical facts to have an employee subject himself to various physical and medical tests if the employee, for instance, alleges that he is incapacitated to work as a result of ill health or injury.

According to this legislation it is clear that analysing the physical work capacity based on the minimum physical ability task requirements is seen as fair and that such assessments are necessary to determine if employees working in jobs with inherent physical requirements, are at risk.

2.2.4.2 Occupational Health and Safety Act 85 of 1993

The new Construction Regulations GNR.1010 of the Occupational Health and Safety Act 85 of 1993 (South Africa, 1993), that came into effect on 18 July 2003, make reference to "physical" and "psychological fitness". This regulation stipulates that a medical certificate of physical and psychological fitness is required when working on heights. For example, Construction Regulation 8: Fall Protection states that:

"It is specified that by law a fall protection plan shall include...

The processes for the evaluation of the employees' physical and psychological fitness necessary to work at elevated positions and the records thereof..."

Similar regulations are made for workers working on suspended platforms, cranes, construction vehicles and other mobile plant. It is, therefore, according to this Act, justifiable to identify the essential physical abilities required to perform these tasks safely.

2.2.4.3 Promotion of Equality and Prevention of Unfair Discrimination Act 4 of 2000

The Office of the Presidency announced on 9 February 2000 that the President of South Africa assented the Promotion of Equality and Prevention of Unfair Discrimination Act 4 of 2000 (South Africa, 2000). This Act became fully operational in the second half of 2003, and prohibits unfair discrimination on any ground, including the 16 grounds explicitly listed in the 1996 Constitution (De Vos, 2004:5). Excerpts from the Act related to physical work capacity are listed below.

- **Section 2: Objects of the Act**

"The main objects of the Act are-

(b) to give effect to the letter and spirit of the Constitution, in particular –

i. the equal enjoyment of all rights and freedoms by every person;
ii. the promotion of equality;
iii. the values of non-racialism and non-sexism contained in section 1 of the Constitution;
iv. the prevention of unfair discrimination and protection of human dignity as contemplated in sections 9 and 10 of the Constitution;

(c) to provide for measures to facilitate the eradication of unfair discrimination, hate speech and harassment, particularly on the grounds of race, gender and disability"

The Act, therefore, emphasizes its purpose to prevent unfair discrimination and sets the boundaries in section 14 whereby fair discrimination is allowed. Only those excerpts applicable to this study are discussed below.

- **Section 14: Determination of fairness or unfairness**

(2) In determining whether the respondent has proved that the discrimination is fair, the following must be taken into account:

(c) whether the discrimination reasonably and justifiably differentiates between persons according to objectivity determinable criteria, intrinsic to the activity concerned.

(f) whether the discrimination has a legitimate purpose.

According to the legislation discussed in this Act it is clear that, in the same manner that the Employment Equity Act 66 of 1998 and the Construction Regulations in the Occupational Health and Safety Act 85 of 1993 prohibits the unfair discrimination of people, especially on the grounds of race, gender and disability. It is, however, seen as fair discrimination when it is intrinsic to the activity concerned or has a legitimate purpose, such as assessing physical work capacity, to determine if employees working in jobs with inherent physical requirements may place them at risk. Therefore, ageing workers or males and females in physically demanding jobs, identified by the physical work capacity assessment as not having the necessary physical ability to perform their physically demanding tasks, could be managed accordingly.

From the literature review related to the effects of human rights legislation on physical work capacity assessments, it is evident that there are clear boundaries set for physical work capacity assessments. Botha *et al.* (1998:22) emphasizes that failure to integrate the physical work capacity assessment with legal requirements may give rise to costly liability for the employer on the basis of unfair discrimination. However, there are still several advantages for employers to perform physical work capacity assessments that are fair according to human rights legislation, and will be briefly discussed in the next section.

2.2.5 Advantages of physical work capacity assessments

The advantages related to the use of physical work capacity assessments are that it can lead to decreased compensation costs and a 22% decrease in absenteeism (Cox *et al.*, 1987:434). Their study also found that workers that were placed according to their task-related physical work capacity showed a 16.2% lower worker turnover than unplaced workers. In addition, a longitudinal study (3 years) by Borofsky and Smith (1993:113) showed that the application of physical work capacity assessments before employment also lead to a marked reduction in worker turnover in the first 60 days after employment. They also found that physically fit workers that were correctly placed, were more productive than workers that were not fit based on the physical task demands. De Kort and Van Dijk (1997:5) showed that physical work capacity assessments based on the physical task demands also contributed to a decrease in sick leave and a marked increase in productivity of workers that complied with the physical task demands.

This literature review therefore suggests that there are clear benefits for the employee and employer alike. It seems that the employee could benefit from a healthy and prolonged working career while the employer could benefit from a safe and productive workforce. Subsequently the use of physical work capacity assessments in different industries will be discussed.

2.2.6 The use of physical work capacity assessments in different industries

Several industries have been highlighted by the literature as having work tasks that are physically demanding (Jackson, 1994:74-84; Punnett & Wegman, 2004:14; Parkhouse & Gall, 2004:660-670; Christie, 2006:16). The mining, fire fighting and timber industries are the most commonly known industries in this regard. However, the electricity utility industry is also regarded by some researches as one of those industries with high physical demands (Parkhouse & Gall, 2004:660-670; Lubbe, 2003b:46). These four industries and there relation to physically demanding tasks will be discussed briefly in the next sections.

2.2.6.1 Mining

Morrison *et al.* (1968:185) stated that despite the technological advances made in the mining industry, especially in South Africa, the industry is largely dependent on the ability of workers to carry out manual labour. According to researchers, it still constitutes a sizeable percentage of the workers' task requirement (Morrison *et al.*, 1968:185; James, 2006:8; Malan, 2007). For example, certain tasks require light work while others require periods of activity that are more strenuous, however, several tasks, from a physiological perspective, require a high level of energy consumption over periods of a few hours (Morrison *et al.*, 1968:185; Strydom & Williams, 1969:262-265). Further, the typical mining environment requires performing tasks in awkward body postures, manually handling material, repetitive movements, high physical work load and with high thermal stress (Renz, 2004:22; James, 2006:8). This could explain the high ill-health retirement prevalence of mine workers due to musculoskeletal and cardiovascular conditions reported by Cox *et al.* (2003:6).

2.2.6.2 Fire fighting

The fire-fighting occupation is regarded as one of the most dangerous and physically demanding work environments in the public sector (Buckwalter & BiNubile, 1997:126-133; Sothmann *et al.*, 2004:874). The findings of a survey at 62 fire departments in the USA indicate that most of the staff sees physical capacity as the most important task dimension (Buckwalter & BiNubile, 1997:126-133). Jackson (1994:77) reports that the physiologic response of fire fighting is the focus of many researchers, and indicates that during fire fighting, the workers work for an average of 15 minutes at about 88% of their maximal heart rate (Jackson, 1994:77). Sothmann *et al.* (2004:874) suggests that a minimum physical performance standard should be applied to all fire-fighters potentially engaged in fire suppression activities.

2.2.6.3 Timber

The main work tasks of timber harvesting are the felling of trees and cross-cutting of the felled trees into sections by a worker referred to as a Chainsaw Operator (Christie, 2006:16). These workers are followed by a group of predominantly female de-barkers who are responsible for removing the bark from the trees with the aid of an axe. Lastly, these logs which have been 'debarked' are then positioned onto a 'stack' by a group of workers referred to as Stackers, in preparation for removal from the area (Smith *et al.*, 1985:656; Christie, 2006:16). The terrain is often steep, uneven and covered with forest debris, the environmental conditions harsh and the work itself is physically demanding (Lilley *et al.*, 2002; Christie, 2006:16; Malan, 2007). Furthermore, the tools of the trade are sharp, heavy and dangerous if not used and maintained properly (Parker *et al.*, 1999).

2.2.6.4 Electricity Utility

The electricity utility technician jobs require the construction and maintenance of electrical power lines (Lubbe, 2003b:46; Gall & Parkhouse, 2004:672). In a physical demand analysis performed in previous studies, the electricity utility technician occupations were classified as being highly physically demanding (Doolittle *et al.* 1988, Parkhouse & Gall, 2004:660-670; Malan, 2007). Malan (1999:1-22), and Gall and Parkhouse (2004:672-680) identified essential physical abilities necessary to perform the minimum physical ability task requirements of the electricity utility technician, which include strength, cardiovascular endurance, muscle endurance and flexibility components. Eskom (study population of this thesis) for example, has 17 jobs in 4 departments for which minimum physical ability task requirements have been set due to the physically demanding nature of the job (Lubbe, 2003b:46). The physical work capacity components tests used for these workers are listed in Table 2.1 as reported by Lubbe (2003b:50-59).

Table 2.1: Physical work capacity test components for Eskom employees

Component	Test
Blood Pressure	Resting blood pressure
Cardiovascular endurance	3 min. Step-up
Grip strength	Static hand grip strength with dynamometer
Back muscle strength	Static back strength with dynamometer
Leg muscle strength	Static leg strength with dynamometer
Arm-/shoulder muscle strength	Static arm/shoulder strength with dynamometer
Flexibility	Sit-and-reach
Abdominal muscle endurance	1-min. Sit-up

These tests are comprised out of muscle strength, flexibility, cardiovascular endurance and muscle endurance components and are directly related to the physical task demands of the job (Lubbe, 2003b:50).

It is clear from the industries reviewed who perform physical work capacity assessments, that the physical work capacity of workers performing physically demanding tasks should be well managed to reduce work-related injury and improve worker productivity. As mentioned earlier, two types of workers are usually pointed out by management as not having the required physical work capacity to perform their physically demanding tasks, namely the older workers and females that are exposed to tasks with a high physical demand (Ayoub & Mital, 1989:9; Smith & Mustard, 2004:755; Sluiter, 2006:438). In the next section the role of ageing on the physical work capacity of workers in physically demanding jobs will firstly be reviewed followed by the role thereof on gender.

2.3 The role of ageing on the physical work capacity of workers in physically demanding jobs

Ageing and the role thereof on the workforce has drawn increasing interest globally during the last decade (Ilmarinen, 2001:546-552; Woods & Buckle, 2002:43-48; Lubbe, 2003b:28-44; WHO, 2003:1-49; Gall & Parkhouse, 2004:671-687;). According to the 2006 United Nations report, the world population is steadily ageing due to long term reductions in fertility and mortality (United Nations, 2007). HIV/AIDS and unemployment are some of the factors identified by researchers that lead to the ageing workforce in South Africa (Statistics South Africa, 2002; Sadie, 2003:49-68; Shisana *et al.*, 2005; Ellis, 2007:29-52). These factors lead to an increased responsibility on older workers to provide financially for their families and, therefore, force them to retire at an older age (Lubbe, 2003b:30; Sadie, 2003:56; Ellis, 2007:29-52).

The increase in the number of ageing workers in the workforce has lead to an increase in physical injuries and disabilities amongst older workers, mostly contributed by their inability to cope with the physical work demands (De Zwart *et al.*, 1995:1, WHO, 1999:1; Ilmarinen, 2001:548). Researchers have recognised that ageing is associated with the progressive decline in physical work capacity, characterised by diminished aerobic capacity and muscular capacity, with male and female workers showing similar decline (Ilmarinen, 2001:547; Woods & Buckle, 2002:43; WHO, 2003:1; Gall & Parkhouse, 2004:683-685;). Some of these physiological changes with ageing and how it influences the ageing worker in physically demanding jobs will be reviewed in the following section.

2.3.1 Physiological changes with ageing and the influence on workers in physically demanding jobs

The normative declines in broad physiological fitness that are associated with chronological age have been research extensively (Sluiter, 2006:434). Sluiter (2006:434) reports that research has revealed wide inter-individual variations in both the nature and the rate of "normal" decline in age among "healthy" people within the same age-cohort. For example, Sharkey (1997:294) found that a physically active lifestyle, at any age, could neutralize certain negative changes or even improve them.

Fleishman (1964), De Zwart *et al.* (1995:1-9) and Ilmarinen (2001:547) indicated that changes in physical work capacity generally concentrated on the cardiovascular and musculoskeletal systems, body structure, and some important sensory systems. On the basis of these findings the physiological changes with ageing on cardiovascular endurance, muscle endurance, muscle strength and balance of workers in physically demanding jobs will be discussed briefly.

2.3.1.1 Cardiovascular endurance

Over the last few decades, maximal oxygen consumption (VO_2-max, also referred to as aerobic capacity) was considered as a valid measurement of overall cardiovascular endurance (Ilmarinen, 2001:547; De Vries *et al.*, 1987; De Zwart *et al.*, 1995:3). Furthermore, VO_2-max was also considered as the single best variable in determining the age-related changes in functional limits of aerobic metabolism and of the cardiovascular system (De Zwart *et al.*, 1995:3).

The first cross-sectional comparison of cardiovascular endurance across different age groups was already done by Robinson in 1938 as reported by De Zwart *et al.* (1995:3). Evidence for a progressive decrease in cardiovascular endurance with ageing was found in this classic investigation. From this study, various cross-sectional- and longitudinal studies were done that indicated that there is a linear decline in cardiovascular endurance in males and females after the age of 20-30 years (De Zwart *et al.*, 1995:3; Ilmarinen, 2001:547; Sluiter, 2006:433). However, according to Ilmarinen (2001:547) longitudinal studies have shown that changes in cardiovascular endurance can be much larger at the individual level than expected. He reports that in four years the cardiovascular endurance can decrease or increase by about

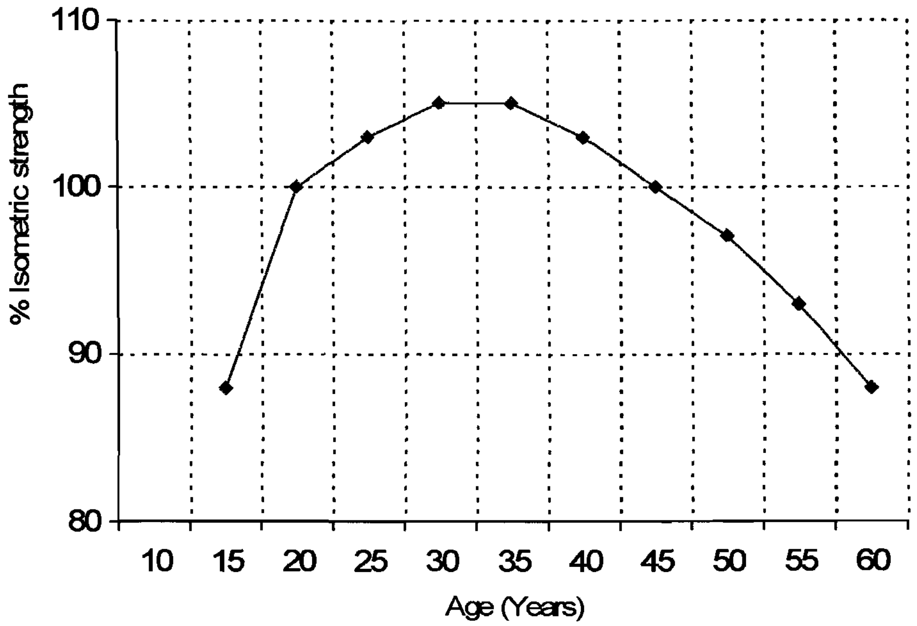
25% in males and females after the age of 45 years. These changes are strongly dependant on the aerobic activity, or lack of it, during the preceding years, therefore, different levels of exercise behaviour can have remarkable effects on cardiovascular endurance (Ilmarinen, 2001:547). It is therefore understandable that cardiovascular endurance can become critical in physically demanding work much earlier than expected.

2.3.1.2 Muscle strength

Together with the decline in cardiovascular endurance, the decrease in muscle strength is considered as one of the most indicative characteristics of physical ageing (De Zwart *et al.*, 1995:5). In recent research, Ilmarinen (2001:547) indicated that changes in musculoskeletal capacity can be pronounced after the age of 45-50 years and that both maximal isometric extension and flexion strength in physically demanding jobs decrease by 40-50% during a 20 year period. These findings are in agreement with previous studies that indicate that for both isometric and isokinetic strength there is a decline in the 5th and 6th decades of life, with an accelerated decline thereafter (De Zwart *et al.*, 1995:6; Sharkey, 1997:337; Shephard, 1999:332; Gall & Parkhouse, 2004:683-686). For example, the comprehensive and classic study of Asmussen and Heebøll-Nielson as illustrated in Figure 2.2 reports an increase in overall isometric strength of 25 different muscle groups from the age group 20-22 years (100%) to age 30 years (104%) for men, whereafter an accelerated decrease takes place to 90% at age of 60 years (De Zwart *et al.*, 1995:6). Figure 2.2 illustrates that at the age of 60 years a person generally has the same muscle strength capacity as a 15-year-old child. Ilmarinen (2001:547) indicates that this decline in physical strength with age is similar for blue and white collar workers and makes two important findings:

a) that the physical nature of today's work does not prevent a decline in musculoskeletal function,
b) that workers involved in physically demanding jobs need positive physical exercise to stay at an average level of age related fitness.

Ilmarinen (2001:547-548) further recommends that for workers in physically demanding jobs, the physical work load should decline with advanced age according to the normal age decline in physical capacity (20-25%) during ages of 45-65 years.



Source: Asmussen and Heebøll-Nielson (in De Zwart *et al.*, 1995:6)

Figure 2.2: Mean isometric strength of 25 different muscle groups in percent of strength of 20-22 year old men (100%) in relation to age for men

2.3.1.3 Muscle endurance

The relationship between muscle endurance and age is less documented than the relationship with muscle strength. Researchers, however, agree that muscle endurance is better preserved with ageing than muscle strength (Wicht, 1984:22; Taylor, 1992:165; Shephard, 1997:171). Half of the age-related decline in muscle endurance and muscle strength can be attributed to loss of muscle mass (Shephard, 1997:171). Wicht (1984:22) indicated that the loss of muscle mass is the result of the lessening of muscle cells with ageing and the gradual replacement of muscle tissue with scar tissue and fat cells. Parenmark *et al.* (quoted by Bridger, 2003:77) reports that musculoskeletal complaints will occur in workers with an inability to sustain their muscle endurance all day long, such as the ageing workers.

2.3.1.4 Flexibility

According to Smith and Zook (1986:33), the physiological changes that are associated with the ageing process are responsible for 98% of the loss of flexibility. The ageing process causes a loss of joint suppleness, which can lead to a decline in general flexibility, (Sweeting, 1990:68). This decline refers to the degenerative changes that take place in the soft tissue of the joints, by which the elastic tissue is replaced by scar tissue and leads to joint stiffness

(Buckwalter & BiNubile, 1997:128-130). Ageing further causes thinning of the synovium, this can lead to thinning of the joint cartilage (Wicht, 1984:22; Shephard, 1997:135). Reduced synovial fluid secretion as a result of the ageing process, also contributes to further joint stiffness (Wicht, 1984:223). To add to this, the change in posture as a result of degenerative changes in articulation cartilage, shortening in tendon, ligament and muscle lengths can also be associated with ageing (Wicht, 1984:223).

Research on the flexibility changes with ageing of workers in physically demanding jobs are limited. However, from the discussion above, the conclusion can be made that joint stiffness and shortened tendon, ligament and muscle length resulting from the ageing process can lead to restricted range of movement affecting proper execution of physically demanding tasks.

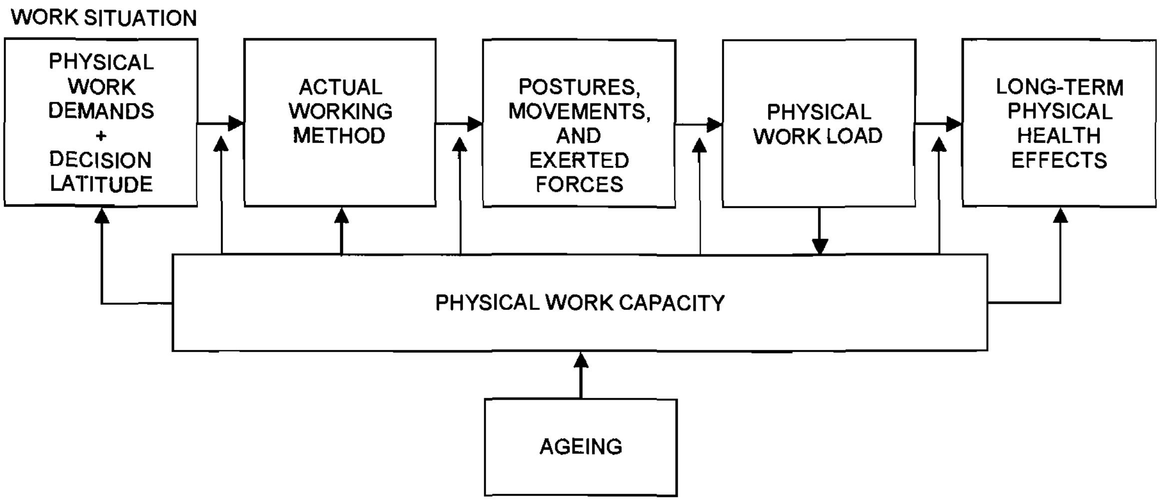
2.3.1.5 Balance

Ageing is usually accompanied with stiffness of the hips, knees, back and neck (Wicht, 1984:223). These aspects lead to consequential posture adjustment, which contributes to the development of the well known bent-over body position (Wicht, 1984:223; Vandervoort, 1992:181). According to Wicht (1984:223), this bent-over attitude results in the centre of gravity moving from the back to the front of the pelvic ridge, which negatively affects balance. Vandervoort (1992:181) further indicates that limited range of movement in the joints, such as single dorsal flexion; has an important influence on balance. This limited range of movement not only has an important influence on balance, but also on the corrective reflex that is needed for balance (Wicht, 1984:223). Punakallio (2003:41) reported a decline in functional and postural balance among workers in physically demanding jobs. She recommends that balance demands of work and deterioration with age should be taken into account when work ability is promoted among older workers in physically demanding jobs.

From the literature review on physiological changes with ageing of workers in physically demanding jobs, it seems that the decrease in ability of certain physiological components such as cardiovascular endurance, muscle strength, muscle endurance and balance could negatively influence the ageing worker. Subsequently, the relationship between the physical work capacity of workers and their physical work demands will be discussed in more detail in the next section, with specific reference to the role it has on the ageing worker.

2.3.2 The relationship between physical work capacity and physical work demands with ageing

Research indicates that a negative effect on health and well-being can be expected when there is an age related imbalance between physical work load and physical work capacity (De Zwart *et al.*, 1995:1-3; Shephard, 2000:467-469, Sluiter, 2006:434-435). The various concepts involved in the study of ageing and physical demands are presented in the conceptual model of De Zwart *et al.* (1995:2) illustrated in Figure 2.3 and Table 2.2. These definitions and concepts give insight into the consequences of ageing on physical work load and physical work capacity. In this model there are three age contributing determinants that affect physical work capacity; namely physical work load, long-term physical health effects and ageing itself (De Zwart *et al.*, 1995:2). A relatively high work load can lead to an insufficient recovery phase after work, which can result in long-term physical health effects like chronic fatigue or musculoskeletal complaints, (De Zwart *et al.* 1995:3). These effects can, according to the researchers, negatively influence the worker's physical work capacity. These findings have been supported by similar studies in this regard by Shephard (2000:331-343) and Ilmarinen (2001:546-552). These researchers have recognised that ageing is associated with the progressive decline in physical work capacity, characterised by diminished aerobic capacity and muscular capacity, with male and female workers showing similar decline.



Source: De Zwart *et al.* (1995:2)

Figure 2.3: The model of "ageing and physical work demands"

Table 2.2: Definitions of concepts used in the model of "ageing and physical work load"

Physical work capacity: physical capacities and characteristics of a worker. Physical work capacity is a dynamic measure. Changes may occur in a short-term period, such as changes over the day caused by fatigue, as well as in long-term periods, such as increase or decrease in muscle strength in months or years.

Work situation:

a) Physical work demands: physical-loading factors in the work situation responsible for physical responses, such as muscular work strength, climate and vibration.

b) Decision latitude: extent of autonomy and possibilities for the worker to improve, or to worsen, the work situation by means of altering the work demands.

Actual working method: the way the work is done. For example, work rate, utilization of (mechanical) devices, lifting technique, number of breaks.

Work posture, movements and exerted forces: the sequence of body postures, movements and exerted forces on the environment during work.

Physical workload: all temporary short-term physical responses which can be regarded as indicators of physical workload – changes in, for example, heart rate, breathing frequency, hormonal responses and blood pressure, but also sweating and feelings of fatigue, during work and some hours thereafter.

Long-term physical health effects: all more chronic, recurrent or permanent physical effects of physical work-load on health, either positive or negative.

Ageing:

The concept of ageing is described here as the sum of the changes in structure and function of an organism that occur with the passage of time. Three determinants of ageing can be distinguished, showing a mutual interaction.

a) Biological ageing: gradual specific changes in the structure of an organism with increasing age that do not result from disease or accidents.

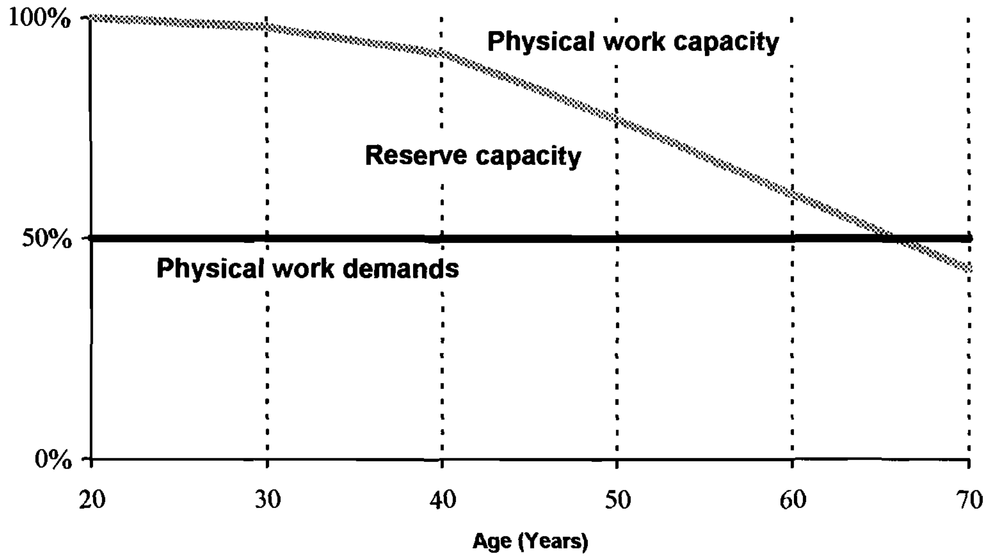
b) Diseases: conditions which alters or interferes with the normal state of an organism, usually characterized by abnormal functioning of one or more of the host's systems, parts or organs. Often manifested by a characteristic set of signs and symptoms.

c) Life style: the way in which an individual lives, expressed by, the level of physical activity, eating, drinking and smoking habits.

Source: De Zwart *et al.* (1995:2)

Ilmarinen *et al.* (1991:135-141) indicated that there is an age-related decline in physical work capacity in relation to the same work load for younger and older workers, as illustrated by Figure 2.4. The result of this relationship implies that the difference between a declining physical work capacity and unchanged work demands contribute significantly towards a decreasing in the reserve capacity of the older worker which, according to Van Dijk *et al.* (1990:3) increases the risk of injury. The ageing worker in physically demanding jobs is affected the most by this age-related decline in physical work capacity (Shephard, 1999:340). This is evident in the increasing on prevalence rates of physical complaints, injuries and disabilities with advancing age in physically demanding jobs (Ilmarinen *et al.*, 1991:135-141; Tuomi *et al.*, 1991:72-74; De Zwart *et al.*, 1995:8; Woods & Buckle, 2002:43-44) and will be discussed in the following section.

Figure 2.4: Theoretical relationship between physical work capacity and physical work demands



Source: Ilmarinen *et al.* (1991:138)

2.3.3 The impact of ageing on work-related injury rates

The findings from a number of studies on musculoskeletal health indicate that older age is a risk factor for or associated with the prevalence of musculoskeletal problems among nurses, railway workers and workers in various other jobs (Woods & Buckle, 2002:43). Studies on back pain and neck pain showed that prevalence of long-term back pain increased with age (Woods & Buckle, 2002:43). The decline in physical work capacity with age has been shown to be a contributing factor to the increase in work injuries amongst ageing workers (WHO, 1993:32-33; Shephard, 1999:331; Ilmarinen, 2001:547-551). Furthermore, ageing workers with lower cardiovascular endurance, muscle strength, muscle endurance and other physiological abilities, show higher incidence of work injuries than workers whose physical work capacity meet the physical work demands (Ilmarinen *et al.*, 1997:55; Shephard, 1999:331-341).

Hansen (1989:88) reports that another major reason for the high prevalence rate of injuries amongst older workers is that a positive correlation exist between injury risk and job experience. The findings of this study suggest that the older workers with more experience usually carry out work tasks with greater risk, and conclude that due to their greater exposure to physically intensive work tasks, it increases the risk of work related injury (Hansen, 1989:88). On the other hand a World Health Organization Study Group (WHO, 1993:25) suggests that the lack of sufficient experience can be an important determining factor for injuries to new employees, but later on experience becomes less important. Although the findings of these researchers might seem contrasting it is, however, evident that job experience plays an important role for young and older workers in relation to work-related injury rates.

To conclude the findings of the literature review on the role of ageing on the physical work capacity of workers in physically demanding jobs, it seems that the physical work capacity declines with age as expected. Further, due to the reduced physical work capacity experienced by the older workers and their unchanged physical work demands, they have increased work-related injury prevalence. However, it must be said that the literature on ageing workers in physically demanding jobs is limited especially regarding the use of physical work capacity assessments in managing these workers and subsequently requires more research. For example, no research could be found that determined at what age the physical work demands exceed the physical work capacity of the workers in physically demanding jobs. Such research could be applied to scientifically determine from what age workers in physically demanding jobs need to be managed based on their insufficient physical work capacity. Shephard (1986:171-172) recommends that for the instance where the physical work demands are known to exceed the physical work capacity of the older worker, options for the employer are, to

a) maximise residual abilities by appropriate work site wellness programs,
b) optimise the design of the workstation,
c) establish compensation packages that encourage voluntary early retirement or transition to part-time work,
d) impose mandatory retirement at a fixed age, or
e) set job related standards which must be met for continued employment.

In the next section, the role of gender on the physical work capacity of workers in physically demanding jobs will be discussed in the same manner as with the ageing workers.

2.4 The role of gender on the physical work capacity of workers in physically demanding jobs

Females progressively account for a larger percentage of the active work force than in earlier decades (Shrey, 1997a:3; WHO, 1999:5-6; Islam *et al.*, 2001:84; Lagerlöf, 2005:6). The World Health Organization estimated that approximately 42% of the global working population comprises of females and they have expanded into male-dominated trade and craft occupations (WHO, 1999:4). This expansion has only recently affected South African industries, and to a lesser extent the physically demanding jobs. In Eskom, for example, females comprise less than 2% of the workforce in physically demanding jobs (Lubbe & Kriek, 2004:7). Botha *et al.* (1998:22-25) concluded that one of the reasons might be that physically demanding jobs were only quite recently made available to female workers in accordance with human rights and labour legislation, namely the Employment Equity Act 55 of 1998, and the Promotion of Equality and Prevention of Unfair Discrimination Act 4 of 2000 (South Africa, 1998 & 2000). In accordance with this legislation, organisations are forced to employ more females and will hence increase the number of these workers in physically demanding jobs (Botha *et al.*, 2000:23-26). It is, however, important to keep the physical requirements of the job in mind.

It has been stated that most of the physically demanding workplaces are usually designed with the male physique in mind, thus making it more suited to male workers (Kelsh & Sahl, 1996:1056; WHO, 1999:6; Messing *et al.*, 2000:21). This places additional physical demands on female workers in these jobs and can thus contribute to increased injury rates (Kelsh & Sahl, 1996:1056; Messing *et al.*, 2000:21) and other musculoskeletal problems.

2.4.1 Gender differences in physical work capacity

Males are on average taller, larger and heavier than females (Messing & Őstlin, 2006:8). The typical female is 0.1 meter (approximately 6%) shorter than the average male, and she also carries a larger and differently distributed body fat that could have a substantial influence on the performance of many physical tasks (Shephard, 2002:3). Shephard (2002:3) for example reports that biological imposed height differences contributes to an average of 12% and 18% male advantage for absolute muscle strength and maximal aerobic power respectively over a female at any given age and that age-related decreases in height would influence function by

3 to 5%, and ethnic group by 18 to 27%. Therefore, when females are exposed to the same physical work load as males, it could place greater physical strain on them (Őstlin, 2000:9).

Research literature on gender differences in physical work capacity, however, is limited. Graig (2006:124) indicates that the vast majority of research on physical work capacity has investigated the physiologic responses in males while comparatively few articles have focused on females or on gender differences. Consequently, research investigating the role of gender on various components of physical work capacity is still evolving. The main reason could be the fact that females have only recently entered physically demanding jobs as mentioned earlier.

Research on strength differences among genders, however, is well documented. Researchers are generally in agreement that there is no difference in strength per lean body weight between males and females. However, the absolute strength of males is greater, mainly due to a larger muscle mass (Falkel *et al.*, 1985:1667; Shephard 1997:306; Mac Duff *et al.*, 2005:21). Snook and Ciriello (1991:1210) report that a female's average lifting strength is only 50% of that of a male, although, the difference for pushing and pulling strength in the horizontal plane could be smaller. Östlin (2000:9) reports that females, on average, can only achieve 60 or 70% of male's muscular strength as their muscle fibres are more slender and shorter. Thus, a 20 kilogram lift for a female is equivalent to a 33 kilogram lift for a male (Östlin, 2000:9).

2.4.2 Gender and work-related injury rates

Few epidemiological studies have evaluated the risk of work-related injuries of females in physically demanding jobs. Most of these studies focus on specific occupations or industries (Kelsh & Sahl, 1996:1050-1058; Sahl *et al.*, 1997:287-292; Gluck & Oleinick, 1998:1572-1586; Berkowitz *et al.*, 1999:412-418; Islam *et al.*, 2001:84-91; Cox *et al.*, 2003:6) and suggest that females are at higher risk than males for work-related injuries, particularly musculoskeletal injuries (Islam *et al.*, 2001:84). In general, the literature on musculoskeletal involvement in the workplace revealed that female workers are more likely to experience a musculoskeletal problem in physically demanding jobs than male workers (Kelsh & Sahl, 1996:1050; Messing *et al.*, 2000:43; Woods & Buckle, 2002:49; Messing & Őslin, 2006:49). In a study by Smith and Mustard (2004:754) on the associations between physical work demands and work injury rates between males and females, they found that although males in physically demanding jobs have higher injury rates that are acute and traumatic in nature, females have twice the risk of chronic musculoskeletal injuries. In a study by Kelsh and Sahl (1996:1050) they reported that although the crude injury rates by gender suggested that male electricity utility workers were at higher risk for occupational injuries than females, they found elevated acute and chronic injury rate ratios for female electricity utility workers. Thus, in this study, the unadjusted rates in males are explained by the fact that occupation was a very strong confounder in the relation between work-related injuries and gender. These findings are consistent with earlier studies among postal workers (Zwerling *et al.*, 1993:46-55), semiconductor industry workers (McCurdy *et al.*, 1989:500), and army trainees (Jones *et al.*, 1993:708).

Smith and Mustard (2004:750) suggest that interpreting male and female injury rates that have not accounted for the differential participation of males and females across occupations and industries will likely lead to inaccurate assessment of the risk of injury between genders. According to them, the reported greater likelihood of males to be injured at work by some studies (Bureau of Labour Statistics, 1998; Human Resources Development Canada, 1999; Dupre, 2002) may be partially representative of the differing job tasks and exposures which are more predominantly associated with male labour force participation, rather than personal characteristics of male labour force participants (DeLeire & Levy, 2001; Islam *et al.*, 2001:84-94; Payne & Mustard, 2002:138-145).

Possible explanations provided by the research literature for these gender differences in injury rates could be summarized as follows:

(a) Insufficient physical capacity to perform high risk task assignments (Falkel *et al.*, 1985:1667; Islam *et al.*, 2001:84; Shephard, 2002:3).

(b) Workplace designs are more appropriate for one gender's average body size or shape (WHO, 1999:5; Messing *et al.*, 2000:31; Islam *et al.*, 2001:84; Smith & Mustard, 2004:754).

(c) Females have additional physical and stress demands due to parental and household responsibilities (Messing & Őstlin, 2006:10-13; Kane, 2006:29).

(d) Females are more likely to report injuries (Zwerling *et al.*, 1993:50; Kelsh & Sahl, 1996:1055).

(e) High risk work techniques to suit their specific physical capabilities (Courville *et al.*, 1991:163, Woods & Buckle, 2002:50).

(f) Within the same integrated job role, team dynamics result in differences in risk exposure that vary according to gender (Messing & Elabidi, 2003:83).

It is therefore evident from the literature that when considering individuals for physically demanding jobs on the basis of gender, some females will impose an increased risk for injury due to their gender-specific prevalence rates of injuries reported in these jobs. Islam *et al.* (2001:91) suggests that the evidence provided on gender differences in injury rates may justify the need for developing injury prevention programs such as specialized training, worker placement, or workplace design modifications, particularly for females.

In conclusion, although the literature on the role of gender on the physical work capacity of workers in physically demanding jobs is limited, there is an indication that researchers generally agree that the physical work capacity of males are superior compared to females. Secondly, due to the reduced physical work capacity of females to perform their physically demanding work tasks, they seem to experience an increased prevalence rate for work-related injuries. However, no literature could be found that examined the physical work capacity of females in physically demanding jobs based on the minimum physical ability task requirement of their job. Such research could give insight into the causes of the high injury rate and poor performance observed by researchers amongst these female workers.

2.5 The impact of worksite wellness programs in improving the physical work capacity of workers in physically demanding jobs

During the last decade there has been an increase in the number of companies offering worksite wellness programs for high-risk employees declared unfit for duty, as a way to improve their work capacity and accelerate return to work (Aldana, 2001:296; Golaszewski, 2001:332; O'Donnell, 2002:xiv; Darling, 2005:52; Serxner *et al.*, 2006:1). These programs offered to employees focus on a total wellness approach in reducing injury risk and improving productivity, and not merely directed at physical fitness per sé (Aldana, 2001:296; Golaszewski, 2001:332; O'Donnell, 2002:xv; Serxner *et al.*, 2006:1). Due to the diverse understanding of the term "wellness", it is necessary to define wellness in the context of this study. The World Health Organization states that health goes beyond disease management and includes optimal physical, spiritual and social well-being (WHO, 1948). Their definition for health that has not been amended since 1948 states that:

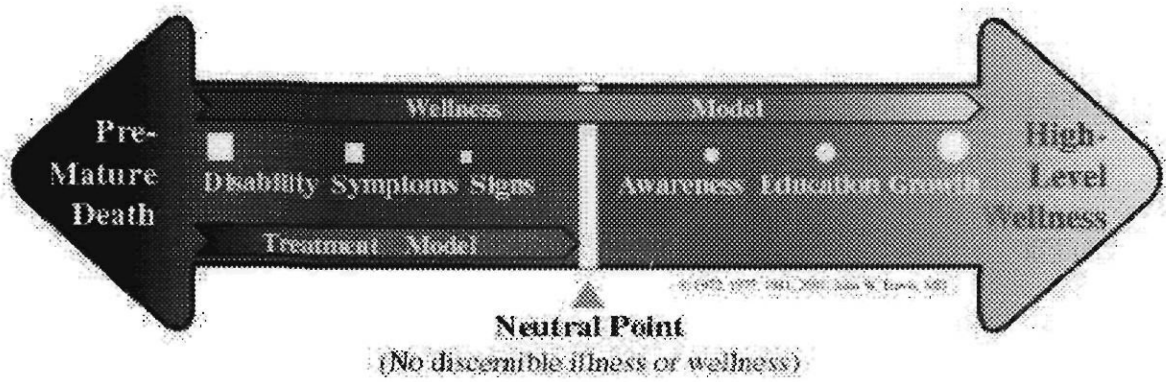
"health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 1948).

There are similarities between the official definition of "health" by the World Health Organization that describes health as a state of complete well-being and Merriam-Webster's collegiate online dictionary definition of "wellness", namely:

"the quality or state of being in good health especially as an actively sought goal" (Merriam-Webster, 2007).

Both these definitions refer to the term "wellness" and describe it as a *quality state of life*. Travis and Ryan (1988:xvii) explain this state of wellness with an illness/wellness-continuum (see Figure 2.5). According to the authors, wellness is not a static state where one is either well or ill, rather, there are levels of wellness, just as there are levels of illness. High-level wellness is situated at one end of the continuum, while premature death is located at the other end. Travis and Ryan (1988:xvii) further states that moving toward high-level wellness will involve the three steps of awareness, education, and growth.

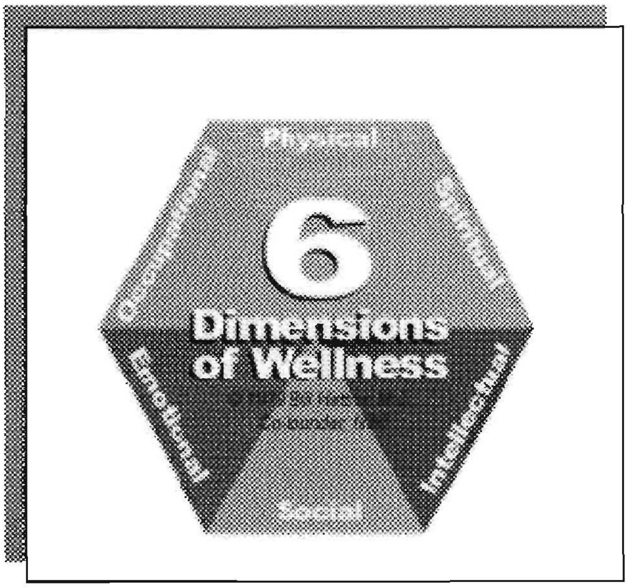
Figure 2.5: The illness/wellness continuum



Source: Travis and Ryan (1988:xvii)

Dreyer (1996:30-39) reports that several researchers have set out to describe the concept of "wellness" with some sort of model. For example Hettler's 6 Dimensions of Wellness (Figure 2.6) consists of the physical, spiritual, emotional, intellectual, social and occupational dimensions.

Figure 2.6: Hettler's 6 Dimensions of Wellness

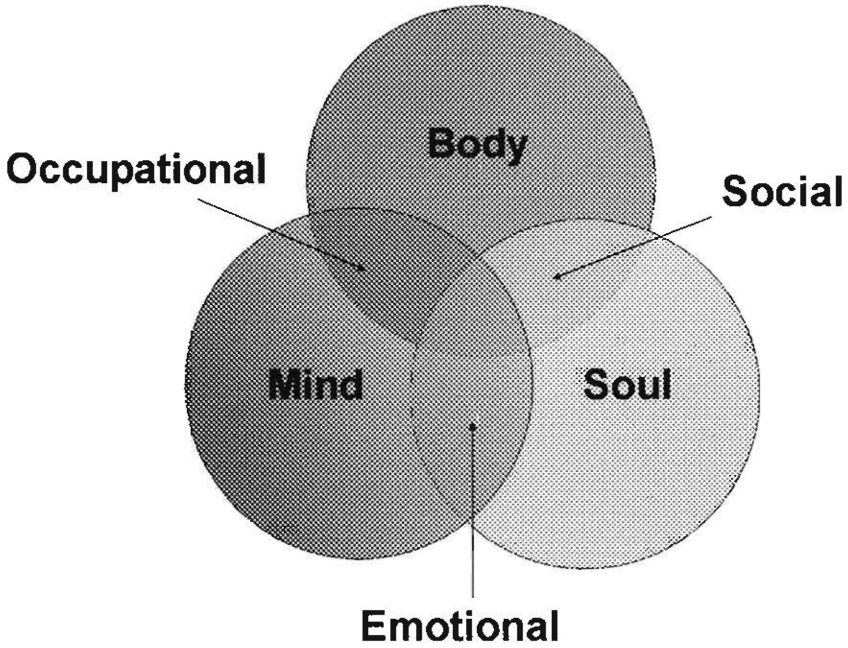


Source: Hettler (2007)

This model, developed in 1977 by Dr. Bill Hettler, co-founder and president of the Board of Directors of the National Wellness Institute is one of the most internationally used models that has been adopted by many universities, corporate, and public health programs (Health Promotion Advocates, 2007).

There are similarities between the model of Hettler and the Wellness Model used by Eskom which is related to this thesis. The Eskom Wellness Model as developed by Lubbe (1997) is illustrated in Figure 2.7. According to this model there are three primary dimensions namely body, mind and soul that are inter-connected to each other (Lubbe, 1997). The interaction of these dimensions shapes and influences the secondary dimensions namely, social, occupational, emotional (Lubbe, 1997). Eskom employees are encouraged to adopt a healthy lifestyle with balance and personal growth in all the wellness dimensions as illustrated in Figure 2.7 (Lubbe, 2002b:17). This also formed the basis of the life skill training component of their worksite wellness program, offered to employees whose physical work capacity did not meet the minimum physical ability task requirements, as will be discussed in section 2.5.4.4 and Chapter 5 in more detail (Lubbe, 2002b:16-17).

Figure 2.7: The Eskom Wellness Model



Source: Lubbe (1997)

There is no agreement in the literature regarding the number and type of dimensions that could be found in a wellness model (Dreyer, 1996:44-45; Grace, 2001:8-24). However, most of these models symbolize the striving of the individual to adopt a lifestyle with self-responsibility and personal development in all dimensions of health (Dreyer, 1996:114).

Out of this literature review on defining wellness, some central understandings that seem to be shared by researchers are:

a) not merely the absence of disease or infirmity
b) self-responsibility
c) balanced lifestyle
d) multi-dimensional
e) development towards a higher quality of life.

With this shared understanding, it is possible to promote common principles to a group of people, such as at the worksite, as a means to create the desired change. More and more companies, as mentioned earlier, are offering wellness programs to their employees as a means to reduce health related costs and improve worker productivity (Aldana, 2001:296; Golaszewski, 2001:332; O'Donnell, 2002:xiv; Darling, 2005:52; Serxner *et al.*, 2006:1). Cox

(2003:7) mentions that worksite wellness programs could have different forms and focuses. Therefore, the use of wellness programs in the worksite will be discussed in the next section.

2.5.1 The use of wellness programs in the worksite

Cox (2003:7) defines a worksite wellness program as a:

"comprehensive, multidisciplinary, and complex field that seeks to promote, improve, and optimize health, well-being, and performance of those associated with a place of employment".

There are similarities in the definition of Cox and that of Opatz (1985) which defines a worksite wellness program as:

"the systematic efforts of an organization to enhance the wellness of its members through education, behavioural change and cultural support".

Both of these approaches strive to enhance and sustain the wellbeing of the workers at the worksite. Robison (2004a:8) indicates that these worksite programs move away from the traditional biomechanical view of health towards a holistic health promotion approach. In Table 2.3 the two approaches are contrasted. According to Robison (2004a:8) these programmes provide the worksite professionals with an opportunity to support people's health and human needs in a more compassionate and effective way, instead of focusing on controlling isolated symptomatic illnesses or behaviours. With this approach, the emphasis in both assessment and intervention shifts from risk factors for disease to what he has termed "supportive factors for health".

It is thus evident then that when working with workers, for instance, those in physically demanding jobs who do not meet the minimum physical ability task requirements, that the worksite wellness program should focus rather on what would make them want to change than emphasizing the risk they pose to the company or themselves. Further it seems out of the literature reviewed that it is better for the professional to focus on bringing the best out of the worker rather than telling the worker what the best is for them. With this understanding of worksite wellness programs, it would be beneficial to identify some of the reasons why the worksite is ideal for wellness programs, and subsequently will be discussed in the next section.

Table 2.3: Comparison of health promotion approaches

	Traditional	Holistic
Focus	**Disease**: Main objective is to identify and eliminate biomedical risk factors for physical disease	**Health**: Main objective is to address the interconnected web of genetic, social, emotional, spiritual, and physical factors that contribute to health
Emphasis	**"Unhealthy" Behaviors**: Poor individual lifestyle choices are considered the primary determinants of sickness and disease	**Meaning and support**: Meaning in life, relationships, work, and supportive human systems are considered the primary determinants of health
Motivation	**Fear**: Reason for change is primarily to prevent disease and premature death	**Happiness**: Reason for change is primarily to enhance a sense of purpose and enjoyment of life
Primary Assumption	**People are Bad**: Left to their own devices, people will naturally gravitate toward "unhealthy" behaviors	**People are good**: People have a natural desire and ability to seek out healthy behaviors
Professional role	**Expert**: Primary job is to police behaviors and prescribe changes to save people from themselves	**Ally**: Primary job is to facilitate people's reconnection with their own internal wisdom about their body and their life
Change Process	**Controlling Behavior**: Behavior change techniques are used to suppress or eliminate targeted behaviors	**Creating Consciousness**: People are assisted in understanding and healing life issues that underline illness and behavioral struggles

Source: Robison, (2004a:8)

2.5.2 Reasons why the worksite is ideal for wellness programs

The worksite has been identified by various researchers as the ideal place for wellness programs (Allen, 2002:202-217; O'Donnell, 2002:xiv-xxvi; Chapman, 2004a:1-6; Robison, 2004a:6-11). O'Donnell (2002:xx) states that:

"Lifestyle changes can be facilitated through a combination of efforts to enhance awareness, change behaviour and create environments that support good health practices. Of the three, supportive environments will probably have the greatest impact in producing lasting changes."

Allen (2002:203) supports this view and alleges that an individual's effort to live a healthy lifestyle can be greatly enhanced by a supportive environment such as the worksite, and thus makes it ideal for wellness programs. Robison (2004a:11) states that worksite wellness programs that acknowledge the vital interconnectedness of relationships, work, and community issues in relation to health is a critical success variable for sustained behaviour change. It is clear from the above-mentioned researchers that the worksite could play an important role in supporting behaviour change initiatives of employees such as those high risk employees for work-related injuries in physically demanding jobs. Dreyer (1996:104-108) summarizes some reasons why the worksite is ideal for wellness enhancement programs:

a) the employees are "trapped" at work and subjected to cultural influences
b) the workplace provides opportunity for incentives as a motivation to change
c) the workplace provides the employer with the opportunity to expose the employee to an intervention program over a long period of time
d) the workplace provides the opportunity for social support
e) the lifestyle of workers' families will probably also be influenced
f) the employer and employee could benefit from these programs.

In summary, it seems that the worksite provides important qualities that if utilised correctly, could support employees in their lifestyle changes, and could, therefore, assist workers that do not meet the minimum physical requirements of their job to improve their physical work capacity.

2.5.3 Best practices in worksite wellness programs

Worksite wellness programs that experience long-term success and are consistently recognized as "best practice" programs share a set of common characteristics (Huber *et al.*, 2003:7; Chapman, 2004a:1-6; Darling, 2005:50; Goetzel *et al.*, 2005:12; Hunnicutt, 2006:2).

According to a review of the literature, best practices characteristics that are central elements of a worksite wellness program mostly include:

a) Building top management support (Allen, 2002:214; Chapman, 2004a:1-6; Hunnicutt, 2006:4).
b) Integrating program with organizational/business goals (Huber *et al.*, 2003:14; Chapman, 2004a:1-6; Goetzel *et al.*, 2005:12; Darling, 2005:51).
c) Sound communication process (Chapman, 2004a:1-6; Darling, 2005:51).
d) Use of the stages of change concept (Prochaska & DiClemente, 1983:390-395; Levesque *et al.*, 1999:226-241).
e) Creating supportive cultures (Allen & Kraft, 1980:257; Allen, 2002:202-217; O'Donnell, 2002:xxiii).
f) Incentive recruitment procedures (Chapman, 2005b:189; Hunnicutt & Chapman, 2005:1-62; Chapman, 2006:431-432).
g) Targeted personal communication (Lubbe, 2004a:6-8; Darling, 2005:51; Goetzel *et al.*, 2005:14).
h) Measurement of results (Aldana, 2001:296-320; Edington, 2001:341-349; Ozminkowski & Goetzel, 2001:289-291; Chapman, 2005a:1-14; Goetzel *et al.*, 2005:14).
i) Creating a cohesive wellness team (Allen & Kraft, 1980:181-183; Huber *et al.*, 2003:11; Hunnicutt, 2006:8).

It seems that these "best practices" in worksite wellness programs are focused not on simply offering a "program of the month," but on impacting the organizations' bottom line. Hunnicutt (2006:2) describes such programs as making the switch from "activity-centred" to "results-oriented" programming. Examples and benefits of such programs that applied "best practices" in industry will be discussed in the following section.

2.5.4 Examples of worksite wellness programs in industries with physically demanding jobs

Few epidemiological studies have evaluated the effect of worksite wellness programs in physically demanding jobs. Most of these studies focus on general health habits (Aldana, 2001:296-320; Edington, 2001: 341-349; Darling, 2005:1-154) and suggest that the health improvements obtained by participants lead to significant financial benefit to the organisation. For example, the best practice programs in both the public and private sectors are recognised for their achievement by the American College of Occupational and Environmental Medicine (ACOEM). Their Corporate Health Achievement Award (CHAA) recognises organisations with exemplary employee health and occupational and environmental medicine practices (ACOEM, 2004). Recipients of the CHAA, according to Darling (2005:52) may serve as model programs that demonstrate successful integration of "best practices" in health, safety and employee well-being to improve productivity and accomplish organisational goals. The programs of three of these organisations that have received this prestigious award, namely Union Pacific Corporation, The Dow Chemical Company, and Johnson & Johnson will be discussed as presented by the US Chamber of Commerce (2005). Although these three worksite wellness programs focus on the general workforce, it is also available to a large percentage of their workers in physically demanding jobs. In the South African literature, two studies were found that reported the effect of a worksite wellness program on the physical work capacity improvements of workers in physically demanding jobs, both on Eskom employees, and will also be discussed. The five studies will be briefly discussed

2.5.4.1 Union Pacific Corporation: Health Track

The "Health Track" program of Union Pacific Corporation, which is one of America's leading transportation companies, operating the largest railroad in North America (Union Pacific Corporation, 2007), is made available to all employees and their spouses. This program is comprised out of wellness assessments that are followed up with independent study guides, stage-based mailings, telephonic health coaching, videos, tobacco cessation program, and lifestyle management classes. Furthermore, 535 contracted fitness facilities provide free exercise opportunities for all employees. Wellness improvements are rewarded through the company's employee reward and recognition process. The key finding of the program is a 10% reduction in lifestyle-related health care claims. Mr. Davidson, Chairman, President, and Chief Executive Officer (CEO) of Union Pacific Corporation say that:

> *'By investing in a wellness program, we are protecting our most important asset—our employees... An aging workforce and continued health care cost increases, however, this means Union Pacific will continue working to improve its Health Track wellness program for long-term success."* (US Chamber of Commerce, 2005.)

Although, this program is not directed at workers in physically demanding jobs per sé, we could assume that a large majority of the rail road workers perform tasks that are physically demanding, and that these workers participate in the worksite wellness program of the company.

2.5.4.2 The Dow Chemical Company: Good Health for the whole self

The "Good Health for the whole self" program of Dow Chemical Company, which manufactures chemical, plastic and agricultural products (Dow Chemicals Company, 2007) is like, the Union Pacific Corporation, made available to all employees with the objective to improve their health status, reduce health related costs and be perceived as a valued service. The main components of the program consist of group programs, one-to-one counselling, web-based information, immunization, home-based and self-managed kit programs. The company also developed a workplace health policy and included preventative health coverage in their benefit plan. The key findings of the program were that participants had statistically significant fewer claims for self-limited illnesses and emergency room visits than those who did not participate. Mr. Liveris, the President and CEO of Dow Chemical Company say:

> *"Prevention has the power to make a real and lasting difference in our individual quality of life."* (US Chamber of Commerce, 2005).

This is a manufacturing company, as mentioned, and therefore this program would also be available to the large number of workers performing physically demanding tasks.

2.5.4.3 Johnson & Johnson: Healthy People

The international "Healthy People" program of Johnson & Johnson, is one of the world's most comprehensive and broadly based manufacturers of health care products (Johnson & Johnson, 2007), is made available to all their employees in 57 countries. Their aim is to have the healthiest and safest workforce in the most environmentally responsible corporation in the world, integrate and coordinate services to improve health and productivity and control health care costs and help employees adapt to rapidly changing business environments. The main program components are online risk assessments, lifestyle/disease management counselling, health risk intervention programs, environmental/cultural support, financial incentives for participation, and the integration of health promotion strategies with the health care benefit plan design. The key findings of the program are savings of about $9-10 million per year from reduced medical utilization and lower administrative expenses. They further exceeded their smoking, blood pressure, cholesterol and physical activity health improvement targets. Mr. Weldon, the Chairman, Board of Directors, and CEO say:

> *"Healthy People is all about our employees--our greatest asset. Their actions can improve their own health and serve as an example to their colleagues. Their efforts will result in the success of this program and its ability to achieve long-term health improvements and to create a motivated and productive workforce."* (US Chamber of Commerce, 2005.)

The findings of these three award winning worksite wellness programs suggest that investing in the health and wellness of employees could result in significant improvements to the benefit of both the employee and the employer in terms of reduction of health care costs and improvement of productivity, despite factors such as the ageing of the workforce. Furthermore, the characteristics of these programs are mostly in agreement with the "best practices" research described in section 2.5.4. Although these three worksite wellness programs that were discussed focus on the general workforce, it is also available to a large percentage of their workers in physically demanding jobs, and seems to benefit employees and employers alike. The question that arises is whether it will have the same effect in industries that specifically focus on workers in physically demanding jobs, and will be discussed next.

2.5.4.4 Eskom: Physical work capacity management program for electricity utility workers

Eskom is regarded as one of the leading organisations in South Africa in the field of health and wellness (Teixeira, 2002). One of their programs, as reported by Lubbe (2002b:16-17) focused on 36 workers performing physically demanding tasks. The electricity utility workers participated in a worksite wellness program situated at 9 company Wellness Centres distributed nationally according to the operations of the company. All the participants were at the Wellness Centres full time for two weeks, where specialised multidisciplinary teams attended to the health and wellness of each participant. The objectives of the program were to empower participants to adopt a wellness lifestyle, facilitate early return to work after injury and for them to meet the minimum physical ability task requirements of their job. The main components of the program included physical work capacity assessments, wellness lifestyle training, lifestyle/disease management counselling, work hardening training, the strengthening of management and peer support, and monthly follow-ups. The key findings of the program were that the participants had a productivity improvement of 13.9%, a physical work capacity improvement of 12%, and an attitude towards change improvement of 12.2%. Further, the program generated an estimated return-on-investment ratio of R1.00:R10.80 for the company (Lubbe, 2002b:16-17).

From this study it seems that a worksite wellness program can offer more than just improving general health, it could also assist workers in physically demanding jobs to sufficiently improve their physical work capacity to perform their physically demanding tasks as required.

2.5.4.5 Eskom: Worksite wellness program for food handling, house keeping and security services

In this study, Grace (2001:iv-v) selected 68 black African food handlers, housekeeping and security workers performing physically demanding tasks and randomly assigned them to a control and experimental group. The experimental group participated in a 6-monthly physical wellness program. The main objective of the program was to determine the impact of a worksite wellness program on the sick leave, absenteeism and health-related fitness. The main components of the program included a clinical and physical evaluation followed up with wellness lifestyle training and a home exercise program. The key findings of the program were a statistical significant change in some physical abilities required to perform their physically demanding tasks and reduced lost workdays due to sick leave and absenteeism.

According to this study it seems that a worksite wellness program could improve worker productivity by reducing lost work days due to sick leave and absenteeism. Both of these studies that focused on workers in physically demanding jobs indicate an improvement in physical work capacity. However, limitations of these studies are the fact that they only studied workers in two distinctive industries and therefore could not be generalized. More studies are required that determine the effect of a worksite wellness program on the physical work capacity of workers in physically demanding jobs in diverse industries.

The literature review on the impact of a worksite wellness program on improving the physical work capacity of workers in physically demanding jobs, therefore, indicate that the worksite is ideal for wellness programs and that organisations that follow the "best practices" in worksite wellness programs lead to substantial benefits for the employee and employer alike. However, the literature on worksite wellness programs for workers in physically demanding jobs is limited and, therefore, requires more research to determine the effect on their physical work capacity based on the minimum physical ability requirements of their job.

2.6 Summary

The objective of this literature review was threefold: firstly to research the use of physical work capacity assessments in the workplace; secondly to examine the role of ageing and gender on the physical work capacity of workers in physically demanding jobs and thirdly to discuss the impact of worksite wellness programs on the physical work capacity of workers in physically demanding jobs.

It is clear from the literature review on the use of physical work capacity assessments in the workplace, that the application possibilities are comprehensive. However, if the number of research in the South African context is taken as a barometer, it seems that our industries with physically demanding jobs have not fully applied physical work capacity assessments as suggested by the research literature. It is also clear from literature related to industries that perform physical work capacity assessments, that the physical work capacity of workers performing physically demanding tasks should be well managed to reduce work-related injury and improve worker productivity. Two types of workers are usually pointed out by management as not having the required physical work capacity to perform their physically demanding tasks, namely the older workers and females that are exposed to tasks with a high physical demand.

For the ageing worker, it seems that the physical work capacity declines with age as expected, and due to the reduced physical work capacity experienced by the older workers and the unchanged physical work demands, they have increased work-related injury prevalence. However, it must be stated that the literature on ageing workers in physically demanding jobs is limited, especially regarding the use of physical work capacity assessments in managing these workers. Subsequently more research is required to determine at what age the physical work demands exceed the physical work capacity of the ageing worker, and if work ability could be sustained up to retirement.

On the role that gender has on the physical work capacity of workers in physically demanding jobs, there is an indication that researchers generally agree that the physical work capacity of males is superior compared to that of females. Secondly, due to the reduced physical work capacity of females to perform their physically demanding work tasks, they seem to experience an increased prevalence rate for work-related injuries. However, no literature could be found that examined the physical work capacity of females in physically demanding jobs based on the minimum physical ability task requirement of their job. Such research could give insight into the causes of the high injury rate and poor performance observed by researchers amongst these female workers.

The literature review on the impact of a worksite wellness program on improving the physical work capacity of workers in physically demanding jobs revealed that the worksite is ideal for wellness programs, and organisations that follow the "best practices" in worksite wellness lead to substantial benefit for the employee and employer alike. However, the literature on worksite wellness programs for workers in physically demanding jobs is limited and, therefore, requires more research to determine the effect on their physical work capacity based on the minimum physical ability requirements of their job, and if such a program could assist those workers whose physical work capacity do not meet the minimum physical work capacity of their job, to attain those requirements.

CHAPTER 3

The role of gender on the physical work capacity profile of workers in an electricity supply company

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The role of gender on the physical work capacity profile of workers in an electricity supply company

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Abstract

The aim of this study was to determine the role of gender on the physical work capacity profile of workers based on the minimum physical ability task requirements of their job. Ten essential physical abilities inherently required were examined for all workers in physically demanding jobs. Participants received a physical work capacity percentage score and an "Approved" or "Rejected" physical work capacity profile. There were 3752 male workers and 71 female workers examined. The results indicate that the physical work capacity as a percentage of male workers in this population are practical significant (d=0.8) greater than that of female workers in the same job. The results further indicate that it is 7 times more likely for a male worker to receive a "Meet" physical work capacity profile than for a female worker. This study explained some of the factual causes of the high injury rate and poor performance observed by researches amongst female electricity utility workers.

1. Introduction

The lack of sufficient physical work capacity of females entering physically demanding jobs in increasing numbers, is of global concern.[1-5] The World Health Organization estimates that approximately 42% of the global working population comprises of females and they are expanding into male-dominated trade and craft occupations.[1] In South Africa, human rights legislation (Employment Equity Act 55 of 1998; Promotion of Equality and Prevention of Unfair Discrimination Act 4 of 2000) has accelerated this increase by forcing organisations to employ more females even in physically demanding jobs without considering the impact on the overall productivity.[6,7] Most of these physically demanding jobs are usually designed with the male physique in mind, thus making it more suited to male workers.[1,8,9] As a result of this, there are now more females in jobs that historically experienced higher injury rates due to the physically demanding nature and manual labour involved in these jobs.[9] This also places additional physical demands on female workers and can thus contribute to increased injury rates and other musculoskeletal ailments.[9] In general, the literature on musculoskeletal involvement in the workplace revealed that female workers are more likely to experience a musculoskeletal problem in physically demanding jobs than male workers.[8-11]

Female workers often suffer from musculoskeletal ailments because neither the tasks nor the equipment they use are most of the time not adapted to their physical build and functional ability.[12,13] This implies that the physical demand of the job will probably exceed their physical ability. [8,14] It has been stated that, although there is no difference in strength per lean body weight between males and females, the absolute strength of males is higher, mostly due to the higher muscle volume.[15-17] This lower strength ability of female workers could place a higher risk on them for injury or musculoskeletal ailments, while performing physical strenuous work tasks normally performed by male workers.[18]

The increased numbers of females entering physically demanding jobs has, for example, forced an electricity supply company (hereafter referred to as "the company") to improve the occupational management of these females. They developed minimum physical ability task requirements for all jobs with inherent physical task demands in order to "fit the right person to the job".[16,19] These minimum requirements enable the company to determine which workers do not have the physical work capacity to perform their work duties effectively and are at risk for work related injuries or disability irrespective of their gender.[16,20] A concern of the company was whether the increased number of female workers that entered into these physically demanding jobs, have the physical work capacity based on the minimum physical ability task requirements of their job. Only one study could be found that dealt with gender differences in physical work capacity and injury prevalence amongst electricity utility workers.[9] In this study, Kelsh and Sahl report that female workers performing physical intensive electricity utility duties, were at higher risk for both acute and chronic injuries than their male co-workers. No research, however, could be found that determined the differences in physical work capacity profile between male and female workers in physically demanding jobs based on the minimum physical ability task requirement of their job. Therefore, the question addressed by this study was what the role of gender is on the physical work capacity profile of workers in physically demanding jobs based on the minimum physical ability task requirements of their job. Answers to this question could give the company insight into the future occupational management of male and female workers in physically demanding jobs. The aim of this study was, therefore, to determine the role of gender on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

2. Method

2.1 Study design

A cross sectional study design was used for the purpose of this study. The study focused on determining the differences in physical work capacity profile between male and female workers.

2.2 Study population

The research was conducted on workers in jobs for which the company had developed minimum physical ability task requirements. The total population of male and female workers in these jobs of the company were included in this study. The physical work capacity profile of 3752 male workers (average age of 45 years) and 71 female workers (average age of 28 years) were assessed according to the procedure outlined in section 2.4. The reason for the small number of female workers (1.9%) could be explained by the fact that physically demanding jobs was only quite recently made available to female workers, in accordance with the equal opportunity labour legislation (Employment Equity Act 55 of 1998) [1,6] Lubbe and Kriek also report that several of the female applicants who applied for physically demanding jobs in the company, failed to meet the minimum physical ability task requirements of these jobs, and could thus not be appointed.[21]

2.3 Apparatus and test protocol

The apparatus and test protocol used to determine the physical work capacity profile of the workers, was in accordance with the company procedure as outlined by Lubbe.[16] A summary of the apparatus and test protocol used, is given in Table 1. According to this procedure, the workers were assessed on ten essential physical abilities inherently required by the related jobs.

Table 1: Summary of apparatus and test protocol#

Test	Apparatus	Protocol
Blood Pressure	Sphygmomanometer and stethoscope	Systolic- and diastolic blood pressure is measured in the sitting position after 5 minutes of rest
3 min. Step-up	25 cm. High step bench; metronome; stethoscope	Step up and down a bench at a rate of 100 steps per min. A metronome gives the rate of stepping. Heart rate is taken after 3 min. for 15 sec. and multiplied by 4 for 1 min. heart rate
Grip strength	Takai hand grip dynamometer	One maximal isometric contraction of the right- and left hand with the palms facing inwards
Back muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the back muscles in a bent-over-straight-leg position with a harness fitted over the lower back and hooked to the dynamometer on a platform
Leg muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the leg muscles in a 100-110 degrees squad position with a harness fitted over the upper back and hooked to the dynamometer on the platform
Arm-/shoulder muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the arm/shoulder muscles in a pick-up-from-the-floor position with a handle bar fitted to the dynamometer on the platform, legs spread out backwards and the chest resting on a cushion
Flexibility	Flexibility box	Push a marker (wooden block) horizontally as far as possible over a fixed ruler while sitting in a straight leg position. One chance
1-min. Sit-up	Stop watch	Perform as many sit-ups as possible in 1 min. with the body in a sitting posture with the legs 90° bent. Up-and-down movement count as one.

The results of the physical work capacity assessment for each participant was analysed by the company Biokineticists§ according to the testing procedure described in section 2.4, to determine the physical work capacity profile for each participant.

2.4 Testing procedure

The male and female workers were tested according to the physical work capacity testing and classification procedure outlined in Figure 1. According to this procedure, the workers were at first screened for readiness to perform physical work capacity testing. The screening was done to determine their risks and test components to be excluded from the test battery. After completion of the tests, their physical work capacity was calculated as a percentage score. This percentage score rates the overall physical work capacity of the worker according to the outcome of the 10 essential physical abilities tested.

References for the apparatus and test protocol used could be found in: Lubbe JPH. Die verband tussen fisieke vermoëns, veroudering en werkspesifieke taakprofiele van manlike werkers in 'n elekterisiteitsvoorsieningsmaatskappy. [Dissertation]. Potchefstroom: PU vir CHO; 2003

§ A Biokineticist is a specialised exercise therapist that functions in professional alliance to health and medicine, and is recognised by and registered with the Health Professions Council of South Africa.[22]

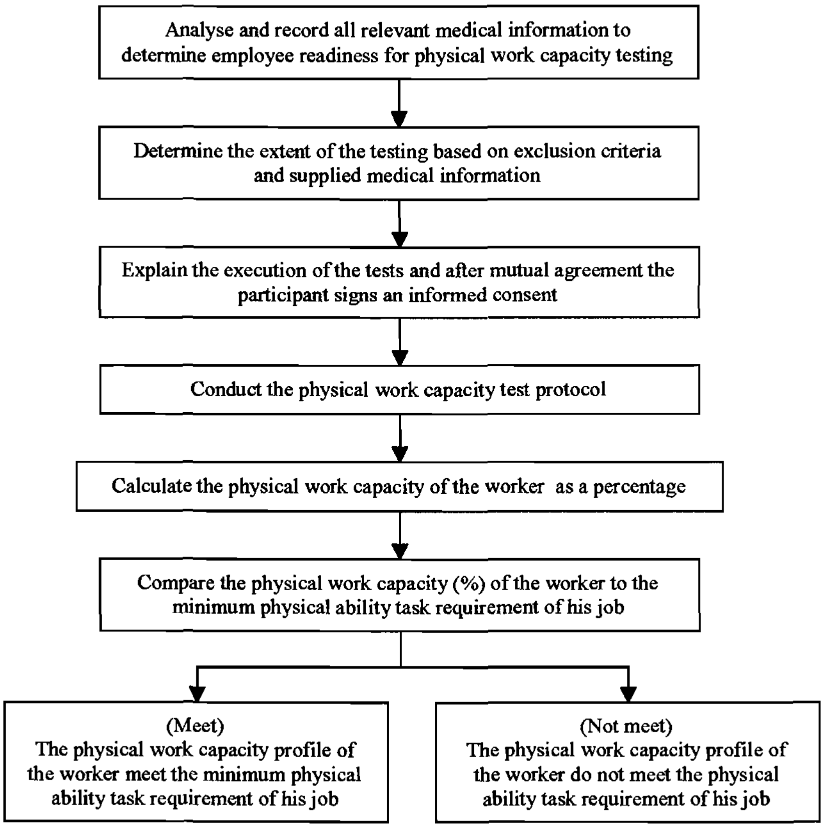

Figure 1: Physical work capacity testing and classification procedure

The physical work capacity score (%) was then compared to the minimum physical ability task requirements of their job to determine the physical work capacity profile of the worker.

The profile of each worker was then classified into one of the following:

(a) Meet the minimum physical ability task requirement (Meet)
(b) Do not meet the minimum physical ability task requirement (Not meet)

2.5 Statistical analysis

Statistical analysis were performed on the data using the STATISTICA software package.[23] Due to the fact that this study used the total population of workers in physically demanding jobs of the company, statistical significance, e.g. Chi-squared tests generally used for random samples, was not relevent.[24] Practical significance tests which is used to determine the effect size of the difference between populations as described by Cohen were, therefore, used for this study.[25] Practical significance implies a large enough difference to have an effect in practice.[25]

The effect size of the difference in physical work capacity as a percentage (see section 2.4) between male and female workers was determined through the formula:

$$d = \frac{p_1 - p_2}{\sqrt{p(100-p)}}$$

were p_1 is the percentage mean for the male workers, p_2 the percentage mean for the female workers and p the average percentage mean of male and female workers.[25] Cohen provides the following guideline values to interpret *d*:

a) small effect: *d*=0.2,
b) medium effect: *d*=0.5 and
c) large effect: *d*=0.8.[25]

Results with *d*=0.8 is considered as practically significant, since it indicates that the difference in physical work capacity as a percentage between male and female workers have a large effect.[25]

The odds ratio statistic was used as an effect size measure for the two-way frequency tables that measured the percentage number of male and female workers with a "Meet" or "Not meet" physical work capacity profile (see section 2.4). According to Steyn, the odds ratio statistic determines the probability that one population is positive in relation to another being negative.[26] Therefore, the odds ratio that either a male or a female worker is more likely to have a "Meet" physical work capacity profile was determine through the formula:

$$\omega = \frac{\pi_M / (1-\pi_M)}{\pi_F / (1-\pi_F)} = \frac{\pi_M (1-\pi_F)}{\pi_F (1-\pi_M)},$$

where the proportion of male and female workers approved are π_M and π_F respectively. Steyn give the following guidelines for the interpretation of ω:

a) small effect: ω=1.5,
b) medium effect: ω=2.5, and
c) large effect: ω=4.25.[26]

Results with ω=4.25 is considered as practically significant, since it indicates that the difference in the proportion of workers with a "Meet" physical work capacity profile between the two groups have a large effect.[26] This could give some insight into the probability that female workers could meet the minimum physical ability task requirements compared to male workers.

3. Results and discussion

The difference in physical work capacity between male and female workers is illustrated in Figure 2.

Figure 2: The physical work capacity differences of male and female workers

The female workers are a small section of the population, however, practically significant differences between male and female workers could still be observed. The physical work capacity as a percentage for male workers is 23.3% greater than the female workers (67.4% compared to 45.1%). The difference between the two genders are of large practical significance (d=0.99). The findings are in accordance with the literature on physical and physiological differences between male and female workers.[15-17] Literature on physical strength, which is a component of the physical work capacity, assessed in this study, indicate that female workers have lower absolute upper and lower body strength than male workers and could partially explain the differences reported.[15-17]

The physical work capacity of male and female workers in relation to the minimum physical ability task requirements (Figure 3) indicate that there are more male workers with a "Meet" physical work capacity profile than with a "Not meet" physical work capacity profile (70.5% compared to 29.5%). For female workers the opposite was observed, 25.4% of them had a "Meet" physical work capacity profile, while 74.7% had a "Not meet" physical work capacity profile. Figure 3 illustrates these differences in percentage between male and female workers. According to the odds ratio statistic, the odds for a male worker to receive a "Meet" physical work capacity profile is 2.39 and 0.34 for a female worker, yielding an odds ratio of 7.04 between male and female workers. This means that it is 7 times more likely for a male worker to receive a "Meet" physical work capacity profile than for a female worker. This calculation is of large practical significance (ω=4.25).[26]

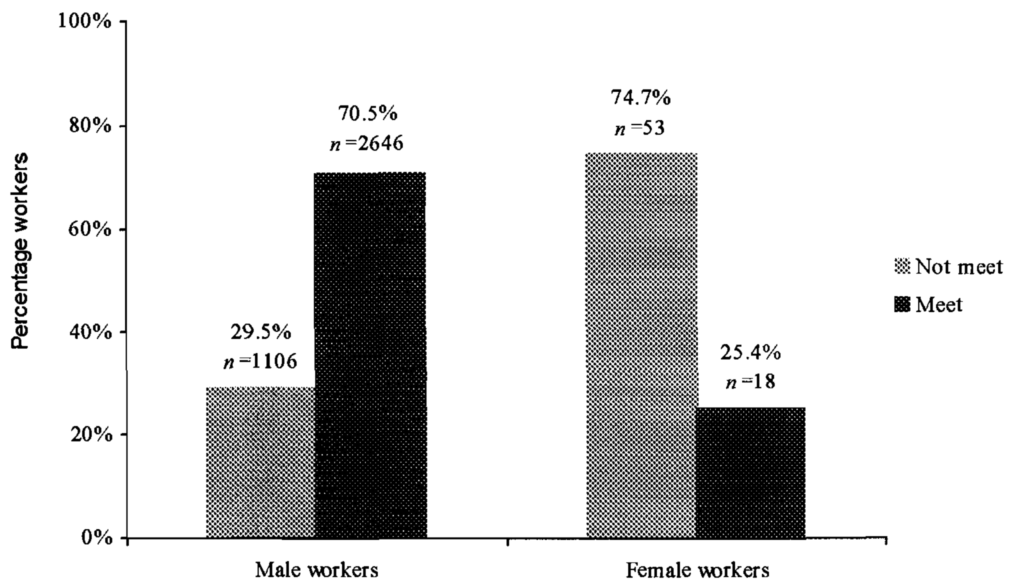

Figure 3: The percentage of male and female workers that had a "Not meet" or "Meet" physical work capacity profile

From the results it is clear that a larger percentage (74.7%) of the female workers do "Not meet" the minimum physical ability task requirements, on the other hand, 25.4% of the female workers do "Meet" the requirements. This could be the indication that although this is a male prone occupation, some females could meet the physical ability task requirements. This supports the argument by Shephard that the average female is less likely than an average male to meet standards specified for recruitment and continuing employment.[18]

4. Conclusion and recommendations

The physical work capacity of male workers in this population are practical significant (d=0.8) greater than that of female workers with the same job-related minimum physical ability task requirements. It is further concluded that when comparing the physical work capacity profile of male and female workers according to the "Meet" or "Not meet" classification, practically significant (ω=4.25) more female workers do not have the minimum physical work capacity required by their job than male workers. This implies that most female workers are at greater risk than their male co-workers in this company due to their inability to perform their contracted tasks, based on the inherent physical ability task requirements. In a similar work environment, Kelsh and Sahl reported that female electricity utility workers were at higher risk for work-related injuries than their male co-workers in the same job.[9] The cause for the higher risk of work-related injuries for female workers observed by these researchers could be partially explained by the results reported by this study, indicating that the physical work capacity profile of a practically significant number of female electricity utility workers do not meet the minimum physical ability task requirements of their job. No previous literature could be found that examined the physical work capacity profiles of male and female workers in relation to the minimum physical ability task requirements of their job. The value of this study lies in the fact that it could explain some of the factual causes of the high injury rate and poor performance observed by researchers amongst female workers in physically demanding jobs.[1,2,10,11] It is, therefore, recommended that companies should more effectively manage the physical work capacity of their female employees in physically demanding jobs. Through determining the physical work capacity profile of female workers in physically demanding jobs, companies could make more informed decisions related to pre-placement-, job re-design-, job accommodation- and, work hardening opportunities. Due to the fact that according to the literature females have only recently expanded into male-dominated trade and craft jobs, further research is required on the role of gender and job experience on the physical work capacity profile of workers in physically demanding jobs.[1,11]

6. References

1. World Health Organisation. Occupational health: ethically correct, economically sound. Geneva.1999; Fact sheet Nr 84.
2. Shrey DE. Worksite disability management and industrial rehabilitation: an overview. In Shrey DE, Lacerate M, editors. Principles and practices of disability management in industry. Florida: GR Press inc. 1997. p. 3-53.
3. Islam S, Velilla AM, Doyle EJ, Ducatman AM. Gender differences in work related injury/illness: analysis of workers compensation claims. Am J Ind Med. 2001; 39(1)84-91.
4. Lagerlöf E. Global gender issues in relation to health and industrial work. Geneva: World Health Organization; 2005.
5. International Labour Organization. Global employment trends for women 2004. Geneva: International Labour Office; March 2004.
6. Employment Equity Act 55 of 1998. Pretoria: Government press; 1998.
7. Promotion of Equality and Prevention of Unfair Discrimination Act 4 of 2000. Pretoria: Government press; 2000.
8. Messing K, Lippel K, Demers D, Mergler D. Equality and difference in the workplace: physical job demands, occupational illnesses, and sex differences. NWSA Journal. 2000; 12(3):21-49.
9. Kelsh MA, Sahl JD. Sex differences in work-related injury rates among electricity utility workers. Am J Epidem. 1996; 143(10):1050-1058.
10. Woods V, Buckle P. Work, inequality and musculoskeletal health. Health and safety executive, contract research report 421/2002. Norwich: St. Clements House; 2002.
11. Messing K, Őslin P. Gender equality, work and health: a review of the evidence. Geneva: World Health Organization; 2006.
12. Kroemer K, Kroemer H, Kroemer-Elbert K. Ergonomics: how to design for ease and efficiency. 2nd ed. Eaglewood Cliffs: Prentice Hall; 2001.
13. Kumar S, editor. Biomechanics in ergonomics. London: Taylor and Francis; 1999.
14. Smith PM, Mustard CA. Examining the associations between physical work demands and work injury rates between men and women in Ontario, 1990-2000. Occup Environ Med. 2004; 61(9):750-756.
15. Falkel JE, Sawka MN, Levine L, Pandolf KB. Upper and lower body muscular strength and endurance ratios for women and men. Ergonomics. 1985; 28:1661-1670.

16. Lubbe JPH. Die verband tussen fisieke vermoëns, veroudering en werkspesifieke taakprofiele van manlike werkers in 'n elekterisiteitsvoorsieningsmaatskappy. [Dissertation]. Potchefstroom: PU vir CHO; 2003.

17. Mac Duff L, De Ridder JH, Malan DDJ. Anthropometric, biomechanical strength and aerobic characteristics of humans and other influences that affect manual handling performance. Ergonomics SA. 2005; 17(1):25-40.

18. Shephard RJ, editor. Gender, physical activity, and aging. Boca Raton: CRC press; 2002.

19. Matheson LN. Functional capacity evaluation. In: Demeter SL, Anderson BJ, Smith GM, editors. Disability evaluation. Missouri: Mosby; 1996. p. 168-188.

20. Kriek N. Biokinetics: periodic physical ability surveillance. Eskom Distribution standard. Document number DISASADK7. Johannesburg; Eskom Holdings (Pty) Ltd. 2004.

21. Lubbe JPH, Kriek N. Women in physical demanding occupations: discrimination through minimum physical ability requirements (Paper presented to Distribution recruitment personnel of Eskom Holdings Pty.Ltd.). Johannesburg; Unpublished 2004.

22. Biokinetics Association of South Africa [Home page on internet]. What is a Biokineticist? 2007 [cited 2007 June 1]. Available from: http://www.biokinetics.org.za

23. Statsoft, Inc. STATISTICA (data analysis software system), version 7 [CD-ROM]. 2002. Available from: http://www.statsoft.com.

24. Thomas JR, Nelson JK. Research method in physical activity. 2nd ed. Champaign: Human Kinetics; 1990.

25. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale Cliffs: Erlbaum; 1988.

26. Steyn HS (Jr.). Handleiding vir die bepaling van effekgrootte-indekse en praktiese betekenisvolheid. Potchefstroom: North-West University; 2005 [cited 2006 Aug 12]. Available from: http://www.puk.ac.za/fakulteite/natuur/skd/index.html

CHAPTER 4

The role of ageing on the physical work capacity profile of workers in an electricity supply company

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The role of ageing on the physical work capacity profile of workers in an electricity supply company

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Abstract

The aim of this study was to determine the role of ageing on the physical work capacity profile of workers with inherent physical ability task requirements in an electricity supply company. Ten critical physical abilities inherently required were examined for all workers in physically demanding jobs to determine their physical work capacity as a percentage. There were 3499 male workers and 65 female workers examined. The findings of this research indicate that the physical work capacity profile of workers in physically demanding jobs within this company declines with age to such an extent that for male workers from the age of 60, the physical work demands of their job exceeds their physical work capacity, whereas female workers never have the required physical work capacity related to the demands of physically demanding tasks. This research can be applied to scientifically determine from what age workers in physically demanding jobs need to be managed based on their poor physical work capacity. This enables management to implement processes to optimise the physical work capacity of these older workers up to retirement through, for instance a task-related physical conditioning program, mentorship training-, job re-design-, and job accommodation opportunities.

1. Introduction

Interest in the study of ageing in the workforce has grown globally in the last decade due to demographic changes in the age structure.[1-5] According to the United Nations' 2006 Revision of World Population Prospects, the world population is steadily ageing due to long term reductions in fertility and mortality.[6] The high rate of unemployment in South Africa has added to the ageing workforce. It was estimated that during the 2001 census that 41.6% of the economically active population was unemployed.[7] This forces workers to work to an older age with relatively few young workers entering the workforce.[2,8,9] The prevalence of HIV among the economically active age group in South Africa is also contributing to the ageing of the workforce.[10-12] It is estimated that 16.2% of the age group 16-49 years are HIV positive.[10] Therefore the increase in deaths among this group could lead to a demographically older workforce due to an increased responsibility on older workers to be productive for their organisations and to provide financially for their families.[11,12]

The increase in the number of ageing workers in the workforce has lead to a rising in physical injuries and disabilities amongst older workers, mostly contributed by their inability to cope with the physical work demands.[8,13,14] Researchers have recognised that ageing is associated with the progressive decline in physical work capacity, and is characterised by diminished aerobic capacity and muscular capacity, with male and female workers showing similar decline.[2,4,5,8,13,15] Ilmarinen *et al.* indicates that there is an age-related decline in physical work capacity in relation to the same work load for younger and older workers as illustrated by Figure 1.[16] The result of this relationship implies that the difference in the deterioration of physical work capacity and unchanged physical work demands contribute significantly towards a decrease in the reserve capacity of the older worker, and lead to an increased risk of injury.[16] The ageing worker in physically demanding jobs according to Shephard is affected the most by this age-related decline in physical work capacity.[15] This is evident in the increase of prevalence rates of physical complaints, injuries and disabilities with advancing age in physically demanding jobs.[3,13,16-18]

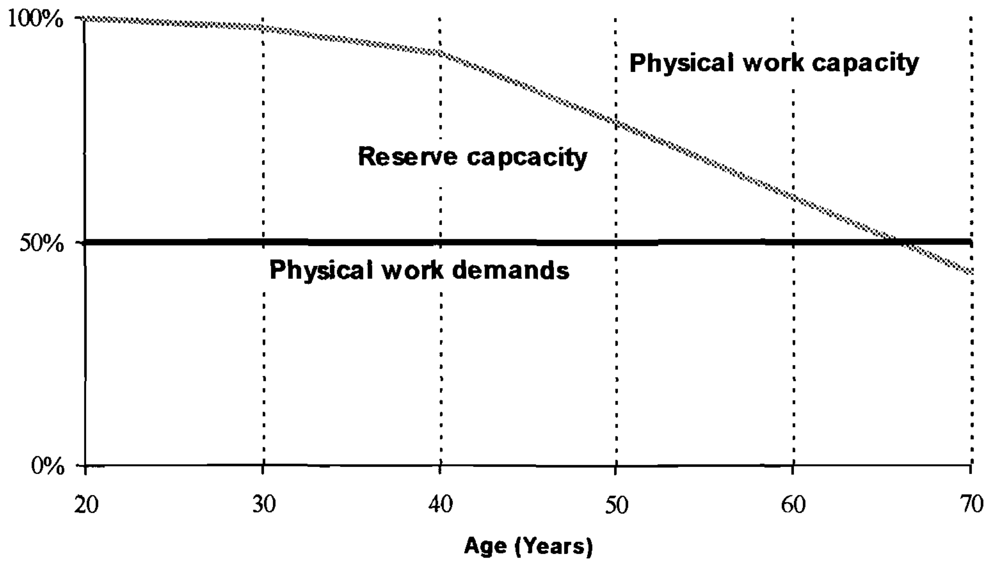


Figure 1: Theoretical relationship between physical work capacity and physical work demands[16]

The management of an electricity supply company in South Africa (hereafter the company) who realised that this trend was also prevalent in their workforce, developed minimum physical ability task requirements, that represent the physical work demands, for all the physically demanding jobs.[2] These minimum requirements enable the company to determine which workers do not have the physical work capacity to perform their physical work demands effectively regardless of gender, and are thus at risk for work related injury or disability.[2,19] The questions that this study addressed were, whether the increasing number of ageing workers in physically demanding jobs in the company have the required physical work capacity, and secondly from what age do the physical work demands of the job exceed the average worker's physical work capacity. Answers to these questions could give the company insight into the future management of ageing workers in such jobs. The aim of this study therefore was to determine the role of ageing on the physical work capacity profile of workers in physically demanding jobs in the company.

2. Method

2.1 Study design

A cross sectional study design was used for the purpose of this study. The study determined the physical work capacity differences among workers in physically demanding jobs with ageing. A prediction was made through a regression analysis were the physical work demands of the job exceed the physical work capacity of the average worker. The physical work demands are represented in the company by the minimum physical ability task requirements.

2.2 Study population

The research was conducted on all workers in jobs for which the company had developed minimum physical ability task requirements. These workers were distributed nationally within South Africa according to the company's operations. Their typical work duties comprise construction and maintenance of electrical power lines. There were 3564 workers assessed according to the procedure outlined in section 2.3, of which 65 workers were female.

2.3 Apparatus and test protocol

The apparatus and test protocol used to measure the physical work capacity of the workers, was according to the procedure outlined by Lubbe.[2] A summary of the apparatus and test protocol used, is given in Table 1. The results of the physical work capacity assessment for each participant was analysed by the company Biokineticists[§] according to the testing procedure described in section 2.4, to determine the physical work capacity profile for each participant.

Table 1: Summary of apparatus and test protocol

Test	Apparatus	Protocol
Blood Pressure	Sphygmomanometer and stethoscope	Systolic- and diastolic blood pressure is measured in the sitting position
3 min. Step-up	25 cm. High step bench; metronome; stethoscope	Step up and down a bench at a rate of 100 steps per min. A metronome gives the rate. Heart rate is taken after 3 min. for 15 sec. and multiplied by 4 for 1 min. heart rate
Grip strength	Takai hand grip dynamometer	One maximal isometric contraction of the right- and left hand.
Back muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the back muscles in a bent-over-straight-leg position with a harness fitted over the lower back and hooked to the dynamometer on a platform
Leg muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the leg muscles in a squad position with a harness fitted over the upper back and hooked to the dynamometer on the platform
Arm-/shoulder muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the arm/shoulder muscles in a pick-up-from-the-floor position with a handle bar fitted to the dynamometer on the platform, legs spread out backwards and the chest resting on a cushion
Flexibility	Flexibility box	Push a marker (wooden block) horizontally as far as possible over a fixed ruler while sitting in a straight leg position
1-min. Sit-up	Stop watch	Perform as many sit-ups as possible in 1 min. with the body in a sitting posture with the legs bent at 90°

2.4 Testing procedure

The workers were tested according to the physical work capacity testing procedure and classification procedure outlined in Figure 2. According to this procedure, the workers were firstly screened for physical testing readiness that determined their risks and identified the test components to be excluded from the test battery and signed an informed consent. After they conducted the test protocol, their physical work capacity as a percentage score was calculated. This percentage score rates the overall physical work capacity of the worker according to the outcome of the 10 critical physical abilities tested.

[#] References for the apparatus and test protocol used could be found in: Lubbe JPH. Die verband tussen fisieke vermoëns, veroudering en werkspesifieke taakprofiele van manlike werkers in 'n elekterisiteitsvoorsieningsmaatskappy. [Dissertation]. Potchefstroom: PU vir CHO; 2003

[§] A Biokineticist is a specialised exercise therapist that functions in professional alliance to health and medicine, and is recognised by and registered with the Health Professions Council of South Africa.[20]

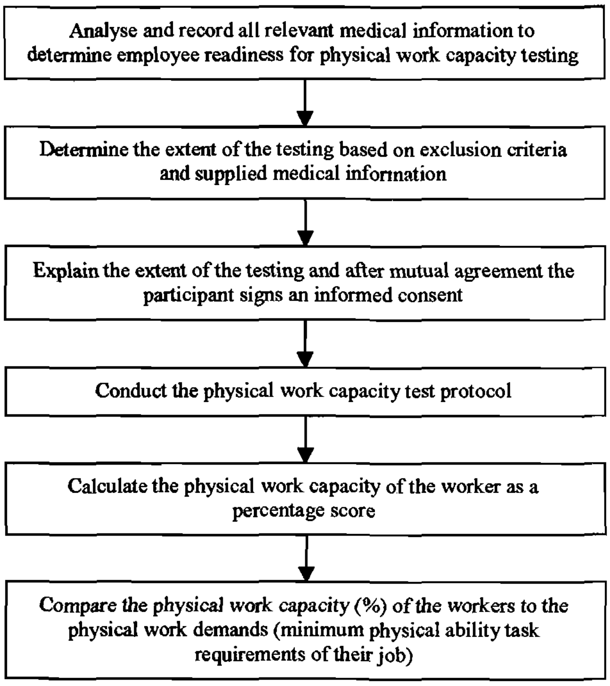


Figure 2: Physical work capacity testing and classification procedure

2.5 Statistical analysis

Statistical analysis was performed on the data using the STATISTICA software package.[21] Due to the fact that this study used the total population of workers in physically demanding jobs of the company, statistical significance calculations for instance, the Chi-squared tests generally used for sample groups, was therefore not relevent.[22] Practical significance tests as described by Cohen that are applied to determine the effective size of the difference between populations, were therefore used for this study.[23] Practical significance implies a large enough difference to have an effect in practice.[23]

The changes in age-related physical work capacity measured as a percentage (see section 2.4) for male and female workers, was determined through a regression analysis, with a ± 95% significance level calculation. The effect size of the regression is determined through the determination coefficient R^2, where $R^2 > 0.25$ is regarded as practically significant.[24]

The physical work capacity as a percentage score was predicted at ages 20, 30, 40, 50, 60 and 70 with a ± 95% confidence interval, for male and female workers using the formula:

$$Y' = bX + A$$

where X is the age variable represented on the abscissa (x-axis), b is the slope of the regression line, A is the physical work capacity intercept, and Y' consists of the predicted values of physical work capacity for the various values of age.

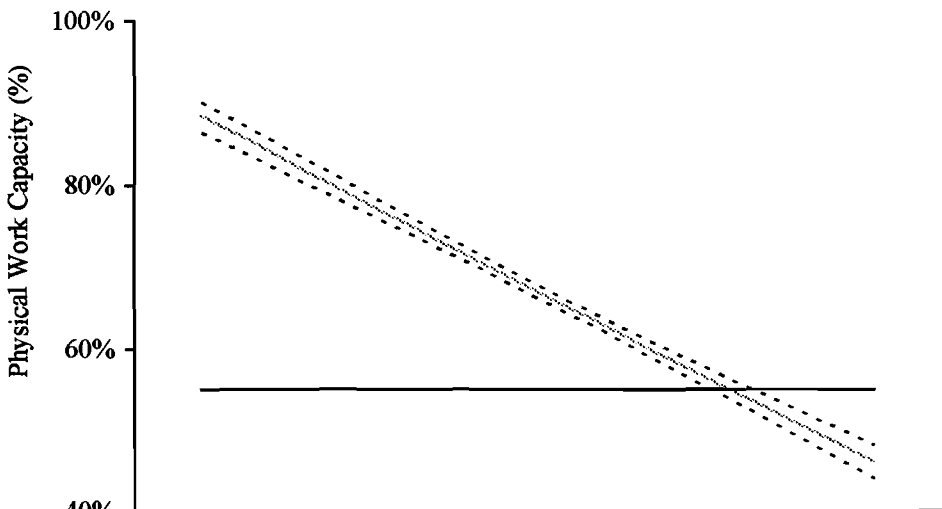
The predicted cut-off age where the physical work demands exceed the physical work capacity of workers was determined with the formula:

$$X' = \overline{X} + \left(Y - \overline{Y}\right)/b$$

with the same variables as in the previous formula, where $\overline{X}$, $\overline{Y}$ and b refer to the population calibration line. The estimate X' involves the ratio of two random variables ($Y - \overline{Y}$) and b.

3. Results and discussion

The changes in age-related physical work capacity in relation to physical work demands, measured as a percentage for male workers are presented and graphically illustrated in Figure 3.



	20	30	40	50	60	70
.... PWC%	88.4%	79.9%	71.4%	63.0%	54.5%	46.1%
- - - - - -95.0%CI	86.4%	78.6%	70.6%	62.2%	53.2%	44.0%
- - - - - +95.%CI	90.0%	81.2%	72.2%	63.8%	55.9%	48.1%
——— PWD (%)	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%

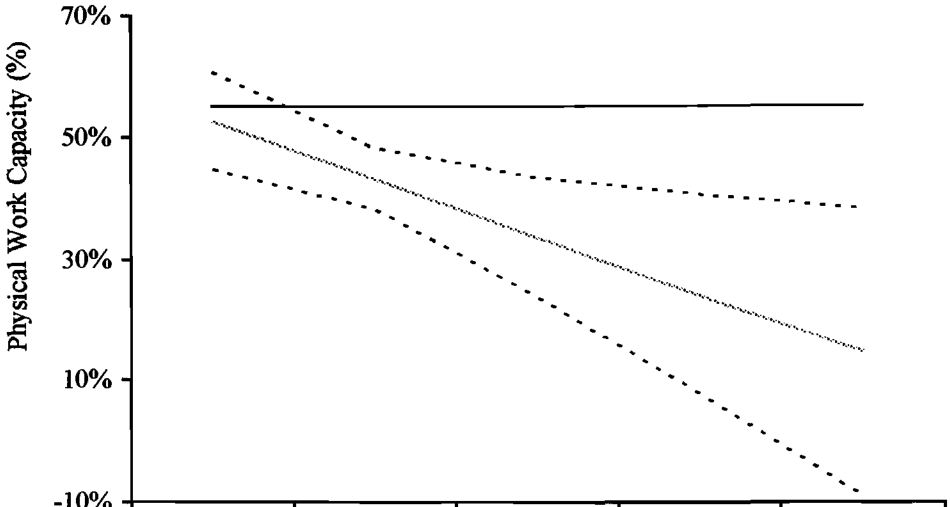
Age (Years)

PWC% = Physical work capacity (%), CI = Confidence interval, PWD% = Physical work demand (%)

Figure 3: The changes in age-related physical work capacity in relation to physical work demands for male workers

The figure indicates a negative linear relationship between the two variables, with the predicted physical work capacity of workers declining with ageing. The practical significance of this correlation is $R^2 = 0.12$, which indicates a moderate effect size ($R^2 > 0.25$ is regarded as practically significant). This is in agreement with previous studies in similar work environments.[2,5,28]

When comparing the predicted physical work capacity decline of male workers with age to the physical work demands, the results indicate that from age 60, the average physical work demands exceed their physical work capacity. This result is in agreement with the theoretical model of Ilmarinen *et al.* (illustrated in Figure 1) suggesting that the decrease in reserve physical work capacity of the older worker could lead to the physical work demands of the older worker exceeding his/her physical work capacity.[16] The literature indicates that for several physically demanding jobs, the older workers could perform their work duties up to retirement with sufficient reserve physical work capacity.[1,3,5,15,25] However, the physical work capacity required by workers in an electricity supply company has been identified in previous studies to be extremely physically demanding.[26,27] These jobs require the construction and maintenance of electrical power lines and therefore could explain the inability of workers 60 years and older in this study, to meet the requirements of the physical work demands. The same linear decline in physical work capacity with an increase in age was evident among female workers as illustrated in Figure 4. The effect size of this correlation is $R^2 = 0.10$, which also indicates a moderate effect, and therefore not practically significant ($R^2 > 0.25$). Due to the small female worker group the predictions are less accurate and could be seen in the physical work capacity range for the ± 95% confidence interval values. The greatest difference between male and female workers is visible when comparing the predicted physical work capacity decline with age to the same physical work demands. It could be seen in Figure 4 that for all the age groups, the physical work demands exceed their physical work capacity and that the physical work capacity deficit increases with age. Whereas this effect for male workers is only visible from the age groups 60 and 70 years. Therefore, not only do the physical work demands exceed the physical work capacity of female workers in this study, it also increases with age, posing a greater risk for injury or disability. In a study by Kelsh & Sahl on similar jobs, they reported that female electricity workers were at higher risk for work-related injuries than male workers in the same job.[28] The inability of female workers to meet the requirements of the physical work demands in this study, could therefore possibly explain the high injury prevalence rate reported by Kelsh & Sahl amongst female workers performing electricity utility duties.



	20	30	40	50	60
PWC%	52.7%	43.2%	33.6%	24.1%	14.6%
- 95%CI	44.8%	38.2%	23.9%	7.6%	-9.1%
+ 95%CI	60.6%	48.2%	43.4%	40.7%	38.2%
PWD%	55.0%	55.0%	55.0%	55.0%	55.0%

Age (Years)

PWC% = Physical work capacity (%), CI = Confidence interval, PWD% = Physical work demand (%)

Figure 4: The changes in age-related physical work capacity in relation to job demands for female workers

The results of the predicted cut-off age where the physical work demands of the job exceed the physical work capacity of the workers, indicate 59 years for male workers and 18 years for female workers. Therefore these results suggest that due to ageing, the male workers will not have the required physical work capacity to perform their duties effectively from the age of 60 years, whereas female workers will never have the required physical work capacity. However, individual differences may vary considerably as could be seen with the variance in the ± 95% confidence interval values indicated in Figures 3 & 4. For example, according to Figure 3, the predicted physical work capacity (54.5%) of male workers at the age of 60 years is below their physical work demand (55.0%) with a ±95% significance level of 54.3%

and 57.0%. This result indicates that with a 95% certainty it is predicted that the mean physical work capacity of workers aged 60 years will be between 54.3% and 57.0%. Therefore at the age of 60, some workers will still have the required physical work capacity to perform their duties. No other studies could be found that predicted such a cut off age for workers in physically demanding jobs and requires more research.

4. Conclusion and recommendations

The findings of this research indicate that the physical work capacity of workers in physically demanding jobs within this company declines with age to such an extent that for male workers from the age of 60, the physical work demands of their job exceed their physical work capacity, whereas female workers in general, will never have the required physical work capacity related to the demands of physically demanding tasks. The scientific literature is in agreement that the physical work capacity of workers declines with age and that the ageing worker experiences an increased risk of injury and disability[3,13,14,16-18] However, no research could be found that determined at what age the physical work demands exceed the physical work capacity of the workers. This research can be applied to scientifically determine from what age workers in physically demanding jobs need to be managed based on their poor physical work capacity. This enables management to implement processes to optimise the physical work capacity of these older workers up to retirement through for instance a task-related physical conditioning program, mentorship training-, job re-design-, and job accommodation opportunities. Shephard recommend that for the instance where the physical work demands exceed the capacity of the older worker, options for the employer are, to

a) maximise residual abilities by appropriate work site wellness programs,
b) optimise the design of the workstation,
c) establish compensation packages that encourage voluntary early retirement or transition to part-time work,
d) impose mandatory retirement at a fixed age, or
e) set job related standards which must be met for continued employment.[29]

5. References

1. Ilmarinen J, Tuomi K, Klockars M. Changes in the work ability of active employees over an 11-year period. Scan J Work Environ Health. 1997; 23 (Suppl.1):49-57.
2. Lubbe JPH. Die verband tussen fisieke vermoëns, veroudering en werkspesifieke taakprofiele van manlike werkers in 'n elekterisiteitsvoorsieningsmaatskappy. [Dissertation]. Potchefstroom: PU vir CHO; 2003.
3. Woods V, Buckle P. Work, inequality and musculoskeletal health. Health and safety executive, contract research report 421/2002. Norwich: St. Clements House; 2002.
4. World Health Organization. Aging and working capacity. Report of a WHO study group, technical report series, No 835. Geneva: WHO Press; 1993.
5. Gall B, Parkhouse W. Changes in physical capacity as a function of age in heavy manual work. Ergonomics. 2004; 47(6):671-687.
6. United Nations. World population prospects: the 2006 revision. New York: United Nations, Population Division; 2007 [cited 2007 May 26]. Available from: http://www.un.org/esa/population/publications/wpp2006/wpp2006.htm
7. Statistics South Africa [Homepage on the Internet]. South African statistics, 2002. [cited 2003 Aug 28]. Available from: http://statssa.gov.za/
8. Ilmarinen JE. Ageing workers. Occup Environ Med. 2001; 58:546-52.
9. Sluiter JK. High-demand jobs: Age-related diversity in work ability? Applied ergonomics. 2006; 37(4):429-440.
10. Shisana O, Rehle T, Simbayi LC, Parker W, Zuma K, Bhana A, Connolly C, Jooste S, Pillay V et al. South African national HIV prevalence, HIV incidence, behaviour and communication survey. Cape Town: HSRC Press; 2005.
11. Sadie JL. Demografiese veroudering in Suid Afrika en sy vernaamste gevolge. J Stud Econ Econometrics. 2003; 27(3):49-68.
12. Ellis LL. The impact of HIV/AIDS on selected business sectors in South Africa. J Stud Econ Econometrics. 2007; 31(1):29-52.
13. De Zwart BCH, Frings-dresen MHW, Van Dijk FJH. Physical workload and the aging worker: a review of the literature. Int J Occ H. 1995; 68(1):1-12.
14. World Health Organisation. Occupational health: Ethically correct, economically sound. Geneva. 1999; Fact sheet Nr 84.
15. Shephard RJ. Age and physical work capacity. Experimental aging research. 1999; 25(4):331-344.
16. Ilmarinen J, Tuomi K, Eskelinen L, Nygård CH, Huuhtanen P, Klockars M. Summary of recommendations of a project involving cross-sectional and follow-up studies on

the aging worker in Finnish municipal occupations (1981-1985). Scan J Work Environ Health. 1991; 17(1):135-41.

17. Shephard RJ. Human rights and the older worker: changes in work capacity with age. Med Sci in Spt Exercise. 1986; 19(2):168-73.
18. Leclerc A, Niedhammer I, Landre MF, Ozguler A, Etore P, Pietri Taleb F. One-year predictive factors for various aspects of neck disorders. Spine. 1999; 24(14):1455-62.
19. Matheson LN. Functional capacity evaluation. In: Demeter SL, Anderson BJ, Smith GM editors. Disability evaluation. Missouri: Mosby; 1996. p. 168-88.
20. Biokinetics Association of South Africa [Home page on internet]. What is a Biokineticist? 2007 [cited 2007 June 1]. Available from: http://www.biokinetics.org.za
21. Statsoft, Inc. STATISTICA (data analysis software system), version 7 [CD-ROM]. 2002. Available from: http://www.statsoft.com.
22. Thomas JR, Nelson JK. Research methods in physical activity. 2nd ed. Champaign: Human Kinetics; 1990.
23. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale: Erlbaum; 1988.
24. Steyn HS (Jr.). Handleiding vir die bepaling van effekgrootte-indekse en praktiese betekenisvolheid. Potchefstroom: North-West University; 2005 [cited 2006 Aug 12]. Available from: http://www.puk.ac.za/fakulteite/natuur/skd/index.html
25. Savinainen M, Nygard C, Ilmarinen J. A 16-year follow-up study of physical capacity in relation to perceived workload among ageing employees. Ergonomics. 2004; 47(10):1087-1102.
26. Doolittle TL, Spurlin O, Kaiyala K, Sovern D. Physical demands of lineworkers. Proceedings of the Human Factors Society – 32nd annual meeting. California: Anaheim; 1988: 632-636.
27. Parkhouse W, Gall B. Task frequency as a function of age for the powerline technician trade. Ergonomics. 2004; 47(6):660-670.
28. Kelsh MA, Sahl JD. Sex differences in work-related injury rates among electricity utility workers. Am J Epidem. 1996; 143(10):1050-1058.
29. Shephard RJ., Aging, physical activity and health. Champaign: Human Kinetics Publishing; 1997.

CHAPTER 5

The effect of a worksite wellness program on the physical work capacity profile of workers in an electricity supply company

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The effect of a worksite wellness program on the physical work capacity profile of workers in an electricity supply company

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Abstract

The aim of this study was to determine the effect of a worksite wellness program on the physical work capacity profile of workers with inherent physical ability task requirements. Twelve male workers whose physical work capacity profile did not meet the minimum physical ability task requirements of their job, formed part of an experimental group that participated in a 24-month worksite wellness program. On the other hand, 62 similar workers formed part of a control group. Pre- and post-tests were performed on all participants to determine if their physical work capacity profile met the minimum physical ability task requirements of their job. Participants received a "Meet" or "Not meet" physical work capacity profile classification according to the results of an assessment on ten essential physical abilities inherently required by their job. There was no practical significant (d = 0.8) difference between the two groups before the start of the program after controlling for age, gender, motivation to change and initial physical work capacity profile differences. The comparative statistics between the experimental and control group indicate that workers whose physical work capacity profile do not meet the minimum physical ability task requirement of their job, are practically significant (ω = 4.25) more likely to improve their physical work capacity profile through the 24-month worksite wellness program to a level were they meet the minimum physical ability task requirement of the job, than receiving no intervention.

1. Introduction

Local and international organisations are suffering from economic strain due to the lack of sufficient physical work capacity of workers.[1-4] Research indicates that a lack of sufficient physical work capacity results in the loss of billions of rands in workers' compensation claims, medical treatment and general production losses due to absenteeism, lost work time and poor quality of work.[5-7] O'Donnell and Shrey suggest that employers can no longer rely on government or outside third parties, like insurance carriers and claims management organisations to manage uncontrolled workers' compensation costs.[8,9] During the last decade these problems has led to an increase in companies offering worksite wellness programs for high-risk employees declared unfit for duty, as a way to improve their physical work capacity and accelerate return to work.[8-12] These programs offered to employees focus on a total wellness approach in reducing risk of work-related injuries and improving productivity, and not merely directed to physical fitness per sé.[8,13] According to the World Health Organization, such an approach goes beyond disease management and includes optimal physical, spiritual and social well-being.[14]

Cox defines a worksite wellness program as a comprehensive, multidisciplinary, and complex field that seeks to promote, improve, and optimize health, well-being, and performance of those associated with a place of employement.[13] According to Robison, these programmes provides the worksite professionals with an opportunity to support people's health and human needs in a more compassionate effective way, instead of focusing on controlling, isolated symptomatic illnesses or behaviours.[15] Program participants then have the unique opportunity to heal their symptoms while also developing a deeper understanding of the underlying life struggles that these symptoms represent.[16] Worksite wellness programs has been shown to expedite return to meaningful employment, minimize workdays lost, reduce premature retirement, and increase the productivity of injured workers.[8,10,13] Therefore it seems that a worksite wellness program could benefit the physical work capacity profile of workers despite their inescapable illnesses, disabilities, and trauma.[17] No literature could, however, be found that indicated the impact of a worksite wellness program on the physical work capacity profile of workers in physically demanding jobs based on the minimum physical ability task requirements of their job.

The management of an electricity supply company (hereafter referred to as "the company") became aware of the increased injury and disability rate amongst workers in physically demanding jobs, which was prevalent in their workforce. As a result of this, the company developed minimum physical ability task requirements for all jobs with inherent physical task demands.[3,18] They also developed a worksite wellness program for physical incapacitated employees in these jobs.[3] The question raised in this study is, how a worksite wellness program can influence the physical work capacity profile of workers in physically demanding jobs, based on the minimum physical ability task requirements of their job. Answers to this question could give the company insight into the future management of physical incapacitated workers in these jobs and the use of a worksite wellness program in this regard. The aim of this study, therefore, was to determine the effect of a worksite wellness program on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

2. Method

2.1 Study design

A quasi-experimental design was used for this study as described by Goetzel and Ozminkowski, which consisted of a pre-test and post-test with comparison group design.[19] The study design is schematically illustrated as follows:

$$\begin{array}{ccc} E_1 & T_e & E_2 \\ \hdashline C_1 & & C_2 \end{array}$$

For the experimental group, E_1 is the pre-test, T_e is the worksite wellness program intervention and E_2 is the post-test. For the control group, C_1 is the pre-test and C_2 the post-test. The experimental design of this study focused on determining the physical work capacity profile differences of the workers in these two groups over a 24-month period. Workers were assigned to the two groups on a non-random basis of which the procedure will be described in more detail in section 2.2. Baseline differences among groups were controlled for through selection and statistical means. Factors controlled for include gender, age, motivation to change, and physical work capacity profile differences.

2.2 Study population

The research was conducted on workers in jobs for which the company had developed minimum physical ability task requirements. All the workers in these jobs were subjected to a physical work capacity assessment (see section 2.3). Workers that did not meet the minimum physical ability task requirement for their job were selected for this study.

Seventy-five (75) workers were identified that met the set criteria, of which one was a female worker. Gender bias was control for by focusing on the seventy-four (74) male workers. In order to control for the effects of voluntary participation, workers were considered for the experimental group according to the capacity of the company Biokineticists to handle them over the period of the research, and the willingness of management to release the selected workers, and not by the motivation of the identified workers to voluntary participate. Prochaska *et al.* indicates that with voluntary participation individuals have, on their own accord, initiated the change process by indicating readiness.[21] This acknowledgement separates them from other individuals who have not yet decided that they wish to change and could provide bias results when comparing an experimental group with a control group.[21]

Twelve (12) workers were finally incorporated into the experimental group and the remaining sixty-two (62) workers formed part of the control group. The intervention procedure for the experimental group is outlined in section 2.5.

2.3 Apparatus and test protocol

The apparatus and test protocol used to measure the physical work capacity profile of the workers, was according to the procedure outlined by Lubbe.[3] A summary of the apparatus and test protocol used, is given in Table 1. The results of the physical work capacity assessment for each participant was analysed by the company Biokineticists according to the testing procedure described in section 2.4, that determined the physical work capacity profile for each participant.

Table 1: Summary of apparatus and test protocol

Test	Apparatus	Protocol
Blood Pressure	Sphygmomanometer and stethoscope	Systolic- and diastolic blood pressure is measured in the sitting position
3 min. Step-up	25 cm. High step bench; metronome; stethoscope	Step up and down a bench at a rate of 100 steps per min. A metronome gives the rate. Heart rate is taken after 3 min. for 15 sec. and multiplied by 4 for 1 min. heart rate
Grip strength	Takai hand grip dynamometer	One maximal isometric contraction of the right- and left hand with the palms facing inwards
Back muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the back muscles in a bent-over-straight-leg position with a harness fitted over the lower back and hooked to the dynamometer on a platform
Leg muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the leg muscles in a squad position with a harness fitted over the upper back and hooked to the dynamometer on the platform
Arm-/shoulder muscle strength	Takai back/leg dynamometer; ergonomically developed platform to ensure correct execution	One maximal isometric contraction of the arm/shoulder muscles in a pick-up-from-the-floor position with a handle bar fitted to the dynamometer on the platform, legs spread out backwards and the chest resting on a cushion
Flexibility	Flexibility box	Push a marker (wooden block) horizontally as far as possible over a fixed ruler while sitting in a straight leg position
1-min. Sit-up	Stop watch	Perform as many sit-ups as possible in 1 min. with the body in a sitting posture with the legs 90° bent

2.4 Testing procedure

All workers in the experimental and the control group were adhered to a pre-test and a post-test after 24 months. Each worker was tested and classified according to the physical work capacity testing and classification procedure outlined in Figure 1. According to this procedure the workers received either a "Meet" or "Not meet" physical work capacity profile determined from the test results.

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§A Biokineticist is a specialised exercise therapist that functions in professional alliance to health and medicine, and is recognised by and registered with the Health Professions Council of South Africa.[20]

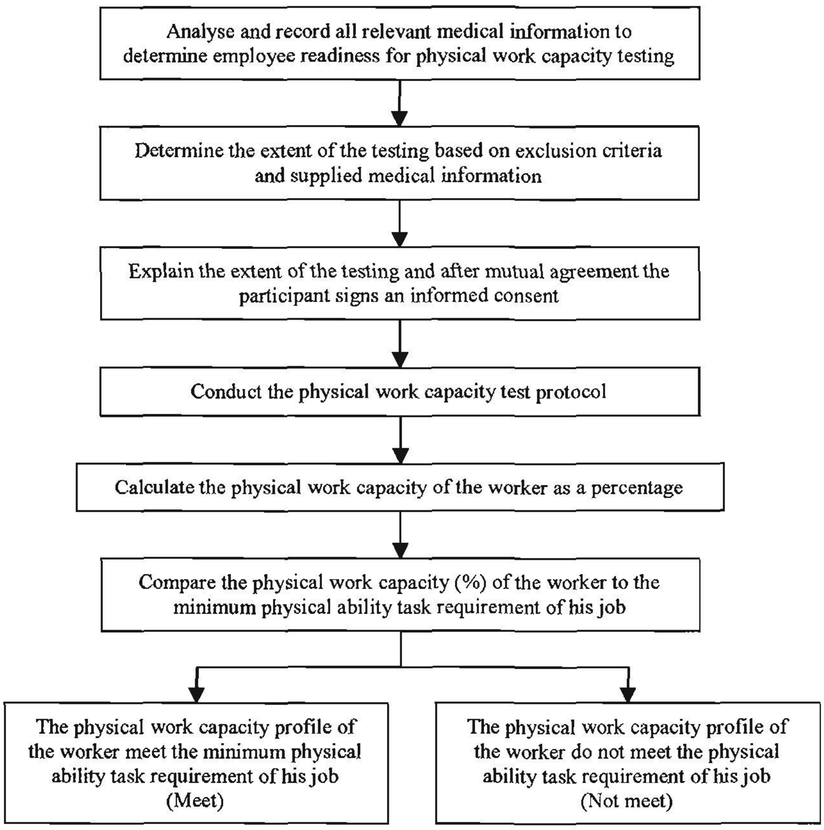

Figure 1: Physical work capacity testing and classification procedure

2.5 Intervention procedure for experimental group

The experimental group was subjected to a worksite wellness program coordinated by the Biokineticists in 4 different Wellness centres of the company across the country. In the worksite wellness program, participants not only followed exercise programs to improve their physical work capacity profile but also received preventative lifestyle and work safety training to empower them to live a healthy lifestyle and productive working career with self-responsibility, balance, and personal development in all areas of their well-being. A specialised multidisciplinary team consisting of Biokineticists, Employee Assistance Practitioners, Occupational Health Practitioners, and Human Resources Practitioners attended to each participant. The multidisciplinary team regularly followed up the participants over the 24-month period to determine their progress made, to make program adjustments and continue with lifestyle, and work productivity enhancement training. This was done to assist the participants to acquire a "Meet" physical work capacity profile and sustain it over the 24-month period. Table 2 displays the progress strategy followed in the worksite wellness program over the 24 months, based on the physical work capacity profile improvements of the workers.

Table 2: Worksite wellness program progress strategy

Intensity phase	Frequency of visits to the Wellness centre	Duration
Intensive	Daily	2 weeks
Periodic	Monthly	6 months
Maintenance	Six monthly	2 years

With this strategy, the workers followed a three phase program, starting with the Intensive phase followed by the Periodic and Maintenance phases. For each of these phases the participants followed a set frequency of visits to the Wellness centre for the given period as indicated in Table 2. After each phase, the participants were re-tested, and if there physical work capacity improved sufficiently according to the professional opinion of the Biokineticist, they moved over to the new intensity phase. Participants that did not display any improvements for the duration of the relevant phase of the program was subjected to a multi-disciplinary team decision whether to continue with the program or propose alternative intervention not part of this study. All participants in the experimental group, however, completed the 24-months intervention period.

2.6 Statistical analysis

Statistical analysis were performed on the data using the STATISTICA software package.[22] Due to the fact that this study used a selected population, statistical significance calculations, for instance the Chi-squared tests, generally used for random groups, was therefore not relevent.[23] Practical significance tests as described by Steyn, that is applied to determine the effect size of the difference between populations, were therefore used for this study.[24] Practical significance implies a large enough difference to have an effect in practice.[24]

Ageing has been identified by researches as a factor that could affect the internal validity of the results when comparing two groups.[8,25] Therefore, to determine if age could have any effect on the results, the effect size of the age difference between the two groups were determined through the formula:

$$d = \frac{|\bar{x}_E - \bar{x}_K|}{s_K},$$

where $\bar{x}_E$ is the mean for the experimental group, $\bar{x}_K$ and s_K the mean and standard deviation for the control group respectively. Steyn provides the following guideline values to interpret *d*:

a) small effect: $d = 0.2$,
b) medium effect: $d = 0.5$ and
c) large effect: $d = 0.8$.[24]

Results with $d = 0.8$ is considered as practically significant, since it indicates that the difference in mean age between the two groups have a large effect.[24]

The percentage number of workers in the experimental and control group who had a physical work capacity profile of "Meet" and "Not meet" (see classification procedure in section 2.4) after the 24-month intervention period, were compared with two-way frequency tables. The odds ratio statistic as described by Steyn was used as an effect size measure for the two-way frequency tables.[24] According to the odds ratio statistic, the odds are determined for the probability that one population is positive in relation to another being negative.[24] Therefore the odds ratio that a worker in the experimental group is more likely to have a "Meet" physical work capacity profile than a worker in the control group was determined through the formula:

$$\omega = \frac{\pi_E/(1-\pi_E)}{\pi_C/(1-\pi_C)} = \frac{\pi_E(1-\pi_C)}{\pi_C(1-\pi_E)},$$

where the proportion of workers approved for experimental and control groups are π_E and π_C respectively. Steyn give the following guidelines for the interpretation of ω:

d) small effect: $\omega = 1.5$,
e) medium effect: $\omega = 2.5$, and
f) large effect: $\omega = 4.25$.[24]

Results with ω=4.25 is considered as practically significant, since it indicates that the difference in the proportion of workers with a "Meet" physical work capacity profile between the two groups have a large effect.[24]

3. Results and discussion

Before the start of the worksite wellness program the physical work capacity profile of the workers in the experimental and control group was as such that none of them met the minimum physical ability task requirements of their job ("Not Meet" according to classification in section 2.4). The percentage number of workers in the experimental and control group that still had a "Not meet" or changed to a "Meet" physical work capacity profile after the 24-month worksite wellness program are illustrated in Figure 2. The results indicate that 75.0% of the workers in the experimental group had a "Meet" physical work capacity profile after 24 months into the worksite wellness program. Whereas, only 27.4% of the workers in the control group had a "Meet" physical work capacity profile after the same period. Thus 72.6% of the workers in the control group still had a "Not meet" physical work capacity profile after the 24-month period, whereas only 25% of the workers in the experimental group that followed the worksite wellness program had a "Not meet" physical work capacity profile. There was no practical significant difference (d = 0.8) in the mean ages of the workers in the control and experimental group (48.9 and 46.4 years respectively). Therefore, ageing had no practical significant effect on the comparative results between the two groups.

According to the odds ratio statistic, the odds for the workers to receive a "Meet" physical work capacity profile after the 24-month intervention period are 0.38 for the control group and 3.0 for the experimental group, yielding an odds ratio of 7.94 for the two groups. This means that it is approximately 8 times more likely for a worker in the experimental group to receive a "Meet" physical work capacity profile after the 24-months, than for a worker in the control group. According to the guidelines given by Steyn, this is practically significant (ω = 4.25).[24]

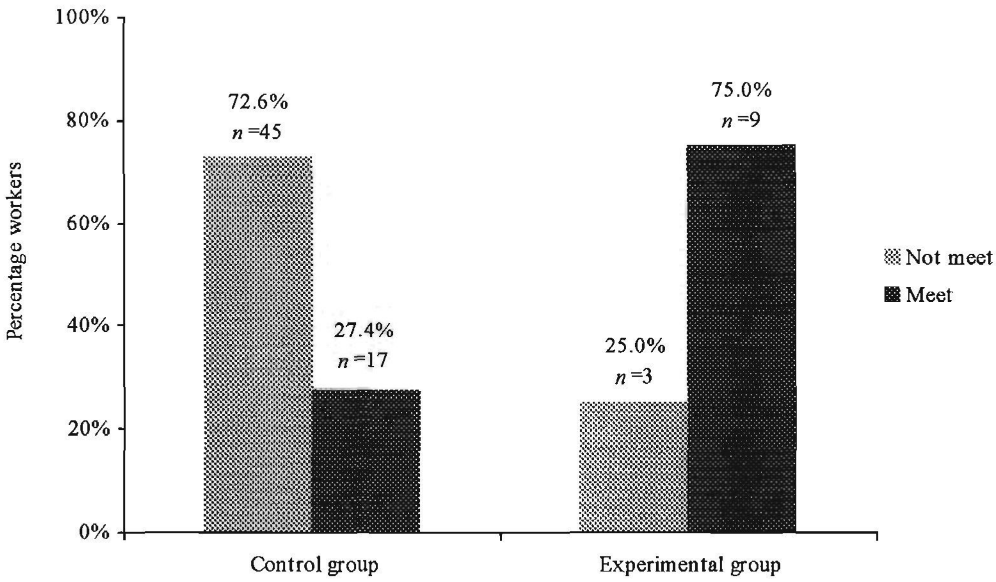

Figure 2: The percentage number of workers in the experimental and control group that had a "Not meet" or "Meet" physical work capacity profile after the 24-month worksite wellness program

The worksite wellness program, therefore, had a practical significant positive effect on the physical work capacity profile of the workers in the experimental group, compared to those in the control group. No comparative literature could be found that indicated the effect of a worksite wellness program on the physical work capacity profile of workers in physically demanding jobs, based on the minimum physical ability task requirements, and needs more research. However, Grace report with a similar study design and work environment, positive changes in some physical ability parameters inherently required of the workers participating in a 6-month physical wellness program.[12] O'Donnell and Cox also report that worksite wellness programs have shown to expedite return to meaningful employment and increased productivity of injured workers.[8,13]

4. Conclusion and recommendations

This study indicated that the worksite wellness program assists workers whose physical work capacity profile do not meet the minimum physical ability task requirements of their job, to regain the required physical work capacity. The comparative statistics between the experimental and control group indicate that workers whose physical work capacity profile do not meet the minimum physical ability task requirement of their job, are practically significant ($\omega = 4.25$) more likely to improve their physical work capacity profile through the 24-month worksite wellness program to a level were they meet the minimum physical ability task requirement of the job, than the workers receiving no intervention.

Previously, no studies could be found that reported the effect of a worksite wellness program on the physical work capacity profile of workers, based on the minimum physical ability task requirements of their job. However, the results of this study support earlier findings indicating that physical exercise and health promotion has a positive influence on the physical health status of workers.[10,12,25,26] Several studies on worksite wellness programs have shown to expedite return to meaningful employment, minimise workdays lost, reduce premature retirement, and increase the productivity of injured workers, but similar research in physically demanding jobs are limited.[10-12,25] Therefore the results of this study suggests that a worksite wellness program, as prescribed according to the procedure outlined in this study, could assist workers in physically demanding jobs whose physical work capacity profile do not meet the minimum physical ability task requirements of their job to regain the physical work capacity required. These results further assist organisations to provide an alternative option to managing the physical work capacity of their workers, other than ill-health retirement, retrenchments or prolonged sick-leave.

5. References

1. Cox RAF, Edwards FC, Palmer K, editors. Fitness for work, the medical aspects. 3rd ed. London: Oxford University Press; 2003.
2. World Health Organisation. Occupational health: ethically correct, economically sound. 1999; Fact sheet Nr 84.
3. Lubbe JPH. Die verband tussen fisieke vermoëns, veroudering en werkspesifieke taakprofiele van manlike werkers in 'n elekterisiteitsvoorsieningsmaatskappy. [Dissertation]. Potchefstroom: PU for CHO; 2003.
4. Woods V, Buckle P. Work, inequality and musculoskeletal health. Health and safety executive, contract research report 421/2002. Norwich: St. Clements House; 2002.
5. Dempsey PG, Hashemi L. Analysis of workers' compensation claims associated with manual materials handling, Ergonomics. 1999; 42(1):183-195.

6. Ciriello VM, Snook SH. Survey of manual handling tasks. Int J Ind Ergo. 1999; 23:149-156.
7. Mital A. Analysis of multiple activity manual materials handling tasks using a guide to manual material handling. Ergonomics. 1999; 42(1):246-257.
8. O'Donnell M. Health promotion in the workplace. 3rd ed. Delmar: Thomson Learning; 2002.
9. Shrey DE. Worksite disability management and industrial rehabilitation: an overview. In: Shrey DE, Lacerate M, editors. Principles and practices of disability management in industry. Florida: GR Press; 1997. p. 3-53.
10. Pohjonen T, Ranta R. Effects of worksite physical exercise intervention on physical fitness, perceived health status, and work ability among home care workers: five-year follow-up. Prev Med. 2001; 32:465-475.
11. O'Halloran. An historical overview of Australian's largest and oldest provider of vocational rehabilitation – CRS Australia. Work. 2002; 19(3):211-8.
12. Grace JM. Impact of a worksite physical wellness program in sick leave, absenteeism and health relate fitness [Dissertation]. Pretoria: University of Pretoria press; 2001.
13. Cox C, editor. ACSM's worksite health promotion manual. A guide to building and sustaining healthy worksites. Champaign: Human Kinetics; 2003.
14. Asvall JE. World Health Organization. Forward to Medical Sociology and the WHO programme for Europe. Social Sc M. 1986; 22(2):117-124.
15. Robison J. Toward a new science. WELCOA's absolute advantage magazine. 2004; 3(7):2-5.
16. Robison J. Reinventing the profession. WELCOA's absolute advantage magazine. 2004; 3(7):6-11.
17. Morris DB. Illness and culture in the postmodern age. Berkeley: University of California press; 1998.
18. Matheson LN. Functional capacity evaluation. In: Demeter SL, Anderson BJ, Smith GM, editors. Disability evaluation. Missouri: Mosby; 1996. p. 168-188.
19. Goetzel R, Ozminkowski. Program Evaluation. In: O'Donnell M, editor. Health promotion in the workplace. 3rd ed. Albany: Delmar; 2002. p 116-165.
20. Biokinetics Association of South Africa [Home page on internet]. What is a Biokineticist? 2007 [cited 2007 June 1]. Available from: http://www.biokinetics.org.za

21. Prochaska JO, DiClemente CC. Stages and processes of self change of smoking: toward an integrative model of change. J Consult Clin Psychol. 1983; 52(3):390-395.

22. Statsoft Inc. STATISTICA (data analysis software system), version 7 [CD-ROM]. 2002. Available from: http://www.statsoft.com

23. Thomas JR, Nelson JK. Research methods in physical activity. 2nd ed. Champaign, IL: Human Kinetics; 1990.

24. Steyn HS (Jr.). Handleiding vir die bepaling van effekgrootte-indekse en praktiese betekenisvolheid. Potchefstroom: North-West University; 2005 [cited 2006 Aug 12]. Available from: http://www.puk.ac.za/fakulteite/natuur/skd/index.html

25. Tuomi K, Ilmarinen J, Martikainen R, Aalto L, Klockars M. Aging, work, life-style and work ability among Finnish municipal workers in 1981-1992. Scand J Work Environ Health. 1997; 23 Suppl 1:58-65

26. Van der Ploeg HP, Streppel KRM, Van der Beek AJ, Van der Woude LHV, Vollenbroek-Hutten MMR, Van Harten WH, Van Mechelen W. Successfully improving physical activity behavior after rehabilitation. Am J Health Prom. Jan/Feb 2007; 21(3):153-159.

CHAPTER 6

Summary, conclusions and recommendations

6.1 Introduction

Workers that carry out physically intensive work tasks have, over the last decade, shown a high incidence of work related injuries and other related physical disorders (Dempsey & Hashemi, 1999:183; Mital & Ramakrishnan, 1999:74; WHO, 1999:1; Weir & Nielson, 2001:128; Cox *et al.*, 2003:6). This has been shown to lead to absence from work, lost work time and poor work quality which in turn give rise to increased costs of worker compensation claims, medical treatment and general production losses (Ciriello & Snook, 1999:149; Mital, 1999:246-247; Cox *et al.*, 2003:6). Research indicates that these types of injuries and/or work disability usually occur when the physical demands of the work tasks exceed the physical work capacity of the worker (Chaffin, 1974:251-254; Fraser, 1992:24; Shrey, 1997a:8). Two types of workers are usually pointed out by management in this regard, namely the older workers and females that are exposed to work tasks with high physical demands (Ayoub & Mital, 1989:9; Smith & Mustard, 2004:775; Sluiter, 2006:438). However, limited research investigated the relationship between the older worker as well as the female's physical work capacity and their physical task demands based on the minimum physical ability task requirement.

The management of the electricity supply company in South Africa (hereafter the company) who realised that this problem was also prevalent in their workforce, developed minimum physical ability task requirements, that represent the physical work demands, for all the physically demanding jobs (Lubbe, 2003b:4). These minimum requirements enable the company to determine which workers do not have the physical work capacity to perform their physical work demands effectively regardless of gender or age, and are thus at risk for work related injury or disability (Matheson, 1996:168-188; Lubbe, 2003b:4). It also allows the implementation of the necessary management programs, such as a worksite wellness program, to address the problem.

The resulting questions that this research aimed to answer were as follows:

a) what the role of gender was on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
b) what the role of age was on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;

c) what the effect of a worksite wellness program was on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

The answers to these questions could give management of the company clarity concerning the effect that older workers and an increasingly female work force, have on their physical work capacity to perform their physically demanding tasks. It could further be determined whether a worksite wellness program could improve the workers' physical work capacity to perform their work and maintain it above the minimum physical ability task requirements of their job.

6.2 Summary

Chapter one discussed the research problem and provided the objectives of this study, that were to determine the:

d) role of gender on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
e) role of age on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job;
f) effect of a worksite wellness program on the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

Chapter 2 consisted of a literature review with the aim to firstly, research the use of physical work capacity assessments in the workplace. Secondly, to examine the role of ageing and gender on the physical work capacity of workers in physically demanding jobs and thirdly to determine the impact of worksite wellness programs on the physical work capacity of workers in physically demanding jobs.

It became evident from the literature review on the use of physical work capacity assessments in the workplace, that the application possibilities are comprehensive. However, when the number of research in the South African context was taken as a barometer, it seemed that our industries with physically demanding jobs had not fully applied physical work capacity assessments as suggested by the research literature. Some employers suggested that strict human rights legislation might be the cause of this. However, fair discrimination on the basis of the inherent requirement of the job, as is the case with workers in physically demanding jobs, where allowed by the three acts discussed. Therefore, although the human rights legislation sets out clear boundaries, there were still several advantages for the employee and employer alike, such as a healthy and prolonged working career for the employee while the employer could benefit from a safe and productive workforce. It was also clear from the industries reviewed, who perform physical work capacity assessments, that the physical work capacity of workers performing physically demanding tasks should be well managed to reduce work-related injury and improve worker productivity. Two types of workers were pointed out by management as not having the required physical work capacity to perform their physically demanding tasks, namely the older workers and females that are exposed to tasks with a high physical demand.

For the ageing worker, it seems that the physical work capacity declines with age as expected, and due to the reduced physical work capacity experienced by the older workers with their unchanged physical work demands, they have increased work-related injury prevalence. However, it seemed that the literature on ageing workers in physically demanding jobs was limited, especially regarding the use of physical work capacity assessments in managing those workers. Subsequently, more research is required to determine at what age the physical work demands exceed the physical work capacity of the ageing worker and if work ability could be sustained up to retirement.

On the role that gender had on the physical work capacity of workers in physically demanding jobs, there was an indication that researchers generally agreed that the physical work capacity of males is superior compared to that of females. Secondly, due to the reduced physical work capacity of females to perform their physically demanding work tasks, they seemed to experience an increased prevalence rate for work-related injuries. However, no literature could be found that examined the physical work capacity of females in physically demanding jobs based on the minimum physical ability task requirements of their job. Such research could have given insight into the factual causes of the high injury rate and poor performance observed by researchers amongst these female workers.

From the literature review on the impact of a worksite wellness program on improving the physical work capacity of workers in physically demanding jobs revealed that the worksite is ideal for wellness programs, and organisations that follow the "best practices" in worksite wellness experienced a substantial benefit for the employee and employer alike. However, the literature on worksite wellness programs for workers in physically demanding jobs was limited and, therefore, requires more research to determine the effect on their physical work capacity based on the minimum physical ability requirements of their job, and if such a program could assist those workers whose physical work capacity does not meet the minimum physical work capacity of their job, to attain those requirements.

On the basis of this literature review the objectives set out in Chapter one were researched with an empirical study design. The research methodology and results thereof were reported in Chapter three, four and five.

In Chapter 3 a cross sectional study was conducted to determine the role of gender on the physical work capacity profile of workers in the electricity supply company, based on the minimum physical ability task requirements of their job. Ten essential physical abilities inherently required were examined for all workers in physically demanding jobs. Participants received a physical work capacity percentage score and an "Approved" or "Rejected" physical work capacity profile. There were 3752 male workers and 71 female workers examined. The results indicated that it is 7 times more likely for a male worker to receive a "Meet" physical work capacity profile than for a female worker. This study explained some of the factual causes of the high injury rate and poor performance observed by researches amongst female electricity utility workers.

Chapter 4 also consisted of a cross sectional study design, in this case to determine the role of ageing on the physical work capacity of workers in an electricity supply company based on the minimum physical ability task requirements. Ten critical physical abilities inherently required were examined for all workers in physically demanding jobs to determine their physical work capacity as a percentage. There were 3499 male workers and 65 female workers examined. The findings of this research indicated that the physical work capacity of workers in physically demanding jobs within this company declined with age to such an extent that for male workers from the age of 60, the physical work demands of their job exceeds their physical work capacity, whereas female workers never had the required physical work capacity related to the demands of physically demanding tasks. This research can be applied to scientifically determine from what age workers in physically demanding jobs need to be managed based on their poor physical work capacity. This enables management to implement processes to optimise the physical work capacity of these older workers up to retirement through, for instance a task-related physical conditioning program, mentorship training-, job re-design-, and job accommodation opportunities.

In Chapter 5 a quasi experimental study with a pre-test and post-test with comparison group design was conducted to determine the effect of a worksite wellness program on the physical work capacity profile of workers in an electricity supply company based on the minimum physical ability task requirements. Twelve male workers whose physical work capacity profile did not meet the minimum physical ability task requirements of their job, formed part of an experimental group that participated in a 24-month worksite wellness program. On the other hand, 62 similar workers formed part of a control group. Pre- and post-tests were performed on all participants to determine if their physical work capacity profile met the minimum physical ability task requirements of their job. Participants received a "Meet" or "Not meet" physical work capacity profile classification according to the results of an assessment on ten essential physical abilities inherently required by their job. There was no practically significant (d = 0.8) difference between the two groups before the start of the program after controlling for age, gender, motivation to change and initial physical work capacity profile differences. The comparative statistics between the experimental and control group indicated that workers whose physical work capacity profile did not meet the minimum physical ability task requirement of their job, were practically significant (ω = 4.25) more likely to improve their physical work capacity profile through the 24-month worksite wellness program to a level were they met the minimum physical ability task requirements of their job, than the worker receiving no intervention.

6.3 Conclusions

The conclusions made with this study will be discussed according to the three research objectives.

6.3.1 The results of the role of gender on the physical work capacity of workers in the company based on the minimum physical ability task requirements of their job

h) The physical work capacity of male workers in this population are practically significant (d=0.8) greater than that of female workers with the same job-related minimum physical ability task requirements.

i) When comparing the physical work capacity profile of male and female workers according to the "Meet" or "Not meet" classification, practically significant (ω=4.25) more female workers do not have the minimum physical work capacity required by their job, than male workers. This implies that most female workers are at greater risk than their male co-workers in this company due to their inability to perform their contracted tasks, based on the inherent physical ability task requirements. In a similar work environment, Kelsh and Sahl (1996:1050-1058) reported that female electricity utility workers were at higher risk for work-related injuries than their male co-workers in the same job. The cause for the higher risk of work-related injuries for female workers observed by these researchers could be partially explained by the results reported by this study, indicating that the physical work capacity profile of a practically significant number of female electricity utility workers does not meet the minimum physical ability task requirements of their job. This is the first time, to our knowledge, that the physical work capacity profiles of male and female workers in relation to the minimum physical ability task requirements of their job have been examined.

j) This study explains some of the factual causes of the high injury rate and poor performance observed by researches (WHO, 1993:32-33; Woods & Buckle, 2002:49; Messing & Őslin, 2006:49) amongst female workers in physically demanding jobs.

From the above-mentioned conclusions, the first research hypothesis is accepted that states that the physical work capacity profile of females in the company do not meet the minimum physical ability task requirements of their job.

6.3.2 The results of the role of age on the physical work capacity of workers in the company based on the minimum physical ability task requirements of their job

k) The physical work capacity of workers in physically demanding jobs within this company, as could be expected, declines with age.

l) The age-related decline in physical work capacity for male workers is to such an extent that from the age of 60, the physical work demands of their job exceed their physical work capacity.

m) The age-related decline in physical work capacity for female workers is to such an extent that, in general, the indication is that they will never have the required physical work capacity based on the minimum physical ability task requirements of their job, for it is predicted that from the age of 18, the physical work demands of their job exceed their physical work capacity.

n) This research can be applied to scientifically determine from what age workers in physically demanding jobs need to be managed based on their insufficient physical work capacity. Previously, no research could be found that scientifically determined at what age the physical work demands exceed the physical work capacity of the workers. This enables management to implement processes to optimise the physical work capacity of these older workers based on the age related physical incapacity to perform their physical work demands, up to retirement.

From the above-mentioned conclusions, the second research hypothesis is accepted for male workers 60 years and older, that states that the physical work capacity profile of the ageing workers in the company do not meet the minimum physical ability task requirements of their job. However, for the male workers younger than 60 years, which has also been described by the literature (WHO, 1993:3, Ilmarinen *et al.*, 1997:49; Shephard, 2000:466; Ilmarinen, 2001:546-547), as ageing workers, this hypothesis is rejected. For example, a World Health Organization Study Group on ageing and working capacity (WHO, 1993:3), are of the opinion that an “ageing worker” is considered such when he/she is older that 45 years.

6.3.3 The results of the effect of a worksite wellness program on the physical work capacity of workers in the company based on the minimum physical ability task requirements of their job

o) This study indicated that the worksite wellness program assists workers whose physical work capacity profile does not meet the minimum physical ability task requirements of their job, to regain the required physical work capacity.

p) The comparative statistics between the experimental and control group indicate that workers whose physical work capacity profile does not meet the minimum physical ability task requirement of their job, are practically significant ($\omega = 4.25$) more likely to improve their physical work capacity profile through the 24-month worksite wellness program to a level were they meet the minimum physical ability task requirements of the job, than the workers receiving no intervention.

q) Previously, no studies could be found that reported the effect of a worksite wellness program on the physical work capacity profile of workers, based on the minimum physical ability task requirements of their job. However, the results of this study support earlier findings indicating that physical exercise and health promotion has a positive influence on the physical health status of workers (Tuomi, *et al.*, 1997:58-65; Pohjonen & Ranta, 2001:465-475; Grace, 2001:iv-v; Van der Ploeg *et al.*, 2007:153-156).

r) The results of this research suggest that a worksite wellness program, as prescribed according to the procedure outlined in this study, could assist workers in physically demanding jobs, whose physical work capacity profile does not meet the minimum physical ability task requirements of their job to regain the physical work capacity required.

s) These results further assist organisations to provide an alternative option to managing the physical work capacity of their workers, other than ill-health retirement, retrenchments or prolonged sick-leave.

From the above-mentioned conclusions, the third research hypothesis is accepted that states that a worksite wellness program can improve the physical work capacity profile of workers in the company based on the minimum physical ability task requirements of their job.

6.4 Recommendations

The recommendations made from this study are the following:

6.4.1 Recommendations for employers

A physical work capacity profile of workers in physically demanding jobs, based on the minimum physical ability task requirements of their job, can have the following benefits to employers:

a) Females applying for these jobs could be screened before continuing with further selection procedures, because from this study it appears that most females in these jobs in the company, do not comply with the minimum requirements.

b) It could determine whether the decline in the physical work capacity which is related to ageing, as indicated by this study, has an impact on the workers' ability to carry out the physical work tasks of his/her job.
c) It could give information about the age from which the average worker's physical work capacity no longer meets the minimum requirements.
d) It could provide feedback regarding the progress of return-to-work interventions of those workers that do not meet the minimum requirements.

Management processes outlined by the literature to better manage older workers, females or any other equality group of workers not meeting the physical work demands include:

e) worker retention program (Shrey & Hursh, 1997:514; Ilmarinen, 2001:546-552),
f) mentor development program (Allen, 1998:27-30; Eby *et al.*, 2006:267-291),
g) disability management program (Shrey, 1997b:55-105; Weir & Nielson, 2001:128-132; Cox *et al.*, 2003:2),
h) establish compensation packages that encourage voluntary early retirement or transition to part-time work (Shephard, 1997:341),
i) impose mandatory retirement at a fixed age (Shephard, 1997:341),
j) optimise the design of the workstation (Shephard, 1997:341 Ilmarinen, 2001549; Sluiter, 2006:439),
k) set job related standards which must be met for continued employment (Shephard, 1997:341 Sluiter, *et al.*, 2006:439),
l) decrease physical work load of job (Ilmarinen, 2001:547),
m) training of supervisors for improved management of these workers (Ilmarinen, 2001549; Sluiter, 2006:439).

A worksite wellness program, as described in this study, aimed at the improvement of the physical work capacity profile of workers could:

n) assist similar organizations to sustain the physical work capacity of workers in physically demanding jobs and in so doing lower costs, increase productivity and create a work culture in which workers can make a meaningful contribution up until retirement.
o) provide an alternative for workers that apply for disability pension and/or prolonged sick leave status, before retrenchment or pension are considered.

6.5 Further research required

Aspects resulting from this study that require further research include:

a) similar research should also be done for older workers, females and various racial groups in other physically demanding industries, as there is little information in this regard in the South African, or to a large extent the international context.
b) the relationship between the physical work capacity of workers in physically demanding jobs based on the minimum physical ability task requirement and their work-related injury prevalence, require further attention. Such studies can possibly give further clarity on how these workers' physical inability contributes to injury risk.
c) the relationship that the physical inability of workers to comply with the work requirements has with their sick leave record and related work absence.
d) the financial advantage of a worksite wellness program directed to the physical work capacity of workers based on the minimum physical ability task requirements of their job.

BIBLIOGRAPHY

ACOEM (American College of Occupational and Environmental Medicine). 2004. Corporate Health Achievement Award. http://www.chaa.org/prioraward.htm Date of access: 3 Jan. 2005.

ACSM (AMERICAN COLLEGE OF SPORT MEDICINE). 1991. Guidelines for exercise testing and prescription. 4th ed. Philadelphia: Lea & Febiger. 314 p.

ACSM (AMERICAN COLLEGE OF SPORT MEDICINE). 1995. Guidelines for exercise testing and prescription. 5th ed. Philadelphia: Williams & Wilkins. 373 p.

ALDANA, S.G. 2001. Financial impact of health promotion programs: a comprehensive review of the literature. *American journal of health promotion*, 15(5): 296-320, May/Jun.

ALEXANDER, R.W., MAIDA, A.S. & WALKER, R.J. 1975. The validity of pre-employment medical evaluations. *Journal of occupational medicine*, 17(11):687-692, Nov.

ALLEN, J.R. 1998. Wellness mentoring can help rebuild the corporate culture. *Worksite health*, 5(3):27-30.

ALLEN, J.R. 2002. Building supportive cultural environments. (*In* O'Donnell, M.P., *ed.* Health promotion in the workplace. 3rd ed. New York: Delmar Publishers. p. 202-217.)

ALLEN, R.F. & SILVER ZWELG, S. 1977. Changing the corporate culture. *Sloan management review*, 17(3):141-154.

ALLEN, R.F., & KRAFT, C. 1980. Beat the system!: a way to create more human environments. Burlington: Human Resources Institute Press. 294 p.

ALLEN, R.F., DUBIN, H.N., PILNICK, S. & YOUTZ, A.C. 1981. Collegefields: from delinquency to freedom. New York: Irvington Publishers. 176 p.

ASTRAND, P.O. & RHYMING, I. 1954. A monogram for calculation of aerobic capacity (physical fitness) from pulse rate during sub-maximal work. *Journal of applied physiology*, 7:218-221.

ASVALL, J.E. 1986. Forward to medical sociology and the WHO programme for Europe. *Social science and medicine*, 22(2):117-124.

AYOUB, M.M. & MITAL, A. 1989. Manual materials handling. London: Taylor and Francis. 324 p.

AYOUB, M.M. 1982. Control of manual lifting hazards II : job redesign. *Journal of occupational medicine*, 24(9):668-676.

AYOUB, M.M. 1991. Determining permissible lifting loads: an approach. (*In* Human Factors Society : Papers delivered at the 35th annual meeting held 2-6 September 1991. San Francisco. [CD]) (Unpublished.)

AYOUB, M.M. 1992. Problems and solutions in manual materials handling: the state of the art. *Ergonomics*, 35(7/8):713-728.

BANISTER, E. 1985. Cost-effective selection of fire fighter recruits . *Medicine and science in sports and exercise*, 17(6):661-668, Dec.

BAUMGARTNER, T.A. & JACKSON, A.S. 1995. Measurement for evaluation in physical education and exercise science. 5th ed. Dubuque: WCB Brown & Benchmark. 285 p.

BAUMGARTNER, T.A. & ZUIDEMAN, M.A. 1972. Factor analysis of physical fitness tests. *Research quarterly*, 43:443-450.

BEELEN, A. & SARGEANT, A. 1991. Effect of fatigue on maximal power output at different contraction velocities in humans. *Journal of applied physiology*, 71(6):2332-2337.

BERKOWITZ, S.M., FEUERSTEIN, M., LOPEZ, M.S. & PECK, C.A., JR 1999. Occupational back disability in U.S. army personnel. *Military medicine*, 164(6):412-418.

BERNAUER, E.M. & BONANNO, J. 1975. Development of physical profiles for specific jobs. *Journal of occupational medicine*, 17(1):47-67.

BIDDLE, D. & SILL, N.S. 1999. Protective service physical ability tests: establishing pass/fail, ranking, and banding procedures. *Public personnel management*, 28(2):217-225.

BIOKINETICS ASSOCIATION OF SOUTH AFRICA. 2007. What is a biokineticist? http://www.biokinetics.org.za Date of access: 1 Jun. 2007.

BLUM, S., TAULBEE, J. & ANDJELKOVICH, D. 1978. Mortality of female workers in a rubber manufacturing plant. *Journal of occupational medicine,* 20(6):461-476.

BORG, G.A. 1982. Psychophysical bases of perceived exertion. *Medicine and science in sports and exercise*, 14(5):377–381.

BOROFSKY, G.L. & SMITH, M. 1993. Reductions in turnover, accidents and absenteeism: the contribution of a pre-employment screening inventory. *Journal of clinical psychology*, 49(1):109-116.

BOTHA, A.T., HUYSER, R.F., KRIEK, N., PUTTER, T. & SCHONKEN, E. 1998. Pre-placement examination and the labour relations act 66 of 1995. *Journal of occupational health South Africa*, 4(3):22-25.

BOTHA, A.T. & HUYSER, R.F. 2004. Employment equity sensitisation. (Workshop presented to all Eskom employees.) Johannesburg: Eskom Holding (Pty) Ltd. (Unpublished.)

BOTHA, A.T., HUYSER, R.F. & SCHONKEN, E. 2000. Managing the incapacitated worker. *Journal of occupational health South Africa*, 6(6): 23-26, Nov/Dec.

BOVENZI, M., & ZADINI, A. 1991. Occupational musculoskeletal disorders in the neck and upper limbs of forestry workers exposed to hand-arm vibration. *Ergonomics*, 34(5):547-562.

BRIDGER, R. 2003. Introduction to ergonomics. 2nd ed. London: Taylor & Francis. 568 p.

BUCKWALTER, J.A. & BINUBILE, N.A. 1997. Decreased mobility in the elderly: the exercise antidote. *The physician and sports medicine*, 25(9):126-133.

BUCKWORTH, J. & WALLACE, L.S. 2002. Application of the transtheoretical model to physically active adults. *Journal of sports medicine and physical activity*, 42:360-367.

BUCKWORTH, J., LEE, R.E., REGAN, G., SCHNEIDER, L.K. & DICLEMENTE, C.C. 2007. Decomposing intrinsic and extrinsic motivation for exercise: application to stages of motivational readiness. *Psychology of sport and exercise*, 8(4):441-461.

BUIS, N. 1990. Ergonomics, legislation and productivity in manual materials handling. *Ergonomics*, 33(3):353-359.

BUNN, W.B., PIKELNY, D.B., SLAVIN, T.J. & PARALKAR, S. 2001. Health, safety, and productivity in a manufacturing environment. *Journal of occupational and environmental medicine*, 43:47-55.

BUREAU OF LABOUR STATISTICS. 1998. Women experience fewer job-related injuries and deaths than men. *Issues in labor statistics, 98-8.* http://www.bls.gov/opub/ils/pdf/opbils23.pdf Date of access: 20 Aug. 2007.

BUREAU OF WORKERS' DISABILITY COMPENSATION. 2000. Report of the task force on vocational rehabilitation in workers' compensation, Dec. 2000. Michigan. 16 p.

CALDWELL, L.S., CHAFFIN, D.B., DUKES-DOBOS, F.N., KROEMER, K.H.E., LAUBACH, L.L., SNOOKS, S.H. & WASSERMAN, D.E. 1974. A proposed standard procedure for static muscle strength testing. *American Industrial Hygiene Association journal,* 35(4):201-206, Apr.

CAMPION, M.A. 1983. Personnel selection for physically demanding jobs: review and recommendations. *Personnel psychology*, 36(3):527-550.

CASCIO, W.F. 1991. Applied psychology in personnel management. New Jersey: Prentice Hall. 345 p.

CHAFFIN, D.B. 1974. Human strength capability and low-back pain. *Journal of occupational medicine*, 16(4):248-254.

CHAFFIN, D.B. 1996. Ergonomic basis for job-related strength testing. (*In* Demeter, S.L., Anderson, B.J. & Smith, G.M., *eds.* Disability evaluation. Missouri: Mosby. p.159-167.)

CHAFFIN, D.B., HERRIN, G.D.& KERSERLING, W.M. 1978. Pre-employment strength testing: an updated position. *Journal of occupational medicine*, 20(6):403-408.

CHAFFIN, D.B., HERRIN, G.D., KEYSERLING, W.M. & FOULKE, J.A. 1977a. Preemployment strength testing. Cincinnati: National Institute for Occupational Safety and Health. 266 p. (NIOSH Publication, 992:77-163.)

CHAFFIN, D.B., HERRIN, G.D., KEYSERLING, W.M. & FOULKE, J.A. 1977b. A method for evaluating the biomechanical stresses resulting from manual materials handling jobs. *American Industrial Hygiene Association journal*, 38(12):662-675.

CHAN, G., TAN, V. & KOH, D. 2000. Ageing and fitness to work. *Journal of occupational medicine*, 50(7):483-491.

CHAPMAN, L.S. 2004a. Expert opinions on "best practice" in worksite health promotion (WHP). *The art of health promotion newsletter*, 2004:1-6, Jul/Aug.

CHAPMAN, L.S. 2004b. Measuring return on investment for worksite wellness programs. *Wellness management*, 20(1): 4-11, Spring.

CHAPMAN, L.S. 2005a. Meta-evaluation of worksite health promotion economic return studies: 2005 update. *American journal of health promotion*, 19(6):1-14.

CHAPMAN, L.S. 2005b. Using wellness incentives: positive tools for healthy lifestyles. Indianapolis: Summex Health Management. 189 p.

CHAPMAN, L.S. 2006. Employee participation in workplace health promotion and wellness programs: how important are incentives, and which work best? *North Carolina medical journal*, 67(6):431-432, Nov/Dec.

CHRISTIE, C.J. 2006. A field investigation of physical work loads imposed on harvesters in South African forestry. Grahamstown: Rhodes University. (Dissertation - D.Phil.) 179 p.

CIRIELLO, V.M. & SNOOK, S.H. 1999. Survey of manual handling tasks. *International journal of industrial ergonomics*, 23:149-156.

COHEN, J. 1988. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale,N.J: Erlbaum. 567 p.

COOPER, K.H. 1989. Controlling cholesterol. New York: Bantam Books. 395 p.

COOPER, M.A., SCHEMER, F.M., GEBHARDT, D.L., MARSHALL-MINES, J.C. & FLEISHMAN, E.A. 1982. The development and validation of physical ability tests for jobs in electric power industry. Washington, D.C: Advanced Research Resources Organization. 34p. (Final report,3056/R82-2.)

CORBIN, B.C. & LINDSEY, R. 1994. Concepts of physical fitness with laboratories. 8th ed. Wisconsin: Brown and Benchmark Publishers. 277 p.

COURVILLE, J. VÉZINA, N. & MESSING, K. 1991. Comparison of the work activity of two mechanics: a women and a man. *International journal of industrial ergonomics*, 7(2):163-174.

COX, C., *ed.* 2003. ACSM's worksite health promotion manual: a guide to building and sustaining healthy worksites. Champaign, Ill.: Human Kinetics. 250 p.

COX, M.H., SHEPHARD, R.J. & COREY, P. 1987. Physical activity and alienation in the work-place. *Journal of sports medicine*, 27(4):429-436.

COX, R.A.F., EDWARDS, F.C. & PALMER, K. 2003. Fitness for work, the medical aspects. 3rd ed. London: Oxford University Press. 294 p.

DARLING, H. 2005. Improving health: an employer toolkit. Washington, D.C.: National Business Group on Health. 154 p.

DAVIS, J.A. 1985. Anaerobic threshold: review of the concept and directions for future research. *Medicine and science in sports and exercise*, 17(1):6-18.

DAVIS, P.O. & DOTSON, C.O. 1986. Job performance testing: an alternative to age discrimination. *Medicine and science in sports and exercise*, 19(2):179-185, Nov.

DE KORT, W. & VAN DIJK, F. 1997. Preventative effectiveness of pre-employment medical assessments. *Occupational and environmental medicine*, 54(1):1-6.

DE VOS, P. 2004. The promotion of equality and prevention of unfair discrimination act and socio-economic rights. *ESR Review : economic and social rights in South Africa*, 5(2):5-8, May.

DE VRIES, H.A., TICHY, M.W., HOUSH, T.J., SMYTH, K.D., TICHY, A.M. & HOUSH, D.J. 1987. A method for estimating physical working capacity at the fatigue threshold. *Ergonomics,* 30(8):1195-1204.

DE ZWART, B.C.H., FRINGS-DRESEN, M.H.W. & VAN DIJK, F.J.H. 1995. Physical workload and the aging worker: a review of the literature. *International journal of occupational and environmental health,* 68(1):1-12.

DELEIRE, T. & LEVY, H. 2001. Gender, occupation choice and the risk of death at work: Working Paper 8574. Cambridge: National Bureau of Economic Research. 30 p.

DEMPSEY, P.G. & HASHEMI, L. 1999. Analysis of workers' compensation claims associated with manual materials handling. *Ergonomics,* 42(1):183-195.

DEPARTMENT OF STATISTICS ***see*** SOUTH AFRICA. Department of Statistics.

DILLINGHAM, A.E. 1981. Age and workplace injuries. *Aging and work,* 4(1):1-10.

DISLER, P.B. & PALLANT, J.F. 2001. Vocational rehabilitation. *British medical journal,* 323:121-123.

DOOLITTLE, T.L., SPURLIN, O., KAIYALA, K, SOVERN, D. 1988. Physical demands of lineworkers. (*In* Human Factors Society. Proceedings of the 32nd Annual Meeting. Anaheim, CA. p. 632-636.)

DOW CHEMICALS COMPANY. 2007. This is Dow. http://www.dow.com/about/ Date of access: 6 Oct. 2007.

DREYER, L.I. 1996. Totale welstand: 'n begripsomskrywing. 2nd ed. Potchefstroom: Johannes van der Walt Institute. 127 p.

DUPRE D. 2002. The health and safety of men and women at work. *Statistics in Focus, Theme 3-4/2002* http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-NK-02-004/EN/KS-NK-02-004-EN.PDF Date of access: 18 Oct. 2007.

EBY, L.T., LOCKWOOD, A.L. & BULTZ, M. 2006. Perceived support for mentoring: a multiple perspectives approach. *Journal of vocational behavior,* 68: 267-291.

EDINGTON, D.W. 2001. Emerging research: a view from one research centre. *American journal of health promotion*, 15(5):341-349, May/Jun.

EISCHEN, B.D., GROSSMEIER, J. & GOLD, D.B. 2005. Fairview Alive-an integrated strategy for enhancing the health and well-being of employees. *Journal on workplace behavioral health*, 20:263-279.

ELLIS, L.L. 2007. The impact of HIV/AIDS on selected business sectors in South Africa. *Journal of studies in economics and econometrics*, 31(1):29-52.

ESKOM. 2007. Company information. http://www.eskom.co.za/live/content.php?Category_ID=14 Date of access: 6 Oct. 2007.

FALKEL, J.E., SAWKA, M.N., LEVINE, L. & PANDOLF, K.B. 1985. Upper and lower body muscular strength and endurance ratios for women and men. *Ergonomics*, 28:1661-1670.

FLEISHMAN, E.A. 1964. The structure and measurement of physical fitness. Englewood Cliffs, N.J.: Prentice Hall. 207 p.

FLEISHMAN, E.A. 1975. Towards a taxonomy of human performance. *American psychologist*, 30(12):1127-1149, Dec.

FLEISHMAN, E.A. 1979. Evaluating physical abilities required by jobs. *The personnel administration*, 24(6):82-90.

FLEISHMAN, E.A., GEBHARDT, D.L. & HOGAN, J.C. 1981. The measurement of effort. *Ergonomics*, 27(9):947-954.

FLOYD, M. & LANDMORE, D. 2003. Vocational rehabilitation. (*In* Cox, R.A.F., Edwards, F.C. & Palmer, K., *eds*. Fitness for work: the medical aspects. 3rd ed. London: Oxford University Press. p. 62-80.)

FORDYCE, W.E., *ed*. 1995. Back pain in the workplace: management of disability in non-specific conditions. Seattle: IASP Press. 97 p.

FRASER, T.M. 1992. Fitness for work. London: Taylor & Francis. 213 p.

GALL, B. & PARKHOUSE, W. 2004. Changes in physical capacity as a function of age in heavy manual work. *Ergonomics*, 47(6):671-687.

GEARY, K.D., IRVINE, D. & CROFT, A.M. 2002. Does military service damage females?: an analysis of medical discharge data in the British armed forces. *Occupational medicine (Oxford, England)*, 52(2):85-90.

GLUCK, J.V. & OLEINICK, A. 1998. Claim rates of compensable back injuries by age, gender, occupation, and industry. *Spine*, 23:1572-1586.

GOETZEL, R., GUINDON, A.M., TURSHEN, J.I. & OZMINKOWSKI, R.J. 2001. Health productivity management: establishing key performance measures, benchmarks, and best practices. *Journal of occupational and environmental medicine*, 43(1):10-17, Jan.

GOETZEL, R.Z. & OZMINKOWSKI, R.J. 2002. How to evaluate workplace health promotion programs. (*In* O'Donnell MP, *ed.* Health promotion in the workplace. 3rd ed. New York: Delmar Publishers. p. 116-165.)

GOETZEL, R.Z., OZMINKOWSKI, R.J. & YUHAXZ, L.S. 2005. Becoming internal champion for health and productivity management. *WELCOA's Absolute advantage magazine*, 4(10):11-15.

GOLASZEWSKI, T. 2001. Shining lights: studies that have most influenced the understanding of health promotion's financial impact. *American journal of health promotion*, 15(5):332-340.

GOLDBERG, R.L., WEYERS, S.G. & SPILBERG, S.W. 2004. Medical screening manual for California law enforcement. California: California Commission on Peace Officer Standards and Training (POST). 352 p.

GRACE, J.M. 2001. Impact of a worksite physical wellness programme in sick leave, absenteeism and health related fitness. Pretoria: UP. (Dissertation M.A.) 106 p.

GRAIG, A.H. 2006. Does gender affect pulmonary function and exercise capacity? *Respiratory physiology and neurobiology*, 151(2,3):124-131.

GRANDJEAN, E. & KROEMER, K.H.E. 2000. Fitting the task to the man. 5th ed. London: Taylor and Francis. 432 p.

GRENIER, S.G., RUSSEL, C. & McGILL, M. 2003. Relationships between lumbar flexibility, sit-and-reach test, and a previous history of low back discomfort in industrial workers. *Canadian journal of applied physiology*, 28(2):165-177.

HABECK, R., LEAHY, M., HUNT, H., CHAN, F. & WELCH, E. 1991. Employer factors related to workers' compensation claims and disability management. *Rehabilitation counselling bulletin*, 34(3):210-226.

HAGBERG, J.M. 1995. Physical activity, fitness, health and aging. (*In* Bouchard, C., Shephard, R.J. & Stephens, R.J., *eds*. Physical activity, fitness and health: international proceeding and consensus statement. Illinois: Human Kinetics. p. 993-1005.)

HALE, N. 1990. The older worker, effective strategies for management and human resource development. San Francisco: Jossey-Bass Publishers. 175 p.

HALES, D. 1992. An invitation to health: taking charge of your life. California: Benjamin/Cummings. 630 p.

HANSEN, C.P. 1989. A consul model of the relationships among accidents, biodata, personality and cognitive factors. *Journal of applied psychology*, 74(1):81-90.

HARBER, P.H., BILLET, E., GUTOWSKI, M., SOOHOO, K., LEW, M. & ROMAN, A. 1985. Occupational low-back pain in hospital nurses. *Journal of occupational medicine*, 27(7):518-524.

HEALTH PROMOTION ADVOCATES. 2007. National Wellness Institute – definition of wellness. http://www.healthpromotionadvocates.org/resources/definitions.htm Date of access: 10 Aug. 2007.

HERBERTS, P., KADEFORS, R., ANDERSSON, G. & PETERSÉN, I. 1981. Shoulder pain in industry: an epidemiological study on welders. *Acta orthopaedica Scandinavica*, 52:299-306.

HETTLER, B. 2007. The six dimensional wellness model. National Wellness Institute. http://www.nationalwellness.org/index.php?id=391&id_tier=381 Date of access: 10 Aug. 2007.

HOGAN, J.C. 1980a. Physical requirements of the workplace: research considerations for personnel selection. (*In* American Psychological Association. Papers presented at the 88th annual convention of the American Psychological Association, Montreal, Quebec, Canada. September. 33 p.)

HOGAN, J.C. 1980b. The state of the art in strength testing. (*In* Walsh, D.C. & Egdahl, R.H., *eds.* Women, work, and health: challenges to corporate policy. New York: Springer. p.75-98.)

HOGAN, J. & QUIGLEY, A.M. 1986. Physical standards for employment and the courts. *American psychologist*, 41(11):1193-1217.

HOGAN, J.C. & BERNACKI, E.J. 1981. Developing job-related pre-placement medical examinations. *Journal of occupational medicine*, 23(7):469-475.

HOGAN, J.C. & FLEISHMAN, E.A. 1979. An index of the physical effort required in task performance. *Journal of applied physiology*, 64:197-204.

HUBER, J.M., KERBER, B.A. & WAGNER, L., *eds.* 2003. Building blocks for a successful workplace wellness program: proven planning and management strategies from wellness program management advisor. Manasquan: American Business Publishing. 82 p.

HUMAN RESOURCES DEVELOPMENT CANADA. 1999. Statistical analysis occupational injuries and fatalities Canada.. Ottawa: Government of Canada. (Report 1999/05/10)

HUNNICUTT, D. 2006. WELCOA's 7 benchmarks of success. *WELCOA's Absolute advantage magazine*, 6(1):2-29.

HUNNICUTT, D. & CHAPMAN, L.S. 2005. Designing wellness incentives. *WELCOA's Absolute advantage magazine*, 4(8):1-62.

HURLEY, B. 1995. Strength training in the elderly to enhance health status. *Medicine, exercise, nutrition and health*, 4(4):217-229, Jul./Aug.

ILMARINEN, J. 1984. Physical load on the cardiovascular system in different work tasks. *Scandinavian journal of work, environment and health*, 10(6 Spec no.):403-408.

ILMARINEN, J. 1988. Physiological criteria for retirement age. *Scandinavian journal of work, environment and health*, 14(1):88-89, Jan.

ILMARINEN, J. 1991. Background and objectives of the Finnish research project on aging workers in municipal occupations. *Scandinavian journal of work, environment and health*, 17(1):7-11.

ILMARINEN, J. 2001. Aging workers. *Occupational and environmental medicine*, 58:546-552, Aug.

ILMARINEN, J., TUOMI, K. & KLOCKARS, M. 1997. Changes in the work ability of active employees over a 11-year period. *Scandinavian journal for environmental health*, 23 (Suppl.1):49-57.

ILMARINEN, J., TUOMI, K., ESKELINEN, L., NYGÅRD, C.H., HUUHTANEN, P. & KLOCKARS, M. 1991. Summary of recommendations of a project involving cross-sectional and follow-up studies on the aging worker in Finnish municipal occupations (1981-1985). *Scandinavian journal of work, environment and health*, 17(1):135-141.

ILO (INTERNATIONAL LABOUR ORGANIZATION). 2000. Gender, poverty and employment programme. Geneva. 57 p.

ILO (INTERNATIONAL LABOUR ORGANIZATION). 2004. Global employment trends for women. Geneva: International Labour Office. 16 p.

ISLAM, S., VELILLA, A.M., DOYLE, E.J. & DUCATMAN, A.M. 2001. Gender differences in work-related injury/illness: analysis of workers compensation claims. *American journal of industrial medicine*, 39(1):84-91.

JACKA, K.L. 1997. The effect of work-hardening on the physical work capacity of manual labourers within South African industry. Grahamstown: Rhodes University. (Dissertation -)

JACKSON, A.S. 1994. Chapter 3. Preemployment physical evaluation. *Exercise and sport science review,* 22:53-90.

JAMES, J. 2006. Ergonomics programmes in mining. (*In* National Institute for Occupational Health, & South African Society of Occupational Medicine. Proceedings of the Art and Science of Ergonomics Conference, 7-8 August 2006, Johannesburg.)

JARVHOLM, U., PALMERUD, G, KADEFORS, R. & HERBERTS, P. 1991. The effect of arm support on supraspinatus muscle load during simulated assembly work and welding. *Ergonomics*, 34(1):57-66, Jan.

JOHNS, R.E., ELEGANTE, J.M., TEYNOR, P.D., SWINYER, L.J., BLOSWICK, D.S. & COLLEDGE, A.L. 1996. Fitness for duty. (*In* Demeter, S.L., Anderson, B.J. & Smith, G.M., *ed.* Disability evaluation. Missouri: Mosby. p.592-604.)

JOHNSON AND JOHNSON. 2007. Our company. http://www.jnj.com/our_company/index.htm Date of access: 6 Oct. 2007.

JOINT WORK ENVIRONMENT COUNCIL FOR THE GOVERNMENT SECTOR. 1997. Reflections on women in working life. Stockholm: SAN.

JONES, B.H., BOVEE, M.W., HARRIS, J.M. & COWAN, D.N. 1993. Intrinsic risk factors for exercise-related injuries among male and female army trainees. *American journal of sports medicine*, 21:7-5-710.

KANE, P., *ed.* 2006. Women and occupational health: issues and policy paper prepared for the Global Commission on Women's Health. Geneva: World Health Organization. 117 p.

KELSH, M.A. & SAHL, J.D. 1996. Sex differences in work-related injury rates among electricity utility workers. *American journal of epidemiology*, 143(10):1050-1058.

KEMPER, H.C.G. 1994. Physical work and the physiological consequences for the aging worker. (*In* Snel, J., Cremer, R. *eds.* Work and aging: a European perspective. London: Taylor & Francis. p.)

KIRKENDALL, D.R. 1990. Mechanisms of peripheral fatigue. *Journal of medicine, science, sports and exercise*, 22(4):444-449.

KIRKENDALL, D.R., GRUBER, J.J. & JOHNSON, R.E. 1987. Measurement and evaluation for physical educators. 2nd ed. Illinois: Human Kinetics. 552 p.

KRIEK, N. 2004. Biokinetics: periodic physical ability surveillance. Johannesburg: Eskom Holdings (Pty) Ltd. (Eskom Distribution standard, Document number DISASADK7) 10 p.

KROEMER, K.H.E. & GRANDJEAN, E. 2000. Fitting the task to the man. 5th ed. London: Taylor and Francis. 416 p.

KROEMER, K.H.E., KROEMER, H. & KROEMER-ELBERT, K. 2001. Ergonomics: how to design for ease and efficiency. 2nd ed. Englewood Cliffs, N.J.: Prentice Hall. 695 p.

KUKKONEN-HARJULA, K. & RAURAMAA, R. 1984. Oxygen consumption of lumberjacks in logging with a power-saw. *Ergonomics*, 27(1):59-65.

KUMAR, S., *ed.* 1999. Biomechanics in ergonomics. London: Taylor and Francis. 400 p.

LAGERLÖF, E. 2005. Global gender issues in relation to health and industrial work. Geneva: World Health Organization. 116 p.

LAING, J.G.D. 1964. A height/weight table for African mine labourers. *Journal of the South African Institute of Mining and Metallurgy*, 64(8):406-419, Aug.

LANGTON, A. 2001. Enhancing employment outcomes through job accommodation and assistive technology resources and services. *Journal of vocational rehabilitation*, 16(1):27-37.

LAWS *see* SOUTH AFRICA.

LECLERC, A., NIEDHAMMER, I., LANDRE, M.F., OZGULER, A., ETORE, P. & PIETRI TALEB, F. 1999. One-year predictive factors for various aspects of neck disorders. *Spine*, 24(14):1455-1462.

LEE, R.E. & DICLEMENTE, C.C. 2001. Extrinsic and intrinsic motivation: which is important for exercise? *Medicine and science in sport and exercise*, 33(5):S112.

LEGG, S.J. & MYLES, W.S. 1985. Metabolic and cardiovascular cost, and perceived effort over an 8 hour day when lifting loads selected by the psychophysical method. *Ergonomics*, 28(1):337-343.

LEGG, S.J. & PATEMAN, C.M. 1985. Human capabilities in repetitive lifting. *Ergonomics*, 28(1):309-321.

LEVESQUE, D.A., JANICE, M., PROCHASKA, J.M. & PROCHASKA, J.O. 1999. Stages of change and integrated service delivery. *Consulting psychology journal: practice and research,* 51(4):226-241, Autumn.

LIAO, H., ARVEY, R.D., BUTLER, R.J. & NUTTING, S.M. 2001. Correlates of work injury frequency and duration among fire fighters. *Journal of occupational health psychology*, 6(3):229-242.

LILLEY, R., FEYER, A., KIRK, P. & GANDER, P. 2002. A survey of forest workers in New Zealand: do hours of work, rest, and recovery play a role in accidents and injury? *Journal of safety research*, 33:53-71.

LJUNGBERG, A., KILBOM, A. & HÄGG, G. 1989. Occupational lifting by nursing aids and warehouse workers. *Ergonomics*, 32(1):59-78.

LUBBE, J.P.H. 1996. Die verband tussen lewenstyl gebruike, fisieke aktiwiteit en gesondheidstatus by dames. Potchefstroom: PU vir CHO. (Mini-dissertation – Hons. B.Sc.). 11 p.

LUBBE, J.P.H. 1997. Wellness Workshop (Workshop presented to all Eskom Distribution employees as part of the employee wellness program.). Johannesburg: Eskom Holding (Pty) Ltd. (Unpublished).

LUBBE, J.P.H. 2002a. Impact of a work-site wellness program on African blue-collar workers productivity. (*In* WELCOSA. Proceedings of the 2nd Wellness Conference of South Africa, Port Elizabeth.).

LUBBE, J.P.H. 2002b. Improving the physical work capacity of employees makes business sense. *Eskom distribution legend*, 56:16-17, May/Jun.

LUBBE, J.P.H. 2003a. Creating a wellness culture – the African experience. (*In* Northwest University Work Wellness Unit. Proceedings of the 2nd South African Workwellness Conference, 24-26 March 2004, North-West University, Potchefstroom Campus.) [CD]

LUBBE, J.P.H. 2003b. Die verband tussen fisieke vermoëns, veroudering en werkspesifieke taakprofiele van manlike werkers in 'n elekterisiteitsvoorsieningsmaatskappy. Potchefstroom: PU vir CHO. (Dissertation - M.Sc.) 131 p.

LUBBE, J.P.H. 2004a. Creating a wellness culture – the South African experience. *Wellness management*, 20(2):6-8.

LUBBE J.P.H. 2004b. Creating a wellness culture. (*In* Wellness Africa (Pty) Ltd., & Nature Care. Proceedings of the 1st Botswana Wellness Seminar: developing and sustaining workplace wellness programmes in the private and public sectors, 4 July 2004, Gaborone, Botswana.) [CD]

LUBBE, J.P.H. 2004c. Creating a wellness culture – the African experience. (*In* National Wellness Institute. Proceedings of the 29th National Wellness Conference, 11-14 July 2004, Stevens Point, USA.) [CD]

LUBBE, J.P.H. 2004d. Creating and sustaining a physical able workforce. (*In* National Wellness Institute. Proceedings of the 29th National Wellness Conference, 11-14 July 2004, Stevens Point, USA.) [CD]

LUBBE, J.P.H. 2005a. Physical ability analysis reporting procedure. (Eskom Distribution Biokinetics Procedure) Johannesburg: Eskom Document Centre. 18 p.

LUBBE, J.P.H. 2005b. Principles and strategies to create a wellness culture – the South African experience. (*In* National Wellness Institute. Proceedings of the 30th National Wellness Conference, 9-14 July 2005, Stevens Point, Wisconsin, USA.) [CD]

LUBBE, J.P.H. 2006a. Creating and sustaining a physical able workforce through a physical work capacity management system. (*In* Ergonomic Society of South Africa. Proceedings of the 9th conference of the Ergonomics Society of South Africa, 19-20 June 2006, Pretoria. p. 50-61.)

LUBBE, J.P.H. 2006b. The effects and management of poor ergonomics. (*In* National Institute for Occupational Health, & South African Society of Occupational Medicine. Proceedings of the Art and Science of Ergonomics Conference, 7-8 August 2006, Johannesburg.)

LUBBE, J.P.H. 2007. Physical ability considerations in selecting female workers for physical demanding occupations. (In Ergonomic Society of South Africa. Proceedings of the 10th Conference of the Ergonomics Society of South Africa, 21-22 June 2007, Durban. p. 50-61.)

LUBBE, J.P.H. & KRIEK, N. 2004. Women in physical demanding occupations: discrimination through minimum physical ability requirements: paper presented to distribution recruitment personnel of Eskom Holdings Pty.Ltd. Johannesburg: Eskom Holdings (Pty) Ltd. 14 p. (Unpublished.)

LUBBE, J.P.H. & MALAN, D.D.J. 2006. The relationship between physical ability, ageing and the work specific task profiles of male workers in an electricity supply company. (*In* Ergonomic Society of South Africa. Proceedings of the 9th Conference of the Ergonomics Society of South Africa, 19-20 June 2006, Pretoria. p. 62-69.)

MAC DUFF, L., DE RIDDER, J.H. & MALAN, D.D.J. 2005. Anthropometric, biomechanical strength and aerobic characteristics of humans and other influences that affect manual handling performance. *Ergonomics SA*, 17(1):25-40.

MALAN, D.D.J. 1992. Die waarde van fisieke seleksie in die voorkoming van werksbeserings. *Arbeid:SA Koöp*:11, Jan.

MALAN, D.D.J. 1999. Physical ability analysis testing procedures. (*In*: Training manual for Eskom Biokineticists, 22 p.) Potchefstroom. (Unpublished.)

MALAN, D.D.J. 2007. Verbal communication with the author. Potchefstroom. (Interview notes were documented.)

MALAN, D.D.J., STRYDOM, G.L. & DELPORT, B.M. 1984. Samestelling van 'n fisieke evalueringskriterium vir keuring en klassifikasie van werknemers by Naschemfabriek, Boskop: navorsingsverslag van die Johannes van der Walt Instituut vir Biokinetika. Potchefstroom: PU vir CHO. 41 p.

MARAS, W.S., LAVENDER, S.A., LEURGANS, S.E., FATHALLAH, F.A., FERGUSON, S.A., ALLREAD, W.G. & RAJULU, S.L. 1995. Biomechanical risk factors for occupationally related low back disorders. *Ergonomics*, 38(2):377-410.

MARCHALL, C. 2003. Coaching and coach training for health and wellness professionals – the foundation, week 1. Arizona: Totally Coached, Inc. p. 1-26. (Intrinsic coaching development series, I.)

MARCHALL, C. 2006. Benchmarking of Intrinsic Coaching™. Totally Coached, Inc. p. 1.

MARRAS, W.S., LAVENDER, S.A., LEURGANS, S.E., FATHALLAH, F.A., FERGUSON, S.A., ALLREAD, W.G. & RAJULU, S.L. 1995. Biomechanical risk factors for occupationally related low back disorders. *Ergonomics*, 38(2):377-410.

MATHESON, L.N. 1996. Functional capacity evaluation. (*In* Demeter, S.L., Anderson, B.J. & Smith, G.M., *eds.* Disability Evaluation. Missouri: Mosby. p. 168-188.)

McARDLE, W.D., KATCH, F.I. & KATCH, V.L. 1991. Exercise physiology: energy, nutrition and human performance. 3rd ed. Philadelphia: Lea & Febiger. 853 p.

McCARTER, R.J.M. 1990. Age-related changes in skeletal muscle function. *Aging: clinical and experimental research (Milano)*, 2(1):27-38, March.

McCURDY, S.A., SCHENKER, M.B. & LASSITER, D.V. 1989. Occupational injury and illness in the semiconductor manufacturing industry. *American journal of industrial medicine*, 15(5):499-510.

MERCER. 2007. National survey of employer-sponsored health plans, 2006 survey report. http://www.mercer.com/knowledgecenter/reportsummary.jhtml/dynamic/idContent/1129600 Date of access: 10 Aug. 2007.

MERRIAM-WEBSTER. 2007. Definition of wellness. www.merriam-webster.com Date of access: 25 Aug. 2007.

MESSING, K. 2004. Physical exposures in work commonly done by women. *Canadian journal of applied physiology*, 29(5):139-156.

MESSING, K. & ÉLABIDI, D. 2003. Desegregation and occupational health: how male and female hospital attendants collaborate on work tasks requiring physical effort. *Policy and practice in health and safety*, 1(1):83-103.

MESSING, K. & ŐSLIN, P. 2006. Gender equality, work and health: a review of the evidence. Geneva: World Health Organization. 57 p.

MESSING, K., DUMAIS, L., COURVILLE, J. SEIFERT, A.M. & BOUCHER, M. 1994. Evaluation of exposure data from men and women with the same job title. *Journal of occupational medicine*, 36(8):913-917.

MESSING, K., LIPPEL, K., DEMERS, D. & MERGLER, D. 2000. Equality and difference in the workplace: physical job demands, occupational illnesses, and sex differences. *National Women's Studies Association journal*, 12(3):21-49.

MILLER, W.R., COMFORTI, K. & ROLLNICK, S. 2002. Motivational interviewing: preparing people for change. 2nd ed. New York: Guilford Press. 421 p.

MITAL, A. 1999. Analysis of multiple activity manual materials handling tasks using A Guide to Manual Materials Handling. *Ergonomics*, 42(1):246-257.

MITAL, A. & PENNATHUR, A. 1999. Musculoskeletal overexertion injuries in the United States: mitigating the problem through ergonomics and engineering interventions. *Journal of occupational rehabilitation*, 9(2):115-149.

MITAL, A. & RAMAKRISHNAN, A. 1999. A comparison of literature-based design recommendations and experimental capacity data for a complex manual materials handling activity. *International journal of industrial ergonomics*, 24(1):73-80.

MORRIS, D.B. 1998. Illness and culture in the postmodern age. Berkeley: University of California Press. 360 p.

MORRISON, J.F., WYNDHAM, C.H., MIENIE, B. & STRYDOM, N.B. 1968. Energy expenditure of mining tasks and the need for the selection of labourers. *Journal of the South African Institute of Mining and Metallurgy*, 68:185-191, Nov.

MYERS, D.C., GERBHARDT, D.L., CRUMP, C.E., AND FLEISHMAN, E.D. 1993. The dimensions of human performance: factor analyses of strength, flexibility, and body composition measures. *Human performance*, 6(4):309-344.

NELSON MANDELA FOUNDATION. 2005. South African national HIV prevalence, HIV incidence, behaviour and communication survey. Cape Town: HSRC Press. 156 p.

NIOSH (NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY AND HEALTH). 1997. Musculoskeletal disorders and workplace factors: a critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity and low back. (DHHS (NIOSH) publication. no. 97-141). http://www.cdc.gov/niosh/docs/97-141/pdfs/97-141.pdf Date of access: 10 Oct. 2007

NIELSON, R. & MEYER, J.P. 1987. Evaluation of metabolism from heart rate in industrial work. *Ergonomics*, 30(3):563-572.

NYANTHUMBU, B., LEDUDI, K., DIAS, B., KGALAMON, S., WHITFORD, T., SESOKO, N., ESTERHUIZEN, T. & KIELKOWSKI, D. 2001. Should South Africans be proactive about the prevention of work-related musculoskeletal disorders? *Occupational health SA*, 7(1):22-23, Jul/Aug.

O'DONNELL, M. 2002. Health promotion in the workplace. 3rd ed. Delmar: Thomson Learning. 614 p.

O'HALLORAN, D. 2002. An historical overview of Australian's largest and oldest provider of vocational rehabilitation – CRS Australia. *Work*, 19(3):211-218.

OPATZ, J.P. 1985. Primer of health promotion: creating healthy organizational cultures. Washington, D.C.: Oryn. [unpaged]

ÖSTLIN, P. 2000. Gender inequalities in occupational health. http://www.globalhealth.harvard.edu/hcpds/wpweb/Ostlin%20wp1009.pdf Date of access: 3 Nov. 2007.

OWENS, L.A. & BUCHHOLZ, R.L. 1997. Principles and practices of disability management in industry. (*In* Shrey, D.E. & Lacerte, M. *eds.* Principles and practices of disability management in industry. Florida, Boca Raton: GR Press Inc. p. 269-352.)

OZMINKOWSKI, R.J. & GOETZEL, R.Z. 2001. Getting to the truth: overcoming research challenges when estimating the financial impact of worksite health promotion programs. *American journal of health promotion*, 15(5):289-295, May/Jun.

OZMINKOWSKI, R.J., LING, D., GOETZEL, R.Z., RON, Z., BRUNO, B. & JENNIFER, A, [et al.] 2002. Long term impact of Johnson & Johnson's health & wellness program on health care utilization and expenditures. *Journal of occupational and environmental medicine*, 44(1): 21-29.

PARKER, R., SULLMAN, M., KIRK, P. & FORD, D. 1999. Chainsaw size for delimbing. *Ergonomics*, 42(7):897-903.

PARKHOUSE, W. & GALL B. 2004. Task frequency as a function of age for the powerline technician trade. *Ergonomics*, 47(6):660-670, May.

PAYNE, J.I. & MUSTARD, C. 2002. Work injuries. (*In* Stewart, D.E., Cheung, A.M., Ferris, L.E., [et al.], *eds.* Ontario women's health status report. Toronto: Ontario Women's Health Council, p. 138–145.)

PELLETIER, K.R. 2005. A review and analysis of the clinical and cost-effectiveness studies of comprehensive health promotion and disease management programs at the worksite: Update VI 2000-2004. *Journal of occupational and environmental medicine*, 47(10):1051-1058, Oct.

POHJONEN, T. & RANTA, R. 2001. Effects of worksite physical exercise intervention on physical fitness, perceived health status, and work ability among home care workers: five-year follow up. *Preventive medicine*, 32(6):465-475, Jun.

POLLOCK, M.L., WILMORE, J.H. & FOX, S.M. 1984. Exercise in health and disease: evaluation and prescription for prevention and rehabilitation. Philadelphia: W.B. Saunders. 471 p.

PRIEN, E.P., GOLDSTEIN, I.L. & MACEY, W.H. 1987. Multidomain job analysis: procedures and applications. *Training and development journal*, 41(8):68-72.

PROCHASKA, J. 1995. Changing for good: the revolutionary program that explains the six stages of change and teaches you how to free yourself from bad habits. *Contempory psychology*, 40(11):1047.

PROCHASKA, J.O. & DICLEMENTE, C.C. 1983. Stages and processes of self change of smoking: toward an integrative model of change. *Journal of consulting and clinical psychology*, 51(3):390-395, Jun.

PROCHASKA, J.O. & DICLEMENTE, C.C. 1984. The transtheoretical approach: crossing the traditional boundaries of therapy. Homewood, IL: Dorsey/Dow Jones-Irwin. 204 p.

PROCHASKA, J.O., NORCROSS, J.C. & DICLEMENTE, C.C. 1994. Changing for good. New York: William Morrow & Company. 304 p.

PUNAKALLIO, A. 2003. Balance abilities of different – aged workers in physically demanding jobs. *Journal of occupational rehabilitation*, 13(1):33-43.

PUNNETT, L. & WEGMAN, D.H. 2004. Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *Journal of electromyography and kinesiology*, 14(1):13-23, Feb.

RAYSON, M.P. 2000. Fitness for work: the need for conducting a job analysis. *Journal of occupational medicine*, 50(6):434-436.

RENZ, M.C. 2004. Laboratory investigation of a simulated industrial task pre-and post-ergonomics intervention. Grahamstown: Rhodes University. (Dissertation - M.Sc.) 159 p.

ROBISON, J. 2004a. Reinventing the profession. *WELCOA's absolute advantage magazine*, 3(7):6-11.

ROBISON, J. 2004b. Toward a new science. *WELCOA's absolute advantage magazine*, 3(7):2-5.

ROLLNICK, S., MASON, P. & BUTLER, C. 1999. Health behaviour change: a guide for practitioners. Edinburgh: Churchill Livingston. 225 p.

RORKE, S.C. & RORKE, L.C. 2002. Optimising human performance using task-specific physical readiness evaluations for physical demanding occupations. *Journal of occupational health South Africa,* 8(6):29-33, Nov/Dec.

ROSENTHAL, D., HURSH, N., SIMMERMAN, W. & PRUETT, S.R. 2005. Case management within employer based disability management. (*In* Chan, F., Leahy, M. & Sanders, J, *eds.* Case management for rehabilitation health professionals. Lake Osage, MO: Aspen Professional Services. p.330-365.)

ROY, S.H., DELUCA, C.J., SNYDER-MACKLER, L., EMLEY, M.S., CRENSHAW, R.L. & LYONS, J.P. 1990. Fatigue, recovery, and low back pain in varsity rowers. *Journal of medicine, science, sports and exercise*, 22(4):463-469, Aug.

RUMRILL, P. 1999. A tool for helping workers identify their on-the-job accommodation needs. *Journal of vocational rehabilitation,* 12(3):135-136.

RYAN, R.M. & DECI, E.L. 2000. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American psychologist,* 55(1):68-78, Jan.

SADIE, J.L. 2003. Demografiese veroudering in Suid Afrika en sy vernaamste gevolge. *Journal of studies in economics and econometrics*, 27(3):49-68.

SAHL, J.D., KELSH, M.A., HAINCS, K.D., SANDS, F.K. & KRAUS, J. 1997. Acute work injuries among electricity utility meter readers. *Epidemiology*, 8(3):287-292, May.

SANDERS, A.F. 1991. Simulation as a tool in the measurement of human performance. *Ergonomics*, 34(8):995-1025.

SANDERS, M.S. & MCCORMICK, E.J. 1993. Human factors in engineering and design. 7th ed. New Jersey, N.J.: McGraw-Hill. 790 p.

SAVINAINEN, M., NYGARD, C. & ILMARINEN, J. 2004. A 16-year follow-up study of physical capacity in relation to perceived workload among ageing employees. *Ergonomics*; 47(10):1087-1102.

SCHNEIDER, M. 1999. Achieving greater independence through assistive technology job accommodation and supported employment. *Journal of vocational rehabilitation*, 12(3):159-164.

SCOTT, P.A. & CHRISTIE, C.J. 2004. An indirect method to assess the energy expenditure of manual labourers in situ. *South African journal of science*, 100(11/12):*694-698*, Nov/Dec.

SERXNER, S., NOELDNER, S.P. & GOLD, D. 2006. Best practices for an integrated population health management (PHM) program. *American journal of health promotion*, 20(5):1-10, Jun/Jul.

SHARKEY, B.J. 1997. Fitness and health. 4th ed. Illinois: Human Kinetics. 488 p.

SHEER, S.J. 1990. Multidisciplinary perspectives in vocational assessment of impaired workers. Maryland, MD: Aspen. 244 p.

SHEPHARD, R.J. 1986. Human rights and the older worker: changes in work capacity with age. *Medicine and science in sport and exercise*, 19(2):168-173.

SHEPHARD, R.J. 1989. The aging of cardiovascular function. (*In* Spirduso, W.W. & Eckert, H.M., *eds*. Physical activity and aging. Champaign, Ill: Human Kinetics. p. 175-185.)

SHEPHARD, R.J. 1990. Assessment of occupational fitness in the context of human rights legislation. *Canadian journal of sport science*, 15(2):89-95.

SHEPHARD, R.J. 1997. Aging, physical activity and health. Champaign, Ill.: Human Kinetics. 488 p.

SHEPHARD, R.J. 1999. Age and physical work capacity. *Experimental aging research*, 25(4):331-343, Oct.-Dec.

SHEPHARD, R.J. 2000. Worksite health promotion and the older worker. *International journal of industrial ergonomics*, 25(5):465-475, May.

SHEPHARD, R.J., *ed.* 2002. Gender, physical activity, and aging. Boca Raton, Fla: CRC Press. 288 p.

SHEPHARD, R.J., LAVALLÉE, H., JÉQUIER, M., LA BARRE, J-C., VOLLE, M. & RAJIC, M. 1980. The basis of data standardization in prepubescent children. (*In* Ostyn, M., Beunen, G., & Simons, J., *eds*. Kinanthropometry II. Baltimore: University Park Press. p. 360.)

SHISANA, O., REHLE, T., SIMBAYI, L.C., PARKER, W., ZUMA, K., BHANA, A., CONNOLLY, C., JOOSTE, S., PILLAY, V. 2005. South African national HIV prevalence, HIV incidence: behaviour and communication survey. Cape Town: HSRC Press. 156 p.

SHREY, D.E. 1997a. Worksite disability management and industrial rehabilitation: an overview. (*In* Shrey, D.E. & Lacerte, M. *eds*. Principles and practices of disability management in industry. Florida, Boca Raton: GR Press Inc. p. 3-53.)

SHREY, D.E. 1997b. Disability management practice at the worksite: developing, implementing, and evaluating transitional work programs. (*In* Shrey, D.E. & Lacerte, M. *eds*. Principles and practices of disability management in industry. Florida, Boca Raton: GR Press Inc. p. 55-105.)

SHREY, D.E. & HURSH, N.G. 1997. Protecting the employability of the working elderly. (*In* Shrey, D.E. & Lacerte, M. *eds*. Principles and practices of disability management in industry. Boca Raton, Fla.: GR Press. p. 499-518.)

SHREY, D.E. & LACERTE, M., *eds*. 1997. Principles and practices of disability management in industry. Florida: GR Press Inc. 658 p.

SHREY, D.E. & OLSHESKI, J. 1992. Disability management & industry-based work return transition programs. (*In* Gordon, E. & Kaplan, P., *eds*. Physical medicine and rehabilitation: state of the art review. Philadelphia.: Hanley & Belfus. p. 303-314.)

SLUITER, J.K. 2006. High-demand jobs: age-related diversity in work ability? *Applied ergonomics*, 37(4):429-440, Jul.

SMITH, E.L. & ZOOK, S.K. 1986. The aging process: benefits of physical activity. *Journal of physical education, recreation and dance*, 57(1):32-34.

SMITH, L.A., WILSON, G.D. & SIROIS, D.L. 1985. Heart-rate response to forest harvesting work in the south-eastern United States during summer. *Ergonomics*, 28(4):655-664.

SMITH, P.M. & MUSTARD, C.A. 2004. Examining the associations between physical work demands and work injury rates between men and women in Ontario, 1990-2000. *Journal of occupational and environmental medicine*, 61(9):750-756, Sep.

SNOOK, S.H. 1985. Psychophysical considerations in permissible loads. *Ergonomics*, 28(1):329-320.

SNOOK, S.M. & CIRIELLO, V.M. 1991. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. *Ergonomics*, 34(9):1197-1213.

SOTHMANN, M., GEBHARDT, D., BAKER, T., KASTELLO, G. & SHEPPARD, V. 2004. Performance requirements of physically strenuous occupations: validating minimum standards for muscular strength and endurance. *Ergonomics*, 47(12):864-875.

SOUTH AFRICA. 1993. Occupational Health and Safety Act 85 of 1993. Pretoria: Government Printer.

SOUTH AFRICA. 1998. Employment Equity Act 66 of 1998. Pretoria: Government Printer.

SOUTH AFRICA. 2000. Promotion of Equality and Prevention of Unfair Discrimination Act 4 of 2000. Pretoria: Government Printer.

SPIRDUSO, W.W. 1995. Physical dimensions of aging. Champaign, Ill.: Human Kinetics. 589 p.

STATISTICS SOUTH AFRICA. 2001. Census 2001: Employment. http://www.statssa.gov.za/specialprojects/census2001/dgiatlas/stats/html Date of access: 28 Aug. 2003.

STATISTICS SOUTH AFRICA. 2002. South African statistics, 2002. Pretoria: Department of Statistics. 465 p.

STATSOFT, INC. 2002. Statistica (data analysis software system). Version 7 [CD-ROM]. http://www.statsoft.com.

STEYN, H.S., Jr. 2000. Practical significance of the difference in means. *Journal of industrial psychology*, 26(3):1-3.

STEYN, H.S., Jr. 2002. Practical significant relationships between two variables. *SA journal of industrial psychology*, 28(3):10-15.

STEYN, H.S., Jr. 2005. Handleiding vir die bepaling van effekgrootte-indekse en praktiese betekenisvolheid. Potchefstroom: North-West University. http://www.puk.ac.za/fakulteite/natuur/skd/index.html Date of access: 12 Aug. 2006.

STRYDOM, N.B. & WILLIAMS, C.G. .1969. Effect of physical conditioning on state of heat acclimatization of Bantu laborers. *Journal of applied physiology*, 27:262-265, Aug.

SUURNAKKI, T, NYGÅRD, C.H. & ILMARINEN, J. 1991. Stress and strain of elderly employees in municipal occupations. *Scandinavian journal of work, environment and health*, 17(1):30-39.

SWEETING, R.L. 1990. A value approach to health behaviour. Champaign, Ill.: Human Kinetics. 251 p.

TAYLOR, A.W. 1992. Ageing: a normal degenerative process - with or without regular exercise. *Canadian journal for sports science*, 17(3):163-167.

TEIXEIRA, M. 2002. Sunday Times: Markinor top brands survey 2002. http://www.biz-community.com/Article/196/12/1015.html Date of access: 17 Aug. 2007.

THOMAS, J.R. & NELSON, J.K. 1990. Research method in physical activity. 2nd ed. Champaign, Ill. Human Kinetics. 550 p.

TORNER, M., ZETTERBURG, C., ANDEN, U., HANSSON, T. & LINDELL, V. 1991. Workload and musculoskeletal problems: a comparison between welders and office clerks (with reference also to fishermen). *Ergonomics*, 34(9):1179-1196.

TRAVIS, J.W. & RYAN, R.S. 1988. The wellness workbook. California: Ten speed. 237 p.

TUOMI, K., ILMARINEN, J., ESKELINEN, L., JÄRVINEN, E., TOIKKAKEN, J. & KLOCKARS, M. 1991. Prevalence and incidence rates of diseases and work ability in different work categories of municipal occupations. *Scandinavian journal of work environmental health*, 17(1):67-74.

TUOMI, K., ILMARINEN, J., MARTIKAINEN, R., AALTO, L. & KLOCKARS, M. 1997. Aging, work, life-style and work ability among Finnish municipal workers in 1981-1992. *Scandinavian journal for environmental health*, 23(1):58-65.

UN (UNITED NATIONS). 2007. World population prospects: the 2006 revision. New York: United Nations, Population Division. http://www.un.org/esa/population/publications/wpp2006/wpp2006.htm Date of access: 26 May 2007.

UNION PACIFIC CORPORATION. 2007. Company overview. http://www.uprr.com/aboutup/corporate_info/uprrover.shtml Date of access: 6 Oct. 2007.

URBANEIK, S.J. 1997. Job analysis: a local government's experience. *Public personnel management*, 26(3):423-430.

US CHAMBER OF COMMERCE. 2005. Partnership for prevention: leading practices for employee health management. http://www.prevent.org/images/stories/Files/docs/Leading_by_Example.pdf Date of access: 15 Aug. 2007.

VAN DER PLOEG, H.P., STREPPEL, K.R.M., VAN DER BEEK, A.J., VAN DER WOUDE, L.H.V., VOLLENBROEK-HUTTEN, M.M.R., VAN HARTEN, W.H. & VAN MECHELEN, W. 2007. Successfully improving physical activity behavior after rehabilitation. *American journal of health promotion,* 21(3):153-159, Jan/Feb.

VAN DER WALT, E.J. 2006. Verwysings. Potchefstroom: Ferdinand Postma Biblioteek. 79 p.

VAN DIJK, F.J.H., VAN DOMOLEN, M. KOMPIER, M.A.J. & MEIJMAN, T.F. 1990. Re-evaluation of the model work demands-capacity [in Dutch]. *Tijdschrift sociale gezondheidszorg,* 68(*):3-10.

VANDERVOORT, A.A. 1992. Effects of ageing on human neuromuscular function: implications for exercise. *Canadian journal for sports science,* 17(3):178-184.

VELICER, W.F. 1996. A criterion measurement model for health behavior change. *Addictive behaviors,* 21(5):555.

VENNING, P.J., WALTER, S.D. & STITT, L.W. 1987. Personal and job-related factors as determinants of incidence of back injuries among nursing personnel. *Journal of occupational medicine,* 29(10):821-826.

VIITASALO, J.T., HEIKKEINEN, E., LESKINEN, A.L. & ERA, P. 1985. Muscular strength profiles and anthropometry in random samples of men aged 31-35, 51-55 and 71-75. *Ergonomics,* 28(11):11563-11574.

VOLINN, E., VAN KOEVERING, D. & LOESER, J.D. 1991. Back sprain in industry: the role of socio-economic factors in chronicity. *Spine,* 16(5):542-548.

WADDELL, G. & BURTON, A.K. 2001. Occupational health guidelines for the management of low back pain at work: evidence review. *Occupational medicine,* 51(2):124-135.

WALLS, R. 2002. Job accommodation resources: lessons from the global neighbourhood. *Journal of rehabilitation,* 33(5):34.

WARR, P. 1993. In what circumstances does job performance vary with age? *European work and organizational psychologist*, 3(3):237-249.

WEIR, R. & NIELSON, W.R. 2001. Interventions for disability management. *Clinical Journal of Pain*, 17(3):128-132.

WETTE *see* SOUTH AFRICA.

WORLD HEALTH ORGANIZATION. 1948. Definition of health. (Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States and entered into force on 7 April 1948). p. 100.

WHO (WORLD HEALTH ORGANIZATION). 1993. Aging and working capacity: report of a WHO study group. Geneva. 55 p. (Technical report series, no. 835.)

WHO (WORLD HEALTH ORGANIZATION). 1999. Occupational health: ethically correct, economically sound. Geneva. 6. p. (Fact sheet, nr. 84.)

WHO (WORLD HEALTH ORGANIZATION). 2003. Active ageing: a policy framework. Geneva. 60 p.

WICHT, C.L. 1984. Die bejaarde en sy kwale. Pretoria: HAUM. 460 p.

WILMORE, J.H. 1986. Sensible fitness. 2nd ed. Champaign, Ill.: Leisure Press. 342 p.

WILSON, J.R. & CORLETT, E.N. 2005. Evaluation of human work: a practical ergonomics methodology. 2nd ed. Bristol: Taylor & Francis. 1152 p.

WOODS, V. & BUCKLE, P. 2002. Work, inequality and musculoskeletal health: Health and safety executive, contract research report 421/2002. Norwich: St. Clements House. 88 p.

ZWERLING, C., SPRINCE, N.L., RYAN, J. & JONES, M.P. 1993. Occupational injuries: comparing the rates of male and female postal workers. *American journal of epidemiology*, 138(1):46-55, Jul.

APPENDICES

APPENDIX A

Data collection

a) List of equipment used

- Height meter gage
- Scale
- Stereoscope
- Blood pressure cuff
- Sit-and-reach bench
- Metronome
- Step-up bench
- Measuring platform
- Grip dynamometer
- Leg/back dynamometer
- Goniometer
- Chain
- Belt
- Stopwatch

b) Participant and program information

Personal detail

Unique NR		Date of Birth	YYYY	MM	DD
Initials		Age			
Surname		Gender	**Male**	**Female**	
Region					
Division		Tel Number			
Section		Supervisor			
Department					
Site location		Biokineticist			
Job Title		Date			
Man Grade		Time			

Worksite Wellness Program Detail

PHASE 1
Week: 1 2

PHASE 2
Visit: 1 2 3 4 5 6

PHASE 3
Visit: 1 2 3 4

Physical Work Capacity Risk Status

....

....

c) Informed consent

Consent to be tested

I declare that all the information about my health is true and correct. I give my consent that the results may be used for report and research purposes, knowing that all my information will be kept confidential. I expressly undertake that in the event of any unforeseen injury during the test that I shall not hold either the evaluator or the evaluator's employer, or my employer liable for any claim I may have resulting from such test / injury. I am aware that I can withdraw my consent. Or discontinue with the assessment at any time.

Signature ______________________ Date __________________________

Consent to be tested and rehabilitated

I hereby voluntarily consent to undergo a full physical assessment and comply with the proposed exercise program. I hereby also declare that all the information about my injuries / physical well being is stated and that all the information is true and correct. I understand that the assessment and the proposed exercise program do not entirely eliminate risk of injury. I indemnify ESKOM or any employee connected with ESKOM from any responsibility relating to any injury, whether temporary or permanent, sustained during the assessment, while exercising or any after effects resulting from such assessment or exercise. I declare to give my full co-operation with the rehabilitation program and that I will do the exercises as they were shown to my knowing that in doing the exercise incorrectly injury may occur. I give my consent that the results may be used for reports and research purposes, knowing that all my information will be kept confidential. I am aware that I can withdraw my consent, or discontinue in the assessment or exercise program at any time. I have read the statement and received satisfactory answers to all my questions.

Signature _____________________ Date ______________________

Witness______________________ Venue ______________________

d) Physical activity readiness questionnaire

1.	Do you suffer from high blood pressure?	Yes	No
2.	Have you ever been told that you have high blood pressure?	Yes	No
3.	Do you presently take any medication for high blood pressure?	Yes	No
4.	Have you injured your back in the last 6 months?	Yes	No
5.	Do you suffer from pain in your lower back at present?	Yes	No
6.	Have you ever been diagnosed with heart problems?	Yes	No
7.	Do you suffer from pain in the chest or heart?	Yes	No
8.	Do you have a hernia?	Yes	No
9.	Do you have osteoporosis?	Yes	No
10.	Family history re: Cardiac diseases, osteoporosis, and chronic diseases?	Yes	No

If you have answered YES to any of the above questions, please specify:

☐ --

☐ --

Have you had any operations in any of the following?

Wrist		Arms		Legs		Back	

Is there any other reason why you can not perform physical activity?

----

e) Data sheet

MEASUREMENT	SCORE				COMMENTS
Height (cm)					
Weight (kg)					
Resting Heart Rate (beats / min)					
Resting systolic BP (mmHg)					
Resting diastolic BP (mmHg)					
Flexibility (cm)					
Heart Rate (b / min) 3min. step-ups					
RPE Scale (1 – 10)					
Grip Strength Right (kg)					
Grip Strength Left (kg)					
Arm / Shoulder Muscle Strength (kg)					
Back Muscle Strength (kg)					
Leg Muscle Strength (kg)					
Stomach Muscle Endurance (reps/min)					

APPENDIX B

Instructions for authors

a) Journal of Occupational Health South Africa

Invitation to submit articles

Occupational Health Southern Africa is the official journal of the South African Society of Occupational Medicine (SASOM), the South African Society of Occupational Health Nursing Practitioners (SASOHN), the Southern African Institute of Occupational Hygiene (SAIOH) and the Mining Medical and Other Health Care Professionals Association (MMOA). Appropriate articles of academic merit are accepted for publication, subject to the following guidelines:

Article categories

• ORIGINAL AND REVIEW

These should follow the format of: Introduction, Methodology, Results, Discussion and References

The length should be between 2000 and 2500 words.

Original and review articles must include a short abstract of less than 150 words and will be refereed. Manuscripts will be submitted to referees as confidential without naming the author and all referees shall remain anonymous.

• OPINION OR SHORT REPORTS

These are short reports, with a length of less than 1000 words.

• CASE STUDIES

Less than 1000 words.

• LETTERS TO THE EDITOR

Less than 400 words.

Factual accuracy

Authors are solely responsible for the factual accuracy of their work and must ensure that their work does not infringe copyright.

Manuscripts

• LAYOUT

Manuscripts should be typed in 1.5 spacing, using only one side of the paper.

❒ Pages should be numbered consecutively and leave wide margins.

❒ Scientific measurements should be expressed in S.I. units.

❒ Abbreviations and acronyms should only be used if absolutely necessary and must be defined on first use.

❒ Illustrations, tables and graphs should be submitted separate to text, preferably as a high-resolution .jpg. They should be clearly identified. Please ensure that they are not embedded in MS Word documents. Tables should use Arabic numerals 1, 2, 3 etc, and illustrations Figure 1, 2, 3, etc.

❒ X-ray films should not be submitted, only glossy prints, clearly captioned.

• AUTHOR'S DETAILS

A separate title page should contain the title, the author(s)' full names, contact details relevant to correspondence and the author(s)' place of work and job designation. A word count should be included on this page.

• SUBMISSION

Manuscripts should be e-mailed or faxed to the contact details below.

• REFERENCES

❒ References should be inserted in the text as superscript numbers and listed at the end of the article in numerical order (not alphabetically). The accuracy of references is the author's responsibility.

❒ Personal communication and unpublished observations may be cited in the text, but not in the reference list.

❒ References should be set out in the Vancouver style and only approved abbreviations of journal titles should be used.

EXAMPLES

1. Zwarenstein, M., Barron, P., Tollman, S., et al. Primary Health Care Depends on the District Health System, S. Afr. Med. J. 1993; 83:568.

Book references

1. Thompson, L.A. History of South Africa. Newhaven and London: Yale University Press, 1990.

PROOFS

Alterations to proofs must be limited to misprints or factual errors. Major alterations or new material cannot be accepted. Proofs not returned within the time limit specified will be regarded as approved.

CONTACT PERSON

Linda Grainger
Tel: 031 764 2302.
Fax: 031 764 0386, **MUST BE MARKED** Attention: Linda Grainger
or e-mail: occhealthsa@technews.co.za

b) Vancouver style reference guide

INTERNATIONAL COMMITTEE OF MEDICAL JOURNAL EDITORS UNIFORM REQUIREMENTS FOR MANUSCRIPTS SUBMITTED TO BIOMEDICAL JOURNALS: SAMPLE REFERENCES
ARTICLES IN JOURNALS

1. *Standard journal article*
List the first six authors followed by et al. (Note: NLM now lists all authors.)
Halpern SD, Ubel PA, Caplan AL. Solid-organ transplantation in HIV-infected patients. N Engl J Med. 2002 Jul 25;347(4):284-7.
As an option, if a journal carries continuous pagination throughout a volume (as many medical journals do) the month and issue number may be omitted.
Halpern SD, Ubel PA, Caplan AL. Solid-organ transplantation in HIV-infected patients. N Engl J Med. 2002;347:284-7.
Optional addition of a database's unique identifier for the citation:
Halpern SD, Ubel PA, Caplan AL. Solid-organ transplantation in HIV-infected patients. N Engl J Med. 2002 Jul 25;347(4):284-7. Cited in PubMed; PMID 12140307.
More than six authors:
Rose ME, Huerbin MB, Melick J, Marion DW, Palmer AM, Schiding JK, et al. Regulation of interstitial excitatory amino acid concentrations after cortical contusion injury. Brain Res. 2002;935(1-2):40-6.

2. *Organization as author*
Diabetes Prevention Program Research Group. Hypertension, insulin, and proinsulin in participants with impaired glucose tolerance. Hypertension. 2002;40(5):679-86.

3. *Both personal authors and an organization as author* (This example does not conform to NISO standards.)
Vallancien G, Emberton M, Harving N, van Moorselaar RJ; Alf-One Study Group. Sexual dysfunction in 1,274 European men suffering from lower urinary tract symptoms. J Urol. 2003;169(6):2257-61.

4. *No author given*
21st century heart solution may have a sting in the tail. BMJ. 2002;325(7357):184.

5. *Article not in English*
(Note: NLM translates the title into English, encloses the translation in square brackets, and adds an abbreviated language designator.)
Ellingsen AE, Wilhelmsen I. Sykdomsangst blant medisin- og jusstudenter. Tidsskr Nor Laegeforen. 2002;122(8):785-7.

6. *Volume with supplement*
Geraud G, Spierings EL, Keywood C. Tolerability and safety of frovatriptan with short- and long-term use for treatment of migraine and in comparison with sumatriptan. Headache. 2002;42 Suppl 2:S93-9.

7. *Issue with supplement*
Glauser TA. Integrating clinical trial data into clinical practice. Neurology. 2002;58(12 Suppl 7):S6-12.

8. *Volume with part*
Abend SM, Kulish N. The psychoanalytic method from an epistemological viewpoint. Int J Psychoanal. 2002;83(Pt 2):491-5.

9. *Issue with part*
Ahrar K, Madoff DC, Gupta S, Wallace MJ, Price RE, Wright KC. Development of a large animal model for lung tumors. J Vasc Interv Radiol. 2002;13(9 Pt 1):923-8.

10. *Issue with no volume*
Banit DM, Kaufer H, Hartford JM. Intraoperative frozen section analysis in revision total joint arthroplasty. Clin Orthop. 2002;(401):230-8.

11. *No volume or issue*
Outreach: bringing HIV-positive individuals into care. HRSA Careaction. 2002 Jun:1-6.

12. *Pagination in roman numerals*
Chadwick R, Schuklenk U. The politics of ethical consensus finding. Bioethics. 2002;16(2):iii-v.

13. *Type of article indicated as needed*
Tor M, Turker H. International approaches to the prescription of long-term oxygen therapy [letter]. Eur Respir J. 2002;20(1):242.
Lofwall MR, Strain EC, Brooner RK, Kindbom KA, Bigelow GE. Characteristics of older methadone maintenance (MM) patients [abstract]. Drug Alcohol Depend. 2002;66 Suppl 1:S105.

14. *Article containing retraction*
Feifel D, Moutier CY, Perry W. Safety and tolerability of a rapidly escalating dose-loading regimen for risperidone. J Clin Psychiatry. 2002;63(2):169. Retraction of: Feifel D, Moutier CY, Perry W. J Clin Psychiatry. 2000;61(12):909-11.

15. *Article retracted*
Feifel D, Moutier CY, Perry W. Safety and tolerability of a rapidly escalating dose-loading regimen for risperidone. J Clin Psychiatry. 2000;61(12):909-11. Retraction in: Feifel D, Moutier CY, Perry W. J Clin Psychiatry. 2002;63(2):169.

16. *Article republished with corrections*
Mansharamani M, Chilton BS. The reproductive importance of P-type ATPases. Mol Cell Endocrinol. 2002;188(1-2):22-5. Corrected and republished from: Mol Cell Endocrinol. 2001;183(1-2):123-6.

17. *Article with published erratum*
Malinowski JM, Bolesta S. Rosiglitazone in the treatment of type 2 diabetes mellitus: a critical review. Clin Ther. 2000;22(10):1151-68; discussion 1149-50. Erratum in: Clin Ther 2001;23(2):309.

18. *Article published electronically ahead of the print version*
Yu WM, Hawley TS, Hawley RG, Qu CK. Immortalization of yolk sac-derived precursor cells. Blood. 2002 Nov 15;100(10):3828-31. Epub 2002 Jul 5.

Books and Other Monographs

19. *Personal author(s)*
Murray PR, Rosenthal KS, Kobayashi GS, Pfaller MA. Medical microbiology. 4th ed. St. Louis: Mosby; 2002.

20. *Editor(s), compiler(s) as author*
Gilstrap LC 3rd, Cunningham FG, VanDorsten JP, editors. Operative obstetrics. 2nd ed. New York: McGraw-Hill; 2002.

21. *Author(s) and editor(s)*
Breedlove GK, Schorfheide AM. Adolescent pregnancy. 2nd ed. Wieczorek RR, editor. White Plains (NY): March of Dimes Education Services; 2001.

22. *Organization(s) as author*
Royal Adelaide Hospital; University of Adelaide, Department of Clinical Nursing. Compendium of nursing research and practice development, 1999-2000. Adelaide (Australia): Adelaide University; 2001.

23. *Chapter in a book*
Meltzer PS, Kallioniemi A, Trent JM. Chromosome alterations in human solid tumors. In: Vogelstein B, Kinzler KW, editors. The genetic basis of human cancer. New York: McGraw-Hill; 2002. p. 93-113.

24. *Conference proceedings*
Harnden P, Joffe JK, Jones WG, editors. Germ cell tumours V. Proceedings of the 5th Germ Cell Tumour Conference; 2001 Sep 13-15; Leeds, UK. New York: Springer; 2002.

25. *Conference paper*
Christensen S, Oppacher F. An analysis of Koza's computational effort statistic for genetic programming. In: Foster JA, Lutton E, Miller J, Ryan C, Tettamanzi AG, editors. Genetic programming. EuroGP 2002: Proceedings of the 5th European Conference on Genetic Programming; 2002 Apr 3-5; Kinsdale, Ireland. Berlin: Springer; 2002. p. 182-91.

26. *Scientific or technical report*
Issued by funding/sponsoring agency:
Yen GG (Oklahoma State University, School of Electrical and Computer Engineering, Stillwater, OK). Health monitoring on vibration signatures. Final report. Arlington (VA): Air Force Office of Scientific Research (US), Air Force Research Laboratory; 2002 Feb. Report No.: AFRLSRBLTR020123. Contract No.: F496209810049.

Issued by performing agency:
Russell ML, Goth-Goldstein R, Apte MG, Fisk WJ. Method for measuring the size distribution of airborne Rhinovirus. Berkeley (CA): Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division; 2002 Jan. Report No.: LBNL49574. Contract No.: DEAC0376SF00098. Sponsored by the Department of Energy.

27. *Dissertation*
Borkowski MM. Infant sleep and feeding: a telephone survey of Hispanic Americans [dissertation]. Mount Pleasant (MI): Central Michigan University; 2002.

28. *Patent*
Pagedas AC, inventor; Ancel Surgical R&D Inc., assignee. Flexible endoscopic grasping and cutting device and positioning tool assembly. United States patent US 20020103498. 2002 Aug 1.

Other Published Material

29. *Newspaper article*
Tynan T. Medical improvements lower homicide rate: study sees drop in assault rate. The Washington Post. 2002 Aug 12;Sect. A:2 (col. 4).

30. *Audiovisual material*
Chason KW, Sallustio S. Hospital preparedness for bioterrorism [videocassette]. Secaucus (NJ): Network for Continuing Medical Education; 2002.

31. *Legal Material*
Public law:
Veterans Hearing Loss Compensation Act of 2002, Pub. L. No. 107-9, 115 Stat. 11 (May 24, 2001).
Unenacted bill:
Healthy Children Learn Act, S. 1012, 107th Cong., 1st Sess. (2001).
Code of Federal Regulations:
Cardiopulmonary Bypass Intracardiac Suction Control, 21 C.F.R. Sect. 870.4430 (2002).
Hearing:
Arsenic in Drinking Water: An Update on the Science, Benefits and Cost: Hearing Before the Subcomm. on Environment, Technology and Standards of the House Comm. on Science, 107th Cong., 1st Sess. (Oct. 4, 2001).

32. *Map*
Pratt B, Flick P, Vynne C, cartographers. Biodiversity hotspots [map]. Washington: Conservation International; 2000.

33. *Dictionary and similar references*
Dorland's illustrated medical dictionary. 29th ed. Philadelphia: W.B. Saunders; 2000. Filamin; p. 675.

Unpublished Material

34. *In press*
(Note: NLM prefers "forthcoming" because not all items will be printed.)
Tian D, Araki H, Stahl E, Bergelson J, Kreitman M. Signature of balancing selection in Arabidopsis. Proc Natl Acad Sci U S A. In press 2002.

Electronic Material

35. *CD-ROM*
Anderson SC, Poulsen KB. Anderson's electronic atlas of hematology [CD-ROM]. Philadelphia: Lippincott Williams & Wilkins; 2002.

36. *Journal article on the Internet*
Abood S. Quality improvement initiative in nursing homes: the ANA acts in an advisory role. Am J Nurs [serial on the Internet]. 2002 Jun [cited 2002 Aug 12];102(6):[about 3 p.]. Available from: http://www.nursingworld.org/AJN/2002/june/Wawatch.htm

37. *Monograph on the Internet*
Foley KM, Gelband H, editors. Improving palliative care for cancer [monograph on the Internet]. Washington: National Academy Press; 2001 [cited 2002 Jul 9]. Available from: http://www.nap.edu/books/0309074029/html/.

38. *Homepage/Web site*
Cancer-Pain.org [homepage on the Internet]. New York: Association of Cancer Online Resources, Inc.; c2000-01 [updated 2002 May 16; cited 2002 Jul 9]. Available from: http://www.cancer-pain.org/.

39. *Part of a homepage/Web site*
American Medical Association [homepage on the Internet]. Chicago: The Association; c1995-2002 [updated 2001 Aug 23; cited 2002 Aug 12]. AMA Office of Group Practice Liaison; [about 2 screens]. Available from: http://www.ama-assn.org/ama/pub/category/1736.html

40. *Database on the Internet*
Open database:
Who's Certified [database on the Internet]. Evanston (IL): The American Board of Medical Specialists. c2000 - [cited 2001 Mar 8]. Available from: http://www.abms.org/newsearch.asp
Closed database:
Jablonski S. Online Multiple Congential Anomaly/Mental Retardation (MCA/MR) Syndromes [database on the Internet]. Bethesda (MD): National Library of Medicine (US). c1999 [updated 2001 Nov 20; cited 2002 Aug 12]. Available from: http://www.nlm.nih.gov/mesh/jablonski/syndrome_title.html

41. *Part of a database on the Internet*
MeSH Browser [database on the Internet]. Bethesda (MD): National Library of Medicine (US); 2002 - [cited 2003 Jun 10]. Meta-analysis; unique ID: D015201; [about 3 p.]. Available from: http://www.nlm.nih.gov/mesh/MBrowser.html Files updated weekly.
Updated June 15, 2005