The impact of a

change in work posture on

work-related musculoskeletal disorders among

sewing-machine operators,

managed within a

physiotherapy and ergonomics programme

by

S. H. GROBLER

Submitted in order to fulfil the requirements for the degree

Magister in Physiotherapy (Research)

in the

Faculty of Health Sciences

University of Pretoria

Date: April 2013

Summary

Title   **The impact of a change in work posture on work-related musculoskeletal disorders among sewing-machine operators, managed within a physiotherapy and ergonomics programme**

Student   Susanna Helena Grobler

Study leader   Ms Karien Mostert-Wentzel

Biostatistician   Prof. Becker (Medical Research Council)

Department   Physiotherapy

Degree   Magister in Physiotherapy (Research)

When implementing a managed healthcare intervention among a working population, evidence-based healthcare is critical. In the current study, the change of work posture of sewing-machine operators from seated to stand-up (the intervention) was managed within a physiotherapy and ergonomics programme (programme) in Johnson Controls Automotive S.A. (Pty) Ltd (company) without local evidence to guide the postural transition.

The management of the intervention, implemented over a period of 4.5 years, presented the opportunity for a retrospective longitudinal study. The study determined the impact of the change in work posture on the incidence of work-related musculoskeletal disorders (WRMSDs) from June 2004 to January 2009 (period). The role of the physiotherapist in the programme was to deliver manual therapy to all sewing-machine operators with WRMSDs, and to provide a clinical - ergonomics service, as a member of a multidisciplinary team, to the company.

The population of sewing-machine operators (n=123) was described in terms of personal factors (e.g. age, medical history, musculoskeletal history, and body mass index (BMI)), ergonomic risk factors (e.g. work posture, force and duration) and overall incidence of WRMSDs. The associations of risk factors (personal and ergonomic) with WRMSDs, and work posture with WRMSDs among sewing-machine operators were statistically determined.

The majority of the population (97.6%) was female, with mean age 42.3± 8 years. At baseline, 17.9% were hypertensive, 3.3% had arthritis, 6.5% were diabetic, and the mean BMI was 29.7 kg/m² (22% of BMIs was normal). The largest proportion of the sewing-machine operators were sewing cloth and leather (79.7%) (compared to sewing cloth and vinyl), and the remainder performed forceful precision stitching (20.3%), including headrest covers, airbags and top stitching on the final product. Job rotation took place between forceful precision stitching and straight stitching (for 36.6% of the sewing-machine operators).

The intervention was implemented within the study period. At baseline 100% of sewing-machine operators were sewing in the seated work posture. Early in the study, 17.9% of them changed their work posture from seated to stand-up, 30.1% changed to the stand-up work posture in January 2007, and 34.9% a year later. The last 17.1% remained seated till the last year of the study period. From July 2008, 100% of the sewing-machine operators were sewing in the stand-up work posture.

The results indicated two strong associations of risk factors and a change in work posture with WRMSDs. Obesity (specifically morbid obesity) was a personal risk factor for upper limb disorders and working in the stand-up work posture was protective for spinal disorders, compared to working in the seated work posture. Furthermore, the results indicated a high incidence of disorders (specifically of the spinal area and upper limb) during the first three months of the programme, as well as an increased incidence of lower leg disorders for the first and consecutive month of the change in work posture from seated to standing up. Lower limb disorders were specifically associated with obesity.

The increase of lower limb disorders during the postural adaptation phase was temporary, and was addressed within the programme with proper shoe wear, silicone innersoles, supportive stockings and exercises. The combination proved to be effective in preventing and/or managing lower limb disorders.

The outcome of the current study provided evidence on the incidence of WRMSDs, and associations between risk factors and work posture, and WRMSDs among sewing-machine operators managed within the programme.

Keywords

Standing

Sedentary

Work-related musculoskeletal disorders

Spinal disorders

Work-related upper extremity musculoskeletal disorders

Lower limb disorders

Sewing-machine operators

Physiotherapy

Ergonomics

Occupational health

Opsomming

Titel	**Die impak van die verandering van werkspostuur op werksverwante muskuloskeletale versteurings in naaimasjienoperateurs, terwyl dit binne 'n fisioterapie en ergonomika program hanteer is**
Student	Susanna Helena Grobler
Studieleier	Me Karien Mostert-Wentzel
Biostatistikus	Prof. Becker (Mediese Navorsings Raad)
Departement	Fisioterapie
Graad	Magister in Fisioterapie (Navorsing)

Bewysgebaseerde gesondheidsorg is van kardinale belang tydens die implementering van 'n bestuurde gesondheidsorgingreep in 'n werkende bevolking. In hierdie studie, is die verandering van werkspostuur van naaimasjienoperateurs van sit na staan (intervensie), binne 'n fisioterapie-en-ergonomika program (program) in Johnson Controls Automotive S.A. (Pty) Ltd (die maatskappy) hanteer sonder plaaslike bewyse om die posturele oorgang te bestuur.

Die hantering van die intervensie, wat oor 'n tydperk van 4.5 jaar geïmplementeer is, het die geleentheid vir 'n terugwerkende longitudinale studie geskep. Die studie het die impak van die werkspostuurverandering op die voorkoms van werksverwante muskuloskeletale versteurings (MSV) vanaf Junie 2004 tot Januarie 2009 (tydperk) bepaal. Die rol van die fisioterapeut in die program was om manuele terapie aan al die beseerde naaimasjienoperateurs te lewer en ook, as lid van 'n multi-dissiplinêre span, 'n kliniese ergonomiese diens aan die maatskappy te lewer.

Die studiegroep van naaimasjienoperateurs (n=123) was beskryf in terme van persoonlike risikofaktore (bv. ouderdom, mediese geskiedenis, muskuloskeletale geskiedenis, en liggaamsmassa-indeks (LMI)), ergonomiese risikofaktore (bv. werkspostuur, krag en durasie) en die oorkoepelende voorkoms van MSV. Die verbande tussen die voorkoms van risikofaktore (persoonlik en ergonomies) en MSV, asook tussen werkspostuur en MSV onder naaimasjienoperateurs is statisties bepaal.

Die meerderheid van die naaimasjienoperateurpopulasie (97,6%) was vroulik. Die gemiddelde ouderdom van die studiegroep aan die begin van die studie was 42.3± 8 jaar, 17.9% was hipertensief, 3.3% het artritis gehad, 6.5% was diabeties, en die gemiddelde LMI was 29.7 kg/m² (22% van die LMIs was normaal). Die data het weerspieël dat die grootste deel van die naaimasjienoperateurs met materiaal en leer gestik het (79.7%), in vergelyking met die stik van materiaal en vinyl. Slegs 'n klein persentasie het kragtige presisie stikwerk uitgevoer - insluitend die stik van kopstutoortreksels, lugsakke en topstiksel op die finale produk (20.3%). Werksrotasie het plaasgevind tussen kragtige presisie stikwerk en reguit stikwerk (vir 36.6% van die naaimasjienoperateurs).

Die intervensie is gedurende die tydperk van die studie geïmplementeer. By basislyn het 100% van die naaimasjienoperateurs in die sittende werkspostuur gestik. Vroeg in die studie, het 17.9% hul werkspostuur van sit na staan verander, 30.1% tydens Januarie 2007, gevolg deur 34.9% 'n jaar later. Die laaste 17.1% het in die sittende werkspostuur gewerk tot die laaste jaar van die tydperk. Vanaf Julie 2008 het 100% van die naaimasjienoperateurs in die staande werkspostuur gestik.

Die resultate het twee sterk verbande tussen risikofaktore en werkspostuurverandering, en versteurings aangedui. Vetsug (spesifiek morbiede vetsug), was 'n persoonlike risiko faktor vir die boonste ledemaat versteurings, en stikwerk in die staande werkspostuur was beskermend vir spinale versteurings, in vergelyking met stikwerk in die sittende werkspostuur. Die resultate het ook 'n hoë voorkoms van MSV (spesifiek van die spinale-areas en boonste ledemate) gedurende die eerste drie maande van die program getoon, sowel as 'n verhoogde voorkoms van onderste ledemaat versteurings

vir die eerste en opeenvolgende maande waarin die werkspostuur verander is van die sit na staan. Onderste ledemaat versteuring het veral verband gehou vetsug.

Die toename van onderste ledemaat versteurings gedurende die posturale-aanpassingsfase was tydelik van aard, en is binne die program hanteer met gemaklike skoene, silikoon binnesole, ondersteunende kouse en oefeninge. Die kombinasie blyk effektief te wees in die voorkoming en/of hantering van onderste ledemaat versteurings.

Die uitkoms van hierdie studie verskaf bewyse rakende die voorkoms van MSV, sowel as die verbande tussen risikofaktore en werkspostuur, en MSV onder naaimasjienoperateurs wat binne die program hanteer is.

Sleutel woorde

Staan

Sit

Werksverwante muskuloskeletale versteurings

Spinale verteurings

Werksverwante boonste ledemaat muskuloskeletale versteurings

Onderste ledemaat versteurings

Naaimasjien operateurs

Fisioterapie

Ergonomika

Beroepsgesondheid

Dedication

Our Heavenly Father

Declaration

I declare that the dissertation, which I hereby submit for the degree Magister in Physiotherapy (research) at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at another university.

Acknowledgements

Many people have helped to stimulate the design of this retrospective study. In particular, I would like to express my thanks to Prof Jan van Tonder for presenting a part-time course on Industrial Ergonomics at the Randse Afrikaanse Universiteit (now known as the University of Johannesburg) in 2001, as this course prepared me to participate in the implementation of the programme described in the current study, three years later.

In addition, the trust invested by Johnson Controls Automotive S.A. (Pty) Ltd in me to participate in this programme, made me aware of the need for 'research-to-practice' findings in South Africa. This awareness was strengthened by the need for published literature in order to equip physiotherapists to participate in similar programmes. This two-way process provided a constant reminder of the complexities of the growing need for evidence-based studies regarding managed health care interventions among working populations in South Africa.

The contributions of my study leader, Karien Mostert-Wentzel, and biostatistician, Prof. Becker, were vital in ensuring that the 'lessons learnt' in the current study were analysed and discussed to equip managers and physiotherapists alike in managing a change in work posture in similar programmes.

Finally, I would like to thank the many family members, friends, colleagues, and critical readers who have provided support and encouragement through this experience. The following persons made valuable contributions towards the study:

- o Dr Lourens Blignaut (Orthopaedic surgeon)
- o Dr Maderi Claassen (Occupational Medicine Practitioner, LIFE Clinic, FORD Motor Co. of S.A.)
- o Dr Katia Costa-Black (Extra-ordinary lecturer, School of Health Systems and Public Health, Faculty of Health Sciences, University of Pretoria)
- o Mrs Barbara English (Language editing)

- o Mr Piet Freysen (Father and engineer)
- o Mrs Magda Papadopoulos (Physiotherapist)
- o Prof Paul Rheeder (Head Epidemiology and Biostatistics Track, School of Health Systems and Public Health, Faculty of Health Sciences, University of Pretoria)
- o Mrs Andrea Roux (Information technologist)
- o Mrs Susan Scheepers (Information specialist)
- o Mr Peter van de Steenoven (Johnson Controls Automotive S.A. (Pty) Ltd)
- o Dr Bernard van Vuuren (Owner of Ergoways)
- o Dr M.E.J. van Zyl (Physician)

Table of contents

List of appendices

1. English summary of German study

2. Summary of literature

3. Data collection and capturing

4. Data coding

5. Ergonomic needs assessment form (PEIL)

6. Powerpoint presentation on basic back care

7. Power point presentation of TRIM training

8. Exercise programmes

9. Approval of ethics committee

10. Medical surveillance forms

List of Tables

List of figures

List of Pictures

List of abbreviations

BMI   Body mass index

CI   Confidence interval

ILBWU   International Ladies' Garment Workers Union

IRR   Incidence rate ratio

LBP   Low back pain

MSD   Musculoskeletal disorders

PEIL   Prevention early intervention list

RSI   Repetitive strain injury

SD   Standard deviation

USA   United Stated of America

WCPT   World Confederation for Physical Therapy

WHO   World Health Organization

WHP   Workplace Health Promotion

WRMSD   Work-related musculoskeletal disorder

WRUEMSD   Work-related upper extremity musculoskeletal disorder

EMG   Electromyogram

1. Orientation to the study

1.1 Introduction

"People work better on their feet than on their seat". A change in work posture from seated to stand-up, can improve employee health (Vercruyssen, Simonton 1994: 119). High volumes of sedentary activity – regardless the amount of physical activity - is not only related to the development of common chronic diseases (Owen, Bauman *et al*. 2009 81-83), but prolonged sitting is also a risk factor for all-cause mortality (Van der Ploeg, Chey *et al*. 2012 494).

"Work-related illness and injury constitutes a costly problem for workers, employers and society" (Baldwin 2004: 34). If companies are to increase profitability, managers need to maximise productivity and minimise medical costs (Pheasant 1991: 17). Likewise, if workers are to maintain the quality of their work and home life, they need to take responsibility for protecting their health. Furthermore, if healthcare is to alleviate disability, health professions must step beyond the clinics onto the 'real world' of industry and business. Cooperatively, productivity must be balanced with health, considering long-term gains versus short-term profit, and re-examining the value of work for the modern-day worker (Sanders 1997: 4).

As "employers play an important role in employee health" (Punnett, Wegman 2004: 22), evidence-based healthcare (regarding the impact of work posture on employee health), is indispensable (Bury, Mead 1998: vii). Although sitting time is detrimentally associated with several health outcomes (Alkhajah 2012: 298), including musculoskeletal pain (Schierhout, Meyers *et al*. 1995: 49), standing for prolonged periods, can cause both discomfort and pain in the lower legs (Lin, Chen *et al*. 2012: 965-970). Furthermore, prolonged sitting is also associated with obesity and diabetes, both known risk factors for work-related upper extremity disorders, i.e. carpal tunnel syndrome (Stallings, Kasdan *et al*. 1997: 211; Becker, Nora *et al*. 2002: 1429; Lam, Thurston 2008: 190; Roquelaure, Ha *et al*. 2009: 342). Therefore, when health intervention programmes focus on reducing sitting time (Roquelaure, Ha *et al*. 2009: 342; Van der Ploeg, Chey *et al*. 2012: 494), it is important for all the role players to

understand the association between personal, ergonomic and psychosocial risk factors and work-related musculoskeletal disorders (WRMSDs), amidst continued pressure in businesses to increase productivity in a safer and healthier work environment (Richardson, Eastlake 1994: 38-52; Wilson 2002: 12-20; Parks, Steelman 2008: 58-68)

Physiotherapists are trained to take a holistic approach to managing their patients with musculoskeletal disorders. This approach includes a natural progression from treatment to education, aimed at the prevention of recurrence of musculoskeletal disorders (MSDs) (Richardson, Eastlake 1994: 28-29). According to the declaration of principle of the World Confederation for Physical Therapy (WCPT) in 2009, the physiotherapy curriculum should equip physiotherapists to practise in a variety of healthcare settings, including, but not limited to, institutional, *industrial, occupational,* and primary health care environments in urban as well as rural communities. Therefore, prevention is an important part of the scope of practice of the occupational-health physiotherapist in a multidisciplinary team (Richardson, Eastlake 1994: 28-29).

According to Enderby, Iliot and Newham (1989) the occupational-health physiotherapist needs considerable clinical experience, to have confidence in herself, to be able to communicate with managers and be persuasive in justifying proposed recommendations for changes in working practices while understanding the cost implications of these changes. Therefore, her contribution in a multi-disciplinary team would inevitably involve more than just clinical treatment of a patient. A major part of her role is to educate and to prevent health problems. In order to deliver this responsible educative service in a multidisciplinary team, evidence-based healthcare is indispensable, as physiotherapists gain the additional confidence that accompanies an increased knowledge of the evidence base in their field when they use evidence to deliver an optimal service. Evidence is a tool with which to enter into partnerships with managers and other professionals to make shared decisions about appropriate interventions, i.e. the change in work posture (Bury, Mead 1998: vii).

The model for this study is therefore based on a clinical approach to prevention, treatment and rehabilitation, as described by Wilson (2002). Two models for treatment and management of the injured patient are described:

The first, the manual model: is a series of manual techniques based on the identification and removal of musculoskeletal dysfunction and the provision of manual techniques for the relief of pain. The second: the clinical-ergonomics model is based on looking at the cause of dysfunction and removing the inputs responsible for the injury process. (Wilson 2002: 71-72)

Clinical ergonomics is predominantly focussed on the individual, trying to optimize the synchronisation between people, their environment and the myriad of influences to which they are subjected: work-related and domestic, biomechanical, physiological and psychosocial. (Wilson 2002: xi)

For the purpose of the current study, manual therapy and clinical ergonomics are conceptualised as the combination of physiotherapy and ergonomics.

Part of the implementation of a work-based physiotherapy and ergonomics programme (hereafter referred to as "the programme") is the managing of risk factors. According to (Wilson 2002: 39-71), the risk factors of WRMSDs are threefold. They include personal, ergonomic and psychosocial risk factors. For the purpose of the current study, the following risk factors were included: firstly, the personal factors, including: age, gender, medical history, musculoskeletal history, and body mass index (BMI), and secondly, the ergonomic factors, including: posture, force, and duration of exposure to work. (See Figure 1.1.) The postural ergonomic risk factor included the change in work posture from sitting to standing (hereafter described to as "the intervention"). The psychosocial factors can include: monotonous work, lack of variety, machine-paced work, fear of job loss, high work load, time pressure, insufficient work breaks, low social support, and environment stress (lighting, noise, temperature and electromagnetic radiation) (Wilson 2002: 51-62) and are excluded from the current study. The associations between risk factors, change in work posture and WRMSDs – managed within the programme in a working setting are shown in Figure 1.1.
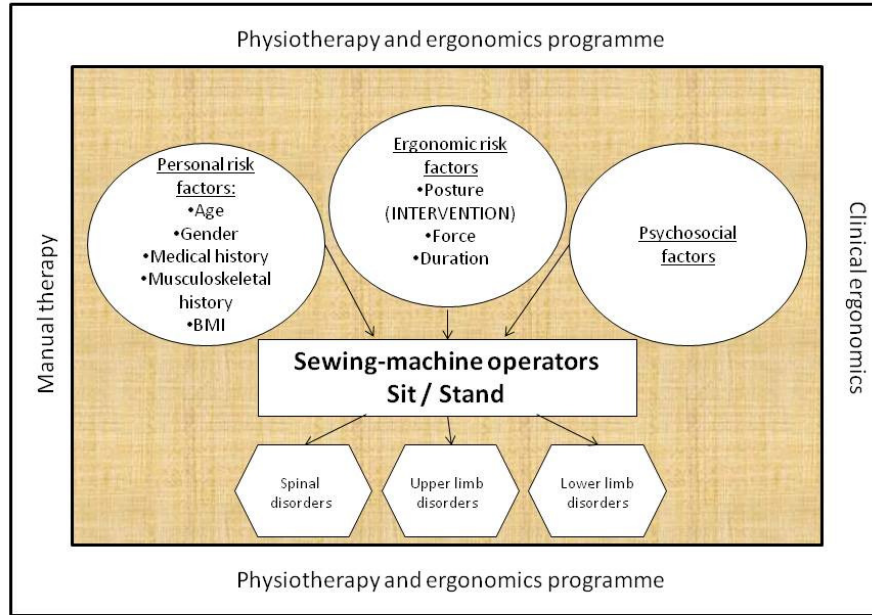
Figure 1.1 Conceptual framework based on (Wilson 2002). (Source: designed by the researcher)

In conclusion: clinical effectiveness is defined by the National Health Service as:

The extent to which clinical interventions, when deployed in the field for a particular patient or population, do what they are intended to do – i.e. maintain and improve health and secure the greatest possible health gain from the available resources (Bury, Mead 1998: 26-27).

Poor ergonomic design leads to poor work posture and is one of the factors that lead to WRMSDs. Poor ergonomics negatively influences company profit and employee health. Physiotherapists working in a multidisciplinary team can make a positive contribution towards the implementation of ergonomic principles. The impact of a change in work posture on WRMSDs can be determined by: 1) investigating the incidence of multiple WRMSDs, as well as in different anatomical areas of the body, e.g. the spinal area, the upper limbs and lower limbs; and 2) investigating the association between work posture, and personal- and ergonomic risk factors and WRMSDs. The incidence can be determined by documenting the number of newly diagnosed WRMSD's during the period of the study. The incidence is distinct from the prevalence, which refers to the number of cases alive on a certain date or over a period (Aldous, Rheeder et al. 2011: 25).

1.2 Background

The company, Johnson Controls, was established 126 years ago (1885), with their main focus on devices that control and regulate room temperature. In 2012, they served the building and automotive industries from three business units: building efficiency, automotive experience and power solutions, in more than 150 countries. They only started manufacturing automotive pro-ducts more than 80 years ago, and are a supplier of automotive seat foam, metal structures and mechanisms, trim, fabric and complete seat systems.

Globally Johnson Controls has 12 research-and-development centres and 30 manufacturing plants, producing 15 million seat sets for more than 200 million vehicles per year. The registered company name in South Africa is Johnson Controls Automotive S.A. (Pty) Ltd, and their four manufacturing plants operate in East London, Pretoria and two plants in Uitenhage. The current study was conducted in its car-seat manufacturing plant at 79 Waltloo road, Samcor Park, Silverton, Pretoria, 0127 (hereafter referred to as "the company"). The company commenced production in Pretoria during 1998, and employed administrative personnel and operators, including sewing-machine operators (hereafter referred to as "sewing-machine operators").

Health-promoting workplace programmes, including a work-based physiotherapy and ergonomics programme, were implemented in all the manufacturing plants globally and aimed at prevention and managing of WRMSDs. These programmes aimed to reduce the negative impact of risk factors on the incidence of WRMSDs, but also to improve health by rehabilitating injured employees.

As part of the programme, the health effects of standing and seated sewing work postures were investigated beforehand in Germany and thereafter, the stand-up work posture was implemented in all their manufacturing plants globally (See an English summary of the German investigation report, in Appendix 1.). This intervention and programme were implemented between June 2004 and January 2009 (hereafter referred to as "the period") among sewing-machine operators in the company, without an impact study to guide the company and the physiotherapist through the process of adaptation (towards the programme and the stand-up work posture).

1.3 The state of the existing research

International studies have been published on the change in work posture of sewing-machine operators, the implementation of similar programmes (models and outcomes), the incidence and prevalence of WRMSDs among sewing-machine operators, as well as suggestions for prevention and management of WRMSDs in the general working population. Unfortunately, most of them were done on sewing-machine operators with demo- and bio graphics that differ from the South African-sewing-machine-operator population – and most of the studies were conducted on sewing-machine operators working in the seated work posture. This gap in the literature is covered in Chapter Two and is discussed on the basis of the results of the current study in Chapter Five.

1.4 Statement of the problem

Many questions were asked by the company, sewing-machine operators (represented by the union) and the physiotherapist when the programme was implemented in June 2004 in the company's plant in Pretoria.

- o Do the personal and ergonomic risk factors of this South African sewing-machine operator population correspond to the populations in the mentioned studies?
- o How could the incidence of WRMSDs be described during the period of the study?
- o What was the association between individual risk factors (personal and ergonomic) and WRMSDs?
- o What was the association between work posture and WRMSDs adjusted for influential risk factors?

The answers to these questions would allow the implementation of evidence-based interventions, applicable to a South-African setting. The aim of the newly established programme should be to enhance health, prevent injuries, and increase the profitability of the company – however most of the questions were unanswered by the implementation team, whom faced some practical challenges.

As part of the implementation of the programme, the change of work posture caused opposition from the sewing-machine operators (who were represented by the union) towards management – who had no research-based answers from a South African setting. This created conflict between employee wellness (sewing-machine operators who experienced difficulty adjusting to a different work posture) and management's concern of ensuring profit to the company.

In spite of all these challenges, the change in work posture was implemented, and managed within the programme for the period of 4.5 years, and thereafter the sewing department was re-located to East-London (January 2009). At the time when the retrospective study was done (2011 to 2012), the unions (representing the sewing-machine operators in East London) required research-based answers again from the company's management in East–London, as to why the sewing-machine operators have to work in a stand-up work-posture. From this request it was observed that there was a need for reducing the "research-to-practice"-gap with regards to a better understanding of the postural demands among sewing-machine operators in a South-African setting. It was very important to document the whole implementation process, in order to advise all the role players in this particular environment later on the outcomes.

South Africa has its own unique background of high unemployment and uses a model of financing medical services amidst labour and security legislation. According to legislation, South African employers must accommodate workers in a safe work environment. Changing the work posture might impact WRMSDs, and implementing a programme could assist companies to optimise a safe work environment.

> Evidence-based health care is all about decision-making. (Bury, Mead 1998: 11)

The current study aimed to answer some questions on managing the impact of a change in work posture on WRMSDs among sewing-machine operators within a programme, in order to make recommendations for the future. The choice of a retrospective study design is therefore justified as the best method to gain insight into the answers to some of the questions posed at the beginning of this section. Therefore,

describing the impact of the change in work posture on the incidence of WRMSDs, as well as determining the association between risk factors and work posture, and WRMSDs among sewing-machine operators should lead to discussions and recommendations in order to advise other industries asking the same questions. This is the first study known to the researcher that describes and investigates an intervention of this nature among sewing-machine operators in South Africa.

1.7 Significance of the study

The findings from the study should contribute to a few sectors:

- o <u>To the company:</u> This is the only sewing company in South Africa known to the researcher where the sewing-machine operators worked in the stand-up work posture. The outcome of the current study could primarily provide answers about on musculoskeletal wellness in a South African setting, i.e. the impact of the change in work posture on WRMSDs to the company's management.

- o <u>To the sewing industry:</u> The implementation of the stand-up work posture is new to South African sewing-machine operators (who were represented by the union). Up to 2012, most research was done on sewing-machine operators in the seated work posture. From a health perspective, the whole industry may benefit if it can be shown that the stand-up work posture had a positive influence on the incidence of WRMSDs.

- o <u>To other industries:</u> If the change in work posture, managed within a programme, lead to a decrease in the incidence WRMSDs in sewing-machine operators in this car-seat manufacturing plant, other industries could also benefit when a similar change in work posture is managed in a programme.

- o <u>Physiotherapists:</u> The clinical environment in which the physiotherapist operates is fundamentally different from that in which the patients earn a living. The ideal is that the positive effect of rehabilitation will reach as far as the work station of the patient. The current study ought to create awareness within the physiotherapy profession of the need for clinical ergonomics in the

workplace. Lessons learnt in this setting could be applied to similar working environments.

The current study documents the benefits of an integral approach for injury prevention in a health-promoting work place.

1.8 The purpose of the study
The purpose of the study was to develop evidence for the company (management and the union representing the sewing-machine operators) and the physiotherapist by determining the impact of the change in work posture on the incidence of WRMSDs among sewing-machine operators, managed within a physiotherapy and ergonomics programme.

1.9 The aim of the study
The aim of the study was to determine the impact of the change in work posture on the incidence of WRMSDs (spinal, upper- and lower limb) among sewing-machine operators.

1.10 Objectives of the study
The objectives of the study were:

1. To describe the population in terms of personal and ergonomic risk factors.
2. To describe the incidence of WRMSDs for the period of the study.
3. To determine the association between individual risk factors (personal and ergonomic) and WRMSDs longitudinal.
4. To determine the association between work posture and WRMSDs adjusted for influential risk factors.

1.11 Outcome measures

Outcome measures of sewing-machine-operator health in the current study were:

- o   Incidence of WRMSDs

- o   Association of risk factors (personal and ergonomic) and WRMSDs

- o   Association of work posture and WRMSDs

1.12 Exposure of interest

The primary exposure variable is work posture

1.13 Clarification of key terms

Change in work posture

The work posture of the sewing-machine operators changed from seated to stand-up.

Company

Johnson Controls Automotive S.A. (Pty) Ltd is a car-seat manufacturing plant in Pretoria, where the retrospective study was conducted.

Ergonomics

Ergonomics is the scientific study of human work; therefore, the application of scientific information concerning human beings to the design of objects, systems and environments for human use (Pheasant 1991: 4). Ergonomics is also referred to as the science of matching the job to the worker and the product to the user. An effective match is one that optimises:

- o   Working efficiency (such as performance, productivity)
- o   Health and safety
- o   Comfort and ease of use (Pheasant 1991: 4).

Incidence

Incidence is the frequency with which something, such as a disease, appears in a particular population or area at a specified time. It is the rate of occurrence per population group. In disease epidemiology, the incidence is the number of newly diagnosed cases during a specific time period. The incidence is distinct from the prevalence, which refers to the number of cases alive on a certain date or over a period (Aldous, Rheeder *et al.* 2011: 24).

Period of the study

The period of the study refers to the period between June 2004 and January 2009, as this was the period when the impact of the change in work posture on WRMSDs was managed within the physiotherapy and ergonomics programme.

However, the retrospective study itself was conducted between 2011 and 2012, and these two years are not included in the period of the study (hereafter referred to as the data collection period).

Furthermore the 'full period' refers to the scenario where data on al 56 months were included. The 'reduced period' refers to the scenario where two groups of data were omitted. The first group was data on the first three months of the study (programme adaptation period), and the second group included data on the month that each sewing-machine operator changed his/her work posture and the consecutive month (postural adaptation period). These data were omitted to determine the effect of the change in work posture, and the implementation of the programme on the incidence of WRMSDs.

Work-based physiotherapy and ergonomics programme

The term programme will refer to the work-based physiotherapy and ergonomics programme, described in the current study. Physiotherapy (manual therapy) aims to minimise the effects of injuries and to reduce musculoskeletal dysfunction that may be exacerbating the symptoms or contributing to the injury. The clinical ergonomist aims to identify barriers to recovery (personal, ergonomic and psychosocial). The programme

assessed people's ability to function in their environment, and meet the demands of their environment and to minimise the risk of developing symptoms (Wilson 2002: xi).

Work-related musculoskeletal disorders

Work-related musculoskeletal disorders are disorders of the muscles, skeleton and related tissues which have been empirically shown or are suspected to have been caused by a workplace activity, particularly a repetitive activity that causes overuse of the tissues or lead to muscle atrophy (Pheasant 1991: 49). These disorders are therefore a heterogeneous group which includes numerous specific clinical entities, including disorders of the muscles and tendon sheaths, nerve entrapment syndromes, joint disorders and neurovascular disorders (Piligian, Herbert *et al*. 2000: 75). The diagnosis of musculoskeletal disorders is based on a physical examination, and work-relatedness is ascertained by relying on general principles of occupational medicine. These principles are: relation of symptoms to work, history of workplace exposures to ergonomic factors likely to contribute to the condition, presence of similar conditions among co-workers, presence of prior trauma to the affected body parts, and vocational activities that may cause or contribute to injury (Piligian, Herbert *et al*. 2000: 76).

Self-reported symptoms are frequently used in studies to determine musculoskeletal health status. As examination techniques that can serve as the 'golden standard' for many of the symptoms that are frequently reported in workplace studies still do not exist, symptom reports are highly correlated with physical findings of musculoskeletal disorders. "Cases defined by symptoms and by physical findings show very similar associations with ergonomics characteristics with the subjects' jobs." (Punnett, Wegman 2004: 15). Collins, Van Rensburg *et al*. confirms this by stating that "ninety per cent of all people purporting to suffer from low back pain have non-specific back pain." (2011: 241). These symptoms can include: pain, swelling, local tenderness, restricted range of movement due to pain, stiffness and/or weakness (Piligian, Herbert *et al.* 2000: 77-79). The symptoms of musculoskeletal disorders are often intermittent and episodic, especially in the early stages (Punnett, Wegman 2004: 15).

For the purpose of the current study, self-reported symptoms of work-related musculoskeletal disorders were divided into individual groups for spinal, upper limb and lower limb disorders, and combined in a multiple group of disorders where a sewing-machine operator had one or more than one disorder in a specific month.

1.14 Scope of the study

The scope of the study covered the personal and ergonomic risk factors, as well as work-related spinal, upper limb and lower limb disorders of the sewing-machine operators (Figure 1.1).

Furthermore, the scope of the study described the content of the programme in terms of the roles of the company, the physiotherapist and the sewing-machine operator as background to the intervention. No analysis of these data was done.

The scope did not cover psychosocial risk factors. All sewing-machine operators were subjected to personal - and work-related psychosocial factors and because of the retrospective design of the study and the fact that the programme was not designed to address these factors, no data were available on any psychosocial factors. All psychosocial risk factors were therefore excluded from the study,

As far as ergonomic risk factors are concerned, the design of the sewing machine, pedals, and chairs influencing posture or force was predetermined and none of these could be adjusted.

2. Literature review

2.1 Introduction

This literature review will report on the prevalence of WRMSDs among sewing-machine operators, applicable risk factors in this population, and the content of similar programmes (to the one that was implemented in the current study). Associations between risk factors and work posture, and WRMSDs will also be investigated.

Epidemiology of WRMSDs

Question 1: Are sewing-machine operators internationally and locally more at risk of developing WRMSDs than the rest of the working population?

Question 2: If sewing-machine operators are more at risk of developing WRMSDs than the rest of the working population, which disorders are more prevalent among sewing-machine operators?

Question 3: Which risk factors are causative to these WRMSDs among sewing-machine operators, and what are the associations between them?

Workplace programmes

Question 4: What are the components of the programmes developed to prevent and manage WRMSDs in the working-population?

Question 5: What are the outcomes of such programmes?

Question 6: What are the key determinants of such a programme?

Question 7: Has a programme been implemented in a sewing plant before?

Research methodology

Question 8: From a conceptual point of view: How should the current study be conducted?

As this is a retrospective study, the scope of the literature review was guided by the objectives of the study.

2.2 Literature search strategy for the dissertation

A comprehensive literature review – guided by the eight questions and the conceptual framework - was carried out using the search strategy described below.

Electronic and manual literature searches were conducted in order to identify available literature to select relevant resources for the review. The search was performed using EBSCHOHost, which included the CINAHL database, as well as Business Source Premier, and Family and Society Studies Worldwide, Medline (Ovid) and Science Direct as databases. The keywords are listed in Table 2.1. From the articles obtained, the researcher searched the reference lists for relevant articles as well

.

Table 2.1 Keywords for the literature search strategy

Concepts	Keywords
Employer/Company	
	Automotive industry, garment industry
Work-based physiotherapy-and-ergonomics programme	
	Occupational health programmes, prevention programmes, ergonomics programmes, education, prevention and control, rehabilitation, participatory ergonomics, ergonomics, health-care delivery.
Risk factors (personal, ergonomic and psychosocial)	
	Work posture, sedentary work posture, job rotation, work force, overtime, production volume, risk factors, and trends.
Employee	
	Sewing machinists, sewing-machine operators, industrial operators, garment workers, sedentary workers, sewing.
Disorders	
	WRMSDs, musculoskeletal disorders, cumulative trauma disorders, work-related upper-extremity/limb musculoskeletal disorders, repetitive strain disorders, diagnosis, neck pain, back pain, upper limb pain, lower limb pain.
Outcomes	
	Epidemiology

2.3 Discussion of the literature

The articles summarised in Appendix 2 are discussed below according to the eight questions asked at the beginning of this chapter and are answered in relation to the conceptual framework shown in Figure 1.1.

2.3.1 Epidemiology of WRMSDs

Question 1: Are sewing-machine operators internationally and locally more at risk of developing WRMSDs than the rest of the working population?

The international working population

Musculoskeletal disorders are a common complaint among the general working population (McDonald, DiBonaventura *et al.* 2011: 767; Kaergaard, Andersen 2000: 533). These disorders are often associated with significantly lower levels of health-related quality of life. Roquelaure, Ha *et al.* (2006: 765) agrees by stating: "Nonspecific upper-limb symptoms and specific upper-limb musculoskeletal disorders are common in the working population." This was the conclusion of a surveillance done on upper extremity musculoskeletal disorders in France among 2,685 men and woman representing almost all economic sectors and occupations in the salaried workforce. More than 50% of the population experienced nonspecific musculoskeletal symptoms during the preceding 12 months of the study. The most affected industries were manufacturing (including garment, shoe and leather industries) and public administration. Occupations with the highest prevalence rates were those employing unskilled industrial workers and agriculture workers of both genders, as well as material handlers, drivers, and employees of public services for men, and personal care employees for women. The study demonstrated wide variations in the prevalence rate of musculoskeletal disorders across economic sectors.

The local working population

In a cross-sectional analytical study conducted in 11 factories from seven sectors of manufacturing industries (mining excluded) in South Africa (n=401), exposure to workplace ergonomic stressors (repetition, force, static posture, dynamic posture and other job exposures) was assessed (Schierhout, Meyers *et al.* 1995: 46-50). Exposure was measured with an observational model developed for this purpose. The highest prevalence for neck and shoulder pain were found in the motor assembly, fruit packaging and clothing industries. Furthermore, the chicken processing and clothing factories had the highest prevalence of low back pain. Ergonomic exposures in the work place were significantly associated with musculoskeletal pain of the neck and shoulders for repetition, and for seated compared with standing work (Schierhout, Meyers *et al.* 1995: 48). Unfortunately, no mentioning was made of the specific work posture of the employees in the clothing industry.

The sewing population

Four studies compared the prevalence of musculoskeletal disorders among sewing-machine operators to another sector of the workforce (Brisson, Vinet *et al.* 1989: 323-328; Sokas, Spiegelman *et al.* 1989: 197-206; Tartaglia, Cinti *et al.* 1990: 39-44; Andersen, Gaardboe 1993: 677-687). In the first study (Brisson, Vinet *et al.* 1989: 326), an increased prevalence of disability (due to musculoskeletal and vascular diseases) among sewing-machine operators currently employed in Quebec (Canada) was documented. Furthermore, an increased prevalence of disability was also documented among sewing-machine operators that left the industry, compared to woman employed in clerical work, services and manufacturing industries. A limitation of the study was that the prevalence of severe disability might have been influenced by the availability of pension and other supports for illness.

The outcome of the second study (Sokas, Spiegelman *et al.* 1989: 197-206) was that sewing-machine operators (members of the ILBWU in the USA) had more back pain lasting six weeks or longer compared to the control group (general population). The sewing-machine operators also complained of ache and swelling of the upper and lower limbs. The shortcoming of this study is that the sewing-machine operators in this study were not representative of the industry as a whole, in that they were all literate in English, and that they were invited to participate at a weekend seminar on health promotion on the basis of union activism and may be more aware of the possible work relatedness of disease because of this activism.

In the third study, carried out in Italy (Tartaglia, Cinti *et al.* 1990: 39-44), the results indicated that sewing-machine operators had a greater risk of contracting spinal disorders than the control population matched for gender and age, and the fourth study also showed that production workers – mainly sewing-machine operators – had significant higher scores with respect to musculoskeletal disorders (95%) compared to the group with more varied tasks (71%) in Norway (Andersen, Gaardboe 1993: 677-687).

The conclusion is that musculoskeletal disorders are common among the general working population, but the prevalence rates of these disorders might be higher among sewing-machine operators, internationally and local.

Question 2: If sewing-machine operators are more at risk of developing WRMSDs than the rest of the working population, which disorders are more prevalent among sewing-machine operators?

It was difficult to make comparisons between musculoskeletal studies, because the measures used in the different studies were not always consistent. Some studies used self-reported medical symptoms, while others studies used a clinical/medical diagnosis. Both measures were taken into account for the purpose of this literature review.

No explanation was found in literature on the specific anatomy regarding joints or muscle groups included/excluded from the four groups listed in Table 2.2. Table 2.2 summarises the categories of musculoskeletal disorders found in the literature, compared to the categories in the conceptual framework (Figure 1.1). For the purpose of the literature review in this chapter, the articles will be discussed according to these four groups of disorders found in the literature (Table 2.2).

Table 2.2 Groups of musculoskeletal disorders as found in literature, compared to the conceptual framework (figure 1.1)

Groups of musculoskeletal disorders found in literature:	Groups of disorders in conceptual framework (figure 1):
1. Neck-and-shoulder area	1. Spinal
2. Upper limb	2. Upper limb
3. Lower back pain or back pain	3. Lower limb
4. Lower limb	

The biomechanics of the seated work posture vary substantially to those of the stand-up work posture, and should be noted when the articles below are discussed, as these biomechanics might have had an influence on the prevalence of injuries (Halpern, Dawson 1997: 429-440).

Neck-and-shoulder area

Seven studies reported on the prevalence of musculoskeletal disorders of the neck-and-shoulder areas of sewing-machine operators. It was interesting to note that three of the studies summarised below were conducted among sewing-machine operators working in a seated posture. Unfortunately the other four did not mention work posture.

The first 'seated' study was a randomised controlled trial conducted by Westgaard and Jansen (1992: 156). The sewing-machine operators had 71% more complaints of the head, neck, shoulders and arms than the secretaries. The other two 'seated' studies that published the prevalence of disorders in a group of sewing-machine operators were cross-sectional surveys. In the second 'seated'-study, Blåder, Barck-Holst *et al.* (1991: 251-257) investigated the frequency of neck-shoulder disorders in a population of sewing-machine operators in Sweden, and clinically examined those who screened positively in order to describe the picture behind the complaints. The prevalence rate of neck-shoulder complaints during the previous 12 months was 75%, the previous seven days 51% and daily problems were experienced by 26% of the sewing-machine operators (1991: 252). Gender of the sewing-machine operators was not mentioned in the article. In the third 'seated' study, Wang, Rempel *et al.* (2007: 806-813) determined that the prevalence among the Los Angeles sewing-machine operators for moderate/severe musculoskeletal pain in the neck/shoulder region was 24.0%.

The following three international studies did not mention work posture. Firstly, only the abstract of the study of Serratos-Perez, Mendiola-Anda (1993: 793-800) was available in the university library. The prevalence rate of musculoskeletal disorders among male Mexican sewing-machine operators in eight shoe factories was investigated. The rate of musculoskeletal disorders was 47.5%. Of sewing-machine operators working on the column-type machines, 14% had shoulder pain (three times more frequent among column-machine operators), and 4.9% of sewing-machine operators working on flat machines had neck pain. In the second study, Kaergaard and Andersen (2000: 528-534) reported on a comparative study carried out on female sewing-machine operators and woman in a control group with varied non-repetitive work in Denmark. At baseline, the overall prevalence of two neck-shoulder disorders, myofascial pain syndrome and

rotator cuff tendinitis, was 15.2% and 5.8% among sewing-machine operators compared with 9.0% and 2.2% respectively, among controls. Lastly, Andersen and Gaardboe (1993: 689-700) conducted a clinical epidemiological study among sewing-machine operators in Denmark. The results indicated a highly significant trend for chronic neck, shoulder and neck/or shoulder pain, while only a tendency was shown for elbow, forearm/wrist and hands.

The seventh study was conducted in South Africa, and confirmed the results of the previous studies, by reporting that the highest prevalences of pain in the neck and shoulders were found among employees in the motor industry, fruit packaging and clothing industries (Schierhout, Meyers *et al.* 1995: 48).

With these high prevalence rates (some more than 70%), one must bear in mind that sewing-machine operators who have experienced persistent pain in the neck and/or shoulders might be expected to be more willing to answer questionnaires than those who have not suffered from pain (Andersen, Gaardboe 1993: 683).

Upper limb

In an epidemiological surveillance of upper extremity musculoskeletal disorders in the working population in France (Roquelaure, Ha *et al.* 2006: 765-778) the most common upper extremity musculoskeletal disorder among this working population, was rotator cuff syndrome (6.8% in men and 9.0% in women), followed by carpal tunnel syndrome (2.3% in men and 4.0% in women) and lateral epicondylitis (2.2% in men and 2.7% in women).

Four studies were found on the prevalence of upper limb disorders specifically among sewing-machine operators. Three studies were conducted on sewing-machine operators working in seated work stations, and in one study (Mostert-Wentzel, Grobler *et al.* 2010: 6-18) the sewing-machine operators gradually changed their work posture during the study period.

In the first study, Sokas, Spiegelman *et al.* (1989: 187-206) conducted a comparative study of sewing-machine operators (active or retired members of the ILGWU) compared

to a matched segment of the general population. These sewing-machine operators complained significantly more of ache and swelling of the fingers, wrists, shoulders elbows and feet than the controls. The sewing-machine operators also complained of: elbow ache, foot swelling and knee pain and – swelling.

In the second study, Vézina, Tierney *et al.* (1992: 268-276) conducted interviews with ten sewing-machine operators in a trouser manufacturing plant in Quebec, Canada, after ergonomic analysis of their work stations. During these interviews, 90% of the sewing-machine operators reported suffering from shoulder pain at the end of the day.

Thirdly, in a more recent study, Wang, Rempel *et al.* (2007: 806-813) reported the results of a cross sectional study of self-reported musculoskeletal symptoms among sewing-machine operators. Face-to-face interviews to assess the association between work organisational factors and the prevalence of musculoskeletal pain among 520 sewing-machine operators from 13 garment shops in Los Angeles were conducted, and the prevalence of moderate/severe musculoskeletal pain for the distal extremity was 15.8%.

Fourthly, the results of the study of Mostert-Wentzel, Grobler *et al.* (2010: 6-18) answered the question on specific injuries to the upper limb in more detail. The study was conducted on the same population of sewing-machine operators as in the current study, and mentioned specific WRUEMSDs; i.e. carpal tunnel syndrome, muscle spasm (thumb, triceps muscle), medial epicondylitis, lateral epicondylitis, finger injuries (tendonitis of the indicis muscle), tendonitis of the biceps muscle, de Quervian tendonitis, tenosynovitis (shoulder) and tendonitis of the forearm muscles.

The conclusion of these studies was that upper limb disorders are highly prevalent among the working population, but even more so among sewing-machine operators.

Lower-back or back pain

Five articles were found on the prevalence of lower-back pain, or back pain among sewing-machine operators. Four of the five studies mentioned the seated work posture, and for the fifth study of Serratos-Perez, Mendiola-Anda (1993: 793-800), work posture was not mentioned. The prevalence of LBP in the latter study was 18.2%, and 14% for

pain in the back-as-a-whole (for the 143 Mexican male sewing-machine operators in the shoe manufacturing industry).

Of the four 'seated' studies found, findings from three researchers agreed on the outcome of a high prevalence of back disorders among sewing-machine operators. The first 'seated' study was done as a cross-sectional study. A group of 144 sewing-machine operators (active or retired members of the ILGWU) was compared with 62 controls in the general population, and the sewing-machine operators had significantly more back pain lasting six weeks or longer than the controls (Sokas, Spiegelman *et al.* 1989: 197-206). The second 'seated' study was published by Tartaglia, Cinti *et al.* (1990: 39-44) in the Italian language, and the abstract was available in English. A sample of female sewing-machine operators was compared to a control group (occupation unknown) matched for gender and age, and a greater risk for contracting spinal disorders was found among the sewing-machine operators, compared to the controls. The third 'seated' study of Westgaard and Jansen (1992: 154-162) was mentioned under the *Neck-and-shoulder area* paragraph. Although the Norwegian sewing-machine operators had significant higher scores than the controls with respect to self-reported musculoskeletal complaints of the head, neck, shoulders and arms, it was not the case for the lower back, hips and lower extremities. Lastly, Sealetsa and Thatcher conducted a 'seated' study in Botswana to identify possible ergonomics deficiencies of sewing-machine operators (2011: 279-289). The baseline data reflected that there were more complaints in the lower back, upper back and mid-back followed by complaints in the shoulders, neck and legs. Therefore, back, neck and shoulder discomfort was highly prevalent among these sewing-machine operators.

Furthermore, in the cross sectional study conducted in South Africa (the study was mentioned under the *local working population* paragraph of question 1), low back pain was mentioned as being more prevalent among the chicken processing and clothing factories, compared to seven other sectors of manufacturing industry (Schierhout, Meyers *et al.* 1995: 48).

Therefore, most of the authors agree on the conclusion that spinal disorders are highly prevalent among certain groups of sewing-machine operators.

Lower limb

Due to the nature of sewing, manually feeding the sewing machine with material, and controlling pedals with feet, Vézina, Tierney *et al.* (1992: 268-276) did a study to describe the components of physical load in sewing. After an ergonomic analysis and interviews were done on ten seated sewing-machine operators in a trouser manufacturing plant, they found that the lower limbs exerted an average of 24 267.9 kg per day with their legs. A literature review was therefore done to determine the impact of sewing as an occupation on the prevalence of lower limb disorders in sewing-machine operators. Two articles were found as part of the review on the prevalence of lower limb disorders among sewing-machine operators, and both mentioned the seated work posture. The first study was cross-sectional. Sokas, Spiegelman *et al.* (1989: 197-206) concluded that seated sewing-machine operators complained more often of knee pain (left and right) than a control group in the general population. Knee swelling was noted more often among sewing-machine operators, although they were not more likely to have undergone knee surgery than were controls. The second study of Westgaard and Jansen (1992: 154-162) has already been mentioned under the *Neck-and-shoulder area,* and *lower-back or back pain* paragraphs. Although the Norwegian sewing-machine operators had significant higher scores than the controls with respect to self-reported musculoskeletal complaints of the head, neck, shoulders and arms, it was not the case for the lower back, hips and lower extremities.

It seems that there are more published studies on spinal- and upper limb disorders than on lower limb disorders. One might derive that the prevalence of upper limb and spinal disorders is higher than for lower limbs, but it does not necessary mean that there is no prevalence of lower limb disorders.

Question 3: Which risk factors are causative to these WRMSDs among sewing-machine operators, and what are the associations between them?

According to Wilson (2002: 39-63), the risk factors of WRMSDs are threefold. (See Figure 1.1.) Firstly, the personal factors in Wilson's (2002) study included: age, gender, medical history, musculoskeletal history, fitness level, physical characteristics,

anatomical variations, smoking and personality. Secondly, the ergonomic factors, included: posture, force, and duration of exposure to work. In the third place, the psychosocial factors, included: monotonous work, lack of variety, machine-paced work, fear of job loss, high work load, time pressure, insufficient work breaks and low social support, and environment stress (lighting, noise, temperature and electromagnetic radiation). Studies found on these factors are summarised below.

As all three categories of risk factors influence the prevalence of musculoskeletal disorders individually and jointly, a literature search was conducted to cover all.

Personal risk factors
Age

The correlation between age as a risk factor and musculoskeletal disorders is not the same on all parts of the body. In a randomised controlled study done in Norway on production workers (mainly seated sewing-machine operators) it was found that the upper three body regions had the same symptom level at all ages, the lower back had a negative correlation, and the lower limb had a positive correlation with age (Westgaard, Jansen 1992: 154-162).

Age (more than 40 years) was found to be a contributory risk factor for neck pain as well as shoulder pain (even though not significant at the chosen level for shoulder pain) among garment workers in Denmark (Andersen, Gaardboe 1993: 677-687) but, among other factors, the elevated prevalence of upper body pain was also associated with age of less than 30 years among sewing-machine operators in Los Angeles (Wang, Rempel *et al.* 2007: 806-813).

Not all researchers agreed that age is a contributory risk factor to musculoskeletal disorders among the general population. One example was a case controlled study conducted in Sweden by Ekberg, Bjorkqvist *et al.* (1994: 262-266). It was concluded that among other factors, age was not associated with neck disease for these musculoskeletal patients. Although the current study was not done on sewing-machine operators, it was still worth mentioning as this study was conducted in a working population.

It was therefore not a foregone conclusion that age is a risk factor for musculoskeletal disorders. Length of employment as a sewing-machine operator should also be considered when age as a risk factor is investigated.

Gender

In a South African study on the general working population, Schierhout, Meyers *et al.* (1995: 48) concluded that gender (being a man) was a significant contributor to pain in the wrists and hands. Men working in the seated posture had a higher prevalence of pain in the wrists and hands than woman. Furthermore, woman had a higher prevalence of regional pain (pain in the neck and shoulders, and back pain) in seated, mixed and standing work than men (Schierhout, Meyers *et al*. 1995: 48). One has to bear in mind that woman tend to report pain more than men, and that the healthy worker effect might have influenced the results (in the healthy worker effect is when workers with problems in the hands and wrists were disabled for their work) (Schierhout, Meyers *et al*. 1995: 49). In contrast with Schierhout, Meyers *et al.* (1995: 48), Ekberg, Bjorkqvist *et al.* (1994: 264) reported that among other factors, female gender is associated with a higher prevalence of neck and shoulder disorders among the general population in Sweden.

With the results of the previously mentioned studies in mind, the outcome of the study of Serratos-Perez, Mendiola-Anda (1993: 793-800) on the prevalence of musculoskeletal disorders among sewing-machine operators in shoemaking in Mexico is interesting. In this group of male sewing-machine operators, the prevalence of spinal and upper limb disorders was lower than those reported by other authors who previously studied (mostly female) sewing-machine operators.

Lastly, in an epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population in France, Roquelaure, Ha *et al.* (2006: 765-778) found the prevalence rate for upper-extremity musculoskeletal disorders in the working population was high for both genders.

In conclusion, it was not generally accepted that female gender is a risk factor for musculoskeletal disorders, as other factors (such as parenting) should also be considered when gender as a risk factor is investigated.

Medical history

A few risk factors for musculoskeletal disorders were mentioned in literature. In the first place, Brisson, Vinet *et al.* (1989: 323-328) found an increased prevalence of disability among sewing-machine operators who had left employment due to musculoskeletal-, cardiovascular- and other diseases combined, compared to women employed in other industries. This finding leads to the question of causative risk factors (regarding medical history) for musculoskeletal pain.

Adverse psychosocial work- environment was associated with increased catabolic metabolism (Hansen, Kaergaard *et al.* 2003: 264-276). This finding could contribute to other findings: Firstly, Wang, Rempel *et al.* (2007: 806-813) found that among other factors, systemic illness (no mention was made of specific illnesses) was associated with the elevated prevalence of upper body pain and no association was found between a high BMI and upper body musculoskeletal disorders among sewing-machine operators. Secondly, arthritis was also found to be associated with significantly lower levels of health-related quality of life among patients with back and fibromyalgia pain (McDonald, DiBonaventura *et al.* 2011: 765-769). In the third place, smoking was significantly associated with disease of the neck and shoulders (Ekberg, Bjorkqvist *et al.* 1994: 262-266) and, lastly, Wilson (2002: 39-63) included medical history as a personal risk factor for musculoskeletal disorders.

In conclusion, certain systemic illnesses (including obesity) might contribute to the prevalence of musculoskeletal disorders among sewing-machine operators.

Musculoskeletal history

Wilson (2002: 39-63), mentioned "previous injury to the musculoskeletal system'" as a personal risk factor to WRMSDs. This correlation between musculoskeletal history and WRMSDs correlated with Westgaard and Jansen's (1992: 158) opinion ten years earlier

that: "Workers who have suffered symptoms before employment may have established a health condition at the time of employment that makes them particularly susceptible to similar injuries at the workplace." Two more studies were in unison with this finding. Firstly, Kaergaard and Andersen (2000: 529-534) found that besides other factors, the risk of having a neck-shoulder disorder at baseline was significantly associated with high stress among sewing-machine operators. Secondly, Wang, Rempel *et al.* (2007: 806-813) concluded that among other factors, the elevated prevalence of upper body pain was associated with having a diagnosis of musculoskeletal disorders before.

In conclusion, musculoskeletal history is a risk factor for musculoskeletal disorders.

Fitness level

Fitness level can be protective to musculoskeletal disorders, but the level should be specified. Ekberg, Bjorkqvist *et al.* (1994: 262-266) concluded that among other factors, exercise of less than five hours per week seemed preventive, whereas exercise of more than five hours per week was significantly associated with disease in the neck and shoulders for musculoskeletal patients in the general population in Sweden.

On the other hand, in a historical follow-up investigation on a dynamic cohort of garment-industry workers in Denmark, the hypothesis of exercise as a protecting factor was not confirmed (Andersen, Gaardboe 1993: 677-687).

In conclusion, when fitness level is investigated as a possible risk factor for musculoskeletal disorders, the level of fitness should be specified.

Length of employment

Four studies were found on employed sewing-machine operators. In the first place, Andersen and Gaardboe (1993: 689-700) found a positive exposure-response relationship between years of employment as a sewing-machine operator and the prevalence of persistent neck and upper limb pain. Work for more than eight years as a sewing-machine operator probably had a cumulative deleterious effect on the neck and shoulders, for currently employed sewing-machine operators as well as for formerly employed sewing-machine operators (Andersen, Gaardboe 1993: 677-687). A second

study confirmed this finding, with a U-shaped association between years of employment and myofascial pain syndrome, as well as a linear trend between duration of employment and rotator cuff tendinitis (Kaergaard, Andersen 2000: 528-534). Thirdly, Wang, Rempel *et al.* (2007: 806-813) confirmed that among other factors, the elevated prevalence of upper body pain was associated with age less than 30 years, and working as a sewing-machine operator more than 10 years. Prevalence rates of WRMSDs were higher among the sewing-machine operators older than 45 years, but there was not a trend of increasing pain with increasing age.

In the fourth study, Schibye, Skov *et al.* (1995: 427-434) reported that sewing-machine operators with musculoskeletal symptoms of the neck and shoulders who quitted sewing were more likely to be relieved of their symptoms than were symptomatic sewing-machine operators who continued sewing. Therefore, the results demonstrated that neck and shoulder disorders in sewing-machine operators were reversible and may be influenced by reallocation to other work tasks.

In conclusion, length of employment should be acknowledged as a possible risk factor for musculoskeletal disorders. Specific attention should be given to newly employed sewing-machine operators, as well as sewing-machine operators employed for longer than eight years.

Parenting

When investigating parenting as a possible risk factor for musculoskeletal disorders, the first question asked was regarding marital status. Wang, Rempel *et al.* (2007: 806-813) concluded that among other factors, the elevated prevalence of upper body pain in Los Angeles sewing-machine operators was associated with 'being single'. 'Being single' was compared to 'being married' and 'living with a spouse'. No relationship was found between pain and 'having children at home'. Ekberg, Bjorkqvist *et al.* (1994: 262-266) were of the same opinion, 13 years before in Denmark when they concluded that, among other factors, 'having pre-school children' was not associated with neck disease for the musculoskeletal patients.

On the other hand, Andersen and Gaardboe (1993: 677-687) found that 'having children' was a significant factor in sewing-machine operators with shoulder pain in Denmark. Seven years later, Kaergaard and Andersen (2000: 528-534) agreed to this, based on the finding that among other factors, 'woman living alone with children' had a higher risk of contracting neck-shoulder disorders.

In conclusion, 'being single', 'having children' or being a 'woman living alone with children' can be a confounding factor to the development of WRMSDs.

Ergonomic risk factors
Posture

The literature review was specifically aimed at distinguishing between sewing-machine operators working in a seated work posture and those working in a stand-up work posture.

o *Seated work posture*

Tartaglia, Cinti *et al.* (1990: 39-44) concluded that: "The cause of spinal disorders appeared to be due to the fact that the sewing work station could not be adjusted to the anthropometric requirements of the individual, and also because the seated position is maintained for long periods." Blåder, Barck-Holst *et al.* (1991: 39-44) conducted a descriptive study on seated sewing-machine operators and agreed with Tartaglia, Cinti *et al.* (1990: 39-44) by concluding: "In spite of possible psychosocial and work-environmental factors it seems obvious that the work position per se among sewing-machine operators increases the risk for symptoms from the neck and shoulder". When the work posture of a sewing-machine operator is analysed, attention must be given to the furniture, and the subsequent posture.

In the first place, the furniture for a sewing workstation was described as: a chair with little adjustability (Halpern, Dawson 1997: 429-440; Rempel, Wang *et al.* 2007: 931-938; Wang, Ritz *et al.* 2008: 255-262; Sealetsa, Thatcher 2011: 279-289) and pedals operated either with the feet (Halpern, Dawson 1997: 429-440), or the right thigh

(Sokas, Spiegelman *et al.* 1989: 197-206). Only one study mentioned a height adjustable table for a seated work station (Westgaard, Jansen 1992: 154-162).

Secondly, it was inevitable that this ergonomically unsound furniture would lead to a poor work posture. Postures were described as a forward upper body posture with arms lower and moderately extended in front of the body, upper back curved and head bent over the sewing machine (Westgaard, Jansen 1992: 154-162). Movement of the upper limbs involved abduction and adduction of the shoulders while exerting force (Vézina, Tierney *et al.* 1992: 268-276). Operation of the knee pedal required lateral motion of the right thigh and pressure on a pedal that might be provided by the patella or the lateral thigh (Sokas, Spiegelman *et al.* 1989: 197-206). Sewing-machine operators that worked on chairs that were too low for their anthropometrical dimensions, retained hunched postures. On the other hand, sewing-machine operators that had their seats raised by cones underneath chair legs, or sat on pillows in an effort to increase the chair height, had their necks bent excessively to the 'now relatively low table' and on top of that, their pedal reach distance was seriously compromised (because their feet could not reach the floor) (Sealetsa, Thatcher 2011: 279-289).

Two studies were carried out to evaluate the effect of new task chairs on shoulder and neck pain (Rempel, Wang *et al.* 2007: 932-938), as well as on back and hip pain among sewing-machine operators (Wang, Ritz *et al.* 2008: 255-262). The results of these studies indicated that an adjustable-height task chair with a curved seat pan could reduce neck and shoulder pain severity (Rempel, Wang *et al.* 2007: 931-938) and that a height adjustable task chair with a swivel function could reduce back and hip pain in sewing-machine operators (Wang, Ritz *et al.* 2008: 255-262).

In conclusion, causative factors of WRMSDs in a seated work station might be incorrect table- and chair heights, non-adjustable equipment, or the seated posture per se.

o *Stand-up work posture*

Few studies mentioned the stand-up work posture among sewing-machine operators. Mostert-Wentzel, Grobler *et al.* (2010: 14) did a study to determine the effect of a work-based physiotherapy and ergonomics programme on WRUEMSDs in the same

population as the current study for the period of June 2004 to September 2007. The individual stand-up dates of sewing-machine operators were not captured, therefore the impact of the postural change on WRUEMSDs could not be determined.

A possible explanation for the prevalence of musculoskeletal disorders was provided by Ekberg, Bjorkqvist *et al.* (1994: 262-266) after conducting a case-controlled study in the general population in Sweden. It was concluded, that among other factors:

> …long durations of uncomfortable sitting and work with lifted arms were significant determinants for neck and shoulder disease, compared to the larger group. To work standing in uncomfortable positions, monotonous work positions, and physically demanding work (heavy lifting) were not significant determinants for disease in the neck and shoulders.

This positive effect of sewing in a stand-up posture, on the neck and back, was confirmed by Schierhout, Meyers *et al.* (1995: 46-50) and Halpern and Dawson (1997: 429-440). Schierhout, Meyers *et al.* (1995: 48) reported that seated rather than standing work, were significantly associated with pain of the neck and shoulders in the working population in South Africa (1995: 49). Furthermore, Halpern and Dawson reported on the design, implementation and ultimately the performance of a participatory programme in an automobile-accessories manufacturing plant in the USA (1997: 429-440). During the initial worksite analysis, the risk factors of excessive reaching, twisting and bending were identified frequently among seated sewing-machine operators. While seated, the sewing-machine operators usually adopted a forward flexed torso and neck posture (similar to the postures described in the studies of Sokas, Spiegelman *et al.* (1989: 197-206); Vézina, Tierney *et al.* (1992: 268-276); Westgaard and Jansen (1992: 154-162); Sealetsa and Thatcher (2011: 279-289), and did not use their backrest. The chairs themselves had little adjustability (similar to the chairs of the control groups as described in the studies of Rempel, Wang *et al.* (2007: 931-938), Wang, Ritz *et al.* (2008: 255-262), and the chairs in the Botswana study of Sealetsa and Thatcher (2011: 279-289). As part of the implementation of the automobile-accessories manufacturing plant's participatory programme, the sewing operations were converted from sit-down to primarily stand-up operations, leading to

improved posture of the torso and back. The results of the programme were determined by the 85% decrease in the number of musculoskeletal disorders, and an overall reduction in workers' compensation incurred loss costs by approximately 42% (Halpern, Dawson 1997: 429-440).

In conclusion, it seems that a stand-up work posture should lead to a lower prevalence of musculoskeletal disorders than a seated work posture.

Force

Difficult levels of work are often associated with the lifting of heavy objects and performing dynamic movements – compared to a sewing-machine operator traditionally working in a seated posture, manipulating light weights. This stereotype could easily lead to the conclusion that sewing is light work in terms of energy expenditure (Vézina, Tierney *et al.* 1992: 268). The question asked, is: 'Why do sewing-machine operators have such a high prevalence of musculoskeletal disorders?' An ergonomic analysis was undertaken in a trouser factory and the results indicated that these ten seated participants (sewing-machine operators) lifted an average of 406.1 kg of trousers, exerted an average total force of 2 858.4 kg with the upper limbs and 24 267.9 kg with the lower limbs each, per day (Vézina, Tierney *et al.* 1992: 268-276). In connection hereto, Ekberg, Bjorkqvist *et al.* (1994: 262-266) concluded that even light lifting was a strong determinant for neck and shoulder disease.

Furthermore, two electromyogram (EMG) studies performed on the neck-shoulder areas of sewing-machine operators were found. In the first study, Jensen, Schibye *et al.* (1993: 467-475) assessed physiological responses of 29 sewing-machine operators to physical work, and determined that industrial sewing-machine work fatigues the shoulder and neck regions, and that static shoulder muscle load was independent of muscle strength. Secondly, the EMG study conducted by Zhang, He *et al.* (2011: 3731-3737) on 18 sewing-machine operators confirmed these results by concluding that: "Female sewing machine operators were exposed to high sustained static load on bilateral neck-shoulder muscles."

As work posture (seated or stand-up) was not mentioned in either of these two EMG studies, the findings cannot be incorporated into the clinical reasoning on the influence of postural changes on the prevalence of neck and shoulder disorders among sewing-machine operators in the current study.

In conclusion, the high physical workloads should be considered when treating sewing-machine operators as patients or planning workplace interventions for managing work-related disorders among sewing-machine operators (Wang, Harrison *et al.* 2010: 352-360).

Duration

Among other factors, "repetitive movement demanding precision is a significant physical determinant with a dose-response relation showing higher risks for neck and shoulder disease for higher degrees of exposure." (Ekberg, Bjorkqvist *et al.* 1994: 262-266). Schierhout, Meyers *et al.* (1995: 49) agreed to this statement, by stating: "repetitive work were significantly associated with pain in the neck and shoulder". Therefore, when investigating the influence of repetition as a risk factor on the prevalence of musculoskeletal disorders among sewing-machine operators, two recommendations are mentioned in the literature; i.e. to reduce work hours, and to implement job rotation.

- o *Overtime*

  A positive correlation between the tension neck syndrome and working hours per week suggest a daily prolonged static load on the neck and shoulder to be of importance for neck-shoulder problems among sewing-machine operators. The study also indicated the importance of exposure time correlated to the seriousness of the neck and shoulder complaints among the sewing-machine operators. (Blåder, Barck-Holst *et al.* 1991: 251-257)

Wang, Rempel *et al.* (2007: 806-813) did not agree with the correlation in this statement. An assessment was made on the contribution of work-organisational and personal factors to the prevalence of WRMSDs among sewing-machine operators, and it was found that the number of hours or number of days worked per week as singular

measures were not as strongly associated with upper body disorders, as with neck-shoulder disorders.

Although there is no consensus in the literature regarding the relationship between overtime and the prevalence of musculoskeletal disorders among sewing-machine operators, the conclusion is: "having less overtime should be considered when treating patients or planning workplace interventions for managing work-related disorders in this underserved immigrant population." (Wang, Harrison *et al.* 2010: 352-360)

o *Job rotation*

Although job rotation is a common suggestion in order to reduce and vary repetitive monotonous work, it is easier said than done. The advantage of job rotation lays in the possibility for relaxation of muscles involved during the action of sewing. Rotating between different sewing machines, or changing between different products is not enough.

> To obtain a real change in working positions, the real working process has to be reorganised, including varying tasks for the sewing-machine operator. Otherwise relaxation will be achieved only by making possible frequent short rest periods for optimum endurance time. (Blåder, Barck-Holst *et al.* 1991: 251-257)

The association between the implementation of a job-rotation policy and the incidence or prevalence of WRMSDs among sewing-machine operators was not pertinently mentioned in any study. Mostert-Wentzel, Grobler *et al.* (2010: 14) conducted a study on the same population as the population of the current study, evaluating the effect of a work-based physiotherapy and ergonomics programme of WRUEMSDs from June 2004 to September 2007. According to them, job rotation was fully implemented in October 2005, but no association with the incidence of WRUEMSDs could be determined. Sealetsa and Thatcher (2011: 283) in Botswana pertinently mentioned that the factory had "no formal policy on job rotation".

Psychosocial risk factors

Although the relationship between psychosocial risk factors and the incidence of WRMSDs is not part of the current study, these factors cannot be ignored as a contributing factor for WRMSDs.

"Work-environment factors influence mood, bodily tension and somatic symptoms and load on the loco motor system." (Theorell, Harms-Ringdahl *et al.* 1991: 165-173). Work-related psychosocial factors that influenced health (specifically the frequency of musculoskeletal disorders) in the general population include:

- o Opportunity to influence decisions plays an important and more direct role in abseentism for sick leave (Theorell, Harms-Ringdahl *et al.* 1991: 165-173).
- o Lack of stimulation and variation in the job are associated with neck disease (Ekberg, Bjorkqvist *et al.* 1994: 262-266).
- o High quantitative job demands, poor social support from co-workers, low job control, low skill discretion, and low job satisfaction have a positive relationship with neck pain (Ariens, van Mechelen *et al.* 2001: 180-193).
- o Adverse psychosocial work environment was associated with increased catabolic metabolism (Hansen, Kaergaard *et al.* 2003: 264-276).

The mechanism that accounts for possible associations between psychosocial factors and musculoskeletal disorders might be: 1) psychosocial demands that exceed an individual's coping capabilities resulting in a stress response, producing muscle tension; 2) psychosocial demands that affect (increase) the awareness and reporting of musculoskeletal disorders; or 3) in a certain situation, psychosocial demands that correlate with physical demands (Ariens, van Mechelen *et al.* 2001: 190).

Although many authors emphasise the influence of psychosocial risk factors on WRMSDs, the results of Feuerstein, Nicholas *et al.* (2004: 565-574) proved in a randomised secondary prevention trial among office workers, that the benefit from an intervention addressing ergonomic risk factors alone, was as strong as that from an intervention that combined ergonomic and psychosocial risk factors.

In conclusion, all three ergonomic risk factors, individually and jointly, can play a causative role to the incidence and prevalence of WRMSDs (Ekberg, Bjorkqvist *et al.* 1994: 262-266; Wang, Rempel *et al.* 2007: 806-813).

2.3.2 Workplace programmes

Question 4: What are the components of the programmes developed to prevent and manage WRMSDs in the working-population?

Unfortunately, the following statement of Gasset is true:

> If WRMSDs are the result of multiple causes, as they appear to be, ergonomic intervention alone will never be 'the cure'". Therefore, to effectively manage these problems, it is critical to understand all factors influencing their development, including age, presence of systemic disease, physiologic preposition, work behaviours, type of job and motivation of the worker as well as ergonomic design. (Olson 1999: 234)

Sewing-machine operators are more at risk for developing WRMSDs than workers in other sectors of the workforce (See the answer to Question One in this chapter.), and it seems that the level of exposure to the mentioned risk factors that are applicable to sewing-machine operators are high as well. (See the answer to Question Three in this chapter.) The combination of the high risk to the exposure level demonstrates the need for prevention programmes aimed at reducing the incidence and prevalence of WRMSDs and reducing the associated socio-economic costs in most economic sectors (Roquelaure, Ha *et al.* 2006: 765-778).

The articles reporting on models and outcomes of ergonomics programmes are listed below:

- o Three models (Olson 1999: 229-238; Chu, Dwyer 2002: 175-186; Wilson 2002: 71-91);
- o One population-based randomised control trial (Loisel, Abenhaim *et al.* 1997: 2911-2918; Loisel, Lemaire *et al.* 2002: 807-815);

- One case study among sewing machine operators (Halpern, Dawson 1997: 429-440);
- One retrospective longitudinal study (Mostert-Wentzel, Grobler *et al.* 2010: 6-18); and
- Two systematic reviews (Maher 2000: 259-269; Williams, Westmorland *et al.* 2007: 607-624).

Three models

"The process to design an organization in order to reduce injuries, illnesses and the associated costs there off, reflects the goal of 'macro-ergonomics'. On a "micro-ergonomics" level, disagreement surrounding the cause and effect relationships between risk factors and diagnosed musculoskeletal disorders continues among researchers. Therefore, many practitioners recommend a 'holistic or macro-ergonomic' approach to identifying and elimination of risk factors. One such macro-ergonomics technique by which a multitude of risk factors can be mitigated in the industrial environment is participatory ergonomics." (Halpern, Dawson 1997: 430). The participatory approach to ergonomics is based on the assumption that a worker is an expert on his or her job (Russel J 2012: 5).

> Participatory ergonomics is often defined as a technique by which employees and management join together to impart ergonomics knowledge and implement procedures in the workplace in order to improve working conditions. The four commonly cited requisites for a participatory ergonomics program include: participation, organisation, ergonomics methods and tools, and job design concept. (Nagamachi 1994, in Halpern, Dawson 1997: 430)

Two models as examples of participatory ergonomics are described below. In the first place, a model for industry (Olson 1999: 229-238) and, secondly, a new model in progress (Chu, Dwyer 2002: 175-186).

Firstly, Olson (1999: 229-238) described an on-site programme as a model for industry in the USA (summarised in Table 2.3)

Table 2.3 A summary of an on-site ergonomics programme as a model for industry (Olson 1999)

Steps in starting an ergonomics programme	Components of each step
1. Identify problem areas	
	o Document accidents and injuries
	o Physician visits
	o Work restrictions and time off due to work-related disorders
	o Absenteeism reports
	o Worker complaints
	o Health screens
	o Ergonomic checklist to identify areas of concern
	o Confidential employee surveys
2. Ergonomic team members	
	o Employees
	o Supervisors
	o Engineers
	o Medical community
3. The role of the ergonomic team	
	o Implement controls to reduce or eliminate exposure to hazards
	o Train all staff on ergonomic principles
4. The programme should address	
	o Hazard prevention and control
	o Education and training
	o Medical management

A comprehensive on-site ergonomics programme is a team effort, with commitment of the management, workforce, medical providers, engineers, and ergonomic professionals. Once the ergonomics programme is implemented, the team should monitor, evaluate and modify the programme based on outcomes (Olson 1999: 229-238).

Secondly, Chu and Dwyer (2002: 175) conclude that: "Employers need to become change agents and visionary leaders who adopt a proactive, interdisciplinary and

integrative system approach to formulate and develop company policies and workplace culture that facilitates employee participation, professional growth and team work."

For the success and sustainability of a workplace health management (WHM) programme, it must be integrated into corporate policy and regular management practice, and should be coordinated by members within the work organisation rather than by costly external consultants. WHM strategies should include not only individual-directed measures but also measures to address environmental, organisational, ergonomic and social factors (Chu, Dwyer 2002: 175-186). The strategies, methods and principles for WHM are summarised in Table 2.4.

Table 2.4 The strategies, methods and principles of a workplace health management (WHM) programme

The participatory needs-based problem solving cycle	The key principles of WHM
o Ensure management support	o Improve work organisation
o Establish a coordination body	o Develop healthy company policy and culture
o Conduct a needs assessment	o Encourage active participation by all involved
o Prioritise needs	o Foster personal development, work styles and lifestyles conducive to health
o Develop an action plan	
o Implement the plan	o Ensure health promotion and disease-prevention strategies become an integral part of management practices
o Evaluate the process and outcome	
o Revise and update the program	

The third model is described by Wilson (2002). The management of the injured patient includes two approaches: 1) the manual therapy model and 2) the clinical-ergonomics model.

The first approach, the *manual model*,

> is a series of manual techniques based on identification and removal of musculoskeletal dysfunction and the provision of manual techniques for the removal of pain. Manual techniques are particularly useful in the acute or sub-

acute injury where they address the painful tissues – the most common cause of the patient presentation. (Wilson 2002: 71)

The second approach, the *clinical-ergonomics model*,

> is based on looking at the cause of dysfunction and removing the inputs responsible for the injury process. This involves a systematic search for 'exposures', which is ergonomic, psychosocial and personal factors that intersect to create musculoskeletal symptoms; and the subsequent modification of these exposures. (Wilson 2002: 71)

In conclusion, Wilson (2002) describes the clinical management of the injured patient on the basis of the manual model, combined with the clinical-ergonomics model. This combination, as well as both models of Olson (1999) and Chu and Dwyer (2002) have this in common: A multidisciplinary team should be established to evaluate needs, implement solutions and then re-evaluate in order to modify the programme – based on outcomes in order to address environmental, organisational, ergonomic and social factors.

One population-based randomised controlled trial

With the summarised models in mind, a population-based randomised controlled study was found. Loisel, Durand *et al.* (1994: 597-602) conducted a population-based, randomised clinical trial on back pain management (described as the Sherbrooke model). The aim was to determine whether a comprehensive clinical and occupational intervention could reduce progression of low back pain to prolonged disability, by reducing time away from regular work for affected workers. With occupational back pain, persistent disability is linked to prolonged absence from work or frequent recurrences of absence from work. Any intervention that reduces absence from regular work is likely to reduce long-term chronicity, with all of its personal and financial cost implications.

The population sample consisted of 104 participants who had been absent from work for more than four weeks from 31 workplaces in Quebec, Canada. Participants were

allocated and randomised to one of four groups: 1) standard care as provided by the worker's physician alone (control); 2) experimental clinical rehabilitation intervention; 3) experimental occupational intervention; and 4) a combination of the two experimental interventions. The participants in the clinical rehabilitation intervention group received a clinical examination, attended a back school and participated in rehabilitation done by a psychologist and/or occupational therapist. The participants in the occupational intervention group consulted the occupational medicine physician and the ergonomist, in order to participate in a participatory ergonomics intervention (Loisel, Abenhaim *et al.* 1997: 2911-2918).

One case study among sewing-machine operators

One case study conducted among sewing-machine operators, and reporting on the implementation of programmes similar to those described in the literature, was found. A participatory ergonomics programme was designed and implemented by Halpern and Dawson to control and reduce workers' compensation costs within an automobile products manufacturing company between 1993 and 1996 (1997: 429-440). Pareto analysis identified a substantial number of musculoskeletal disorders among 250 sewing-machine operators who manually machine-sewed canvas automobile accessory products. This case study documented the benefits of a comprehensive, integrated programme approach for injury as well as illness reduction. Therefore,

> a participatory ergonomics program, with multi-disciplinary participation, is one approach by which a company can weave together its manufacturing objectives of quality, productivity, safety, and cost containment to achieve effective production and injury reduction. (Halpern, Dawson 1997: 429-440)

One retrospective longitudinal study among sewing- machine operators

Mostert-Wentzel, Grobler *et al.* (2010: 6-18) published a study with a retrospective longitudinal design, using a record review to investigate a work-based physiotherapy and ergonomics occupational programme in car-seat seamstresses. The purpose of the study was to determine the effect of the programme on the incidence rate of work-

related upper extremity musculoskeletal disorders over a period of three years, and to investigate possible predictors. Data from 38 sewing-machine operators with 43 work-related upper extremity musculoskeletal disorders were analysed. The intervention comprised ergonomic adaptations, health education and conventional physiotherapy.

Two systematic reviews

The first systematic review included 13 randomised controlled trials on the prevention of LBP. It was concluded that workplace exercise was effective, braces and education were ineffective and workplace modification plus education were of unknown value (Maher 2000: 259-269).

Seven years later, a second systematic review was conducted by Williams, Westmorland *et al.* (2007: 607-624) to evaluate the effectiveness of workplace rehabilitation interventions for injured workers with LBP. The best evidence was that the combination of clinical interventions with occupational interventions was effective in: returning injured workers with LBP to regular work faster, and decreasing pain and disability. The authors concluded that early return to work/modified work was effective in decreasing the rates of back injuries as well as lost-time back injuries, and reducing pain and disability. These studies included early contact with the worker by the workplace and a health care provider intervention at the workplace. The authors also found that ergonomic interventions such as participatory ergonomics and workplace adaptation, adaptation of job tasks and adaptation of working hours were effective in returning injured workers to work.

Although both reviews were carried out on LBP only and, therefore, did not include other WRMSDs, the conclusion can be made that workplace modification proved to be effective, along with workplace exercises in the management and prevention of LBP.

In conclusion, the garment industry employed 11 million workers worldwide by 1998 (according to the International Labour Organisation (ILO)). Three per cent of workers were employed in Africa, while the rest were divided between Asia, America and Europe. Although, these studies published evidence that the combination of medical care and ergonomic intervention was effective in the management of WRMSDs in the

working population and among sewing-machine operators specifically, such health programmes have, however, primarily been limited to large-scale enterprises in developed countries.

Question 5: What are the outcomes of such programmes?

A health-promoting workplace influences many aspects in society – including health and motivation of employees, profitability of companies, and the socio-economic well-being of countries. The work environment is a key determinant of the health of employees. Since the majority of the adult population spend much of their waking life at work, many employers realised that the workplace offers an opportunity for promoting health, and that healthy workers are more likely to be productive workers. Similarly, if neglected, the work environment can have extremely negative consequences to the health of workers, causing stress, injury, illness, disability and even death (The World Health Report (2012)).

Although the study of Mostert-Wentzel, Grobler et al. (2010: 6-18) provided weak evidence that an integrated physiotherapy and ergonomics programme was effective, and recommended that further research with larger samples was considered necessary, other authors reported two major positive outcomes of such programmes.

- o   The benefit to the employer

Apart from the positive effects of a health-promoting workplace on employees, there is also the benefit to the employer – decreased injury nets fewer costs (Olson 1999: 229-238) and, whilst a healthy workforce is essential to a successful enterprise, it is also fundamental to the socio-economic well-being of countries (Chu, Driscoll et al. 1997: 380).

Furthermore, Halpern and Dawson reported a decrease in the average cost per claim for musculoskeletal disorders of 83% over a period of three years. An initial increase in the numbers of reported WRMSDs can be expected when a programme is implemented, but it should be followed by a decrease (1997: 429-440).

In summary, Loisel, Lemaire et al. reported a cost benefit for the workers' compensation board over a period of 6.4 years. Their results demonstrated that the integrated clinical occupational model of management (a combination of the two experimental interventions) of back pain was effective in increasing the rate of return to regular work more than twofold, compared with the effectiveness of the usual medical care (2002: 813).

- The benefit to the employee

A health-promoting workplace is not only free of hazards, but also provides an environment which is stimulating and satisfying to those who work there. Therefore, apart from health outcomes, it has the potential to promote work satisfaction and morale, improve the quality and productivity of work, and create a supportive social climate and workplace culture (Olson 1999: 229-238).

Question 6: What are the key determinants of such a programme?

The key determinants of such a programme are twofold. In the first place early reporting of strains, and aggressive medical management (Halpern, Dawson 1997: 429-440) and, secondly, close association of occupational intervention with clinical care is of primary importance in impeding progression towards chronicity of LBP (Loisel, Lemaire *et al.* 2002: 813).

Williams, Westmorland *et al.* (2007: 607-624) confirm the benefits of these two determinants to faster return to regular work after LBP and, and decreased pain and disability. In addition to the above, Williams, Westmorland *et al.* also found that ergonomic interventions, such as participatory ergonomics and workplace adaptation, adaptation of job tasks, and adaptation of working hours, were effective in returning injured workers to work (2007: 607-624).

Question 7: Has a programme been implemented in a sewing plant before?

The answer is: "Yes". The implementation of a participatory ergonomics programme with multi-disciplinary representation in the sewing industry has been described by

Halpern and Dawson in Denver, USA (1997: 429-440). Risk management objectives of quality, safety and cost containment were weaved together so as to achieve effective production while simultaneously preventing injuries and illnesses.

2.3.3 Research methodology

Question 8: From a conceptual point of view: How should the current study be conducted?

In the hierarchy of research designs, the results of randomized, controlled trials are considered to be evidence of the highest grade (golden standard), whereas observational studies are viewed as having less validity because they reportedly overestimate treatment effects (Concato, Shah *et a*l. 2000: 1887-1892). In randomised controlled trials, subjects are assigned by statistically randomised methods to two or more groups. In doing so it is assumed that all variables other than the proposed intervention are evenly distributed between the groups. In this way bias is minimised (Mann 2003: 54–60).

Concato, Shah *et al.(* 2000: 1887-1892) used published meta-analyses to identify randomized clinical trials and observational studies that examined the same clinical topics. They concluded that the results of well-designed observational studies (with either a cohort or a case control design) do not systematically overestimate the magnitude of the effects of treatment as compared with those in randomized, controlled trials on the same topic.

Cohort, and case-control studies are collectively referred to as observational studies. Cohort studies are used to study incidence, causes, and prognosis. Because cohort studies measure events in chronological order they can be used to distinguish between cause and effect. Furthermore, case controlled studies compare groups retrospectively. They seek to identify possible predictors of outcome (Mann 2003: 54–60). An important strength of most retrospective databases is that they allow researchers to examine medical care utilization as it occurs in routine clinical care (Motheral, Brooks *et al*. 2003: 90).

In France, the focus of a study was mainly on the methodological aspects of the surveillance of musculoskeletal disorders (Roquelaure, Mariel *et al.* 2002: 452-458). The two aims of the study included; 1) the assessment of a strategy of active surveillance, and 2) to compare different criteria for deciding whether or not a work-situation could be considered at high risk for musculoskeletal disorders.

In the first aim of the study, Leclerc *et al.* defined surveillance as:

> "...the on-going systematic collection, analysis and interpretation of health and exposure data in the process of describing and monitoring a health event. The main objective of surveillance of musculoskeletal disorders is to determine the need for action and to plan, implement and evaluate ergonomic intervention and programmes." (Roquelaure, Mariel *et al.* 2002: 452-458)

Two systems are available for routine analysis of health and exposure to risk factors: passive and active systems. Passive surveillance is using workers' compensation and sickness data, which is easy to implement. This method will probably be unreliable in South Africa compared to France, because WRMSDs are not reported routinely to the Compensation Commissioner in South Africa, and the probability of abuse of sick leave and/or sickness presenteeism (Aronsson, Gustafsson *et al.* 2000: 502-509) can make sick-note data unreliable.

Furthermore, active surveillance involves a workplace-specific system to identify musculoskeletal disorders and their risk factors. Two levels are available for active surveillance of both health and risk factors. The first level uses questionnaires and checklists, which provide a quick assessment of the situation, and was proven as insufficient to identify cases of musculoskeletal disorders with any precision (Roquelaure, Mariel *et al.* 2002: 452). The second level uses physical examination and in-depth job analysis by a trained health care provider.

The outcome of the study of Roquelaure, Mariel *et al.* (2002: 452-458) was that health and risk factor surveillance must be combined to predict the risk of musculoskeletal disorders in a company, which agrees with the clinical-ergonomics model as described by Wilson (2002: 84-91).

The second aim of Roquelaure, Mariel *et al.* (2002: 452-458) addressed the evaluation of different criteria to decide whether or not a work situation could be considered at high risk of musculoskeletal disorder or not. The conclusion was that incidence data were more valid than those based on prevalence data.

The reasoning for determining incidence in the current longitudinal study, and not prevalence as in the study of Schibye, Skov *et al.* (1995: 427-434), was as follows: in the study of Schibye, Skov *et al.* (1995: 427-434) data on the prevalence of musculoskeletal symptoms among sewing-machine operators were assessed with the use of a questionnaire in 1985, and repeated in 1991. In 1991, the original group of sewing-machine operators was divided in three groups (a third were still sewing, a third changed occupation and a third were unemployed) and this data on the prevalence of musculoskeletal symptoms of three groups were compared with baseline data. Although both studies have a longitudinal design, the current study determine the incidence of WRMSDs over 4.5 years, while the study of Schibye, Skov et al. (1995: 427-434), determined the prevalence of musculoskeletal symptoms in two separate time periods (1985 and 1991).

Lastly, a retrospective study was conducted by Sadi, Macdemid *et al.* (2007: 610-622) in an on-site, auto-sector physiotherapy clinic. The purpose of the study was to describe the musculoskeletal disorders and related physiotherapy service utilisation over a 13-year period and to provide preliminary information on the utility of these services. The specific purposes were: 1) to describe the distribution of musculoskeletal injury according to year, age, type of injury, gender, body area affected, cause of injury, working status, Workplace Safety and Insurance Board claims, and job departments within the plant; 2) to identify differences in the rate of musculoskeletal injury and physiotherapy utilization based on gender and job; and 3) to identify differences in body part affected, service utilisation, and work status between disorders attributed to work (industrial) versus those that were not (non-industrial). The study design of this study (Sadi, MacDermid et al. 2007: 610-622) was similar to the study design of the current study, due to the fact that the rate and distribution of treatment visits to the physiotherapy clinic were described over a period of a few years.

A difference between the two studies is the fact that the study of Sadi, MacDermid et al. (2007: 610-622) included the total number of visits to the physiotherapy clinic. The average number of visits per worker for industrial on-site physiotherapy was 8.3 ± 7.0 visits over a 13-year time period. This is much higher than the average of 2.7 visits per disorder for the current study. In the current study, only the first visit was taken into account when the incidence of WRMSDs was determined. The reason for this was that it often happened that a relatively few cases account for the vast majority of medical expenses (physiotherapy visits) (Pransky, Verma et al. 200: 690-697).

The retrospective study of Sadi, MacDermid et al. (2007: 610-622) also lacked a comparison group as in the current study. This limits definitive conclusions about treatment effects or cost-effectiveness, and in the case of the current study – the impact of the change in work posture on the incidence of WRMSDs. Both studies are therefore limited by its observational nature and lack of a concurrent control group, but are strengthened by the complete and long-term follow-up of a large cohort of workers. These studies provide descriptive information on the characteristics of those using an onsite physiotherapy clinic in an automobile plant in Canada (Sadi, MacDermid et al. 2007: 610-622) as well as in the current study in South Africa.

Therefore, the logical corollary is to follow a retrospective design with active surveillance's level two surveillance methodology (physical examination and in depth job analysis by a trained health care provider) (Roquelaure, Mariel et al. 2002: 452-458), and to determine incidence, rather than prevalence rates for the current study.

2.4 Summary of the literature study

The literature findings on the relationships between ergonomics programmes, risk factors and their influence on the incidence of WRMSDs in a working setting can be summarised in figure 2.1.
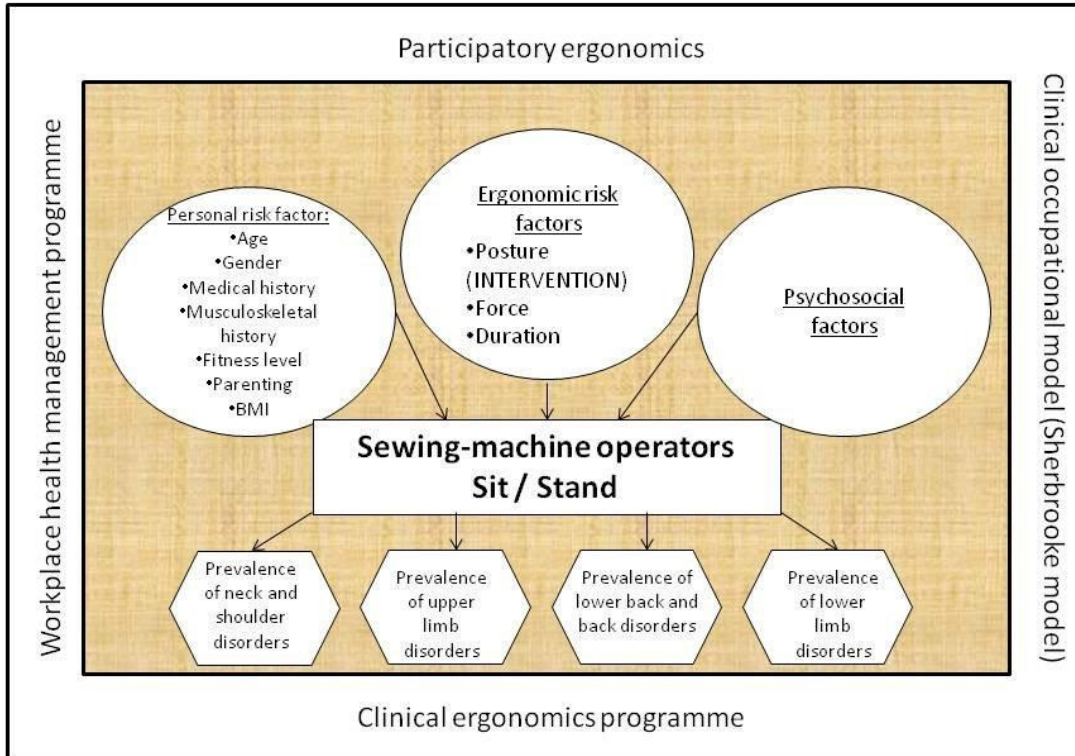
Figure 2.1 The relationships between ergonomics programmes, risk factors and their influence on the incidence of WRMSDs as described in the literature

2.5 Integration into the conceptual framework of the current study

From the literature review on the relationship between ergonomics programmes, risk factors and their association with the incidence of WRMSDs in a working setting, it was clear that the lack of similar studies in a South African setting, specifically the sewing industry, is a pressing reality.

In the first place, ergonomics programmes can assist companies in educating managers and employees (represented by unions) on: 1) the early detection of risk factors for WRMSDs; 2) early reporting of strains to initiate aggressive medical management; and 3) implementing ergonomic-related recommendations for the prevention of recurrence of WRMSDs in the working population. (See Table 2.3.)

During the process of implementation of ergonomics programmes, data should be collected on the prevalence and incidence of WRMSDs. The value of ergonomics programmes to managers and employees (represented by unions) alike is that these data may motivate the implementation as well as funding for future programmes – based on the proven cost-effectiveness of previously implemented programmes. These results would be useful to the entire industrial sector in South Africa, as well as shareholders, with the aim of increasing profit by preventing WRMSDs.

Secondly, it was also important to realise that many studies were done on specific disorders of the human body; e.g. only the lower back. One must bear in mind that any possible musculoskeletal disorder that an employee can sustain will influence the big picture, including the individual (personal well-being and social implications) and the company (training, profitability, etc.). When the implementation of an ergonomics programme is planned on the prevention and management of a WRMSD of employees, all possible WRMSDs (to the whole body) amidst the interaction among all possible risk factors (personal, ergonomic and psychosocial) should be taken into account.

Therefore, with all the WRMSDs and risk factors in mind, the researcher evaluated the available data for the current study. The methodology is presented in Chapter Three, on the basis of the conceptual framework set out in Chapter One. (See Figure 1.1.)

3. Methods

Chapter Three outlines the setting and describes the population of this retrospective longitudinal study. The intervention, as well as the two groups of risk factors and outcomes with strategies to eliminate bias, is described on the basis of the relationship between the company, physiotherapist and sewing-machine operators during the period of implementation of the programme (figure 3.1). Data collection, capturing (Appendix 3) and statistical analysis will be explained, and coding of data can be found in Appendix 4.

3.1 Study design

A longitudinal study design was applied. Incidence was assessed in this retrospective cohort study (Aldous, Rheeder *et al.* 2011: 25).

The golden standard to determine effectiveness, a randomised controlled study design, was not possible. In the first place, the current study was not initially planned as part of the implementation of the programme, and secondly, no control group existed in this demographical area.

3.2 Study setting

Physiotherapy and ergonomics programmes (programmes) were implemented in all the manufacturing plants of Johnson Controls globally. The programme, adapted to a South African context, was implemented between June 2004 and January 2009 (the period) in Johnson Controls Automotive S.A. (Pty) Ltd.'s (the company) car-seat manufacturing plant in Pretoria. The programme created an optimal ergonomic and physical milieu (the background) to implement the intervention, i.e. the change of work posture.

3.3 Study population

The current study was done on sewing-machine operators only. Factors that make up the profile of the current study population are listed below.

- o All 123 sewing-machine operators who were employed by the company between June 2004 and January 2009, performing sewing operations only.

- The sewing-machine operators were divided between seven production lines, all working on the same production floor.
- The sewing-machine operators were sewing car-seat covers.
- The physiotherapist treated 70 sewing-machine during the period.
- Ages of sewing-machine operators varied from 18 to 62 years.
- Three sewing-machine operators were male and the rest female.
- The average number of treatments per injury was 2.7.
- All sewing-machine operators were working in a seated posture until February 2005, and started working in a stand-up posture per production line by date until all were working in a stand-up posture by August 2008 (the dates of the change in work posture for each production line was pre-determined by management, and compulsory to the sewing-machine operators).
- Some sewing-machine operators were working with cloth and vinyl, while others were working with cloth and leather.
- Some sewing-machine operators were performing relatively easy stitching, while others performed forceful precision stitching.
- Some sewing-machine operators were not rotating between sewing different types of materials, or stitching tasks, while others were.
- All sewing-machine operators were subjected to the same daily working hours.
- All sewing-machine operators were paid per hour.

3.3.1 Inclusion criteria

Inclusion criteria on data of sewing-machine operators with self-reported disorders applied to:

Incidents of self-reported work-related musculoskeletal symptoms, which may be episodic or acute in nature (Jordan, Clarke *et al.* 2007: 8), sustained to one of three areas – spine, upper limb and/or lower limb.

3.3.2 Exclusion criteria

Exclusion criteria applied to:

o   Work description: Not physically sewing most of the working day; e.g. administrative personnel, non-sewing operators, team leaders, coordinators and quality inspectors.

o   Disorders: Certain disorders were not regarded as WRMSDs in the current study. These included traumatic injuries sustained outside of working hours (e.g. sport injuries, motor vehicle accidents), dermatological-, neurological-, and respiratory conditions.

3.4 Background to the intervention

The implementation of a work-based programme took place as illustrated in the conceptual framework shown in Figure 1.1. The implementation was initiated by the company that contracted the researcher to assist in implementing the programme. The relationship between the company, physiotherapist and sewing-machine operators during the period of implementation of the programme is explained in Figure 3.1 and sections 3.4.1 to 3.4.3 . The explanation of the interaction between the three role players, was documented in the minutes of the monthly health-and safety meetings. Although the personal risk and ergonomic factors were managed in the programme (Section 3.4.4), only the postural ergonomic risk factor is described as the intervention, i.e. the change in work posture (Section 3.5).

3.4.1 The role of the company during the implementation of the programme

The company initiated and funded the programme and was committed to the implementation of recommendations. To drive the process, the company used the existing health-and-safety committee. This coordinating body included representatives from all levels and sectors of the plant (e.g. management, an occupational health-and-safety agency, production coordinators, team leaders, maintenance, an occupational health doctor, the occupational nurse, and representatives of the labour union) and the physiotherapist.

The committee received feedback from two sources; the physiotherapist's clinical-ergonomics service and the ergonomics needs assessment. In the first place, the physiotherapist provided a monthly report on the prevalence of WRMSDs and the need to manage these. Secondly, an ergonomics needs assessment was done on every

sewing work station, early in the study, by using the company's ergonomic needs assessment form (Prevention Ergonomics Issues List (PEIL)) and was kept updated, as work stations changed regularly. (See Appendix 5.)

COMPANY

Initiate and fund the programme

Provide clinical ergonomic service

Ergonomic assessment (PEIL), implement ergonomic recommendations, and motivate the programme

Feed-back on ergonomic assessment and participate in discussions on ergonomic re-design of work stations

Provide information on musculoskeletal disorders, and ergonomic needs

PHYSIOTHERAPIST

Provide manual physiotherapy service

SEWING MACHINE OPERATOR

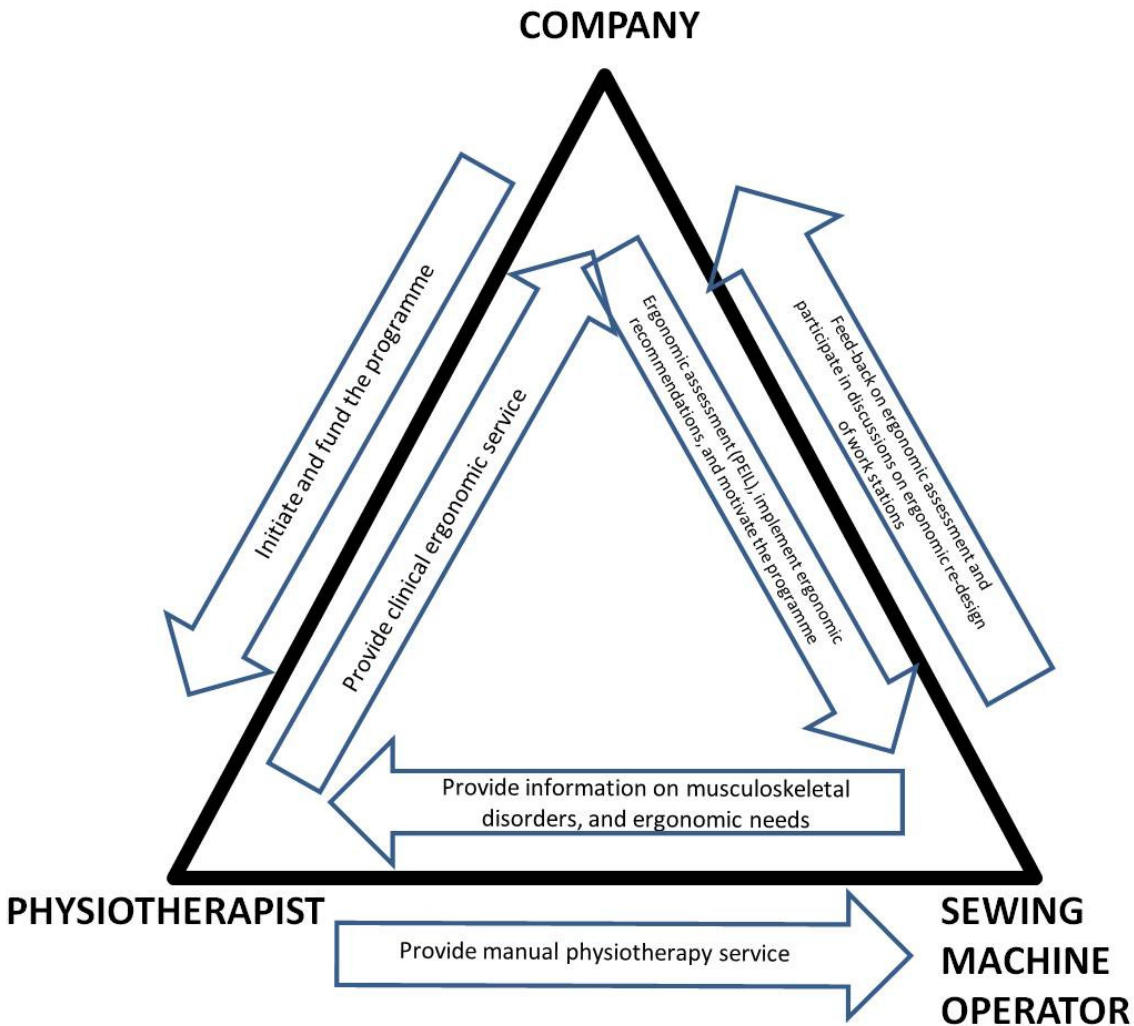Figure 3.1 **A graphic description of the programme (Source: Developed by the researcher)**

Although the PEIL was designed by USA-based experts in the company before 1992, it has not been used in the company before June 2004. It had content validity and covered all the main domains of the ergonomic factors in the conceptual framework developed from the literature (Schierhout, Meyers *et al.* 1995: 46; Wilson 2002: 39-50).

These assessments were initially done by the physiotherapist in June 2004, and kept updated by trained team leaders, and the process involved data collection regarding the need for possible workplace re-designs.

Once the causative ergonomic risk factors of WRMSDs had been identified by committee members, multidisciplinary recommendations were made, and implemented by the company as far as available resources allowed.

3.4.2. The role of the physiotherapist during the implementation of the programme

As illustrated in Figure 3.1, the physiotherapist delivered a manual physiotherapy service to individual sewing-machine operators and a clinical ergonomic service to the company. The physiotherapist, as well as the occupational nurse in the medical clinic, was part of the health-and-safety committee – providing clinical services to the company's employees. The nurse did pre-employment screenings.

3.4.2.1 Individual manual therapy service

The physiotherapist's aim on the initial visit was to make a working diagnosis, determine work relatedness and initiate appropriate management of the disorder. This aim was accomplished by documenting a comprehensive medical history and performing a clinical examination. The clinical examination was based on knowledge of biomechanics, physics, anthropometry, anatomy and physiology. This examination included: an overall postural evaluation; the testing of appropriate active and passive range of movements; the testing of resisted muscle strength; a neurological examination; appropriate orthopaedic tests; the determination of neural tissue mobility; and performing an examination by palpation (Wilson 2002: 73).

The initial aim of treatment was to break the pain-spasm-dysfunction cycle and to accelerate the healing process (Wilson 2002: 72). A good understanding of all the dimensions of the symptoms of the disorder (including muscle atrophy, joint stiffness, neurological deficit and the identification of abnormal movement patterns) was important to create effective change and to ensure that this change would be sustained.

According to Wilson (2002: 72) a patient is seen from three perspectives. The first dimension is the history of the patient prior to his/her first appointment, including medical, family, social and work history. The second dimension is the person that presents for examination and treatment, and the third dimension is the environment that a patient ventures into after the physiotherapy. With this in mind, individual management plans were based on a clear understanding of the nature of the injury and the patient.

Physiotherapy treatment modalities included: manual therapy, mobilisation, muscle release techniques, therapeutic exercises, ice, heat and electrotherapy (ultrasound, interferential current and laser). The curriculum of group classes for patients with spinal disorders covered basic back care, ergonomic principles and included one practical exercise session (See Appendix 6.), and was presented in the physiotherapy practice.

3.4.2.2 Clinical-ergonomic service

The clinical-ergonomics service involved a careful assessment of exposure to risk factors. Exposure to personal and ergonomic risk factors was identified by investigating the patient's case history, presenting symptoms and response to treatment. These elements usually gave a good indication of the personal or ergonomic factors that were contributing to symptoms or were delaying recovery. Tension patterns involved indicated overused muscles, and clinical reasoning identified likely work-related actions or postures that might have led to these musculoskeletal changes. The aim of clinical ergonomics was therefore to reduce harmful exposures and create effective rehabilitation strategies (Wilson 2002: 84).

3.4.3 The role of the sewing-machine operator during the implementation of the programme

As described in the conceptual framework of the study shown in Figure 1.1, sewing-machine operators were subjected to personal, ergonomic and psychosocial risk factors. This exposure could lead to WRMSDs of the spinal area, upper and/or lower limbs. With the aim of preventing WRMSDs, the company implemented the programme, to the benefit of all the sewing-machine operators, as illustrated in Figure 3.1. After the initial physiotherapy evaluation, the injured sewing-machine operator

received individual manual therapy at the physiotherapy practice, as well as a work station visit from the physiotherapist (as part of the clinical-ergonomics service). During this visit the team leader, sewing-machine operator and physiotherapist evaluated possible causative ergonomic risk factors and, thereafter (with the sewing-machine operator's permission), feedback was given to the health and safety committee on a monthly basis. Therefore, the sewing-machine operator played an important role during the implementation of the intervention. In other words, a "participatory ergonomics"' process (Halpern, Dawson 1997: 430) was followed.

3.4.4 Risk factors addressed by the programme

Personal risk factors

Personal risk factors were not addressed per se, as age, gender, medical history and musculoskeletal history were a given. The negative impact of high BMIs, combined with the expected benefit of a reduction of a high BMI (categories: overweight, obese and morbidly obese) were explained during individual physiotherapy sessions, but there was no official strategy addressing the reduction of high BMIs.

Ergonomic risk factors

The change from a seated work posture to a stand-up work posture is described as the intervention in section 3.5. The rest of the ergonomic risk-factor management strategies were implemented before, or at the beginning of the period of the study. These included force and duration.

Force

Increased force was generated by doing top-stitch operations versus straight stitching, sewing leather instead of cloth, sewing small parts (e.g. headrests) and hard plastic retainers (especially during the winter) rather than standard parts of the seat cover, and the frequent use of scissors to cut thread. Force as a risk factor was addressed by:

- o   Implementing job rotation between forceful and relatively easier straight stitching. This process was started in June 2004, and fully integrated in production in October 2005 (Mostert-Wentzel, Grobler *et al.* 2010: 8);

- ○ Heating/softening of hard plastic retainers underneath infra-red lights before sewing was performed, was implemented before June 2004;

- ○ Regular sharpening of scissors was implemented during 2005, and scheduled by the maintenance department; and

- ○ Participation in a 15-minute group session of flex-and-stretch every morning before the work-day started. This session was compulsory, and all the sewing-machine operators participated.

This exercise session mentioned in the last point was presented by a trained employee, supervised by the physiotherapist. These sessions were part of the daily routine of the sewing-machine operators before June 2004. The exercises were done in a standing posture and included breathing exercises, as well as light exercises to mobilise and stretch the neck, back, upper- and lower limbs.

Pictures 3.1 and 3.2 illustrate the difference between the relatively forceful, precision stitching (Picture 3.1) and straight stitching (Picture 3.2) of bulkier parts.

.

Picture 3.1 Forceful, precision stitching

Picture 3.2 Straight stitching of bulkier parts

Duration

The impact of forceful sewing actions and working overtime because of high production volume was decreased by implementing job rotation. Sewing-machine operators rotated between the precision stitching and straight stitching in order to relieve strain on the upper limbs.

3.5 The intervention

With the implemented programme as a background during the period of the study (as described in Section 3.4), only one ergonomic risk factor was altered as part of the intervention – namely the change of work posture from seated to stand-up. The sewing-machine operators were divided between seven production lines, and each line was managed by a team leader, delivering seats to a specific client in the automotive industry. Each line had an individual implementation date for the change in work posture, which was predetermined by management and compulsory to the sewing-machine operators.

Being part of the programme, the physiotherapist was involved in managing the health of the sewing-machine operators during this period of change in work posture.

Strategies to prevent and manage WRMSDs included job redesign, employee training and employee selection.

3.5.1 Job redesign

Attention was given to the following aspects regarding job redesign in order to ensure an ergonomically sound work environment:

- o Optimised storage-heights for both seated and stand-up work stations to minimise regular, excessive reaching;
- o Optimised work station layout regarding the floor plan and work flow for both seated and stand-up work stations to minimise regular, excessive reaching;
- o For the seated work station, pedal position, chair maintenance, and adjustments of work-surface height in relation to chair height to ensure a supported and comfortable work posture;
- o For the stand-up work station: the implementation of height adjustability of work surfaces and supplying of an ergonomically designed pedal and shock-absorbing carpets ensured a supported and comfortable work posture.

Storage heights for seated and stand-up work stations

Picture 3.3 demonstrates the unilateral reaching above shoulder-height in the seated work posture compared to the relatively easily accessible storage height in the stand-up work station shown in Picture 3.4.

Picture 3.3 The seated work station demonstrates storage heights

Picture 3.4 The stand-up work station demonstrates storage heights

Work station layout for seated- and stand-up work stations

The floor layout of the seated work stations required extreme reaching by the sewing-machine operators in order to pass parts between them - as seen in Picture 3.5. At the stand-up work stations, the sewing-machine operators operated in cells, with a conveyor belt as a method of transportation of the parts. (See Picture 3.6.)

Picture 3.5 The floor layout of seated work stations

Picture 3.6 The floor layout of stand-up work stations

The seated work station

Attention was specifically given to the pedal position, chair maintenance, and adjustments of work-surface height in relation to chair height to ensure a supported and comfortable work posture.

Pedals

Picture 3.7 illustrates the position of the pedal to the right of the sewing-needle – causing it to be operated by the right foot only. Picture 3.8 illustrated the pedal position as seen from the side, preventing the sewing-machine operator from moving closer to the work-surface. These design-problems were attended to by adjusting furniture as far as possible in order to ensure a supported work posture of each individual sewing-machine operator.
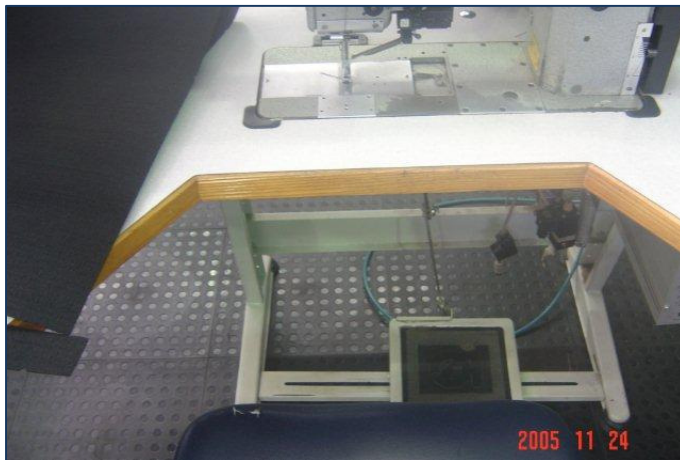
Picture 3.7 The seated work station demonstrates pedal position as seen from the operator's point of view

Picture 3.8 The seated work station demonstrates pedal position as seen from the side

64

Chairs

All chairs with fixed backrests were replaced with chairs with height adjustability of the chair backrest, as illustrated in Picture 3.9. Picture 3.10 illustrates the need for regular maintenance.

Picture 3.9 Height adjustable back rest of a sewing-machine operator's chair

Picture 3.10 A broken back rest

The stand-up work station

Attention was specifically given to motivate height adjustability of tables for the stand-up work stations, as this feature was critical to accommodate anthropometrical differences among the sewing-machine operators (Picture 3.11). This feature was not implemented until 2006. An ergonomically designed pedal to encourage the use of both feet for sewing speed and lifting of the needle (Picture 3.12) and shock-absorbing carpets to lessen the impact of standing on the feet (Picture 3.13) were supplied immediately when a stand-up work station was installed.

Picture 3.11 Height-adjustability controls of a stand-up work station

Picture 3.12 The pedal of a stand-up work station

Picture 3.13 Shock-absorbing carpets for the stand-up work stations

3.5.2 Training

"Good communicating skills and strategies are particularly important in the diagnosis, treatment and management of chronic diseases." (Adebajo, Blenkiron *et al*. 2004: 1321). The first language of the physiotherapist was Afrikaans and for the sewing-machine operators it was one of the nine indigenous languages of South Africa. English was the official language of the company, and the second language for both the physiotherapist and the sewing-machine operators – therefore English was the language of choice for presenting training (to individuals and during group sessions). Written exercise material to the sewing-machine operators as well as the multimedia presentations to management were in English. Visual resources (anatomy charts and models) were also used to demonstrate ergonomic principles (Picture 3.17).

As personal or ergonomic risk factors surfaced as barriers to recovery, they were dealt with between the physiotherapist, the involved sewing-machine operator and/or a health-and-safety committee member. Training sessions were designed and presented by the physiotherapist. The content focused on basic ergonomic principles and the on-going role and responsibilities of both sewing-machine operators and management for creating a healthy workplace. (See Appendix 7.)

Once-off training to management addressed:

- o Background on anatomical, ergonomic, and anthropometrical principles applicable to the possible development of WRMSDs at both the seated- and stand-up sewing work stations.
- o The importance of adjustability features of furniture at all sewing work stations.

Continuous training to sewing-machine operators addressed:

- o Seated work posture: How to set the chair at the correct settings according to individual anthropometrical requirements regarding seat- and back-rest height (Picture 3.14);
- o Stand-up work posture: How to set the work surface at the correct height according to individual anthropometrical requirements (Pictures 3.15 and 3.16);
- o Basic functional anatomy regarding hand work posture (Picture 3.17);
- o Increase fitness;
- o Decrease overweight;
- o Stop the excessive use of stimulants for pain relief;
- o Awareness regarding domestic ergonomic exposure;
- o Basic back care;
- o Guidelines of purchasing supportive footwear, inserting silicone innersoles, and wearing compressive stockings when sewing in the stand-up posture started (Picture 3.18);
- o Alteration in weight bearing when working in the stand-up work posture;
- o Exercises: Personal home- and work-based exercise programmes were taught to all sewing-machine operators to address postural weaknesses before and during the period when they had to adapt from the seated work posture to the stand-up work posture. The physiotherapist designed and supplied hand-outs with a comprehensive home exercise programme for strengthening lower limbs and trunk, and taught each sewing-machine operator individually some easy-to-do exercises (to be done for 30 seconds, every two hours during the working day in the work station) (See Appendix

8.). To ensure that the sewing-machine operators understood the exercise programmes, the hand-outs included pictorial and textual (English language) explanations (Adebajo, Blenkiron *et al.* 2004: 1321). No data were available to verify how dedicated operators were at doing these exercises.

Training on the use of the chair

The physiotherapist trained the sewing-machine operators regularly in small groups (as part of the morning-sessions between team leaders and sewing-machine operators) on the importance of a proper work posture in order to prevent the development of WRMSDs. Thereafter she assisted each sewing-machine operator (whilst sewing) how to determine what his/her optimal chair settings were according to eyesight and individual anthropometrical requirements. Picture 3.14 illustrates a supported seated work posture.

Picture 3.14 The back rest of the chair is supporting the sewing-machine operator's back

Training on work-surface height in the stand-up work stations

Sewing-machine operators were advised to set the work surface at the optimum height – balanced between good eyesight, and without strain on the musculoskeletal system of the upper body and arms. Picture 3.15 illustrates a work station that was too high – causing the sewing-machine operator to sew in shoulder abduction and - elevation. On the other hand, Picture 3.16 illustrates the forward flexed work posture of a sewing-machine operator at a work surface relatively low for his individual anthropometrical requirements.

Picture 3.15 The work surface is too high, causing the sewing-machine operator to sew in shoulder abduction and - elevation

Picture 3.16 The work surface is too low, causing the sewing-machine operator to work in a forward flexed work posture

Basic functional anatomy training of sewing-machine operators

In order to convey basic preventative advice regarding hand-work posture, the physiotherapist utilised visual resources (anatomy charts and models) during trainingl sessions with sewing-machine operators whilst they were sewing on the production line (Picture 3.17).

Picture 3.17 Individual session between the physiotherapist and a sewing-machine operator regarding safe hand postures whilst sewing

Advice on foot care

In order to prevent WRMSDs to the lower limbs, the physiotherapist advised the sewing-machine operators on the principles of supportive foot wear, silicone innersoles and compressive stockings, as well as alteration in weight-bearing in order to prevent lower-limb disorders when sewing in the stand-up posture (Picture 3.18). The last-mentioned piece of advice was new to the sewing-machine operators, as pedal design in the seated work stations was different from that in the stand-up work stations.

**Picture 3.18 Comfortable foot wear and alternative weight bearing minimised strain on the lower limbs**

The aim of health education was to ensure that the environment for prevention and recovery of WRMSDs was optimised. Initially, the physiotherapist's training was designed to address the musculoskeletal needs of the seated sewing-machine operator. As the production lines were re-designed by the company to accommodate the stand-up work posture during the period of the study, work posture was adjusted per production line. The physiotherapist then altered the training content to accommodate the postural needs of the sewing-machine operator in the stand-up work posture. Thereafter, 'lessons learnt' from the increase in disorders experienced by the first group of sewing-machine operators during the postural adaptation phase during January to March 2007 (the first two months in the stand-up work posture) were implemented among the second group of sewing-machine operators before they had to adjust their work posture a year later in 2008. This was done according to the clinical-ergonomics model of Wilson (2002) (described in Chapter One) in order to prevent recurrence of a similar increase of WRMSDs in 2008. These lessons included: advice on acquisition of supportive footwear, silicon innersoles, compressive stockings, and performing regular work-based exercises. Hand-outs with a comprehensive home exercise programme for strengthening lower limbs and trunk to prepare the sewing-machine operators for the anticipated postural change were also designed and distributed by the physiotherapist (Appendix 8).

3.5.3 Employee selection

As far as possible, the strategies of job re-design and employee training accommodated each sewing-machine operator physically in his/her work station. Allocation of an employee to a specific workstation, according to anthropometrical requirements, was done only when the range of adjustability of furniture could not accommodate the employee's individual measurements. This strategy to avoid WRMSDs was implemented only among the seated work stations due to encroached leg space under the sewing-table.

Leg space under the sewing table in the seated work stations

Pictures 3.19 and 3.20 illustrate sewing-machine operators in a seated workstation. In Picture 3.19, the sewing-machine operator had to move her chair backwards in order to fit her relatively long lower legs under the sewing table. This led to a forward-flexed posture without back support as illustrated in Picture 3.20. As all the pedal designs were not the same, due to different measurements between the floor and the top surface of the pedal, a match between pedal design, sewing-table height and lower-leg length of each sewing-machine operator was sought to ensure that each sewing-machine operator had sufficient leg space underneath the table. Picture 3.21 illustrates a sewing-machine operator with sufficient leg space under the sewing table.
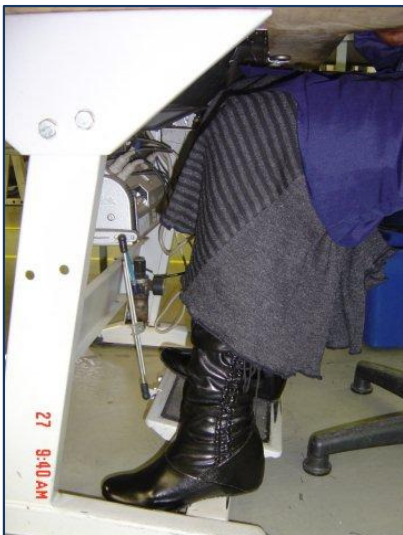
Picture 3.19 Encroached leg space underneath the table of a sewing-machine operator

Picture 3.20 A sewing-machine operator in a forward flexed posture

Picture 3.21 A sewing-machine operator working in a seated work station with sufficient leg space underneath the sewing table.

3.6 Risk factors

As described in Figure 1.1, the sewing-machine operators were subjected to three groups of risk factors, some possibly acting as confounding factors in recovery (influencing the outcome of the programme). These factors – identified from the literature – are summarised in Figure 2.1. Unfortunately, data on some risk factors as summarised in Figure 2.1, were not available as described below.

3.6.1 Personal risk factors

Factors in the conceptual framework of the study (Figure 1.1) included in the study

- o Age
- o Gender
- o Medical history (rumathoid arthritis, hypertension, diabetes)
- o Musculoskeletal history
- o BMI

Factors in the revised framework according to the literature (Figure 2.1) excluded from the study, as data were not available on these

- o Fitness level
- o Length of employment
- o Parenting status

3.6.2 Ergonomic risk factors

Factors given in Figure 1.1 and Figure 2.1 were all included in the study. As explained in sections 3.4 and 3.5

- o Posture: Working in a seated or stand-up posture
- o Force: Working with cloth/vinyl or cloth/leather
  Straight stitching or precision stitching
- o Duration: Working overtime or not
  Doing job rotation or not

3.6.3 The programme

The minutes of the health-and-safety meetings were screened in order to describe the programme as the background to the intervention. No analysis of these data was done.

3.7 Strategies to eliminate bias

Strategies to minimise bias are summarised in Table 3.1.

Table 3.1 Limitations and strategies to eliminate bias

Possible source of bias	Strategy
Manual therapy	
Two physiotherapists provided the manual therapy part of the physiotherapy intervention.	Both were registered physiotherapists and used the same theoretical foundation for clinical reasoning based on findings from a comprehensive evaluation. 90 per cent + of the clinical treatments were done by the physiotherapist as researcher, and less that ten per cent by another employed physiotherapist.
Data from off-site physiotherapists treating sewing-machine operators with WRMSDs were not included in the current study. Therefore, theoretically there could be a higher incidence of WRMSDs – unknown to the researcher.	Sewing-machine operators preferred having manual therapy on site with the physiotherapist, as they still received their hourly fee from the company. This was in contrast with forfeiting their hourly fee by attending an off-site physiotherapist. Off-site physiotherapists were also not involved in the clinical-ergonomics model and, therefore, feedback from their manual therapy service could not be included in the study. The influence of off-site physiotherapy was therefore assumed to have been minimal.
Risk factors	
Some patient files in the medical clinic were incomplete in terms of personal risk factors due to time pressure or oversight by the nurse.	These cases were (less than ten per cent) handled as missing data during analysis.
Some sewing-machine operators who might have received primary health care for self-reported WRMSDs from the nurse in the clinic did not report it to the physiotherapist.	Those were minor disorders and were assumed not to have had a significant effect on the incidence of WRULMDs. This variable was therefore not included in the current study.
Some data on ergonomic risk factors were not documented in full by the physiotherapist during the period of the study.	Team leaders and sewing-machine operators were contacted during the data-collection period to complete missing data retrospectively.
Data capturing	
The researcher collected and captured all the data and might have been prone to mistakes.	The researcher double checked all captured information.

3.8 Ethical considerations

Three ethical considerations were taken into account during the period of the study, as well as the handling of data. Firstly, the Ethics Committee of the Faculty of Health Sciences University of Pretoria approved the ethical aspects of the study (Protocol number: S157/2011). (See Appendix 9.) Secondly, the company gave written permission for the study to be conducted, as well as the publication of its name. Thirdly, the sewing-machine operators gave written permission that the nature of the work-related disorders could be communicated to the company.

3.9 Data management

3.9.1 Data collection and capturing

Data were captured by the researcher on three locations during the data collection period (2011 to 2012). The three locations were; the company's human resource department, the medical clinic, and the physiotherapy practice. Data were captured on a Microsoft excel worksheet (version 2007).

Appendix 3 summarises the process of the collection and capturing of data. Data collected at the company's human resource department and medical clinic included information about all the employed sewing-machine operators for the period of the study, whereas the physiotherapy practice only kept information on those sewing-machine operators who received individual physiotherapy.

Data collection started at the physiotherapy practice, as data on WRMSDs were provided to the company on a monthly basis on Microsoft Excel work sheets (version 2003) as the period of the study progressed.

The next step of the data-collection- and data-capturing process was to compile a baseline data work sheet with the personal information of all the sewing-machine operators who were employed during the period of the study, regardless of whether they were treated for a WRMSD or not. The baseline data was collected three years after the period of the study had ended, during the data collection period (2012). This compilation was achieved by cross checking the information received in electronic format (version 2007) from the company's human resource department with the physical

employee records of each sewing-machine operator kept on-site in cabinets (archive). (Refer to Appendix 3.)

Thereafter, data regarding the ergonomic risk factors were collected and captured. The researcher consulted two senior team leaders, as well as one senior sewing-machine operator who worked at the company during the period of the study. The only personal information that was available to them were the names and surnames of the sewing-machine operators on name stickers. These were categorised by pinning them onto a floor plan of the company's sewing department – according to the production lines of the factory. The ergonomic risk factors applicable to each production line included: posture, force (material and stitch) and duration (job rotation). All the pinned data were then transferred by the researcher into the applicable columns on the baseline data work sheet.

From there, the researcher collected and captured data on the medical history of all the sewing-machine operators at the medical clinic. These data included information on hypertension, arthritis, diabetes mellitus, and BMI. Initially the occupational nurse captured this information on the occupational health care company's pre-employment medical surveillance form and kept it in the physical patient records. (See Appendix 10.) The researcher collected data from the physical patient records and captured them in the applicable columns on the baseline-data work sheet.

Thereafter the company provided data on the amount of units produced per month, and it was captured per category in the applicable columns on the baseline-data work sheet.

Finally, the physiotherapy data of each sewing-machine operator who was treated with a self-reported WRMSD were captured by the researcher in the applicable column on the baseline-data work sheet.

3.9.2 Data preparation

Data on personal information and risk factors were collected and coded during the data capturing phase. (See Appendices 3 and 4.)

3.10 Statistical analysis

Each episode of acute symptoms of a WRMSD was self-reported by the sewing-machine operator at the physiotherapy practice for a course of an average of 2.7 physiotherapy sessions per reported disorder. Only the first date of the course of physiotherapy sessions was captured on the data sheet. Should the course of sessions overlap between two consecutive months, the denominator for calculating the incidence rate ratio was decreased accordingly for the second of the two months. This happened only in a few cases, and had a negligible influence on the outcome of the results.

3.10.1 Descriptive statistics

Sewing-machine operators were followed for a maximum period of 56 months. Demographic and baseline risk factors for the 123 sewing-machine operators, working on seven production lines in the automotive industry, were summarised using frequencies, percentages and cross-tabulations. A comparison between different production lines was not considered, since production line was not a significant determinant for any of the disorders.

The incidence of disorders was analysed in three anatomical areas: the spinal area, upper and lower limbs. The primary exposure variable of interest was work posture, i.e. seated or stand-up. The disorders were analysed both individually as well as multiple, i.e. one or more disorders were present.

3.10.2 Analytical statistics

Incidence rate ratios for risk factors were determined using random effects Poisson regression considering risk factors individually and also in a multivariable analysis of individual and collective outcomes. Following univariable analysis those risk factors for which the incidence rate ratio P value was less than 0.2 were included in the multivariable analysis. According to Hosmer, Hosmer *et al*. (1997: 968), this is standard procedure in model building. For the duration of the programme, the incidence of disorders by month was displayed graphically along with local polynomial smoothing over the follow-up period (Rabe-Hesketh, Skrondal 2008: 273-428).

Testing was done at the 0.05 level of significance both for the scenario where all the months were considered (hereafter referred to as the "full period"), and also the scenario where the first three months and the 'initial stand-up month and the consecutive month" were omitted (hereafter referred to as the "reduced period"). This data were omitted to accommodate two transitional periods during the period of the study, and therefore determine the impact of the implementation of the programme and the change in work posture on the incidence of WRMSDs. The first period accommodated the initial adaptation of the sewing-machine operators as a group in the first three months after implementation of the programme (hereafter referred to as "programme adaptation period"), and the second period accommodated the individual adaptation of each sewing-machine operator when his/her work posture changed (hereafter referred to as "postural adaptation periods").

3.11 Summary

This chapter outlined the setting, described the population and the background to the intervention, as well as the intervention, data collection and data analysis. Chapter Four presents the results of the study.

4. Results

4.1 Introduction

After the data were collected at the company, medical clinic and physiotherapy practice, it was analysed according to the conceptual framework (Figure 1.1). The first objective was to describe the population of sewing-machine operators in terms of personal and ergonomic risk factors. The second objective was to describe the incidence of WRMSDs for the period of the study. The third objective was to determine the association between individual risk factors (personal and ergonomic) and WRMSDs longitudinal, and the last objective was to determine the association between work posture and WRMSDs, adjusted for influential risk factors. The results for the four objectives will be discussed descriptively and thereafter analytically.

4.2 Description of the population (objective 1)

Objective 1 was to describe the population of sewing-machine operators in terms of personal and ergonomic risk factors

4.2.1 Description of the population in terms of personal risk factors

Data on personal risk factors were collected at the company and the medical clinic at baseline.

Table 4.1 Personal risk factors of the sewing-machine operators at baseline (n=123)

Personal risk factors		Frequency (%)
Gender (=123)		
Male		3 (2.4%)
Female		120 (97.6%)
Age in years (n=123)*		
≤35 years		25 (20.3%)
35<age≤50		78 (63.4%)
>50 years		20 (16.3%)
Medical history (n=114)		
Hypertension	No	92 (74.8%)
	Yes	22 (17.9%)
	Missing	9 (7.3%)
Arthritis:	No	110 (89.4%)
	Yes	4 (3.3%)
	Missing	9 (7.3%)
Diabetes	No	106 (86.2%)
	Yes	8 (6.5%)
	Missing	9 (3.3%)
Musculoskeletal history		
Yes/No		No data available at baseline
BMI in kg/m² (n=113)**		
Normal		27 (22.0%)
Overweight		34 (27.6%)
Obese		36 (29.3%)
Morbidly obese		16 (13.0%)
Missing		10 (8.1%)

* Mean age was 42.3 years; Standard deviation (SD)=8.0 years; 95% Confidence Interval (CI) (40.8 ; 43.7) years.

** Mean BMI was 29.7 ±6.1 kg/m², and 95% CI (28.6; 30.8 kg/m²)

The population of sewing-machine operators comprised 97.6% females, of which the largest proportion was between 36 and 50 years of age (63.4%); 16.3% were older than 50 years; and the rest 35 years and younger (20.3%). Mean age was 42.3 years at baseline. As for medical history, 17.9% had hypertension, 3.3% reported as having arthritis and 6.5% had diabetes at baseline. For only 22% of the sewing-machine operators, BMI was normal at baseline. Of the remaining 69.9%, 13% were morbidly obese, and the mean BMI was 29.7 km/m² at baseline.

4.2.2 Description of the population in terms of ergonomic risk factors

Of the three ergonomic risk factors, only the change in work posture was part of the intervention. Force and duration were part of the programme as background to the intervention. Data on ergonomic risk factors were collected at baseline.

Table 4.2 (a) summarises the profile of all three risk factors at baseline and Table 4.2 (b) gives the dates at which the change in work posture was implemented as part of the intervention during the period of the study.

Table 4.2 (a) Ergonomic risk factors of the sewing-machine operators at baseline (n=123)

Ergonomic risk factors		Frequency (%)
Work posture		
Sit		123 (100%)
Stand		0 (0 %)
Force		
Material	Cloth & vinyl	13 (10.6%)
	Cloth and leather	110 (89.4%)
Stitching	Straight stitching	98 (79.7%)
	Forceful precision stitching	25 (20.3%)
Duration		
No job rotation		78 (63.4%)
Job rotation		45 (36.6%)

The data shows that the largest proportion of sewing-machine operators were sewing cloth and leather (79.7%). Only a small proportion performed forceful precision stitching (20.3%), including the sewing of headrests and airbags, and performing top stitching. Job rotation between forceful precision stitching and straight stitching, was applied for 36.6% of the sewing-machine operators.

Table 4.2 (b) A summary of the distribution of sewing-machine operators between different production lines at baseline and the dates that each production line adjusted the seated work posture to the stand-up work posture during the period of the study (n=123)

Production line category	n	(%)	Date of change of work posture from seated to stand-up
C 307	22	(17.9%)	2005 January
FORD J97	14	(11.4%)	2007 January
J97 FORD	23	(18.7%)	2007 January
Nissan X11C	18	(14.6%)	2008 January
Nissan QW	25	(20.3%)	2008 January
P 301	8	(6.5%)	2008 March
Nissan D22	13	(10.6%)	2008 July

Only 17.9% of the sewing-machine operators changed their work posture early in the study. Just over 30% (30.1%) of the sewing-machine operators stood up in January 2007, and 34.9% a year later in January 2008. Just over 17% (17.1%) of the sewing-machine operators remained seated till the last year of the study. From July 2008 onwards, 100% of the sewing-machine operators performed sewing in the stand-up work posture.

4.2.3 Incidence of WRMSDs (Objective 2)

Objective 2 was to describe the incidence of WRMSDs for the period of the study (Figures 4.1 and 4.2 and Table 4.3).

In Figure 4.1 local polynomial smoothing was used to display the trend of monthly incidence of WRMSDs, by disorder group and for the multiple disorders group, over the 'full period'; i.e. all 56 months. In Figure 4.2, the initial three months of the study were removed (hereafter referred to as 'programme adaptation period'), and also the month when each sewing-machine operator adjusted his/her work posture along with the

consecutive month (hereafter referred to as 'postural adaptation period'). The remaining months now constitutes the 'reduced period'.
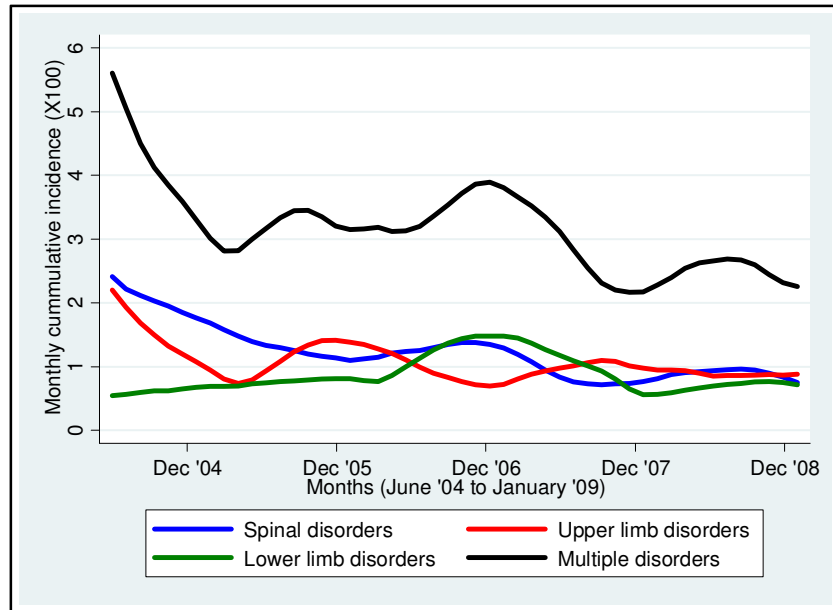

Figure 4.1 Monthly cumulative incidence (x100) for spinal, upper limb, lower limb and also multiple disorders for the full period of the study (n=123)
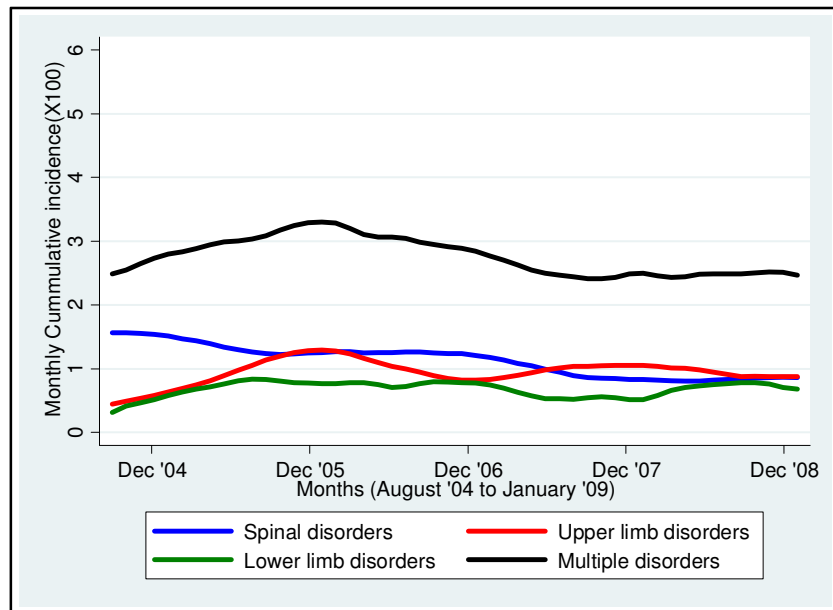

Figure 4.2 Monthly cumulative incidence (x100) for spinal, upper limb, lower limb and also multiple disorders for the reduced period of the study (n=123)

The effect of the removal of the data of the programme adaptation period and the postural adaptation period demonstrates the impact of the implementation of the programme and the change in work posture on the disorder groups in Figures 4.1 and 4.2. Figure 4.1 demonstrates a high incidence of WRMSDs at the beginning of the programme, especially for the spinal and upper limb disorders. Thereafter, spinal disorders gradually levelled off over time, with noticeable peaks during the postural-adaptation periods. Figure 4.2 displays the situation after removing the programme- and postural-adaptation periods – June to August 2004 (for the programme) and the individual 'stand-up months' and the consecutive month (for postural adaptation). Here the initial high incidences are absent and, furthermore, the former peaks are now less marked. (For most sewing-machine operators, their postural adaptation period was either early in 2007 or early in 2008.) Subsequently, the incidence in upper limb disorders did not change much over time.

The incidence of lower limb disorders spiked during the first two months of 2007 when 30.1% of the sewing-machine operators changed their work posture (as demonstrated in Figure 4.1). This did not recur to the same extent in 2008 when the last 52% of the sewing-machine operators changed their work posture (Figure 4.2). Figure 4.2 demonstrates that the increase of lower limb disorders during the change of work posture was temporary. The multiple disorder ("multiple" denotes that more than one of the disorders was present in the same month) sequence reflected that of the three groups of disorders.

The overall incidence per disorder was also determined and is displayed in Table 4.3.

Table 4.3 The overall incidence per 1 000 person months per disorder (n=123)

Disorders	Spinal disorders		Upper limb disorders		Lower limb disorders		Multiple disorders	
Periods	Full period	Reduced period	Full period	Reduced period	Full period	Reduced period	Full period	Reduced period
Overall incidence rates	12.2	11.5	10.8	9.8	8.8	6.8	31.8	28.1

Table 4.3 indicates the incidence of spinal, upper limb, lower limb and multiple disorders for the full period and the reduced period. The incidence of spinal disorders decreased by 5.7% (from 12.2 to 11.5 disorders per 1 000 person-months) when the programme- and postural-adaptation periods were removed from the incidence of the full period (reflected as the reduced period).

Furthermore, the incidence of upper limb disorders decreased by 9.3% (from 10.8 to 9.8 disorders per 1 000 person-months) and the incidence of lower limb disorders decreased by 22.7% (from 8.8 to 6.8 disorders per 1 000 person-months) when both adaptation periods were removed from the incidence of the full period (reflected as the reduced period).

The incidence of multiple disorders decreased by 11.6% (from 31.8 to 28.1 disorders per 1 000 person-months) after removal of the adaptation periods (reflected as the reduced period).

4.3 Analytical findings (objectives 3 and 4)

Objective 3 was to determine the association between individual risk factors (personal and ergonomic) and WRMSDs longitudinally, and objective 4 was to determine the association between work posture and WRMSDs – adjusted for influential risk factors. Results of analytical findings related to objectives 3 and 4 were derived from univariable- and multivariable analysis. Tables 4.4 to 4.6 report on the univariable analysis and Tables 4.7 to 4.10 on the multivariable analysis. Note the significant influence of the intervention (changing the work posture) on the incidence of disorders.

4.3.1 Univariable analysis

Tables 4.4 to 4.6 show the univariable analysis for spinal disorders, upper limb disorders, lower limb disorders and multiple disorders.

Table 4.4 Incidence rate ratio (IRR)** from univariable random-effects Poisson regressions, 95% confidence intervals (95% CI) and P values * of personal risk factors by type of disorder for the full- and reduced time periods (n=123)

Personal risk factors		Spinal disorders		Upper limb disorders		Lower limb disorders		Multiple disorders **	
		Full period	Reduced period ***	Full period	Reduced period ***	Full period	Reduced period ***	Full period	Reduced period ***
Age(years)									
36 to 50	IRR	0.51	0.63	0.46	0.62	0.42	0.56	0.32	0.41
	95% CI	(0.21; 1.24)	(0.25; 1.6)	(0.16; 1.34)	(0.17; 2.27)	(0.12; 1.43)	(0.11; 3.01)	(0.66; 0.64)	(0.18; 0.93)
	P value	0.14	0.33	0.15	0.47	0.16	0.5	0.001*	0.03*
Older than 50	IRR	0.41	0.57	0.54	0.6	0.51	0.71	0.33	0.42
	95% CI	(0.15; 1.18)	(0.2; 1.66)	(0.16; 1.85)	(0.14; 2.6)	(0.14; 1.88)	(0.12; 4.13)	(0.14; 0.74)	(0.17; 1.09)
	P value	0.1	0.3	0.33	0.49	0.31	0.71	0.007*	0.07
Hypertension									
Yes	IRR	1.16	1.28	1.31	1.53	1.561	1.79	1.35	1.56
	95% CI	(0.57; 2.34)	(0.64; 2.57)	(0.5; 3.41)	(0.52; 4.51)	(0.76; 3.2)	(0.78; 4.28)	(0.75; 2.44)	(0.81; 3.0)
	P value	0.68	0.49	0.58	0.44	0.22	0.19	0.32	0.18
Arthritis									
Yes	IRR	0.63	0.72	1.43	1.66	Insufficient data	Insufficient data	0.72	0.87
	95% CI	(0.07; 5.53)	(0.09; 5.94)	(0.15; 13.7)	(0.14; 20.19)			(0.15; 3.57)	(0.16; 4.7)
	P value	0.68	0.76	0.76	0.69			0.69	0.87
Diabetic									
Yes	IRR	0.83	1.0	1.0	1.19	1.19	0.84	0.95	1.0
	95% CI	(0.26; 2.63)	(0.32; 3.03)	(0.23; 4.24)	(0.24; 5.97)	(0.37; 3.85)	(0.16; 4.34)	(0.39; 2.36)	(0.37; 2.73)
	P value	0.74	0.98	0.99	0.83	0.78	0.84	0.92	1.0
Musculoskeletal history									
Yes	IRR	1.82	1.91	0.85	0.94	0.74	0.64	1.1	1.16
	95% CI	(1.12; 2.94)	(1.14; 3.21)	(0.51; 1.42)	(0.53; 1.65)	(0.41; 1.32)	(0.31; 1.33)	(0.82; 1.48)	(0.83; 1.61)
	P value	0.02	0.01	0.53	0.82	0.31	0.23	0.54	0.38
BMI									
Overweight	IRR	0.96	0.99	1.88	1.99	2.54	2.8	1.57	1.62
	95% CI	(0.47; 1.98)	(0.49; 1.99)	(0.67; 5.31)	(0.63; 6.32)	(0.88; 7.31)	(0.8; 9.76)	(0.82; 2.98)	(0.8; 3.27)
	P value	0.92	0.98	0.23	0.24	0.09	0.11	0.17	0.18
Obese	IRR	0.66	0.5	1.04	0.84	2.4	1.97	1.04	0.81
	95% CI	(0.31; 1.41)	(0.23; 1.11)	(0.35; 3.1)	(0.24; 2.96)	(0.84; 6.84)	(0.55; 7.04)	(0.54; 1.98)	(0.39; 1.69)
	P value	0.29	0.09	0.94	0.79	0.1	0.3	0.92	0.57
Morbidly obese	IRR	0.76	0.73	3.34	3.81	6.26	4.81	2.24	2.09
	95% CI	(0.3; 1.95)	(0.29; 1.87)	(1.04; 10.69)	(1.05; 13.81)	(2.2; 17.82)	(1.3; 17.79)	(1.07; 4.69)	(0.92; 4.72)
	P value	0.57	0.51	0.04*	0.04*	.001*	0.02*	0.03*	0.08

*   Significant at p<0.05

**   Refer to Table 4.1 for reference categories

***   "Multiple" denotes that more than one of the disorders were present in the same month

**** Reduced time period excluded the first three months of the study for all the sewing-machine operators and the month that each sewing-machine operator changed his/her work posture, as well as the consecutive month

89

Table 4.5 Incidence rate ratio (IRR)** from univariable random-effects Poisson regressions, 95% confidence intervals (95% CI) and P values * of ergonomic risk factors by type of disorder for the full- and reduced time periods (n=123)

Ergonomic risk factors		Spinal disorders		Upper limb disorders		Lower limb disorders		Multiple disorders **	
		Full period	Reduced period ***	Full period	Reduced period *	Full period	Reduced period ***	Full period	Reduced period ***
Work posture									
Stand	IRR	0.37	0.48	0.72	1.24	1.51	1.32	0.63	0.77
	95% CI	(0.22; 0.64)	(0.28; 0.84)	(0.41; 1.28)	(0.64; 2.41)	(0.87; 2.78)	(0.64; 2.72)	(0.45; 0.89)	(0.52; 1.12)
	P value	<001*	0.01*	0.26	0.52	0.19	0.45	0.008*	0.17
Force/Material									
Cloth and leather	IRR	1.36	1.5	1	1.6	1.63	1.1	1.24	1.35
	95% CI	(0.49; 3.87)	(0.49; 4.54)	(0.21; 4.89)	(0.21; 12.28)	(0.45; 5.85)	(0.27; 4.44)	(0.51; 3.01)	(0.49; 3.68)
	P value	0.56	0.48	1.0	0.65	0.45	0.89	0.63	0.56
Forceful precision stitching									
Forceful precision stitching	IRR	0.71	0.75	0.42	0.51	0.72	0.78	0.59	0.65
	95% CI	(0.35; 1.46)	(0.36; 1.55)	(0.15; 1.21)	(0.16; 1.62)	(0.32; 1.63)	(0.29; 2.08)	(0.33; 1.08)	(0.34; 1.26)
	P value	0.35	0.44	0.11	0.25	0.43	0.62	0.09	0.2
Overtime									
More than 10 000 units per month	IRR	0.81	0.9	1.03	1.24	0.58	0.82	0.81	1.0
	95% CI	(0.43; 1.55)	(0.48; 1.78)	(0.55; 1.94)	(0.64 ; 2.38)	(0.25; 1.37)	(0.34; 1.98)	(0.55; 1.21)	(0.66; 1.5)
	P value	0.53	0.82	0.93	0.52	0.22	0.66	0.31	0.98
Rotate									
Performing job rotation	IRR	1.04	0.93	0.77	0.64	1.12	0.48	0.85	0.66
	95% CI	(0.6; 1.8)	(0.53; 1.63)	(0.37; 1.6)	(0.29; 1.43)	(0.6; 2.12)	(0.21; 1.09)	(0.55; 1.31)	(0.41; 1.05)
	P value	0.88	0.79	0.49	0.28	0.72	0.08	0.46	0.08

*   Significant at p<0.05
**   Refer to Table 4.1 for reference categories
***   "Multiple" denotes that more than one of the disorders were present in the same month
**** Reduced time period excluded the first three months of the study for all the sewing-machine operators and the month that each sewing-machine operator   changed his/her work posture, as well as the consecutive month

Table 4.6 Risk factors that were associated with WRMSDs at the 0.2-level of significance, to be included in the multivariable analysis

Risk factor	Spinal disorders		Upper limb disorders		Lower limb disorders		Multiple disorders***	
	Full period	Reduced period****	Full period	Reduced period****	Full period	Reduced period****	Full period	Reduced period****
Age	√		√				√	√
Hypertension								√
Musculoskeletal history	√	√						
BMI			√	√	√	√	√	√
Work posture	√	√	√	√	√	√	√	√
Forceful precision stitching			√				√	
Overtime					√			

*** "Multiple" denotes that more than one of the disorders were present in the same month

**** Reduced time period excluded the first three months of the study for all the sewing-machine operators and the month that each sewing-machine operator changed his/her work posture, as well as the consecutive month

4.3.2 Multivariable analysis

Objective 3 was to determine the association between work posture and WRMSDs adjusted for influential risk factors. Tables 4.7, 4.8, 4.9, and 4.10 show the multivariable analysis for spinal, upper limb, lower limb and multiple disorders.

Table 4.7 Incidence rate ratio (IRR) from multivariable random effects Poisson regressions, 95% CI and *P* values * of risk factors for spinal disorders for full - and reduced time periods** (n=123)**

Risk factors		Spinal disorders	
		Full period	Reduced period****
Musculoskeletal history			
Yes	IRR	1.4	1.49
	95% CI	(0.86; 2.3)	(0.87; 2.55)
	P value	0.18	0.144
Work posture			
Stand	IRR	0.29	0.4
	95% CI	(0.17; 0.48)	(0.23; 0.68)
	P value	<0.001*	0.001*

* Significant at p<0.05

**** Reduced time period excluded the first three months of the study for all the sewing-machine operators and the month that each sewing-machine operator changed his/her work posture, as well as the consecutive month

Spinal disorders (full period included)

Age category did not contribute in any way while "musculoskeletal history" was a confounder for work posture and the stand-up work posture reduced the incidence for spinal disorders to 0.29 fold the incidence for the seated work posture (p < 0.001).

Spinal disorders (reduced period)

Similar to the above, the incidence for spinal disorders in the stand-up work posture was reduced to 0.4 times the incidence for the seated work posture (p=0.001).

Table 4.8 Incidence rate ratio (IRR) from multivariable random effects Poisson regressions, 95% CI and *P* values * of risk factors for upper limb disorders for full - and reduced time periods** (n=123)**

Risk factors		Upper limb disorders	
		Full period	**Reduced period****
Stand			
	IRR	0.78	1.21
	95% CI	(0.44; 1.39)	(0.63; 2.34)
	P value	0.4	0.57
Age (years)			
36 to 50	IRR	0.37	
	95% CI	(0.14; 1.01)	
	P value	0.05	
Older than 50	IRR	0.52	
	95% CI	(0.16; 1.68)	
	P value	0.28	
BMI			
Overweight	IRR	1.52	2.05
	95% CI	(0.54: 4.30)	(0.64; 6.51)
	P value	0.43	0.23
Obese	IRR	0.89	0.88
	95% CI	(0.28; 2.82)	(0.25; 3.08)
	P value	0.85	0.84
Morbidly obese	IRR	3.35	3.91
	95% CI	(1.06; 10.64)	(1.08; 14.13)
	P value	0.04*	0.04*
Forceful precision stitching			
Forceful precision stitching	IRR	0.42	
	95% CI	(0.15; 1.20)	
	P value	0.011	

* Significant at p<0.05

**** Reduced time period excluded the first three months of the study for all the sewing-machine operators and the month that each sewing-machine operator changed his/her work posture, as well as the consecutive month

Upper limb (full period included)

Age was a confounder for forceful precision stitching and, although not statistically significant (p=0.11), the incidence for forceful precision stitching was reduced to 0.42 times of that for straight stitching. Morbid obesity had significantly increased (p=0.04) incidence of upper limb disorders, 3.35 times that of normal BMI.

Upper limb (reduced period)

Morbid obesity was the only risk factor for upper limb disorders with an increased (p=0.04) incidence of 3.91 times that of normal BMI.

Table 4.9 Incidence rate ratio (IRR)) from multivariable random effects Poisson regressions, 95% CI and *P* values * of risk factors for lower limb disorders for full - and reduced time periods** (n=123)**

Risk factors			Lower limb disorders	
			Full period	Reduced period****
BMI				
Overweight	IRR		2.58	2.82
	95% CI		(0.9; 7.43)	(0.81 ; 9.79)
	P value		0.08	0.1
Obese	IRR		2.45	2.02
	95% CI		(0.86 ; 6.99)	(0.57 ; 7.20)
	P value		0.09	0.28
Morbidly obese	IRR		6.24	4.87
	95% CI		(2.2 ; 17.72)	(1.32 ; 17.89)
	P value		0.001*	0.02*
Work posture				
Stand	IRR		1.49	1.42
	95% CI		(0.8 ; 2.8)	(0.68 ; 2.96)
	P value		0.21	0.34
Overtime				
More than	IRR		0.67	
10 000 units	95% CI		(0.28 ; 1.6)	
per month	*P* value		0.37	

* Significant at p<0.05

**** Reduced time period excluded the first three months of the study for all the sewing-machine operators and the month that each sewing-machine operator changed his/her work posture, as well as the consecutive month

Lower limb (full period included)

Overtime (more than 10 000 units per month) was a confounder for work posture and the incidence for stand-up work posture increased to 1.49 times of the incidence for the seated work posture (p=0.21). Although not statistically significant (p=0.21), standing was associated with an increase IRR (1.49) for lower limb disorders. For BMI, overweight (IRR 2.58; p=0.08) and obese (IRR=2.45; p=0.09) categories were associated with an increased IRR in lower limb disorders, though only marginally significant. However, the morbidly obese group had a significantly increased association with lower limb disorders (IRR=6.24; p=0.001).

Lower limb (reduced period)

Although not statistically significant, overweight (IRR=2.82; p=0.1) and obese (IRR=2.02; p=0.28) categories were associated with an elevated IRR for lower limb disorders. However, the morbidly obese group had a significantly increased association with lower limb disorders (IRR=4.87; p=0.02). Therefore, on removing the adaptation time periods, the IRR was also significantly increased for the morbidly obese sewing-machine operators.

Table 4.10 Incidence rate ratio (IRR) from multivariable random effects Poisson regressions, 95% CI and *P* values * of risk factors for multiple disorders for full - and reduced time periods** (n=123)**

Risk factors		Multiple disorders***	
		Full period	Reduced period****
Age (years)			
36 to 50	IRR	0.36	0.44
	95% CI	(0.18 ; 0.7)	(0.2 ; 0.96)
	P value	0.003*	0.04*
Older than 50	IRR	0.4	0.53
	95% CI	(0.18 ; 0.9)	(0.21 ; 1.35)
	P value	0.03*	0.18
BMI			
Overweight	IRR	1.48	1.59
	95% CI	(0.75 ; 2.91)	(0.76 ; 3.31)
	P value	0.26	0.22
Obese	IRR	1.03	0.78
	95% CI	(0.5 ; 2.11)	(0.35 ; 1.74)
	P value	0.94	0.54
Morbidly obese	IRR	2.43	2.21
	95% CI	(1.12 ; 5.28)	(0.94 ; 5.16)
	P value	0.03*	0.07
Work posture			
Stand	IRR	0.68	0.81
	995% CI	(0.48 ; 0.95)	(0.55 ; 1.2)
	P value	0.03*	0.29

* Significant at p<0.05

*** "Multiple" denotes that more than one of the disorders were present in the same month

**** Reduced time period excluded the first three months of the study for all the sewing-machine operators and the month that each sewing-machine operator changed his/her work posture, as well as the consecutive month

Multiple disorders (full period)

Age was a confounder for work posture and in work posture the incidence of multiple disorders for standing was reduced (p=0.03) to 0.68 times that for sitting down. Morbid obesity had a significantly increased (p=0.03) incidence of multiple disorders, 2.43 times that of normal BMI.

Multiple disorders (reduced period)

Age was a confounder for work posture and incidence for standing was now no longer significantly reduced (p=0.29); i.e. incidence was 0.81 times that for sitting down. Morbid obesity had a marginally significantly increased (p=0.07) incidence of multiple disorders, 2.21 times that of normal BMI.

4.4 Concise overview of the data analysis

This chapter reported on the results of the study – the incidence of disorders to the spinal area, upper and lower limbs. The disorders were analysed both individually as well as collectively (multiple disorders). The primary exposure variable of interest was work posture, i.e. sitting and standing.

For the duration of the period of programme implementation, the incidence of disorders by month was displayed graphically and described in reference to the change in work posture.

5. Discussion and recommendations

In order to address the first objective of the study, the population of sewing-machine operators was described in terms of personal- and ergonomic risk factors. The second objective was to describe incidence of WRMSDs for the period of the study. The third objective was to determine the association between individual risk factors (personal and ergonomic) and WRMSDs longitudinally, and fourthly, to determine the association between work posture and WRMSDs adjusted for influential risk factors. The correspondence between personal and ergonomic risk factors of the population of sewing-machine operators in the current study will be compared with the populations in the mentioned studies.

5.1 Personal risk factors (objective 1)

Descriptive data regarding sample size, gender, age, medical history, musculoskeletal history and BMI of sewing-machine operators and the association of personal risk factors and WRMSDs in the current study (objective 3), are discussed in relation to findings in literature.

Sample size

This sample consisted of all 123 sewing-machine operators employed by the company. Although population-based samples are large (2,685 participants in the study of Roquelaure, Ha *et al.* (2006: 765-778), and 34,868 participants in the study of McDonald, DiBonaventura *et al.* (2011: 767-769)), some studies on sewing-machine operators have included smaller cohorts of participants – n=120 (Westgaard, Jansen 1992: 154-162); n=89 (Andersen, Gaardboe 1993: 677-687); n=178 (Kaergaard, Andersen 2000: 528-534); n=253 (Roquelaure, Mariel *et al.* 2002: 452-458); n=520 (Wang, Rempel *et al.* 2007: 806-813); n=157 (Sealetsa, Thatcher 2011: 279-289), and n=38 (Mostert-Wentzel, Grobler *et al.* 2010: 6-18). The sample size of the current study was large enough for statistical comparison of sub-groups.

Gender

Of the 123 sewing-machine operators in the current study, only three were male. This over-representation of females among sewing-machine operators is also found in the

literature. While some studies have been female-only studies (Westgaard, Jansen 1992: 154-162; Andersen, Gaardboe 1993: 677-687; Kaergaard, Andersen 2000: 528-534; Sealetsa, Thatcher 2011: 279-289), in other studies females represented the majority of the study population (62% (Roquelaure, Mariel *et al.* 2002: 452-458), 62.4% (Wang, Rempel *et al.* 2007: 806-813) or only one male in a cohort of 38 sewing-machine operators (Mostert-Wentzel, Grobler *et al.* 2010: 12)). Only one study of sewing-machine operators was a male-only study (Serratos-Perez, Mendiola-Anda 1993: 793-800). As the current study sample consisted of females mainly, it correlated with the mentioned studies on gender representation, but no associations between gender as a personal risk factor and WRMSDs could be determined.

Age

The mean age of the sewing-machine operators in the current study at baseline was 42.3 ±8, with a 95% CI of 40.5 to 43.7 years. The age group '36 to 50 years' represented 63.4% of this cohort of sewing-machine operators at baseline. These sewing-machine operators were older than sewing-machine operators in four other studies, and slightly younger than the population in one study.

In the first study, that of Kaergaard and Andersen (2000: 528-534), the mean age was 5.4 years younger (38.3 ±10.4) than the study population of the current study. In the second study of Roquelaure, Mariel *et al.* (2002: 452-458), the mean age was 40.2 years, two years younger than the study population of the current study. In the third study, the mean age was 4.3 years younger (38 years, ranging from 18 to 65 years) than the study population of the current study (Wang, Rempel *et al.* 2007: 806-813). In the fourth study of Sealetsa and Thatcher (2011: 279-289), the mean age was ten years younger than the population of the current study, i.e. 32.25 ±7.

On the other hand, the mean age of the population in the current study was 2.3 years older (44 ±1) than the population of the study of Mostert-Wentzel, Grobler *et al.* (2010: 12) at baseline (June 2004 in both studies). Both studies were conducted on the same population, with the difference that the study of (Mostert-Wentzel, Grobler *et al.* 2010: 12) was conducted on sewing-machine operators with WRUEMSDs only (n=38), and the current study included spinal, and lower limb disorders (n=123) as well. This

corresponded with the results of the current study, with age (being 36 to 50 years) being a confounder for forceful precision stitching (although not statistically significant (p=0.11)) among upper limb disorders. (Refer to Section 4.3.2.)

These differences are important, as age, as well as 'length of employment' (a function of age) is mentioned as a risk factor for WRMSD in the literature.

Age category did not contribute to spinal disorders or lower limb disorders. Being older than 36 years of age was also a confounder for the stand-up work posture among multiple disorders for the full - and reduced periods. (Refer to Section 4.3.2.)

According to the literature, a higher prevalence of upper body pain could be expected among sewing-machine operators younger than 30 years (Wang, Rempel *et al.* 2007: 806-813), and of neck and shoulder pain among sewing-machine operators older than 40 years (Andersen, Gaardboe 1993: 677-678). These findings correspond with the results that age older than 36 was a confounder for upper limb disorders and can be expected.

Medical history

At baseline, 17.9% of sewing-machine operators in the current study were hypertensive. Cardiovascular diseases were mentioned among other diseases as reasons for disability among the study population of sewing-machine operators who had left employment (Brisson, Vinet *et al.* 1989: 323-328). The difference between the current and this study populations, was that blood pressure was measured pre-employed in the population in the current study and in the study described in the literature (Brisson, Vinet *et al.* 1989: 323-328), it was mentioned as a reason for disability. Therefore, a higher incidence of hypertension is not necessarily associated with being a sewing-machine operator. No hypertensive values were mentioned in one of the studies. According to the Demographic and Health Survey of 1998 (performed on 13 802 randomly selected South Africans 15 years and older, who were visited in their homes), using the cut-off point of 160/95 mmHg, the prevalence of hypertension in South Africa was 11% for men and 14% for women (Steyn, Gaziano *et al.* 2001: 1717-1725). Blood pressure of the sewing-machine operators in the current study was measured when

they were appointed at the company to screen for hypertension, but the exact values were not captured.

The fact that only 3.3% of sewing-machine operators complained of arthritis at baseline in the current study corresponds well with populations described in the literature. In an epidemiological study conducted among healthy French workers representing all sectors of the workforce (Roquelaure, Ha *et al.* 2006: 770), only 2% of workers reported having inflammatory rheumatism or arthritis of the upper limbs or back. Although arthritis was not associated with WRMSDs in this population of sewing-machine operators, one should bear in mind that the healthy-worker effect might have played a role here, as this occupation required forceful actions with the upper limbs. (The healthy-worker effect can be described as sewing-machine operators with arthritis leaving employment because of pain. Therefore, only sewing-machine operators without pain stayed employed as sewing-machine operators).

For the third condition, the incidence of diabetic mellitus among the study population of sewing-machine operators was three times higher (6.5%) at baseline than the incidence of diabetic mellitus of 2% in the French study (Roquelaure, Ha *et al.* 2006: 770). Although the World Health Organization (WHO), reported that the prevalence of diabetes in France compared to the prevalence in South Africa in 2000 was 1:2, these two populations cannot be compared meaningfully. Levitt, Steyn *et al.* (2001: 946) investigated the prevalence of type-2 diabetes in a similar community (a working class peri-urban community, 55 km from the centre of Cape Town) as the sewing-machine operators in the current study. The crude prevalence of diabetes mellitus type-2 was 7.1% in the Cape Town study. The prevalence of diabetic mellitus in these two South-African populations was in agreement, and diabetes mellitus did not influence the incidence of WRMSDs in the current study.

Although the prevalence of hypertension and diabetes of this study group of sedentary sewing-machine operators was in agreement with the prevalence in the general local population, it contradicted the findings of Wilmot, Edwardson *et al.* (2012: 2989) They concluded that higher levels of sedentary behavior are associated with a 112% increase in the effect estimate of diabetes, 147% increase in the risk of cardiovascular disease,

90% increase in the risk of cardiovascular mortality and 49% increase in the risk of all-cause mortality in a systematic review and meta-analysis conducted on eighteen studies including 794,577 participants in the United Kingdom.

Musculoskeletal history

No data on pre-employment musculoskeletal history were available in the current study at baseline - data were collected during the period of the study. Musculoskeletal history was a confounder for work posture; the stand-up work posture reduced the incidence for spinal disorders to 0.29 times the incidence for the seated work posture (P<0.001) during the full period, and 0.4 times (P=0.001) during the reduced period. Having had a 'pre-employment musculoskeletal disorder' is a known risk factor for the development of WRMSDs during employment (Westgaard, Jansen 1992: 158; Wilson 2002: 39-63; Kaergaard, Andersen 2000: 528-534; Wang, Rempel *et al.* 2007: 806-813). The conclusion is that a sewing-machine operator who had previously contracted a spinal disorder might experience future incidents, regardless of work posture in sewing.

Body mass index

The mean BMI of this population of sewing-machine operators (29.7 kg/m², ±6.1, 95% CI 28.6; 30.8 kg/m²) was higher than the mean BMI for woman the general population in South Africa (27.3 kg/m²) in 2003.

Of the 69% with a BMI higher than 25 kg/m², 27.6% were overweight, 29.3% obese and 13.0% morbidly obese (BMI ≥ 35 kg/m²). Missing data accounted for 8.1% and only 22% of the sewing-machine-operator population's BMI was normal at baseline. This is similar to the BMI of a group of 80 (mostly female) clothing and textile manufacturing employees in Cape Town, South Africa, that participated in the study of Edries, Jelsma *et al.* (2013: 7). The mean BMI of the experimental group of 39 participants was 28.9 kg/m², and for the control group of 41 participants, the mean BMI was 29.80 kg/m².

According to the South African Department of Health, African urban women had the highest mean BMI (27.6 kg/m²) in 2003. Therefore, both local populations of sewing-machine operators had a higher BMI than the rest of the population in South Africa.

Being a sewing-machine operator does not necessarily imply a high BMI. The BMIs of sewing-machine operators in three international studies were compared to the BMIs of the general population in the specific countries where the studies were carried out. For the studies carried out in Denmark, and Botswana, the sewing-machine-operator BMI correlated well with the BMI of the general population in those countries. No correlation could be drawn for the study in the USA.

In the study conducted on sewing-machine operators in Denmark, the mean BMI of a group of 96 females was 24.7 km/m², ranging from 18.4 to 39.9 (Hansen, Kaergaard *et al.* 2003: 268). This prevalence was the same as the mean BMI (24.7 kg/m², 95%CI 24.6; 24.9) of 3 352 Danish woman in the general population (Bendixen, Holst *et al.* 2012: 1465).

Sealetsa and Thatcher reported on the situation among sewing-machine operators in Botswana (2011: 282). Their BMI averaged 24.2 kg/m². This corresponded well to the mean BMI of 24.4 kg/m² for the rest of the Botswana population (Letamo 2011: 75-84).

In the study conducted on sewing-machine operators in Los Angeles (USA), it was concluded that more than half (54%) of the study population of sewing-machine operators were overweight or obese, with a BMI of more than 24.9 kg/m² (39% were overweight and 16% obese) (Wang, Rempel *et al.* 2007: 808). This population cannot be compared to the general population in the USA, because probably all of these sewing-machine operators were immigrant workers (Hispanic or Asian).

In the current study, an increased BMI had no association with spinal disorders, only with upper limb, lower limb and multiple disorders. Although not statistically significant, overweight and obese categories were associated with an increased IRR for lower limb disorders. However, morbid obesity had significantly increased the IRR of upper limb, lower limb and multiple disorders among this South African population of sewing-machine operators. Only one study investigated the association of BMI with WRMSDs, and no association was found between a high BMI and upper body musculoskeletal disorders among sewing-machine operators in Los Angeles, USA (Wang, Rempel *et al.* 2007: 806-813). This finding can be explained on the basis that only 54% of the

sewing-machine operators in their study population were overweight and obese, and none were morbidly obese as was the case in the South African study.

When the results from the literature are compared to the baseline results in this South African study, the local challenge is clear: The South African sewing-machine operators were much heavier than their peers in other studies.

In conclusion, the population of sewing-machine operators in the current study had a slightly increased prevalence of hypertension and arthritis, and a decreased prevalence of diabetes compared to the general population of South-Africa. In spite of the fact that and this population of sewing-machine operators had a high mean BMI and that sedentary time is associated with an increased risk of diabetes, cardiovascular disease and all-cause mortality (the strength of the association is most consistent for diabetes), the conclusion can be made that this was a relatively healthy working population (Wilmot, Edwardson *et al.* 2012: 2898). Neither hypertension, nor arthritis, nor diabetic mellitus influenced the incidence of WRMSDs, which lead to the conclusion that among personal risk factors, age, BMI, and musculoskeletal history had a stronger association with WRMSDs than medical history did.

5.2 Ergonomic risk factors (objective 1)

Descriptive data regarding force (including material used and method of stitching) and duration (working overtime and performing job rotation), and the association of ergonomic risk factors with WRMSDs in the current study (objective 3) are discussed in relation to findings in the literature. The association between work posture (objective 4) and WRMSDs, adjusted for influential factors, will be discussed as well.

5.2.1 Work posture

At baseline, all the sewing-machine operators in the current study worked in the seated work posture. Only 17.9% of the sewing-machine operators changed their work posture early in the study. Of the remaining group of sewing-machine operators, 30.1% changed their work posture in January 2007, and 34.9% a year later in January 2008. Seventeen per cent of the sewing-machine operators remained seated till the last year of the study (20.3% changed in January 2008, 6.5% changed in March 2008 and 10.6%

changed in July 2008). From July 2008 onwards, 100% of the sewing-machine operators performed sewing in the stand-up work posture.

The result was that the stand-up work posture reduced the incidence for spinal disorders to 0.29 times the incidence for the seated work posture (P<0.001) for the full period, and 0.4 times for the reduced period (P=0.001). The incidence of multiple disorders for the stand-up work posture was also reduced 0.68 times that of the seated work posture for the full period. Although the incidence of multiple disorders was not reduced significantly for the reduced period, it was still reduced 0.81 times that of the seated work posture.

With the exception of the studies of Halpern and Dawson (1997: 429-440) and Mostert-Wentzel, Grobler *et al.* (2010: 6-18), the current study is the only one that refers to the change work posture among sewing-machine operators. The study of Mostert-Wentzel, Grobler *et al.* (2010: 6-18) only mentioned postural change and did not investigate the influence of postural change on the incidence of WRMSDs. Furthermore, Halpern and Dawson (1997: 429-440) reported on the design, implementation and ultimately performance of a participatory programme in an automobile-accessories manufacturing plant. As part of the implementation of the participatory programme, the sewing operations were converted from seated to primarily stand-up operations, leading to an improved posture of the torso and back. The results of the programme were reflected in the 85% decrease in the number of musculoskeletal disorders. The results of this South African study confirmed the positive results of Halpern and Dawson (1997: 429-440) in the USA as far as the incidence of WRMSDs in sewing-machine operators – and specifically spinal disorders – is concerned.

Furthermore, the protective effect of the stand-up work posture on spinal disorders, is confirmed by Schierhout, Meyers *et al.*, who reported that "seated, rather than standing work was significantly associated with pain of the neck and shoulders" among 401 employees from seven different manufacturing industries in South Africa (1995: 49).

> Standing appears to be a good rest from sitting, given the change in lumbar spine posture and shift in loading of the posture dependant passive tissues.

Therefore, standing, used alternatively as a rest from sitting, could form a basis for injury prevention when designing work. However, the constant loading with little dynamic movement present in both standing and sitting would provide little rest or change for muscular activation levels and the resultant low back loads. (Callaghan, McGill 2001: 292)

From the current study, it is clear than the stand-up work posture was protective towards WRMSDs in this population of sewing-machine operators, specifically for spinal disorders. The results confirm the outcomes of other authors internationally and locally.

5.2.2 Force

Material

These sewing-machine operators sewed car-seat covers for the automotive industry. The majority of sewing-machine operators (89.4%) sewed with cloth and leather, compared to a smaller group that sewed with cloth and vinyl (10.6%). Although both groups sewed the same product – a car-seat cover – the logical assumption was that sewing with cloth and vinyl was relatively 'easier' material to sew compared to the cloth and leather combination, as cloth and vinyl required less force from the upper limb.

The background to this assumption was searched for in the literature, as sewing can be done on many different types of materials, ranging from lightweight material used for making children's clothes, to canvas and leather as required by the automotive industry. The material sewed in the study conducted by Westgaard and Jansen (1992: 154-162) for making thermal clothing was similar to the light material sewn by sewing-machine operators in other studies (Andersen, Gaardboe 1993: 677-687; Sealetsa, Thatcher 2011: 279-289; Wang, Rempel *et al.* 2007: 806-813; Kaergaard, Andersen 2000: 528-534). Unlike these, other studies reported on sewing-machine operators working with canvas automobile products (Halpern, Dawson 1997: 429-440), car seat material (Mostert-Wentzel, Grobler *et al.* 2010: 6-18) and leather in a shoe factory (Roquelaure, Mariel *et al.* 2002: 452-458).

Although these differences were taken into account in the current study, no association was determined between this ergonomic risk factor and WRMSDs. The sewing-

machine operators did not rotate between the two categories of material investigated in the current study. Therefore, the reason that no association was found between the type of material sewn and WRMSDs might be that the healthy-worker effect was present, or that the work-hardening effect was protective regarding WRMSDs.

Forceful precision stitching

A fifth (20.3%) of the population of sewing-machine operators in the current study, performed forceful precision stitching. This kind of stitching included: 1) assembling headrests; 2) airbags, as well as; 3) performing top-stitch operations that required a combination of precision and force along with increased responsibilities regarding quality of work. The rest of the sewing-machine operators sewed bulkier parts together, mainly by straight stitching. Age was a confounder for forceful precision stitching and, although not statistically significant (p=0.11), the incidence for forceful precision stitching was reduced to 0.42 times that for straight stitching in upper limb disorders.

This ergonomic factor was taken into account in the current study, to fill a gap in the literature regarding the influence of method of stitching on the incidence of WRMSDs. Only one study mentioned this ergonomic risk factor among sewing-machine operators, but no association with WRUEMSDs was investigated (Mostert-Wentzel, Grobler *et al.* 2010: 6-18).

The fact that the incidence for forceful precision stitching was reduced 0.42 times than for straight stitching, in upper limb disorders for the full period, indicated that the handling of bulkier parts, compared to forceful precision stitching, influenced the incidence of upper limb disorders negatively.

Forceful precision stitching (method of stitching) was managed in the current study by the application of a job-rotation policy. The results regarding the association of method of stitching and the incidence of upper limb disorders confirmed the importance of the implementation of a job-rotation policy among sewing-machine operators, who were carefully planned to rotate between different types stitching-method.

5.2.3 Duration

Overtime

Overtime was captured according to the number of car-seat units produced by the company per month. No baseline information was available, as the number of units was captured by month. Working overtime was regarded as working longer hours (more than 10 000 units were produced by the company per month). Although working overtime in the current study was found to be a confounder for work posture and the incidence for stand-up work posture increased to 1.49 times of the incidence for the seated work posture (p=0.21) for the full period, this did not apply to the reduced period for lower limb disorders.

Although there is no consensus in the literature regarding the relationship between working overtime and the prevalence of musculoskeletal disorders (Blåder, Barck-Holst *et al.* 1991: 251-257; Wang, Rempel *et al.* 2007: 806-813), a previous conclusion was: "having less overtime should be considered when treating patients or planning workplace interventions for managing work-related disorders." (Wang, Harrison *et al.* 2010: 352-360).

Therefore, when working overtime – especially during the transition in work posture – accommodation for regular breaks (to sit) should be made in order to relieve spinal discomfort.

Job rotation

No association was found between job rotation and the incidence of WRMSDs in the current study. Rotation between forceful precision stitching and straight stitching operations accounted for 36.6% of this population of sewing-machine operators. The implementation of job rotation from the beginning of the study possibly had a positive outcome regarding upper limb disorders among these sewing-machine operators. In spite of the implemented job-rotation policy – aiming to prevent upper limb disorders, morbid obesity was proven to be a significant risk factor to upper limb disorders.

5.3 Incidence of WRMSDs (objective 2)

The incidence of WRMSDs during the study can be described and discussed for the period of the study. There was a high incidence of WRMSDs at the beginning of the programme, especially for the spinal and upper limb disorders. The initial high incidence of spinal disorders could be attributed to musculoskeletal history as a confounding factor for spinal disorders, as well as the fact that there was no programme implemented to facilitate physiotherapy treatment before June 2004 (as demonstrated by the removal of the programme adaptation period). Thereafter, spinal disorders gradually levelled off over time, with noticeable peaks during the postural adaptation periods when large percentages of the population changed their work posture. This decrease in incidence of spinal disorders during the study period could be attributed to the fact that poorly rehabilitated spinal disorders were addressed by the physiotherapist with manual therapy, education and exercises during the period, as well as the protective effect of the change in work posture.

Likewise, the high incidence of upper limb disorders at the beginning of the study period could be attributed to unattended upper limb WRMSDs, specifically carpal tunnel syndrome (Mostert-Wentzel, Grobler *et al.* 2010: 16). Although these disorders were also influenced by the physiotherapy treatment and the adjusted work posture, the incidence in upper limb disorders did not change much over time. This fact can be attributed to the negative influence of the high mean BMI of this population and the reasoning that the change in work posture does not influence the biomechanics of the upper limb as much as it does for the spinal and lower limb areas.

In contrast with the spinal and upper limb disorders, the incidence of lower limb disorders was low while the majority of the population worked in a seated work posture. As expected, the incidence of lower limb disorders spiked during the first two months of 2007 when 30.1% of the sewing-machine operators changed their work posture (Lin, Chen et al. 2012: 965-970). This increase resulted from the fact that the involved group was not physically prepared for the adaptation to the stand-up work posture. The increase in incidence of lower limb disorders did not recur to the same extent during 2008 when the last 52% of the sewing-machine operators stood up to work. When the

postural adaptation period was removed from the statistical analysis, the increase of lower limb disorders during the change of work posture was shown to be temporary. This adaptation to the stand-up work posture can be attributed to the management of these disorders with advice on acquisition of proper footwear, silicon innersoles, and supportive stockings, and regular exercises from the physiotherapist.

The multiple- disorder ("multiple" denotes that more than one of the disorders was present in the same month) sequence reflected the incidence of injuries in a similar way to the three groups of disorders.

In summary, the incidence of spinal disorders decreased by 5.7% disorders per 1 000 person-months when the programme and postural adaptation periods were statistically removed, compared to the 9.3% disorders per 1 000 person-months decrease in incidence of upper limb disorders and the 22.7% disorders per 1 000 person-months decrease in incidence of lower limb disorders. Likewise, the incidence of multiple disorders decreased by 11.6% disorders per 1 000 person-months after removal of the adaptation periods. The largest contributor to these trends was the influence of the removal of the 'programme adaptation period' on the upper limb and spinal disorders and the removal of the 'postural adaptation period' on the lower limb disorders. It is clear that the stand-up work posture had a temporary negative impact in the incidence of lower limb disorders, and this can be attributed to the influence of the high mean BMI as an influential risk factor.

Similar results on an increase of disorders during adaptations periods had been documented. An initial increase in the incidence of WRMSDs following the implementation of a participatory ergonomics programme was reported by Halpern and Dawson (1997: 429-440), and the German study (Appendix 1) reported on a similar postural adaptation period following a change in work posture. Both studies reported that the increase in incidence was temporary, as was reflected by the current study.

Although these results can be summarised by the saying: "Sometimes one has to be cruel to be kind", it is important that lessons learnt during the implementation of a

programme, as well as a change in work posture, be documented as part of a continuous process of improvement in order to prevent and manage WRMSDs.

5.4 Disorders (objectives 3 and 4)

The association between personal and ergonomic risk factors, work posture and WRMSDs, are discussed. These results cannot be compared to similar studies, as most of the studies determined the prevalence of disorders among sewing-machine operators. Some studies reported on the prevalence of WRMSDs applicable to the whole body, and others only to a specific body region.

Spinal disorders

The association of risk factors with spinal disorders during the period of implementing the change of work posture is concluded as such: For the full period, when considering spinal disorders, musculoskeletal history was a confounder for work posture and the incidence for stand-up work posture reduced to 0.29 times the incidence for the seated work posture (P<0.001). After period adaptations for the programme and postural change, musculoskeletal history was again a confounder and the incidence for spinal disorders in the stand-up work posture was reduced to 0.4 times the incidence of the seated work posture. Some of the pre-existing spinal disorders were treated after adjusting for programme and postural change; however, musculoskeletal history remained a confounder for spinal disorders throughout the study period. Note that the high BMI had no association with spinal disorders - only with disorders of the upper limbs and lower limbs.

Two possible explanations for the association of a decreased incidence of spinal disorders with working in the stand-up work posture lies with biomechanics and nutrition of vertebral discs. In the first place, figure 5.1 explains why most people find it difficult to maintain a 90^0 angle at the hip, and still maintain a reasonable lumbar lordosis. In most people, the pelvis starts to rotate posteriorly and the lumbar curve reverses when hip flexion reaches 60^0. In order to maintain a 90° angle between the trunk and thighs, there is 0° to 20°'s of lumbar flexion (Bendix, Bloch 1986: 127-135; Wilson 2002: 156).
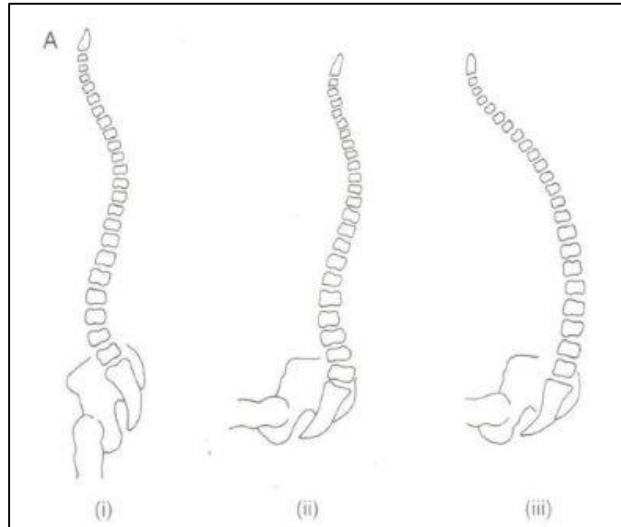
Figure 5.1 A (i) The normal standing posture, (ii) the idealised sitting posture, (iii) the actual sitting posture usually adopted with a reverse lumbar curve. Source: Wilson (2002: 157)

Secondly, intervertebral discs are avascular and viscoelastic, in that their nutrition depends entirely on diffusion. While an individual is sitting, the load on the intervertebral disc is 140% more than that imposed by standing. The static load of a seated posture progressively decreases the water content of a disc; and increased load accelerates this process. Loss of water from a disc makes the diffusion process more difficult and results in reduced oxygen tension and lack of nourishment, leading to disc degeneration. According to Kumar and Konz (in Nordin, Pope *et al)*, sedentary occupations involve prolonged exposure to static loads, hastening this process and making the disc more vulnerable to injuries. A constant static load also deforms the viscoelastic disc and causes compression creep. Because creep is time dependent, elimination of a load (by standing up) does not immediately restore either the pre-load disc configuration or the water content. The reduction in water and oxygen is therefore prolonged, interfering with disc metabolism by decreasing the amount of glycosaminoglycans (which have a strong affinity for water) and increasing the content of keratin sulphate (which is amorphous with far less capacity to imbibe water). In the short term, the viscoelastic deformation may lead also to laxity of the ligament and lack of coordination, potentiating injury through biomechanical perturbations. Over the long

term, it leads to degenerative and permanent changes that are a hazard to the back (2007: 137). This susceptibility to injury might explain why musculoskeletal history was a confounder for work posture.

Recommendation: Russel (2012: 15) agrees with the view expressed by Callaghan, and McGill (2001: 292):

> The best way to reduce pressure in the back is to be in a standing position. However, there are times when you need to sit. (2012: 15)

Upper limb disorders

The association of risk factors and upper limb disorders during the period of implementing the change of work posture is concluded as such: For the full period, when considering upper limb disorders, age (36 to 50 years) was a confounder for forceful precision stitching and the incidence for forceful precision stitching. Although not statistically significant (P=0.11), adjusted for age, the incidence of upper limb disorders for forceful precision stitching was 0.42 times that for straight stitching. Furthermore, the incidence for morbid obesity was increased 3.35 times (P=0.04) relative to normal BMI. For the reduced period, the incidence for morbid obesity was only increased 3.91 times (P=0.04) relative to normal BMI. After the periods of adaptation for the programme and postural change were removed (reduced period), age (36 to 50 years) was no longer a confounder. With reference to figures 4.1 and 4.2, the reason for this result may be that the majority of upper limb disorders that were self-reported at the onset of the programme, were reported by sewing-machine operators in the age group 36 to 50 (44 ±10 years) (Mostert-Wentzel, Grobler *et al.* 2010: 12), who complained of carpal tunnel syndrome (2010: 8).

The high incidence of upper limb disorders among obese subjects (performing a sedentary job) can be explained on the basis of biomechanics. Roberts and McCollum (1996: 147-157) described the sit-to-stand change as involving two phases: before lift-off and after lift-off. In the before lift-off phase, propulsion is generated by trunk flexion and arm flexion. The after-lift-off phase is characterised by knee extension. An emphasis on arm use for propulsion during sit-to-stand change has been noted by Carr

and Gentile (1994: 175-193). When examining these basic movements during sit-to-stand, differences have been detected between obese patients, and patients with a normal BMI. Sibella, Galli *et al.* (2003:1488-192) observed that obese individuals have significantly less trunk flexion in the first few position changes from sitting to standing.

> Average, obese, and athletic individuals all use their upper limb to help pull themselves from a sitting to upright position and to assist in lowering the body back to a sitting position. Larger individuals rely on the upper arm more in this action because it performs as a leverage system to pull weight and assist other muscles in transitioning to an upright position. (Godde, Taylor 2011: 238)

Therefore, for this overweight population of sewing-machine operators (working in a sedentary work posture for many years) the combination of frequent change between standing and sitting combined with sewing, probably contributed towards a high incidence of upper limb disorders. This biomechanical explanation of increased upper limb strain during the postural change between sitting and standing for obese individuals, might explain why the postural change in work posture did not influence the incidence of upper limb disorders during the study period.

Recommendation: Since morbid obesity is strongly associated with an elevated risk of upper limb disorders, reduction in BMI should be promoted as there was no association between the change in work posture and upper limb disorders.

Lower limb disorders
The association of risk factors with lower limb disorders during the period of implementing the change of work posture is concluded as such: For the full period, when considering lower limb disorders, overtime (more than 10 000 units per month) was a confounder for work posture and the incidence for stand-up work posture increased to 1.49 times the incidence for the seated work posture (P=0.21). BMI was an independent risk factor and for morbidly obese sewing-machine operators the incidence increased 6.24 times compared to normal (P < 0.001). After the periods of adaptation for the programme and postural change were removed *reduced period), lower limb disorders were associated with BMI only and for morbidly obese sewing-

115

machine operators the incidence increased 4.87 times compared to normal BMI (P=0.02).

Parameters measuring discomfort in the lower limbs include total foot volume, vascular volume, interstitial volume, biomechanical heel impact and perceived discomfort in the legs and feet. Hansen, Winkel *et al.* (1998: 217-224) conducted a study to investigate the significance of mat and shoe softness during prolonged work in an upright position on these physiological, biomechanical and comfort measurements related to the lower extremities (and the low back) on eight healthy female Danish volunteers with a mean BMI of 21 kg/m², and a mean age of 24 years. The results indicated that for both standing/walking work, the largest oedema-preventing effect occurs with the combination of soft shoes and a hard floor (Hansen, Winkel *et al.* 1998: 223). These facts explain the preventative results of the current study by advising the purchasing of supportive shoes and silicone innersoles.

Furthermore, the implication of a high BMI is that there is more strain on muscles and ligaments in the body – during working - and during domestic hours of the day. This fact was particularly highlighted when the incidence of lower limb disorders increased when work posture for the first group changed during January to March in 2007. Although the incidence of lower limb disorders increased during this period, it was effectively managed by advising sewing-machine operators on purchasing supportive footwear, inserting silicone innersoles in shoes, wearing compressive stockings, and performing regular work-based exercises. Thereafter, the incidence decreased, confirming that this discomfort was only temporary. In fact, a recurrence of an increased incidence of lower limb disorders was possible to prevent, as was indicated by the fact that the incidence in lower limb disorders did not rise to the same extend during January to March 2008 when the second group, who had physically been prepared, changed their work posture.

Recommendation: Since morbid obesity was strongly associated with an elevated risk of lower limb disorders, reduction in BMI should be promoted. Although the combination of supportive footwear, silicone innersoles, compressive stockings, shock-absorbing mats and regular work-based exercises played an important role in the

management and prevention of lower limb disorders, these components were not compared with each other to determine to what extent each component contributed.

Multiple disorders

The association of risk factors with multiple disorders during the period of implementing the change of work posture is concluded as such: For the full period, when considering multiple disorders, age (older than 35 years) was a confounder for work posture and the incidence for the stand-up work posture reduced to 0.68 times that of the seated work posture (P=0.03). Furthermore, the incidence for morbid obesity was increased 2.43 times (P=0.03) relative to normal BMI. For the reduced period, age (older than 35 years) was a confounder for work posture and, although not statistically significant (P=0.29), the incidence for the stand-up work posture reduced to 0.81 times that of the seated work posture. Furthermore, the incidence for morbid obesity was increased 2.21 times (P=0.07) relative to normal BMI.

Recommendation: Since morbid obesity was strongly associated with an elevated risk of multiple disorders, a reduction in BMI should be promoted.

5.5 Limitations and strengths of the study

Internal validity is the validity of inferences in scientific studies. External validity is the validity of generalised inferences in scientific studies, usually based on experiments as experimental validity (Internal and External Validity: 2012). Limitations and benefits of the study are discussed on the basis of internal and external validity.

5.5.1 Internal validity

Internal validity refers both to how well a study was run (i.e. research design, operational definitions used, how variables were measured, what was/was not measured) and how confidently one can conclude that the observed effect(s) was (were) produced solely by the independent variable and not extraneous ones.

5.5.1.1 Study design

The benefit of this longitudinal study compared to a randomised controlled study is that 'actual things, happening in actual places, were seen while they happened' ("Genba

genbutsu" in Japanese [1]), as this intervention took place among many uncertainties. Complexity theory has been used in the fields of strategic management and organisational studies. Application areas include understanding how organisations or firms adapt to their environments and how they cope with conditions of uncertainty. This contribution to the body of knowledge is important, as no incident happens in isolation (Mitleton-Kelly 2003: 1).

Another benefit to the study was that because of the retrospective longitudinal study design, causal relationships could be determined in the absence of a control group. A strong point was that trends in the incidence of WRMSDs were determined for the period of implementation of the change in work posture and the programme.

A possible threat to internal validity in the current study was maturation. Maturation might have happened during the implementation of the intervention. The sewing-machine operators signed acknowledgement of the expected change of work posture when they were employed (some in 1998). Over the study period of 4.5 years, the sewing-machine operators aged and realised that the stand-up work posture was inevitable and permanent. This might have contributed towards the lower incidence of lower limb disorders during January to March 2008.

History was not a threat to internal validity, as no study had previously been conducted on this population of sewing-machine operators. No programme or change in work posture of this kind has ever been implemented in this area.

Experimental mortality was not a threat to internal validity either. All the employed sewing-machine operators were included in the implementation of the change in work posture, as well as the programme for the full duration of the study. No dropouts occurred. Unfortunately, there was 9% missing data regarding medical history. This fact has been reported and taken into account during the analysis (Internal and External Validity: 2012).

[*1] Quoted by Ken Baine at FORD Motor Company of South Africa.

5.5.1.2 Risk factors

A shortcoming of the study was the fact that no parenting-data or data on 'length of employment' were available. Traditionally in this community females take care of households and children after hours (often being single parents), and there might have been an association between female gender and parenting status. There might also have been an association between age, and 'length of employment' in this group of sewing-machine operators.

5.5.2 External validity

External validity represents the extent to which a study's results can be generalised or applied to other people or settings.

The benefit of this retrospective study is that the sewing-machine operators were not aware of the fact that they were participants in a study. Therefore the response, regarding incidence of WRMSDs, to the implementation of the change in work posture and the programme can be expected among other populations of sewing-machine operators with similar demo - and biographic profiles.

The majority of the study population sewed with leather and cloth, compared to the relatively smaller group that sewed with vinyl and cloth. Therefore, the outcome of the current study, specifically for WRMSDs of the upper limb, might not be applicable to other sewing industries that work with lighter materials.

5.6 Summary

In many ways, the implementation of a European policy regarding work posture among a South African population of sewing-machine operators was characterised by adaptation difficulties. Fortunately, the implementation of changing the work posture was managed within a programme. This service enabled the company to manage developed WRMSDs and prevent recurrence of WRMSDs to a certain extent.

5.7 Recommendations

Recommendations are based on lessons learnt in the current study and are made in relation to managing a change in work posture among the sewing-machine operators,

within a programme. Further recommendations are also made for managers (and the union representing the sewing-machine operators), physiotherapists and for research.

5.7.1 Managers and the union (representing the sewing-machine operators)

Change of work posture

- o   Since sewing in the stand-up work posture was protective compared to sewing in the seated work posture, the change in work posture is recommended to reduce the risk of spinal disorders.
- o   Other strategies to prevent and manage lower limb disorders in the stand-up work posture could include supportive foot wear, silicone innersoles, compressive stockings and regular work-based exercises before sewing in the stand-up posture is commenced, and thereafter.
- o   Ergonomic design of stand-up work stations should include: height-adjustable work surfaces to enhance a good work posture; optimised layout and storage heights to prevent excessive reaching; shock absorbing mats, and pedal design to encourage alternative weight bearing.

The programme
- o   Personal risk factor: Since morbid obesity was a risk factor for upper limb disorders and had a significantly increased association with lower limb disorders, reduction in BMI should be promoted.

- o   Ergonomic risk factor: As forceful precision stitching was protective compared to straight stitching, job rotation is recommended to reduce the risk of upper limb disorders while carrying out straight stitching.

5.7.2 Physiotherapists

Change of work posture

- o When physiotherapists manage WRMSDs in the clinical setting, it is important that advice to patients and their employers of the impact of changing work posture on the musculoskeletal system, is evidence-based.

The programme

- o In order to promote similar programmes in industry, physiotherapists should be set on demonstrating the cost benefits of such programmes. Evidence-based healthcare in an occupational setting is needed in order to prove that the benefits obtained outweigh cost of providing occupational physiotherapy, due to decreased medical expenses, and improved productivity of workers.

5.7.3 Research

Areas that arise from the findings of the current study need to be explored further. The first is the characteristics of this population of sewing-machine operators compared to the populations in the literature, including the relatively higher age and the increased BMI of sewing-machine operators in South Africa. The second is the fact that the incidence of WRMSDs demonstrated that the programme succeeded in preventing and managing WRMSDs. The third is the better understanding of the association of the personal and ergonomic risk factors and WRMSDs. Therefore,

- o Similar studies could be repeated on other working populations to determine the association between personal and ergonomic risk factors, work posture and WRMSDs, in order to develop strategies to prevent and manage WRMSDs.
- o The change of work posture had a positive impact on WRMSDs – specifically spinal disorders – but may also impact other systems. Further recommendations are to investigate the impact of the stand-up work posture

on other systems – i.e. the cardiovascular, respiratory and digestive systems – as well as strategies to manage risk factors within a managed healthcare programme.

o   Similar studies could include psychosocial risk factors in the multivariate analysis of the data as psychosocial risk factors might influence the incidence of WRMSDs.

o   A retrospective qualitative study on the content and nature of the programme can be done.

o   A randomised controlled study can be conducted to compare the value of supportive footwear, silicone innersoles, compressive stockings, shock-absorbing mats and regular work-based exercises with each other in order to decrease the incidence of lower limb disorders in a standing work population.

6. Conclusion

The change in work posture led to a temporarily increased incidence of WRMSDs. The situation was aggravated by the fact that this population of sewing-machine operators was relatively older and had a higher mean BMI than sewing-machine operators in most other studies. The benefit of the stand-up work posture was statistically relevant for the incidence of spinal disorders, and the negative impact on the lower limbs as a result of the change in work posture, was temporarily (especially for the overweight, obese and morbidly obese sewing-machine operators). Furthermore, being obese was a risk factor for upper limb disorders, regardless of the change in work posture.

In the management of WRMDS within a health-promoting workplace programme, a physiotherapy service should be included in the multidisciplinary team in order to deliver a clinical intervention in close association with clinical ergonomics.

The responsibilities, of the employer as well as the employee for optimised health in the work place, can be described as two sides of the same coin. As for the employer, the responsibility is to create and manage a safe work environment, including sound ergonomic workplace design and a stand-up work posture, as well as a programme to prevent and manage work-related musculoskeletal disorders. As for the employee, the responsibility is to maintain a healthy personal lifestyle, including regular exercise and a balanced diet.

7. References

ADEBAJO, A., BLENKIRON, L. and DIEPPE, P., 2004. Patient education for diverse populations. *Rheumatology*, **43**(11), pp. 1321-1322.

ALDOUS, C., RHEEDER, P. and ESTERHUIZEN, T., 2011. *Writing your first clinical research protocol.* Cape Town: Juta.

ALKHAJAH, T.A., REEVES, M.M., EAKIN, E.G., WINKLER, E.A.H., OWEN, N. and HEALY, G.N., 2012. Sit–Stand Workstations: A Pilot Intervention to Reduce Office Sitting Time. *American Journal of Preventive Medicine,* **43**(3), pp. 298-303.

ANDERSEN, J.H. and GAARDBOE, O., 1993. Musculoskeletal disorders of the neck and upper limb among sewing machine operators: a clinical investigation. *American Journal of Industrial Medicine,* **24**(6), pp. 689-700.

ANDERSEN, J.H. and GAARDBOE, O., 1993. Prevalence of persistent neck and upper limb pain in a historical cohort of sewing machine operators. *American Journal of Industrial Medicine,* **24**(6), pp. 677-687.

ARIENS, G.A., VAN MECHELEN, W., BONGERS, P.M., BOUTER, L.M. and VAN DER WAL, G., 2001. Psychosocial risk factors for neck pain: a systematic review. *American Journal of Industrial Medicine,* **39**(2), pp. 180-193.

ARONSSON, G., GUSTAFSSON, K. and DALLNER, M., 2000. Sick but yet at work. An empirical study of sickness presenteeism. *Journal of Epidemiology & Community Health,* **54**(7), pp. 502-509.

BALDWIN, M.L., 2004. Reducing the costs of work-related musculoskeletal disorders: targeting strategies to chronic disability cases. *Journal of Electromyography & Kinesiology,* **14**(1), pp. 33.

BECKER, J., NORA, D.B., GOMES, I., STRINGARI, F.F., SEITENSUS, R., PANOSSO, J.S. and EHLERS, J.A.C., 2002. An evaluation of gender, obesity, age and diabetes

mellitus as risk factors for carpal tunnel syndrome. *Clinical Neurophysiology*, **113**(9), pp. 1429-1434.

BENDIX, T. and BLOCH, I., 1986. How should a seated workplace with a tiltable chair be adjusted? *Applied Ergonomics,* **17**(2), pp. 127-135.

BENDIXEN, H., HOLST, C., SØRENSEN, T.I.A., RABEN, A., BARTELS, E.M. and ASTRUP, A., 2012. Major increase in prevalence of overweight and obesity between 1987 and 2001 among Danish adults. *Obesity research,* **12**(9), pp. 1464-1472.

BLÅDER, S., BARCK-HOLST, U., DANIELSSON, S., FERHM, E., KALPAMAA, M., LEIJON, M., LINDH, M. and MARKHEDE, G., 1991. Neck and shoulder complaints among sewing-machine operators: a study concerning frequency, symptomatology and dysfunction. *Applied Ergonomics,* **22**(4), pp. 251-257.

BRISSON, C., VINET, A. and VEZINA, M., 1989. Disability among female garment workers. A comparison with a national sample. *Scandinavian Journal of Work, Environment & Health,* **15**(5), pp. 323-328.

BURY, T.J. and MEAD, J.M., 1998. *Evidence-based healthcare: a practical guide for therapists.* Oxford ; Boston: Butterworth-Heinemann.

CALLAGHAN, J. and MCGILL, S., 2001. Low back joint loading and kinematics during standing and unsupported sitting. *Ergonomics,* **44**(3), pp. 280-294.

CARR, J.H. and GENTILE, A., 1994. The effect of arm movement on the biomechanics of standing up. *Human Movement Science,* **13**(2), pp. 175-193.

CHU, C., DRISCOLL, T. and DWYER, S., 1997. The health–promoting workplace: an integrative perspective. *Australian and New Zealand Journal of Public Health,* **21**(4), pp. 377-385.

CHU, C. and DWYER, S., 2002. Employer role in integrative workplace health management: a new model in progress. *Disease Management & Health Outcomes,* **10**(3), pp. 175-186.

COLLINS, R., VAN RENSBURG, D.C.J. and PATRICIOS, J., 2011. Common work-related musculoskeletal strains and injuries: CPD article.

CONCATO, J., SHAH, N. and HORWITZ, R.I., 2000. Randomized, controlled trials, observational studies, and the hierarchy of research designs. *New England Journal of Medicine,* **342**(25), pp. 1887-1892.

DEPARTMENT OF HEALTH, , South African Demographic and Health Survey (SADHS). Available: http://www.info.gov.za/view/DownloadFileAction?id=90143 [24/09/2012, 2012].

EDRIES, N., JELSMA, J. and MAART, S., 2013. The impact of an employee wellness programme in clothing/textile manufacturing companies: a randomised controlled trial. *BMC Public Health,* **13**(1), pp. 25.

EKBERG, K., BJORKQVIST, B., MALM, P., BJERRE-KIELY, B., KARLSSON, M. and AXELSON, O., 1994. Case-control study of risk factors for disease in the neck and shoulder area. *Occupational & Environmental Medicine,* **51**(4), pp. 262-266.

ENGLISH, B. and VAN TONDER, S.L., 2009. *Putting it into words: how to write a great research report.* Wandsbeck, South Africa: Reach Publishers.

FEUERSTEIN, M., NICHOLAS, R.A., HUANG, G.D., DIMBERG, L., ALI, D. and ROGERS, H., 2004. Job stress management and ergonomic intervention for work-related upper extremity symptoms. *Applied Ergonomics,* **35**(6), pp. 565-574.

GENEVA: INTERNATIONAL LABOUR ORGANISATION (ILO), WORLD EMPLOYMENT REPORT 1998-1999, 10 October 2000, 2000-last update,

Labour practices in the footwear, leather, textiles and clothing industries [9 August 2011, 2011].

GODDE, K. and TAYLOR, R.W., 2011. Musculoskeletal stress marker (MSM) differences in the modern American upper limb and pectoral girdle in relation to activity level and body mass index (BMI). *Forensic Science International,* **210**(1), pp. 237-242.

HALPERN, C.A. and DAWSON, K.D., 1997. Design and implementation of a participatory ergonomics program for machine sewing tasks. *International Journal of Industrial Ergonomics,* **20**(6), pp. 429-440.

HANSEN, ÅM., KAERGAARD, A., ANDERSEN, J.H. and NETTERSTRØM, B., 2003. Associations between repetitive work and endocrinological indicators of stress. *Work & Stress,* **17**(3), pp. 264-276.

HANSEN, L., WINKEL, J. and JØRGENSEN, K., 1998. Significance of mat and shoe softness during prolonged work in upright position: based on measurements of low back muscle EMG, foot volume changes, discomfort and ground force reactions. *Applied Ergonomics,* **29**(3), pp. 217-224.

HOSMER, D.W., HOSMER, T., LE CESSIE, S. and LEMESHOW, S., 1997. A comparison of goodness-of-fit tests for the logistic regression model. *Statistics in Medicine*, **16**(9), pp. 965-980.

Internal and External Validity. Available:
http://www.umdnj.edu/idsweb/shared/internal_external_validty.htm [10/15/2012, 2012].

JENSEN, B.R., SCHIBYE, B., SOGAARD, K., SIMONSEN, E.B. and SJOGAARD, G., 1993. Shoulder muscle load and muscle fatigue among industrial sewing-machine operators. *European Journal of Applied Physiology & Occupational Physiology,* **67**(5), pp. 467-475.

JORDAN, K., CLARKE, A.M., SYMMONS, D.P.M., FLEMING, D., PORCHERET, M., KADAM, U.T. and CROFT, P., 2007. Measuring disease prevalence: a comparison of musculoskeletal disease using four general practice consultation databases. *The British Journal of General Practice*, **57**(534), pp. 7.

KAERGAARD, A. and ANDERSEN, J.H., 2000. Musculoskeletal disorders of the neck and shoulders in female sewing machine operators: prevalence, incidence, and prognosis. *Occupational & Environmental Medicine,* **57**(8), pp. 528-534.

KARWOWSKI, W., 1997. Ergonomics: How to Design for Ease and Efficiency by Karl Kroemer, Henrike Kroemer, & Katrin Kroemer-Elbert 1994, 766 pages, $86.00 Englewood Cliffs, NJ: Prentice-Hall ISBN 0-13-278359-2. *Ergonomics in Design,* **5**(2), pp. 33-35.

KUMAR, S. and KONZ, S., 2007. Workplace adaptation for the low back region. *Musculoskeletal Disorders in the Workplace: Principles and Practice*, pp. 135-144.

LAM, N. and THURSTON, A., 2008. Association of obesity, gender, age and occupation with carpal tunnel syndrome. *Australian and New Zealand Journal of Surgery*, **68**(3), pp. 190-193.

LETAMO, G., 2011. The prevalence of, and factors associated with, overweight and obesity in Botswana. *Journal of Biosocial Science,* **43**(01), pp. 75-84.

LEVITT, N., STEYN, K., LAMBERT, E., REAGON, G., LOMBARD, C., FOURIE, J., ROSSOUW, K. and HOFFMAN, M., 2001. Modifiable risk factors for Type 2 diabetes mellitus in a peri-urban community in South Africa. *Diabetic Medicine,* **16**(11), pp. 946-950.

LIN, Y.H., CHEN, C.Y. and CHO, M.H., 2012. Influence of shoe/floor conditions on lower leg circumference and subjective discomfort during prolonged standing. *Applied Ergonomics, 43(5), pp. 965-70.*

LOISEL, P., ABENHAIM, L., DURAND, P., ESDAILE, J.M., SUISSA, S., GOSSELIN, L., SIMARD, R., TURCOTTE, J. and LEMAIRE, J., 1997. A population-based, randomized clinical trial on back pain management. *Spine,* **22**(24), pp. 2911-2918.

LOISEL, P., DURAND, P., ABENHAIM, L., GOSSELIN, L., SIMARD, R., TURCOTTE, J. and ESDAILE, J.M., 1994. Management of occupational back pain: the Sherbrooke

model. Results of a pilot and feasibility study. *Occupational & Environmental Medicine,* **51**(9), pp. 597-602.

LOISEL, P., LEMAIRE, J., POITRAS, S., DURAND, M.J., CHAMPAGNE, F., STOCK, S., DIALLO, B. and TREMBLAY, C., 2002. Cost-benefit and cost-effectiveness analysis of a disability prevention model for back pain management: a six year follow up study. *Occupational & Environmental Medicine,* **59**(12), pp. 807-815.

MAHER, C.G., 2000. A systematic review of workplace interventions to prevent low back pain. *Australian Journal of Physiotherapy,* **46**(4), pp. 259-269.

MANN, C.J., 2003. Observational research methods. Research design II: cohort, cross sectional, and case-control studies. *Emergency Medicine Journal,* **20**(1), pp. 54-60.

MCDONALD, M., DIBONAVENTURA, M. and ULLMAN, S., 2011. Musculoskeletal pain in the workforce: the effects of back, arthritis, and fibromyalgia pain on quality of life and work productivity. *Journal of Occupational & Environmental Medicine,* **53**(7), pp. 765-770.

MITLETON-KELLY, E., 2003. *Complex systems and evolutionary perspectives on organisations: the application of complexity theory to organisations.* Emerald Group Pub Limited.

MOSTERT-WENTZEL, K., GROBLER, S., FERREIRA, N. and LUMLEY, M., 2010. Effect of a work-based physiotherapy and ergonomics programme on work-related upper-extremity musculo skeletal disorders in car-seat seamstresses. *Occupational Health Southern Africa.* pp. 6-18.

MOTHERAL, B., BROOKS, J., CLARK, M.A., CROWN, W.H., DAVEY, P., HUTCHINS, D., MARTIN, B.C. and STANG, P., 2003. A checklist for retrospective database studies--report of the ISPOR Task Force on Retrospective Databases. *Value In Health: The Journal Of The International Society For Pharmacoeconomics And Outcomes Research,* **6**(2), pp. 90-97.

NORDIN, M., POPE, M.H. and ANDERSSON, G., 2007. *Musculoskeletal disorders in the workplace: principles and practice.* 2 edn. Philadelphia: Mosby Elsevier.

OLSON, D.L., 1999. An on-site ergonomic program: A model for industry. *Work,* **13**(3), pp. 229-238.

OWEN, N., BAUMAN, A. and BROWN, W., 2009. Too much sitting: a novel and important predictor of chronic disease risk? *British Journal of Sports Medicine,* **43**(2), pp. 81-83.

PARKS, K.M. and STEELMAN, L.A., 2008. Organizational wellness programs: a meta-analysis. *Journal of Occupational Health Psychology*, **13**(1), pp. 58.

PHEASANT, S., *Ergonomics,Work and Health.* Macmillan Academic & Professional.

PILIGIAN, G., HERBERT, R., HEARNS, M., DROPKIN, J., LANDSBERGIS, P. and CHERNIACK, M., 2000. Evaluation and management of chronic work-related musculoskeletal disorders of the distal upper extremity. *American Journal of Industrial Medicine*, **37**(1), pp. 75-93.

Policy statement: Primary health care | WCPT.org. Available: http://www.wcpt.org/policy/ps-primary-health-care [10/16/2012, 2012].

PRANSKY, G.S., VERMA, S.K., OKUROWSKI, L. and WEBSTER, B., 2006. Length of disability prognosis in acute occupational low back pain: development and testing of a practical approach. *Spine*, **31**(6), pp. 690-697.

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

RABE-HESKETH, S. and SKRONDAL, A., 2008. *Multilevel and longitudinal modeling using stata.* 2 edn. College Station, Tex.: Stata Press.

REMPEL, D.M., WANG, P.C., JANOWITZ, I., HARRISON, R.J., YU, F. and RITZ, B.R., 2007. A randomized controlled trial evaluating the effects of new task chairs on shoulder and neck pain among sewing machine operators: the Los Angeles garment study. *Spine,* **32**(9), pp. 931-938.

RICHARDSON, B. and EASTLAKE, A., 1994. *Physiotherapy in occupational health: management, prevention and health promotion in the work place.* Oxford: Butterworth-Heinemann.

ROBERTS, P.D. and MCCOLLUM, G., 1996. Dynamics of the sit-to-stand movement. *Biological cybernetics,* **74**(2), pp. 147-157.

ROQUELAURE, Y., MARIEL, J., FANELLO, S., BOISSIERE, J.C., CHIRON, H., DANO, C., BUREAU, D. and PENNEAU-FONTBONNE, D., 2002. Active epidemiological surveillance of musculoskeletal disorders in a shoe factory. *Occupational & Environmental Medicine,* **59**(7), pp. 452-458.

ROQUELAURE, Y., HA, C., LECLERC, A., TOURANCHET, A., SAUTERON, M., MELCHIOR, M., IMBERNON, E. and GOLDBERG, M., 2006. Epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population. *Arthritis & Rheumatism*, **55**(5), pp. 765-778.

ROQUELAURE, Y., HA, C., FOUQUET, N., DESCATHA, A., LECLERC, A., GOLDBERG, M. and IMBERNON, E., 2009. Attributable risk of carpal tunnel syndrome in the general population: implications for intervention programs in the workplace. *Scandinavian Journal of Work, Environment & Health*, **35**(5), pp. 342.

RUSSEL J, C.R., 2012. *Participatory ergonomics.* Edinburgh: LENNEX Corp.

SADI, J., MACDERMID, J.C., CHESWORTH, B. and BIRMINGHAM, T., 2007. A 13-year cohort study of musculoskeletal disorders treated in an autoplant, on-site physiotherapy clinic. *Journal of Occupational Rehabilitation*, **17**(4), pp. 610-622.

SANDERS, M.J., 1997. *Management of cumulative trauma disorders.* Boston: Butterworth-Heinemann.

SCHIBYE, B., SKOV, T., EKNER, D., CHRISTIANSEN, J.U. and SJOGAARD, G., 1995. Musculoskeletal symptoms among sewing machine operators. *Scandinavian Journal of Work, Environment & Health,* **21**(6), pp. 427-434.

SCHIERHOUT, G., MEYERS, J. and BRIDGER, R., 1995. Work related musculoskeletal disorders and ergonomic stressors in the South African workforce. *Occupational and Environmental Medicine*, **52**(1), pp. 46-50.

SEALETSA, O. and THATCHER, A., 2011. Ergonomics issues among sewing machine operators in the textile manufacturing industry in Botswana. *Work: A Journal of Prevention, Assessment and Rehabilitation,* **38**(3), pp. 279-289.

SERRATOS-PEREZ, J.N. and MENDIOLA-ANDA, C., 1993. Musculoskeletal disorders among male sewing machine operators in shoemaking. *Ergonomics,* **36**(7), pp. 793-800.

SIBELLA, F., GALLI, M., ROMEI, M., MONTESANO, A. and CRIVELLINI, M., 2003. Biomechanical analysis of sit-to-stand movement in normal and obese subjects. *Clinical Biomechanics,* **18**(8), pp. 745-750.

SOKAS, R.K., SPIEGELMAN, D. and WEGMAN, D.H., 1989. Self-reported musculoskeletal complaints among garment workers. *American Journal of Industrial Medicine,* **15**(2), pp. 197-206.

STALLINGS, S.P., KASDAN, M.L., SOERGEL, T.M. and CORWIN, H.M., 1997. A case-control study of obesity as a risk factor for carpal tunnel syndrome in a population of 600 patients presenting for independent medical examination. *The Journal of Hand Surgery,* **22**(2), pp. 211-215.

STEYN, K., GAZIANO, T.A., BRADSHAW, D., LAUBSCHER, R. and FOURIE, J., 2001. Hypertension in South African adults: results from the Demographic and Health Survey, 1998. *Journal of Hypertension,* **19**(10), pp. 1717-1725.

TARTAGLIA, R., CINTI, G., CARRARA, S., COLOMBINI, D., OCCHIPINTI, E. and LOI, F., 1990. [Work posture and changes in the spine of sewing workers in the clothing industry]. *Medicina del Lavoro,* **81**(1), pp. 39-44.

THEORELL, T., HARMS-RINGDAHL, K., AHLBERG-HULTEN, G. and WESTIN, B., 1991. Psychosocial job factors and symptoms from the locomotor system--a multicausal analysis. *Scandinavian Journal of Rehabilitation Medicine,* **23**(3), pp. 165-173.

The World Health Report. Available: http://www.who.int/whr/1998/en/whr98_en.pdf [10/16/2011, 2011].

VAN DER PLOEG, H.P., CHEY, T., KORDA, R.J., BANKS, E. and BAUMAN, A., 2012. Sitting time and all-cause mortality risk in 222 497 Australian adults. *Archives of Internal Medicine*, **172**(6), pp. 494.

VERCRUYSSEN, M. and SIMONTON, K., 1994. *Effects of posture on mental performance: we think faster on our feet than on our seat. Hard facts about soft machines: the ergonomics of seating* (Lueder RNK, ed), pp. 119-131.

VÉZINA, N., TIERNEY, D. and MESSING, K., 1992. When is light work heavy? Components of the physical workload of sewing machine operators working at piecework rates. *Applied Ergonomics,* **23**(4), pp. 268-276.

WANG, P., REMPEL, D.M., HARRISON, R.J., CHAN, J. and RITZ, B.R., 2007. Work-organisational and personal factors associated with upper body musculoskeletal disorders among sewing machine operators. *Occupational & Environmental Medicine,* **64**(12), pp. 806-813.

WANG, P.C., RITZ, B.R., JANOWITZ, I., HARRISON, R.J., YU, F., CHAN, J. and REMPEL, D.M., 2008. A randomized controlled trial of chair interventions on back and

hip pain among sewing machine operators: the los angeles garment study. *Journal of Occupational & Environmental Medicine,* **50**(3), pp. 255-262.

WANG, P.C., HARRISON, R.J., YU, F., REMPEL, D.M. and RITZ, B.R., 2010. Follow-up of neck and shoulder pain among sewing machine operators: The Los Angeles garment study. *American Journal of Industrial Medicine,* **53**(4), pp. 352-360.

WESTGAARD, R. and JANSEN, T., 1992. Individual and work related factors associated with symptoms of musculoskeletal complaints. II. Different risk factors among sewing machine operators. *British Journal of Industrial Medicine,* **49**(3), pp. 154-162.

WHO | Country and regional data on diabetes. Available: http://www.who.int/diabetes/facts/world_figures/en/index1.html [24/09/2012, 2012].

WILLIAMS, R.M., WESTMORLAND, M.G., LIN, C.A., SCHMUCK, G. and CREEN, M., 2007. Effectiveness of workplace rehabilitation interventions in the treatment of work-related low back pain: a systematic review. *Disability & Rehabilitation,* **29**(8), pp. 607-624.

WILMOT, E., EDWARDSON, C., ACHANA, F., DAVIES, M., GORELY, T., GRAY, L., KHUNTI, K., YATES, T. and BIDDLE, S.J.H., 2012. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia,* pp. 1-11.

WILSON, A., 2002. *Effective management of musculoskeletal injury : a clinical ergonomics approach to prevention, treatment and rehabilitation.* Edinburgh: Churchill Livingstone.

ZHANG, F.R., HE, L.H., WU, S.S., LI, J.Y., YE, K.P. and WANG, S., 2011. Quantify work load and muscle functional activation patterns in neck-shoulder muscles of female sewing machine operators using surface electromyogram. *Chinese medical journal,* **124**(22), pp. 3731-3737.

Appendix 1

English summary of German study

Appendix 2

Summary of literature

Appendix 3

Data collection and capturing

Appendix 4

Data coding

Appendix 5

Ergonomics needs assessment form

Potential Ergonomics Issues List (PEIL)

Appendix 6

Power point presentation on basic back care

Appendix 7

Power point presentation of TRIM training

Appendix 8

Exercises

Appendix 9

Approval from ethics committee

Appendix 10

Medical surveillance forms

Ergonomics at sewing workplaces

Problem

Elevated sickness rates and levels of the corresponding absenteeism have been observed for years in the German sewing industry. The main group of diseases observed in this area are those of the musculoskeletal system, particularly of the spine and the upper extremities. Under their prevention mandate, the BGs responsible for the leather industry and (at that time) for the textile and clothing industry (now the BG ETE) therefore launched a research project with the aim of developing an ergonomic sewing workplace and a practical guide to setting up ergonomic sewing workplaces.

Activities

The project, which was funded by the DGUV, was conducted in collaboration with the Munich University of Applied Sciences and the Schwan engineering office in Frankfurt. In eight selected sewing businesses, physiological strain parameters such as pulse rate and electrical muscle activity were measured in conjunction with body postures and movements during typical sewing tasks. The body postures and movements of the upper extremities, head, spine, and lower extremities were recorded continuously by means of the CUELA measurement system developed at the BGIA. In addition, environmental conditions such as lighting, noise and climatic conditions were measured. The subjective impression of the strain for the sewing operatives involved and their disorders and diseases were documented. Based upon the measurement results, an ergonomically improved model sewing workplace was developed, which was then installed in a number of sewing businesses.

The newly developed ergonomic sewing workplace; sewing operative fitted with the CUELA measurement system

Results and application

It was possible to demonstrate and quantify for the first time the typical stress situations at sewing workplaces, such as the performance of work in extreme joint angle positions, static postures, continually repeated movements, and the application of high forces. These results were incorporated during development of the ergonomic workplace, the characteristics of which included the following (cf. figure):

- Extension of the legroom
- Sewing with changing body postures (seated or standing) is possible
- Support for the arm and hand
- Reduction of awkward postures of the upper body

The comparison between the strain and stress profiles revealed a substantial improvement in the trunk posture and a reduction in arm and shoulder postures at extreme joint angles for tasks performed at the ergonomic workplace. The reduction in physical strain was also measurable. Following a period to adjust, acceptance of the new workplace among the sewing operatives is very high; subjective assessment by the test subjects also confirms the reduction in stress and strain brought about by the modified work situation.

The results of the research project have been incorporated into a guidance document (BGI 804-2) and are thus available directly to parties working in the field. The ergonomic sewing workplaces are available commercially and have since been installed at over 20 German companies, over half of which are small and medium-sized enterprises (SMEs). Following their installation, some companies observed particular personnel and economic benefits. An example was a medium-sized textile service company which in 2007 was awarded a prize in the European competition for the prevention of work-related musculoskeletal diseases. Following conversion of a total of 40 sewing workplaces, sick leaves in this company fell by 16%; at the same time, productivity rose by approximately 15%. The costs of the conversion were recouped after only a few months.

Area of Application

Textile and garment industry, leather industry, industrial sewing plants

Additional Information

- Ellegast, R. P.; Herda, C.; Hoehne-Hückstädt, U.; Lesser, W.; Kraus, G.; Schwan, W.: Ergonomie an Näharbeitsplätzen. BIA-Report 7/2004. Ed.: Hauptverband der gewerblichen Berufsgenossenschaften (HVBG), Sankt Augustin 2004
www.dguv.de/bgia, Webcode d6353
- BGI 804-2: Ergonomie an Näharbeitsplätzen – Ratgeber für die Praxis. Carl Heymanns, Cologne 2005
www.arbeitssicherheit.de

Expert Assistance:

BGIA, Division 4: Ergonomics – Physical environmental factors

Literature Requests:

BGIA, Central Division

"Focus on BGIA's Work"

Appendix 2

Summary of literature

Appendix 2
Summary of literature

2.1 Article selection

Each citation found in the search was screened by the researcher for relevance to the study. For the purpose of this literature review, articles were considered relevant if the the main topic-related criteria set out below applied to them.

Inclusion criteria:

1. Proposed occupational health programmes that included ergonomics;
2. Outcomes of the implementation of such health programmes, also described as case studies in industries related to sewing;
3. Studies that examined the prevalence, incidence, risk factors, and/or prevention of WRMSDs to the spinal area, upper limb and lower limb;
4. Studies that examined the association between risk factors and WRMSDs; and
5. Full articles available in the English language, and relevant abstracts available in English for articles that were published in other languages.

Studies that did not include human subjects were excluded.

2.2 Critical review of the literature

Articles meeting the inclusion criteria were reviewed using standard criteria review forms (English, Van Tonder 2009: 40-41). The review was concise, but included all the elements relevant to the research. Initially, the review forms prompted the researcher to appraise the methodological merit of the study by focusing on selection bias, information and confounding. Furthermore, randomised controlled studies, and reviews were evaluated according to the critical appraisal skills programme (CASP) (Bury, Mead 1998: 141). Thereafter the forms assisted the researcher in understanding the impact of bias on the study results. (See Appendix 2.)

The literature review included descriptive studies, randomised controlled trials, a longitudinal study, a retrospective longitudinal study, case studies, literature reviews and cross-sectional studies. They were summarised in three groups:

- o   Epidemiology of WRMSDs among sewing-machine operators;
- o   Risk factors causative to WRMSDs in the working population; and
- o   Similar programmes to the programme implemented in the current study. (See Appendix 2.)

2.2.1 Descriptive studies

Five studies, with epidemiological data on the prevalence of WRMSDs among the general working population and sewing-machine operators, were included in the review in order to compare the general working population with sewing-machine-operator populations. As the demographical data of populations differ between countries, studies conducted in France, Sweden, United States of America (USA) and Botswana were included in an attempt to

African population of the current study. These aspects are discussed in the rest of this chapter and are compared to the South African sewing-machine-operator population in Chapter Five. (Refer to Objective 1.)

Two of the five studies mentioned were based on surveillance data, and included data on the general working population (Roquelaure, Ha *et al.* 2006: 765-778; McDonald, DiBonaventura *et al.* 2011: 767-769). The study samples were 2,685 for the study of Roquelaure *et al.*, and 34 868 for McDonald *et al.* Furthermore, three studies were included on operators employed in sewing industries, and included sample sizes of 131 to 191 (Roquelaure, Mariel *et al.* 2002: 452-458; Sealetsa, Thatcher 2011: 279-289; Blåder, Barck-Holst *et al.* 1991: 251-257). Sample sizes were thus large enough to make significant conclusions. The relevant aspects of each study will be discussed in the rest of the chapter.

Furthermore, two descriptive studies on ergonomic models were included. The first study was included to compare the four components described as part of the model with the programme that was implemented in the current study (Olson 1999: 229-238). The components included workplace analysis, hazard prevention and control, training and education, and medical management, and were all four part of the programme implemented in the current study.

The second descriptive study was a review article, describing a model for workplace health management (Chu, Dwyer 2002: 175-186). In this study, the role of employers was examined in the first place; secondly, developments in a range of fields relevant to workplace health was reviewed; and, thirdly, the review explained a model and examined its development and successful outcomes from different parts of the world. All three of these elements were applicable to the current study and, therefore, the study was included in the literature review.

2.2.2 Randomised controlled trials

All randomised controlled trials found on sewing-machine operators and programmes were included in the review.

2.2.2.1 *Randomised controlled trials on sewing-machine operators and WRMSDs*

For the purpose of this review, 12 randomised controlled trials conducted among sewing-machine operators were included (Brisson, Vinet *et al.* 1989: 323-328; Tartaglia, Cinti *et al.* 1990: 39-44; Westgaard, Jansen 1992: 154-162; Andersen, Gaardboe 1993: 677-687; Andersen, Gaardboe 1993: 689-700; Serratos-Perez, Mendiola-Anda 1993: 793-800; Kaergaard, Andersen 2000: 528-534; Hansen, Kaergaard *et al.* 2003: 264-276; Rempel, Wang *et al.* 2007: 931-938; Wang, Rempel *et al.* 2007: 806-813; Wang, Ritz *et al.* 2008: 255-262; Wang, Harrison *et al.* 2010: 352-360). Only one study conducted in the general population (Ekberg, Bjorkqvist *et al.* 1994: 262-266), was included – where 109 musculoskeletal patients were compared to a sample of 637 healthy persons in the general population. Articles reported on drop-outs (example: Kaergaard and Andersen (2000: 528-534) where the drop-outs were still compared to the study group) and missing data were reported (example: data were imputed by replacement with the mean value in the same treatment group at the corresponding point in time (Wang, Ritz *et al.* 2008: 255-262; Rempel, Wang *et al.* 2007: 931-938).

Study samples were mentioned in all studies, except for the study of Tartaglia, Cinti *et al.* (1990: 39-44) and varied from 80 to 520 participants. In some studies, the occupation of the control groups was not mentioned (Brisson, Vinet *et al.* 1989: 323-328; Sokas, Spiegelman *et al.* 1989: 197-206; Andersen, Gaardboe 1993: 677-687; Hansen, Kaergaard *et al.* 2003: 264-276) but others mentioned occupations. A group of sewing-machine operators were compared to 35 females performing secretarial work in one study (Westgaard, Jansen 1992: 154-162), and in

another study sewing-machine operators a group of 25 nurses (Andersen, Gaardboe 1993: 689-700). Sewing-machine operator sample sizes varied from 35 to 781.

Owing to the nature of the intervention, blinding was not always possible. Blinding of the assessors were applied in the study of Kaergaard and Andersen (2000: 528-534) when clinical examinations were done by trained physicians (on a cohort of sewing-machine operators, as well as a control group of women who performed varied non-repetitive work). On the other hand, blinding can also be masked as in the four Los Angeles studies, where simple randomisation was followed with the participants (all were sewing-machine operators) and assessors were not blinded (Rempel, Wang *et al.* 2007: 931-938; Wang, Ritz *et al.* 2008: 255-262; Wang, Harrison *et al.* 2010: 352-360). The sewing-machine operators were employed in 13 different shops, and received two different chairs, as well as a large number of miscellaneous items. The items that were really evaluated (i.e., chairs) were masked.

All the studies made valuable contributions to the current study in terms of baseline information and the association of risk factors with WRMSDs, as the outcomes were objective, reliable and valid.

2.2.2.2 Randomised controlled trials on programmes

In the publications on the Sherbrooke-model (Loisel, Durand *et al.* 1994: 597-602; Loisel, Abenhaim *et al.* 1997: 2911-2918; Loisel, Lemaire *et al.* 2002: 807-815), participants were allocated to one of four groups. The four groups consisted of: 1) usual care, 2) clinical intervention only, 3) occupational intervention only, and 4) a combination of clinical and occupational intervention. The study was performed over a period of 6.4 years with 104 participants.

2.2.3 Longitudinal study

The only longitudinal study included in this review was conducted on a cohort of 327 sewing-machine operators. These sewing-machine operators were followed over a period of six years, to describe the prevalence and development of musculoskeletal symptoms among sewing-machine operators in relation to age and exposure among former sewing-machine operators who changed exposure by changing occupation (Schibye, Skov *et al.* 1995: 427-434). Six years after the beginning of the study, a third of the sewing-machine operators were still working as sewing-machine operators, another third had changed occupation, and the last third were unemployed. The outcome of this study gave perspective to the question regarding the extent of the impact of sewing on the development of WRMSDs.

2.2.4 Longitudinal retrospective study

One longitudinal retrospective study was included in this literature review (Mostert-Wentzel, Grobler *et al.* 2010: 6-18). The study described the effect of a work-based physiotherapy and ergonomics programme on work-related upper extremity musculoskeletal disorders (WRUEMSDs) in seamstresses in the same car-seat manufacturing plant in South Africa as the current study used. The study was carried out over a three-year period from June 2004 to September 2007, and included 38 sewing-machine operators with 43 work-related upper extremity musculoskeletal disorders. Job rotation between forceful precision stitching and straight stitching, and the change in work posture from seated to stand-up was mentioned, but no specific association was investigated between work posture and WRUEMSDs. The intervention comprised ergonomic adaptations, health education and conventional physiotherapy, as in the current study. The only personal risk factors included were age and gender. Limitations of the study were that it was performed on a small sample of sewing-machine operators and the scope of the study covered upper limb disorders only. The findings

provided weak evidence that the integ
s effective in decreasing the incidence of WREUMSDs, and further research with larger samples was recommended.

2.2.4 Case studies

The only case study included in this literature review was conducted for a period of three years among a cohort of 250 sewing-machine operators in the USA, sewing canvas products in the automotive industry (Halpern, Dawson 1997: 429-440)– similar to the sewing-machine operators in the current study. Although no baseline information was reported regarding sewing-machine operator biographical data, and no control group existed either, the focus documented the implementation of a participatory ergonomics programme among sewing-machine operators in detail. This detail was necessary to validate their results against the outcome of the current study.

2.2.5 Literature reviews

2.2.5.1 Literature reviews carried out on the association between risk factors and WRMSDs

One review conducted to identify psychosocial risk factors for neck pain was included in order to confirm the association between psychosocial risk factors and WRMSDs. Although this was not in the scope of the current study, it was important to take note of the association.

2.2.5.2 Systematic reviews carried out on programmes

Two review articles were included in this literature review. The first, a systematic review, investigated the efficacy of workplace interventions to prevent low back pain (LBP) in workers (Maher 2000: 259-269) and included 12 randomised controlled trials. All trials were rated for methodological quality using the PEDro scale. Most PEDro scale item components have been validated empirically (randomisation, concealment, and blinding). All trials were rated by two raters, with discrepancies in ratings arbitrated by a third rater. Inclusion criteria were that all the studies were randomised controlled trials, that all subjects in the trials were workers, the studies were performed in an industrial setting, that the studies provided outcomes for LBP, and that the studies were full papers – published in English. These inclusion criteria made the review valuable to the current study, as well as the fact that management of LBP by using braces, education, exercises and work-place modification were investigated. These components were part of the manual physiotherapy in the programme of the current study, and therefore the systematic review was included in this literature review.

The second systematic review that was included in this literature review was conducted to evaluate the effectiveness of workplace interventions with LBP (Williams, Westmorland *et al.* 2007: 607-624). From a total of 1,224 studies evaluated, 15 articles (covering 10 studies) were included in this systematic review. To determine whether a study should be included, they were assessed by five reviewers. Abstracts that contained information on study design, participants, interventions, outcomes, and methodological quality that met the inclusion criteria were reviewed. For this systematic review, the inclusion and exclusion criteria were met if the article had the following characteristics: (1) the intervention was carried out at the workplace; (2) the sample consisted of workers with work-related musculoskeletal LBP injuries; (3) the intervention involved secondary prevention; (4) the study involved primary research on one or more than one patient groups; (5) the study design was prospective or cross-sectional; (6) case studies and retrospective studies were excluded; (7) abstracts and unpublished materials were excluded; and (8) the study was published in English. Each study was independently reviewed by two pairs of reviewers for methodological quality and the level of evidence. If consensus could not be reached, a third and fourth reviewer independently evaluated the article until agreement was determined. As the current study was centred on work-based rehabilitation and

secondary prevention interventions o programme of the current study (as described in Chapter Three) – this systematic review was included in the literature review.

2.2.6 Cross-sectional study

In the cross-sectional study of Sokas, Spiegelman *et al.* (1989: 197-206) subjects were recruited form active or retired members of the International Ladies' Garment Workers Union (ILBWU). They were interviewed telephonically, were screened at a mobile unit, and laboratory tests were done in order to measure and compare the prevalence of symptoms and demographic characteristics.

Wang, Rempel *et al.* (2007: 806-813) conducted a cross-sectional study on self-reported musculoskeletal symptoms. They assessed the association between work-organisational factors and the prevalence of musculoskeletal pain among 520 sewing-machine operators from 13 garment industries with face-to-face interviews.

Schierhout, *et al.* (1995: 46-50) conducted a cross-sectional analytical study to investigate exposure relations between adverse musculoskeletal outcomes and ergonomic variables on the work force in South Africa. Repetition, force, static posture, dynamic movement and other job exposures were measures in 46 floor jobs, including the clothing industry (n=401).

2.3 Summary of articles

Summaries of articles found on the three aspects mentioned in chapter 2 can be found in tables 1 to 3.

Table 1 A summary of published articles on epidemiology of WRMSDs and data analyzes from 1989 to 2011

Table 2 A summary of published articles on personal, ergonomic and psychosocial risk factors for WRMSDs and sewing machine operators from 1991 to 2012

Table 3 A summary of published articles on programmes similar to the physiotherapy and ergonomics programme that was implemented in this study from 1994 to 2010

Table 1 A summary of published articles on epidemiology of WRMSDs and data analyzes from 1989 to 2011

	Reference	Objectives of the study	Relevant methodological details	Sample size	Main findings	Conclusions	Relation to conceptual framework
48	Brisson *et al.*, 1989 Quebec, Canada	To determine if garment workers, and particularly those who leave employment, have an increased risk of chronic health problems when compared with women employed in other industries.	Comparative study	• 800 female garment workers between 1976 and 1985 in Quebec • Comparative group: national disability data of woman employed in clerical work, services and manufacturing industries.	• The garment workers who had left employment had an increased prevalence of severe disability (in comparison with that of workers who had left other types of employment) and an increased prevalence of moderate and slight disability. • Currently employed garment workers had an increased prevalence of moderate and slight disability when compared with workers currently employed in other occupations.	This study found an increased prevalence of disability (musculoskeletal, cardiovascular and other diseases combined) among female garment workers as compared with women employed in other occupations.	• Personal risk factors: Medical history • Disorders: Musculoskeletal

	Reference	Objectives of the study	Relevant methodological details	Sample size	Main findings	Conclusions	Relation to conceptual framework
22	Sokas *et al.* 1989 Washington DC USA	To determine the prevalence of all musculoskeletal complaints among garment workers compared with a matched segment of the general population	A cross-sectional study that measures and compares the prevalence of symptoms and demographic characteristics. • Questionnaires concerning occupational history and musculoskeletal symptoms • In-home general medicine screening survey • Physical examination • Laboratory tests	• 144 SMOs were recruited from active or retired members of the International Ladies' Garment Workers' Union weekend seminar • 62 in control group (general population).	Significant outcomes: • SMOs had more back pain lasting six weeks or longer than controls. • SMOs complained more of ache & swelling of the fingers, wrists & shoulders. SMOs also complained of: • Elbow ache and foot swelling and knee pain and –swelling.	Ergonomic redesign of sewing machines needs to address knee and upper-back movements as well as the arm, and finger movements.	• Ergonomic risk factors: Seated work posture • Disorders: Spinal, upper limb and lower limb.
50	Tartaglia *et al.*, 1990 Arezzo, Italy (Article was published in Italian, and abstract is available in English)	To evaluate work posture and changes in the spine of sewing machine workers in the clothing industry	An evaluation was made of the posture risk and occurrence of alterations of the spine	• A sample of female SMOs in the clothing industry. • Control population matched for sex and age.	• A greater risk for SMOs of contracting spinal disorders compared with the control population.	• The cause of these disorders appears to be due to the fact that the work station cannot be adjusted to the anthropometric requirements of the individual subject, and also because the seated position is maintained for long periods.	• Ergonomic risk factor: seated posture • Disorders: Spinal

	Reference	Objectives of the study	Relevant methodological details	Sample size	Main findings	Conclusions	Relation to conceptual framework
23	Westgaard *et al.*, 1992 Oslo, Norway	• Individual and work related factors associated with symptoms of musculoskeletal complaints. • Different risk factors among sewing machine operators	Randomized control study. Interviews related to: • Work task • Musculoskeletal symptoms • Individual factors	• 210 production workers (mainly SMOs) • 35 employees performing secretarial or laboratory duties. • All females, employed by a Norwegian clothing company	• The production workers had significantly higher scores with respect to self-reported musculoskeletal complaints (95%) than the group with more varied tasks (71%)for the head, neck, shoulders and arms, but not for the lower back, hips and the lower extremities. • Age: The three upper body regions had the same symptom level at all age groups. • Age: Lower back – statistically significant negative correlation. • Age: Lower limb – positive correlation.	The study showed a high rate of musculoskeletal complaints among SMOs.	• Ergonomic risk factor: Seated posture • Personal risk factor: Age, Previous help (for neck and shoulders). • Disorders: Spinal, upper limb, lower limb.
45	Serratos-Perez *et al.*, 1993 Ganajuato Mexico (Only abstract available)	To identify the body regions more liable to develop musculoskeletal disorders and the rates of appearance.	• Cross sectional study • Questionnaire on work history, presence of MSDs, and sick leave frequency. • A video was filmed to identify the body regions undergoing the major work demands.	• 143 Mexican men operating sewing machines in eight shoe factories • 132 operated flat-type machines, and 11 operated column-type machines.	• 47.5% declared MSDs. • 18.2% had low back pain. • 14% had shoulder pain (three times more frequent among column-machine operators). • 14% had pain in the back as a whole (all flat-machine operators) • 4.9% had neck pain (on flat-machine operators)	• The body parts affected were those expected from the video recording analysis. • The rates of MSDs were lower than those reported by other authors who studied SMOs.	• Disorders: Spinal and upper limb
	Schier hout, et al. 1995 South Africa	Investigate exposure response relations between adverse musculoskeletal outcomes and ergonomic exposure variables.	Longitudinal study	• 11 factories from seven sectors of manufacturing industry • N=401	• Ergonomic exposures in the workplace (e.g. clothing industry) were significantly associated with neck and shoulder pain, for repetition and for seated compared to standing work.	• This study indicates good predictive ability to reduce ergonomic stress with the exposure model, simple surveillance methods, and educational programmes in the workplace.	• Disorders: spinal • Ergonomic risk factor: standing

	Reference	Objectives of the study	Relevant methodological details	Sample size	Main findings	Conclusions	Relation to conceptual framework
25	Roquelaure et al., 2006 Pays de la Loire region, France	Since 2002, an epidemiologic surveillance system of work-related, upper limb musculoskeletal disorders (MSD) has been implemented in France's de la Loire region to assess the prevalence of MSDs and their risk factors in the working population.	An epidemiologic surveillance system was implemented to assess the prevalence of MSD and their risk factors • Nordic questionnaire • Physical examination.	2685 workers(1566 men, 1119 woman) from almost all economic sectors and occupations of the salaried workforce .	• More than 50% of the population experienced nonspecific musculoskeletal symptoms during the preceding 12 months. • The most frequent MSDs were: rotator cuff syndrome, carpal tunnel syndrome, and lateral epicondylitis.	• Nonspecific upper-limb symptoms and specific upper-limb musculoskeletal disorders are common among the working population. • There is a need to implement prevention programs in most sectors to reduce the prevalence of MSDs.	• Disorders: upper limb • Study design: Prevalence
36	Eaton et al., 2009 Workplace Safety and Insurance Board (WSIB) Ontario, Canada	To document and describe the current work conditions throughout the clothing industry. The goal was to identify good practices that are currently in use in the industry, and to share these practices to prevent injuries.	• Review of lost-time injury claims between 1993 and 1998. • Questionnaire on work organization characteristics, • Assessment of ergonomic conditions	• 29 unionized clothing manufacturers	• WRMSDs (WMSDs) are a major issue in the clothing industry. • There is strong scientific evidence to support the work-related nature of WMSDs.	With the advances that has been made towards understanding the organizational, psychosocial and physical risk factors, WMSD should no longer be accepted as "Just part of the job". These injuries can be prevented.	Areas for improvement included: 1. Communication 2. Involvement of employees in decision making 3. Education and training of employees and management regarding WRMSDs (WMSD) and ergonomics. Physical ergonomic conditions
7	Roquelaure et al., 2011 France	1 To evaluate an active method of surveillance of musculoskeletal disorders. 2 To compare different criteria for deciding whether or not a work situation could be considered at high risk of musculoskeletal disorders in a large, modern shoe factory	• Blue collar workers were interviewed and examined by the same physician, and a job site work analysis was done • Re-examination one year later	• 1996: 253 blue collar workers in a large, modern, mechanised shoe factory were interviewed and examined. • 1997: 191 of the group were re-examined • Risk factors of MSDs were assessed for each worker by standardised job site work analysis. • Carpal tunnel syndrome, rotator cuff syndrome and tension neck syndrome were calculated for each of the nine types of work situations.	Types of work situation to be at high risk of MSD: • On the basis of prevalence data: cutting, sewing and assembly preparation • On the basis of incidence data: sewing preparation, mechanised assembling and finishing. The ergonomic risk could be considered as serious for the four types of work situations having the highest scores (sewing, assembly preparation, pasting and cutting).	• The incidence rate is more valid than the prevalence rate to detect types of work situations with high risk of MSDs, since the incidence rate is less affected by the healthy worker effect. • Health and risk factor surveillance must be combined to predict the risk of MSDs in the company	• Disorders: Spinal and upper limb

	Reference	Objectives of the study	Relevant methodological details	Sample size	Main findings	Conclusions	Relation to conceptual framework
1	Sealetsa *et al.*, 2011 Botswana	• To identify and describe possible ergonomics deficiencies in the workstation of sewing machine operators in a textile industry in Botswana as well as their perception of workload and bodily discomfort.	• A modified Corlett and Bischop body map questionnaire and the NASA TLX were administered • Relevant anthropometric and work place measures were collected	• 157 female SMOs	• A high prevalence of musculoskeletal disorders • Back, neck and shoulder discomfort are highly prevalent among these SMOs.	Proposed intervention strategies included re-design of the: • Work stations • Sitting, and • Provision of training in basic ergonomic principles.	• Disorders: Spinal and upper limb • Ergonomic risk factors: Seated posture
35	McDonald *et al.* 2011 New York, USA	To investigate the impact of musculoskeletal pain on health-related quality of work productivity losses among US workers.	• Data were analyzed for the 2008 US National Health and Wellness Survey • Workers with arthritis, back pain and fibromyalgia were compared with workers without these conditions.	• N=34 868 • All were employed, and aged 20 years and older.	• Arthritis, back and fibromyalgia pain were associated with significantly lower levels of health-related quality of life, often at clinically meaningful levels. All pain conditions were associated with higher levels of work productivity loss, even after adjusting for demographic and health characteristics.	• Musculoskeletal pain conditions were highly prevalent and associated with a significant burden.	• Personal risk factors: Arthritis. • Disorders: Spinal.

Table 2 A summary of published articles on personal, ergonomic and psychosocial risk factors for WRMSDs and sewing machine operators from 1991 to 2012.

	Reference	Objective of the study	Relevant methodological details	Sample size	Outcome measures, strength of association	Conclusion	Relation to conceptual framework
46	Blåder *et al.*, 1991 Gothenburg Sweden	This study concerned to: • Study the frequency of neck-shoulder disorders in a population of SMOs, and to • Describe the clinical picture behind the complaints.	• Questionnaire part 1: social-, medical-, psychosocial- and occupational conditions. • Questionnaire part 2: Musculoskeletal symptoms in the neck and shoulder • Clinical examination	• 224 SMOs • 199 SMOs replied on the questionnaire • 131 SMOs had a clinical examination	Questionnaire: Prevalence rates during the past 12 months of 75% and during the past seven days a rate of 51%. Daily problems were experienced by 26%. Examination: Tension neck syndrome was most frequent, followed by cervical syndrome. In half of those examined, symptoms and findings were too unspecific for diagnosis	• In spite of possible psychosocial and work environmental factors, it seems obvious that the sedentary work position per se among SMOs increases the risk for symptoms in the neck and shoulder. • Work rotation between sewing and varying tasks is a common suggestion to reduce and vary repetitive and monotonous muscular work.	• Ergonomic risk factor: seated posture. • Ergonomic risk factor: rotation • Disorder: Spinal
13	Theorell *et al.* 1991 Sweden	To analyse how variables such as job conditions and individual factors correlate with psychological and physiological reactions and how all these factors influence perceived locomotor pain and health.	Separate hypotheses were formulated for direct associations between work environment and health by collecting data form: ▪ Diaries describing different emotional states hourly. ▪ Hourly blood pressure. ▪ Fasting blood tests in the mornings ▪ Questionnaires describing work environment	• 147 men • 60 women • Six occupations representing widely different physical and psychological activities.	Psychosocial work demands were associated with physiological indicators of strain (plasma cortisol and self-reported muscle tension) and that self-reported muscle tension was associated with several emotional reactions as well as with symptoms from the back, neck and shoulders.	The results indicated that work environment factors influence mood, bodily tension and somatic symptoms, but that load on the locomotor system and opportunity to influence decisions play an important and more direct role in absenteeism for sickness.	Psychosocial risk factors Disorders: Spinal and upper limb

	Reference	Objective of the study	Relevant methodological details	Sample size	Outcome measures, strength of association	Conclusion	Relation to conceptual framework
44	Vezina *et al.*, 1992 Quebec, Canada	To describe components of the physical load of sewing in a trouser factory: Force exerted, repetitions, time allocated and postures.	• Ergonomic analysis • Interviews to determine the types of musculoskeletal complaints.	• The trouser manufacturing plant employed 178 SMOs. • Ten SMOs participated in the study (five operators who sew the inner seam, and five operators who sew the outer seam).	Ergonomic analysis showed that operators: • Lift an average of 406.1kg of trousers per day • Exert an average total force of 1 858.4kg with the upper limbs, and 24 267.9kg with the lower limbs. Interviews: • All operators report musculoskeletal fatigue at the end of the work day • 90% of operators report suffering from shoulder pain	• Some of the physical workload presented in this article can be interpreted as being representative of SMOs in general. • Sewing machine operation in this trouser manufacturing plant requires an enormous amount of exertion in a constrained position.	• Ergonomic risk factor: seated posture. • Ergonomic risk factor: force • Disorder: Upper limb
15	Andersen *et al.*, 1993a Denmark	To examine whether an exposure-response relationship exists between years of employment as a sewing machine operator and prevalence of persistent pain from the neck and upper limbs	Historical follow-up investigation on a dynamic cohort of garment industry workers. 1. A short preliminary clinical study 2. Self-administered questionnaire 3. More comprehensive clinical study including medical and psychological examination	• 424 SMOs • 781 woman from the general population • Control group: 89 woman from the garment industry	• The exposure-response relationships between years of employment as a SMO and prevalence of persistent pain from the neck and upper limbs remained when adjusted for potential confounders, of which age, current shoulder-neck exposure, and child bearing were the most contributing.		• Disorders: Spinal and upper limb • Personal risk factor: Duration of employment

	Reference	Objective of the study	Relevant methodological details	Sample size	Outcome measures, strength of association	Conclusion	Relation to conceptual framework
16	Andersen *et al.*, 1993b Denmark	• Assess the occurrence of neck and upper limb disorders and to evaluate the exposure-response relationship between years of sewing machine work and clinically confirmed syndromes. • To evaluate the reliability of the clinical examination and the correlation between subjective complaints of pain and palpatory findings from the myofascial structures.	• Questionnaire-based epidemiological study. • An age-stratified random sample. Methodology: • General health examination • Neck, shoulder and arm comprehensive examination • Interview: health and work history • Second examination of heck and upper limb • Laboratory examination (thyroid & rheumatic diseases) • Radiographs of Cx spine and shoulders • Psychological examination (interview, cognitive and personality tests).	• 170 Sewing machine operators • 25 Auxiliary nurses and home helpers as a control group.	A significant exposure-response trend existed for the three neck/shoulder diagnosis: • cervicobrachial fibromyalgia • cervical syndrome • rotator cuff syndrome with increasing duration of employment as a SMO. No muscles in the lower legs were involved, thus the musculoskeletal disorders among SMOs were probably of a localized nature and not generalized muscle pain.	• Being a SMO for more than eight years had a cumulative permanent deleterious effect. • Muscle palpation proved to be a reproducible examination.	• Disorders: Spinal and upper limb • Personal risk factor: Duration of employment
51	Jensen *et al.*, 1993 Copenhagen, Denmark	Physiological responses to physical work.	• 1) EMG was done on M. Trapezius of the whole group for a working day. • 2) Thereafter the group was divided into two groups, according to frequency of troubles of the shoulder/neck-area, and muscle strength of M. Trapezius was tested	• 29 female industrial sewing machine operators • The study was performed during an eight-hour working day, under ordinary working conditions	• 1) Left and right M.Trapezius fatigued during the working day. • 2) The group with the highest frequency of troubles of the neck/shoulder-area had the weakest M. Trapezius, despite the fact that no differences in the surface EMG during sewing were found between the two groups.	• Industrial sewing machine work involves a pattern of shoulder muscle activity which induces fatiguing processes in the shoulder and neck regions • Since the static shoulder muscle load was independent of muscle strength, factors other than working posture may be of significance for the static shoulder muscle load. •	• Ergonomic risk factor: Force • Disorders: Spinal and upper limb

	Reference	Objective of the study	Relevant methodological details	Sample size	Outcome measures, strength of association	Conclusion	Relation to conceptual framework
14	Ekberg *et al.* 1994 Semirural Sweden	To elucidate the strength of the relation between disease in the neck and shoulder area and physical as well as organisational and psychosocial aspects of the work environment	• Case control study • Nordic questionnaire on symptoms and a questionnaire on work conditions and background factors.	• Done between August 1988 and October 1989. • 109 patients with a musculoskeletal complaint of the neck, shoulder, and or upper thorax and booked off from work for four weeks. • 637 controls	• Factors not associated with neck disease: Age, Having pre-school children, to work standing in uncomfortable positions, monotonous positions. • Factors associated with neck disease: Female sex, working in uncomfortable sitting and work with elevated arms, repetitive movement demanding precision, light lifting, high demands on attention, lack of stimulation and variation in the job,.	Work organisation and psychosocial work conditions are as important determinants for disease in the neck and shoulders as are the physical work conditions	• Personal risk factors: Gender, age • Ergonomic risk factors: Seated posture, forcc (precision) • Psychosocial risk factors
43	Schibye *et al.* 1995 Copenhagen, Denmark	To describe the prevalences and development of musculoskeletal symptoms among SMOs in relation to age and exposure among former SMOs who changed exposure by changing occupation.	• Longitudinal study	• 1985: 327 SMOs - assessed musculoskeletal symptoms via Nordic questionnaire. • 1991: Follow-up study showed that 1/3 was still working as a SMO, 1/3 changed occupation, and 1/3 were unemployed.	Symptomatic SMOs who quit sewing were much more likely to be relieved of their symptoms than were symptomatic SMOs who continued sewing. This trend also applied to long-lasting symptoms.	For many SMOs, neck and shoulder symptoms are reversible and may be influenced by reallocation to other work tasks.	• Disorders: Spinal and upper limb

	Reference	Objective of the study	Relevant methodological details	Sample size	Outcome measures, strength of association	Conclusion	Relation to conceptual framework
18	Kaergaard *et al.*, 2000 Denmark	• To assess the occurrence and persistence of two restrictively defined neck-shoulder disorders among sewing machine operators. • To assess factors associated with the development of neck-shoulder disorder and prognostic factors for remaining a case, when disorders were already present.	• Comparative study • Clinical examination of neck and arms, • Questionnaire on musculoskeletal complaints completed at baseline, one and two years.	• 178 SMOs • 357 woman in control group with varied non-repetitive work	• U-shaped association between years as a SMO and myofascial pain syndrome and positive linear trend between duration of employment and rotator cuff tendinitis • Rotator cuff tendinitis showed a higher degree of persistence than myofascial pain syndrome.	• Rotator cuff tendinitis showed a higher degree of persistence than myofascial pain syndrome. Both disorders highly influenced the perception of general health. • Women who lived alone with children, were smokers, or experienced low support from colleagues and supervisors had a higher risk of contracting a neck-shoulder disorder	• Personal risk factors: Length of employment, • Psychosocial risk factors • Disorders: Upper limb
9	Hansen *et al.* 2003 Sweden	Are total plasma cholesterol, HbA1c, IgA and prolactin, urinary catecholamines and cortisol higher and plasma DHEA-S and free plasma testosterone lower in repetitive work vs non-repetitive work?	• Blood samples were taken to test for five endocrine markers, and urine for the measurement of three endocrine markers representing anabolic and catabolic metabolism. • Questionnaires (23 items from the Whitehall job characteristic scales on job demands, job control, social support at work and job satisfaction)	• 96 female SMOs from three textile plants (81 did repetitive work, and 14 non-repetitive work) • 46 females form a toy manufacturing factory performing process monitoring (20 did repetitive work, and 26 non-repetitive work).	In sewing machine operators - psychosocial factor associated with ↑catabolic system: • High job demands Psychosocial factors associated with ↑total cholesterol: • Low job control • Low social support • Low job satisfaction	Adverse psychosocial work environment was associated with increased catabolic metabolism.	• Psychosocial risk factors

	Reference	Objective of the study	Relevant methodological details	Sample size	Outcome measures, strength of association	Conclusion	Relation to conceptual framework
17	Ariëns et al. 2001 The Netherlands	To identify psychosocial risk factors for neck pain	Systematic review of literature from 1966 to 1997	From 1026 studies, 29 were identified	The results showed some evidence for a positive relationship between neck pain and: 1) high quantitative job demands, 2) poor social support (co-worker), 3) low job control, 4) low skill discretion and 5) low job satisfaction.		• Psychosocial risk factors • Disorders: Spinal
5	Rempel et al., 2007 Los Angeles USA	Determine whether a chair with a curved seat pan leads to improved changes in monthly neck/shoulder scores compared with a control intervention.	• A randomized control trial • Control group receive placebo. • Two intervention groups receive placebo, and chairs with different seat pans. • Monthly questionnaire	• 277 SMOs with neck/shoulder pain.	Compared to the control group: • The participants with the flat seat chair experienced a decline in pain of 0.14 (95% confidence interval, 0.07-0.22) points/month. • The participants with the curved seat chair experienced a decline in pain of 0.34 (95% confidence interval, 0.28-0.41) points/month.	• An adjustable height task chair with a curved seat pan can reduce neck and shoulder pain severity among SMOs.	• Ergonomic risk factors: Seated posture. • Disorders: Spinal and upper limb
8	Wang et al., 2007 Los Angeles USA	To assess the contribution of work-organizational and personal factors to the prevalence of WRMSDs among garment workers in Los Angeles.	• Cross sectional study of self-reported musculoskeletal symptoms • Face-to-face interviews. • Assess the association between work organizational factors and personal factors and the prevalence of musculoskeletal pain	• 520 SMOs from 13 garment industry sewing shops	• The prevalence of moderate/severe musculoskeletal pain in the neck/shoulder region was 24.0% and for distal extremity it was 15.8%. • Elevated prevalence of upper body pain was associated with age less than 30yr, female gender, Hispanic ethnicity, being single, having a diagnosis of a MSD, working as a SMO for more than 10yr, Using a single machine, work in a large shop, higher work-rest ratios, high physical exertion, high physical isometric loads, high job demand and low job satisfaction.	• Work-organizational and personal factors were associated with increased prevalence of moderate or severe upper body musculoskeletal pain among garment workers.	• Personal risk factors: Age, systemic illness, previous musculoskeletal disorder, duration of employment • Ergonomic risk factors: Seated posture, force, • Psychosocial risk factors: High work load, time pressure and deadlines, low job satisfaction • Disorders: Spinal and upper limb

	Reference	Objective of the study	Relevant methodological details	Sample size	Outcome measures, strength of association	Conclusion	Relation to conceptual framework
4	Wang *et al*., 2008 Los Angeles USA	Determine whether an adjustable chair with a curved or flat seat pan improved monthly back and hip pain scores in sewing machine operators.	Randomized controlled trial. • Control group receive placebo. • Two intervention groups receive placebo, and chairs with different seat pans. • Monthly questionnaire	• 293 SMOs	• Compared with control group: • Mean pain improvement for flat chairs was 0.43. 95% CI = 0.34, 0.51 • Mean pain improvement for curved chairs was 0.25. 95% CI = 0.16, 0.34	• A height-adjustable task chair with a swivel function can reduce back and hip pain in SMOs	• Ergonomics risk factors: Seated posture • Disorders: Spinal and lower limb
42	Wang *et al*., 2010 Los Angeles USA	To explore factors affecting or modifying self-reported neck/shoulder pain in sewing machine operators.	Randomized controlled trial • Basic modifications • Basic modifications and a Height adjustable swivel chair • Basic modifications and an ergonomic chair custom designed for SMOs.	• 247 SMOs with self-reported neck/shoulder pain	• 72% decline in self-reported pain intensity in the first month, and 4% from the first to the fourth month. • SMOs who perceived and reported their physical workload as high or worked overtime experienced less overall reduction. • Higher baseline pain intensity, being of Hispanic ethnicity (vs Asian), and taking cumulative daily rest time during work of >35 min were associated with a larger pain reduction in the first month, but not thereafter.	• Having lower physical workloads and less overtime work should be considered when treating patients or planning workplace interventions for managing WRMSDs in this immigrant population.	• Ergonomic factors: Working overtime and seated posture • Disorders: Spinal and upper limb
41	Zhang *et al*., 2011 Beijing, China	To quantify work load and muscle functional activation patterns in neck-shoulder muscles of female sewing machine operators using surface electromyogram (EMG).	Work load of SMOs' neck-shoulder muscles during their daily operating task were quantified, and thereafter EMG signals were analyzed to determinate the work load and activity patterns of neck-shoulder muscles.	• 18 healthy female SMOs • Ages 20-30 years • Weighed 41-80 Kg and 154-167cm tall • 2-7 years employment • Right dominant • No smoking/alcohol abuse • No neck-shoulder musculoskeletal disorders of trauma history.	• The amplitude value before operating was significantly higher than that of after work. • $P<0.01$	• Female SMOs were exposed to high sustained load on bilateral shoulder muscles.	• Ergonomic risk factor: Force • Disorders: Upper limb

Table 3 A summary of published articles on programmes similar to the physiotherapy and ergonomics programme that was implemented in this study from 1994 to 2010.

	Reference	Objective of the study	Relevant methodological details	Sample size	Main findings	Outcome measures and strength of association	Elements of the program
26	Loisel *et al.* 1994 Quebec, Canada	The aim was to combat occurrence of chronic back pain. Title: Management of occupational back pain: the Sherbrooke model. Results of a pilot and feasibility study.	• Randomized control trial • Ergonomic and clinical management interventions were implemented.	• 20 000 workers in 31 industrial settlements	• After one year – this global clinical and ergonomic management program has shown to be feasible in a general population.	• A global management programme of back pain joining ergonomic and clinical intervention with a multidisciplinary approach has not been tested yet. Linking these two strategies in a same multidisciplinary team represents a multidisciplinary team represents a systemic approach to this multifactorial ailment. During the first year of this trial, there was no conflict found between these two interventions form the employer's of the worker's point of view.	The elements of the program included a combination of: 1. Occupational medicine 2. Ergonomic intervention

	Reference	Objective of the study	Relevant methodological details	Sample size	Main findings	Outcome measures and strength of association	Elements of the program
20	Loisel *et al.*, 1997 Quebec, Canada	To develop and test a model of management of sub-acute back pain, to prevent prolonged disability.	• Population-based randomized clinical trial. • Participants were allocated randomized to one of four groups (usual care, clinical intervention, occupational intervention, and combination of occupational and clinical intervention).	• 104 participants who have been absent from work for more than four weeks from 31 workplaces	• Combination of occupational medicine and ergonomic intervention led to a significant reduction in the duration of absence from regular work, compared with rates recorded with usual care.	• Rate ratio of return to regular work was 1.91 (95% confidence interval = 1.18-3-3.10; P<0.01)	The elements of the program included a combination of: 3. Occupational medicine 4. Ergonomic intervention
2	Halpern *et al.*, 1997 Denver USA	Discussion of the elements of the participatory ergonomics program, describe its implementation highlight intervention measurements, and present program elements.	• Case study	• The study was done from 1993 to 1996. • 250 sewing machine operators within an automobile products manufacturing plant • Material to be sewn: heavy canvas	• Between 1990 and 1993, the total incurred loss for worker's compensation was 172%, while the number of claims increased by 34% and employment levels increased 61%. Workers compensation incurred losses for musculoskeletal disorders increased from 33% to 70% of the total losses. • Pareto analysis identified that 82% of the musculoskeletal disorders were associated with sewing tasks	• Musculoskeletal disorders among sewing machine operators were reduced by approximately 82% • This contributed to an overall reduction in workers compensation incurred loss costs by approximately 42%.	The elements of the program were: 1. Participatory ergonomics: 2. Hazard intervention and abatement strategies.
24	Olson., 1998 Janesville USA	A model is described for industry on starting and managing a successful on-site ergonomic program.	• A model is described	• N/A	• N/A	• N/A	The four elements of a successful ergonomic program were: 1. Workplace analysis, 2. Hazard prevention and control, 3. Training and education, and 4. Medical management.

	Reference	Objective of the study	Relevant methodological details	Sample size	Main findings	Outcome measures and strength of association	Elements of the program
27	Maher 2000 Sydney, Australia	To investigate the efficacy of workplace interventions to prevent low back pain (LBP) in workers.	A systematic review of randomised controlled trials	• 13 trials. • Aspects evaluated were: 1) Braces, 2) Education, 3) Exercises, and 4) Workplace modification and education.	Levels of evidence for efficacy to prevent LBP: • Braces: Ineffective to reduce prevalence. • Education: moderate effective to reduce prevalence and severity.. Ineffective to reduce cost. • Exercise: Moderate effective to reduce severity. Limited evidence to reduce prevalence. • Workplace modification and education: Ineffective in reducing prevalence, costs and leave.	Trials suggest that workplace exercise is effective, braces and education are ineffective, and workplace modification plus education is of unknown value in prevention low back pain.	Individual aspects were evaluated: • Braces, • Education, • Workplace exercise, and • Workplace modification and education.
11	Loisel et al., 2002 Quebec Canada	To test the long term cost-benefit and cost effectiveness of the Sherbrooke model of management of sub-acute occupational back pain, combining an occupational and a clinical rehabilitation intervention.	Population-based randomized clinical trial.	• 6,4 years • 104 participants who have been absent from work for more than four weeks from 31 workplaces • Participants were allocated randomized to one of four groups (usual care, clinical intervention, occupational intervention, and combination of occupational and clinical intervention).	A fully integrated disability prevention model for occupational back pain appeared to be cost beneficial for the workers' compensation board and to save more days on benefits than usual care and partial interventions.	• The Sherbrooke model was the most cost-beneficial (saving $18 585 per worker). There was no statistical difference between the four arms. • The results indicate an important trend towards the hypothesis: Early intervention investment in appropriate interventions of disability prevention would allow savings in the long term.	The elements of the program included a combination of: 1. Occupational medicine 2. Ergonomic intervention

	Reference	Objective of the study	Relevant methodological details	Sample size	Main findings	Outcome measures and strength of association	Elements of the program
31	Chu *et al.*, 2002 Queensland, Australia	The article explores employer roles in employee health in the context of global and local challenges.	Review 92 references	A strategy is suggested for employers to deal with the multifaceted workplaces pressures and health impacts on employees i.e. implementing an integrative holistic model of workplace health management (WHM).	Employers need to become change agents and visionary leaders who adopt a proactive, interdisciplinary and integrative system approach to formulate and develop company policies and workplace culture that facilitates employee participation, professional growth and team work.	WHM is an approach to workplace health that includes: • health promotion, • disease prevention, • safety management, and • organizational development.	
37	Feuerstein *et al.* 2004 Washington DC USA	To examine the effectiveness of an individual-focussed job stress management component on specific clinical outcome measures like self-reported pain, functional limitation, physical and mental health, job stress, and self-reported and observable ergonomic risk factors.	Randomized secondary prevention trial.	70 office workers with work-related upper extremity symptoms were randomly assigned to: • Ergonomics intervention group • Combined ergonomics and job stress intervention group.	While both groups experienced significant decreases in pain, symptoms, and functional limitation from baseline to three months with improvements continuing to 12 months post baseline, no significant differences between groups were observed for any outcome measures.	Findings indicated that additional job stress management component did not significantly enhance the short- or long-term improvements brought about by the ergonomic intervention alone.	• Ergonomic intervention

	Reference	Objective of the study	Relevant methodological details	Sample size	Main findings	Outcome measures and strength of association	Elements of the program
32	Verbeek 2006 Kuopio, Finland	Explore the possibilities for evaluation of effectiveness in occupational health and apply the basics of evidence-based medicine to occupational health.	149 articles were selected out of around 11 000.	Evidence as in evidence-based medicine is made up by the results of evaluation studies. The transfer of results of trials into practice will be along the line of systematic reviews and guidelines for occupational health professional. Current practice for many occupational health interventions is more based on expert opinion and tradition than on scientific evidence.	Evidence-based medicine models are applicable to occupational health.		

	Reference	Objective of the study	Relevant methodological details	Sample size	Main findings	Outcome measures and strength of association	Elements of the program
34	Williams *et al.*, 2007 Ontario, Canada	Results of a systematic review that investigated the evidence on the effectiveness of work-based rehabilitation interventions for injured workers with musculoskeletal work-related low back pain (LBP). This included interventions that were conducted at the workplace as well as studies that involved secondary prevention interventions of LBP.	From 1224 articles, 15 (consisting of 10 studies) were included.	• Clinical interventions with occupational interventions was effective in returning injured workers with LBP to regular work faster, and decreasing pain and disability. • Early return to work/modified work interventions were effective, in decreasing the rates of back injuries, lost-time back injuries and reducing pain and disability returning workers to work faster, reducing pain and disability and decreasing the rate of back injuries.	• There is some evidence on the effectiveness of workplace rehabilitation interventions for injured workers with LBP. These findings are useful as they provide information for stakeholders and policy makers to assist them in making decisions about workplace interventions for LBP.	• These studies also included early contact with the worker by the workplace and a health care provider intervention at the workplace. • Ergonomic interventions such as participatory ergonomics and workplace adaptation, adaptation of job tasks and adaptation of working hours were effective in returning injured workers to work.	
49	Mostert-Wentzel *et al.*, 2010 South Africa	To describe the effect of a work-based physiotherapy and ergonomics programme on WRUEMDs in seamstresses in a car-seat manufacturing plant in South Africa.	• A retrospective longitudinal design using a record review to investigate a work-based physiotherapy and ergonomics occupational programme.	• 37 female and one male SMOs with a work-related upper extremity musculoskeletal disorder • Period of three years	The incidence of WRUEMDs decreased significantly over the study duration as did the incidence of carpal tunnel syndrome. The carpal tunnel syndrome group was older than the other group.	The findings provided weak evidence that this integrated programme was effective.	The intervention comprised: • ergonomic adaptations, • health education and • conventional physiotherapy.

Appendix 3

Data collection and capturing

Appendix 3

Data collection and capturing

Summary of the process of collection and capturing of data. Data collected at the company's human resource department and medical clinic included information about all the employed sewing-machine operators for the period of the study, whereas the physiotherapy practice only kept information on those sewing-machine operators who received individual physiotherapy (See tables 3.1 to 3.4).

Memorandums of Health-and-Safety meetings were e-mailed to all the attendants on a monthly basis, and were read by the researcher in order to explain the background to the intervention Section 3.4)

3.1 Collection and capturing of personal information

Type of data		Source of data		Capturer	
	Company	Medical Clinic	Physiotherapy practice	Researcher	Company
Name and surname, national ID*no, company ID* no, job title, employment dates.	Electronic Excel work sheet form HR department and physical employee records	Physical patient records	Physical patient records and monthly reports to company	√	√

∗ ID = South-African Identification number

Table 3.2 Collection and capturing of personal risk factors

Type of data	Source of data			Capturer	
	Company	Medical Clinic	Physiotherapy practice	Researcher	Company
Age					
	Calculated from national ID no			√	√
Gender					
		Physical patient records		√	
Medical history:					
Hypertension		Physical patient records		√	
Arthritis		Physical patient records		√	
Diabetes Mellitus		Physical patient records		√	
Musculoskeletal history:					
Previous medical consultation			Physical patient records	√	
BMI		Physical patient records		√	

Table 3.3 Collection and capturing of ergonomic risk factors

Type of data	Source of data			Capturer	
	Company	Medical Clinic	Physiotherapy practice	Researcher	Company
Posture					
	Consultation with team leaders			√	√
Force					
Material type	Consultation with team leaders			√	√
Stitching	Consultation with team leaders			√	√
Duration					
Job rotation	Consultation with team leaders			√	√
Production volumes per month	Electronic Excel work sheet form Finance department			√	√

Table 3.4: Collection and capturing outcomes

Type of data	Source of data			Capturer	
	Company	Medical Clinic	Physiotherapy practice	Researcher	Company
Body part affected by WRMSD					
			√	√ Physical patient records & monthly reports to company	

Appendix 4

Data coding

Appendix 4

Data coding

On the baseline data work sheet, each sewing machine operator had a row for each month that she was employed between June 2004 and January 2009. From there on, all the personal information and risk factors were ticked off in columns. Data from the Finance department of the company on monthly production volumes, were also received by the researcher in an excel work sheet. This was then added into the baseline data work sheet per month, and per operator.

Coding of data on personal information:

- o Name and surname: Captured as on the physical employee records at the company. Surnames of married woman were changed of the date as indicated in the marriage certificate in the physical employee records.
- o National identification number: Captured as on the physical employee records at the company, physical patient records at the medical clinic and physiotherapy practice.
- o Company identification number: Captured as on the physical employee records at the company, physical patient records at the medical clinic and physiotherapy practice.
- o Job title: Captured as on the physical employee records at the company. Only data of the job title: "Sewing machine operator" were included
- o Maternity leave dates: Captured as on leave records in physical employee records at the company only.
- o Employment dates: Captured as on the physical employee records at the company.

Data from the company

Categorisation of data on *personal risk factors:*
- o Age: Age was calculated by starting at the date of birth, as in the national identification number, and re-calculated for every year of the study. Initially it was captured as a numerical value, and then divided into one of three categories:

category 0: <=35 years, category 1: >35 & >=50 years and category 2: >50 years old.

Categorisation of data on *ergonomic risk factors:*

- o   Force - material: Working with cloth/vinyl was indicated with a 0, and cloth/leather with a 1.
- o   Force - stitch: Straight and relatively easy stitching was indicated with a 0, and precision stitch e.g. top-stitch, stitching air bags and stitching headrests were indicated with a 1.
- o   Duration – job rotation: Physically staying in the same work station, and doing the same job without rotation was indicated with a 0. Physically rotating between work stations, or physically staying in one work station, but rotating between different jobs was indicated with a 1.
- o   Duration – production volume: This was indicated as a numerical value per month for each sewing machine operator. Initially it was captured as a numerical value, and then divided into one of two categories: 0 = less than 9 999 units per month and 1 = more than 10 000 units per month.

Data from the primary health care clinic (medical clinic)

Categorisation of data on *personal risk factors:*

- o   Gender: As captured form the physical patient records. Male = 0, and female = 1.
- o   BMI: Body mass in kg, and length in cm was captured form the physical patient records. BMI was calculated with a formula, and indicated as a numeric value per category: 0 = normal (<25) , 1 = overweight (>=25 – <30), 2 = obese (30 - <35) and 3 = morbidly obese (>=35).

The following risk factors were also captured from the physical patient records, and indicated with a 0 for a negative, and a 1 for a positive answer.

- o   Hypertension
- o   Arthritis
- o   Diabetes Mellitus

Data from the physiotherapy practice

Coding of data on *personal risk factors:*

- o   Musculoskeletal history: This data was collected from the physical patient records, and captured in the rows of months that a patient received treatment onto the base-line data work sheet. If no previous medical consultation (e.g. medication, doctor's consultations, X-rays etc.) was mentioned during the history of the WRMSD, or if the patient had no memory there-off – it was indicated with a 0. A 1 indicated that medical consultation happened before the patient consulted the physiotherapist.

Coding of data on *WRMSDs:*

Data was collected from the physical patient records, and captured onto the base-line data work sheet - indicating each month that the patient received no treatment with a 0, and a 1 for the months that the patient was treated.

- o   Spinal - including cervical, thoracic, lumbar and sacroiliac areas,
- o   Upper limb - from the gleno-humeral joint to the fingers, and the
- o   Lower limb - from the hip joint to the toes.

Appendix 5

Ergonomics needs assessment form

Potential Ergonomics Issues List (PEIL)

JOHNSON CONTROLS **Appendix A**

Signature/Date: _____

(Applies to Pre-Launch PEIL only)

Group Ergonomics Engineer

Product Approved (Initial) ☐

Product Not Approved (Initial) ☐

(Applies to Pre-Launch PEIL only)

POTENTIAL ERGONOMICS ISSUES LIST (PEIL)

Basis/Location Number	_____	PEIL Date (Orig.)	_____	Created By	_____
Customer/Vehicle	_____	Modified Date	_____	Modified By	_____
Model Yr/Platform	_____	Pre-Launch (Phase)/Post Launch	**Post Launch**	Document Status	_____
Product	_____	Document ID	_____	Revision Level/Version	_____
Core Team	_____				

Hazard Identification					Risk Assessment				Operational Controls		Action Results				
Station	Component	Task (Description)	Potential Issue	Body Part Affected	Repetition	Force	Posture	**Priority**	Control Plan (Recommended Action)	Responsibility & Target Date	Actions Taken & Completion Date	Repetition	Force	Posture	**Priority**

Potential Ergonomics Issues List (PEIL) Instructions

NOTE: *A PEIL must be completed for all programs, both prior to launch (PRE-Launch) and after launch (Post Launch, or in Manufacturing). The responsible parties and follow-up will vary depending on the product's status (Pre or Post Launch).*

INSTRUCTIONS: PRE-LAUNCH

1) *PEIL Management:*
The appropriate ASG Corporate Ergonomics Engineer (or trained Advanced Manufacturing Engineer if no Ergonomics Engineer is assigned) is charged with identifying potential ergonomic hazards associated with product and process. PEILs are living documents a

2) *PEIL Development:*
 The PEIL is initially created prior to the Phase Two Exit Review and updated a minimum of once prior to each phase exit review.

3) *PEIL Review:*
The Launch Manager or Advanced Manufacturing Engineer schedules a PEIL review with the product launch team prior to each Manufacturing Readiness Review (MRR) and PSO. All information on the PEIL should be filled in prior to PSO.

4) *Pre-Launch PEIL Status and Approval:*
At the time of PSO, the appropriate ASG Corporate Ergonomics Engineer team member must initial either "Product Approved" or "Product Not Approved" box, and sign and date the document. The appropriate ASG Corporate Ergonomics Engineering Team Member can

5) *Pre- Launch PEIL Storage:*
Electronic masters may be stored and maintained in the CHESS electronic database system by the Group Ergonomics Engineer or the AME. At the time of PSO, the signed and dated copy of the PEIL should be transferred by the Project Manager to the Johnson Con

INSTRUCTIONS: POST LAUNCH

1) *PEIL Management:*
The Ergonomics Task Force (ETF) is responsible for developing and maintaining all Potential Ergonomics Issues Lists (PEILs) post launch. The ETF is also responsible for reviewing any pre-launch PEILs for newly launched products. All ETF members should r

2) *PEIL Development:*

The PEIL should be conducted within the first six months after the start of production. Lines completing the launch process will have pre-launch PEILs, which should be reviewed prior to conducting the post launch PEIL.

3) *PEIL Review:*
The PEIL ratings should be updated a minimum of once per year.

4) *Post Launch PEIL Storage:*
 Electronic masters are kept by the ETF Lead and may be stored and maintained in the CHESS electronic database system.

Instructions for PEIL Development

The basis number is also known as the projectnumber ni launch. Manufacturing plants that do not know the basis number for the program can also enter the department number in this field. Location number applies to Post Launch Documents only.

Customer: Ex. Ford, GM, Toyota

Vehicle: Ex. Buick Century, Accord

Model Yr: Ex. 2001, 2003

Platform: Ex. P225, GMX367

Product: Enter Product (i.e. Seat, OHS, Visor, Floor Console, etc.)

Core Team:	Should consist of anyone who is involved in the PEIL. Pre-Launch: Minimum of Group Ergonomics Engineer and/or Advanced Manufacturing Engineer, and Packaging Engineer. Post-Launch: Author of PEIL and any person responsible for follow-up on a Recommended
PEIL Date (Orig.)	The original date the PEIL was conducted. (mm/dd/yyyy)
Modified Date:	Date of latest revision/ update to PEIL. (mm/dd/yyyy)
Pre-Launch (Phase) /Post Launch:	List PEIL type. If a Pre-Launch, list phase as well. Ex. Pre-Launch (Phase 3).
Document ID:	Use platform name and product abbreviation: ex. LH FC (floor console), GMX367 IP (Instrument panel)
Created By:	Name of original PEIL author (ex. J. Smith).
Modified By:	Name of most person who has most recently updated the PEIL (ex. J. Jones).
Document Status:	Active (most recent version, currently in use), Inactive (unfinished document, older document version, etc.), or Frozen (document frozen to retain history at specific point, I.e. Phase Exit review).
Revision Level/ Version Number:	List revision level or version number.
Station/Activity:	Follow Process Flow or Operator Description Sheets (ODS) if possible
Component:	List major product component associated with station or activity (if applicable).
Task:	Main task or process at station. Follow Process Flow or Operator Description Sheets (ODS) if possible
Task Description:	More detailed description of task.
Potential Issue:	Ex. Stress on shoulder due to 48" reach, 20 # palm press, Asymetrical lift - back, wrist flexion due to part clearance.
Body Part Affected:	Body part(s) most susceptible to injury from potential issue identified.
Repetition:	Follow guide on Table A to rate Repetition for task. (High = H, Moderate = M, Low = L)
Force:	Follow guide on Table B to rate Force. (High = H, Moderate = M, Low = L)
Posture:	Follow guide on Table C to rate Posture of worst body part during task. (High = H, Moderate = M, Low = L)
Priority:	The overall priority associated to performing this task will be automatically calculated. The Priority Matrix with the rating combinations can also be found in Table D. **NOTE:** If any of the ratings is not known, the Priority should be "worst case" or High.
Control Plan:	General category or type of control, ie.design change, automation, training, etc.
Recommended Action:	If the Priority rating is a "high", actions will be initiated to reduce the rating to "low". Moderate ratings should be reviewed for potential action. If no action plans are recommended for a specific task, it is necessary to enter "None" in the "Recomme
Responsibility:	Enter the person responsible for following up on the recommended/needed action. Ex. M. Engineer
Target Date:	Enter the target date assigned. Ex. 03/15/2001
Action Results:	List action taken, completion date, and new ratings for Repetition, Force, and Posture, as well as the new Priority rating for the task.
Completion Date:	Enter the date the action was completed.
Priority:	Re-rate Force, Repetition, and Posture following changes to the issues to obtain the new priority of the potential risk associated with the task.

PEIL Checklist

This checklist is a guide only.

PEIL Checklist

DESIGN ISSUES

Forces
1. Insertion forces (e.g. rivets, x-mas trees)
2. Closure forces
3. Tie-down forces
4. Pulling or tucking trim (e.g. force required)
5. Pinch forces (e.g. j-clip)
6. Contact stresses
7. Push force for moving containers (on rollers, etc)

Securing Method
8. Preferred closure methods
9. Preferred tie-down methods
10. Position/size of targets (e.g. screw holes)
11. Clearance and access
12. Preferred fastening types
13. Number of fastening types

Handling
14. Size, weight of handled parts
15. Part edges (rounded & hemmed, not sharp)
16. Structural integrity of handled parts (e.g packaging)

Other
17. Carry over component issues
18. Preferred build type (e.g. upright)
19. Repetition minimize
20. Clearance and access to components
21. Location and thickness of flash/gates/runners
22. Single plane assembly
23. Contrast/visual issues
24. Safety features on packaging (safety straps, etc)

Workstation Design

Facility
1. Preferred assembly line design (indexing, toe room and proper height.
2. Adequate facility size - appropriate aisle widths, etc.
3. Workstation layout
4. Floor mats (anti-fatigue)

Work Station Design Issues (continued)

Handling
5. Component box/tote weight (ref. NIOSH equation)
6. Material storage/handling
7. Special line considerations for products + 10lbs
8. Frequency of handling
9. Lift assist for all complete seats
10. Static muscle loading (avoid)

Fixtures/Tools/Equipment
11. Compression fixtures
12. Fixturing for high insertion forces (automated)
13. Assist for high tugging/pulling forces
14. Balancers and reaction arms (no retractors)
15. Tool selection/interface with hand
16. Workstation adjustability (e.g. tables, fixtures)
17. Automated vs. manual

Access
18. Light sensors and guarding
19. All work below shoulder height
20. Clearance and access to all assembly
21. Location of controls/displays
22. Work in good postures (no twisting, no static bending, neutral postures)
23. Orientation of part on line and to material handling device (e.g. hi-lo forks)
24. Manipulation of dunnage
25. Adequate egress (consider size of lifted parts)
26. Infrequent reaches within 24" horizontal envelope and 12" for functional non-extended reach

Environment
27. Rotation considerations
28. Contact with hot/cold temps (e.g. tools, welding)
29. Noise levels (less than 85 db acceptable)
30. Vibration
31. Adequate lighting for task
32. Allowance for personal protective equipment

Other
33. Motion efficiency

SUMMARY OF INSTRUCTIONS

1) Fill out top section of PEIL form with OEM, program name, etc.
2) Write down station & all operator tasks. Follow process flow where available.
3) Classify repetition, force, and posture for each task. See Tables A-C for benchmark ratings.
4) Use the matrix located in Table D (see below) to determine the priority (automatically inserted).
5) All tasks receiving a priority rating of moderate or high should have a corresponding action plan with a target date and a person responsible.
6) After action items have been completed the task should be re-rated. If the new priority score is reduced to a low the item should be closed. If the item remains moderate or high a new action plan should be generated and re-rated upon completion.

TABLE D- Rating Combinations

RFP	RFP	RFP
HHH	MHH	LHH
HHM	MHM	LHM
HHL	MMH	LHL
HMH	MHL	LMH
HMM	MMM	LMM
HLH	MLH	LLH
HML	MML	LML
HLM	MLM	LLM
HLL	MLL	LLL

High Risk - H, Non-compliant, Action plan & Ergonomic review required

Moderate Risk - M, Partially Compliant, Action plan required

Low Risk - L, Compliant, No action plan required, but recommended

Table A - Repetition Benchmarks

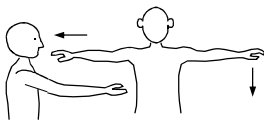| LOW	MODERATE	HIGH
Leisurely Pace	Steady Pace	Rapid Pace
Frequent Pauses	Infrequent Pauses	No Rest Pauses
Non-cyclical Tasks		Bottleneck Stations
		High Frequency of Similar Tasks

Table B - Force Benchmarks
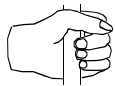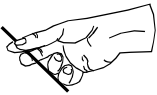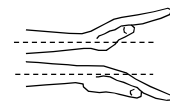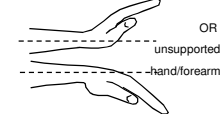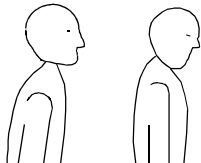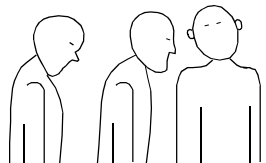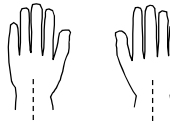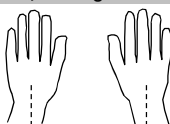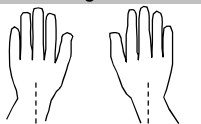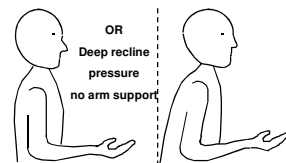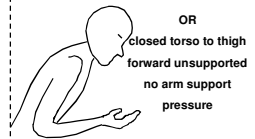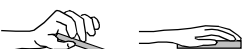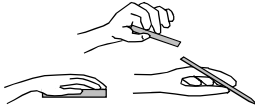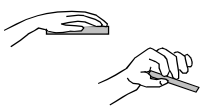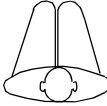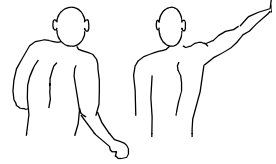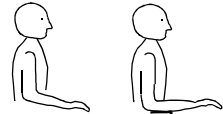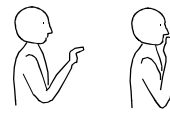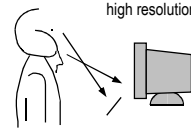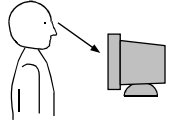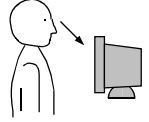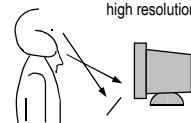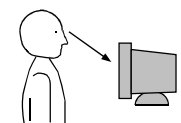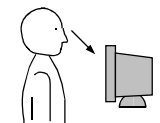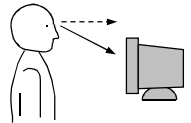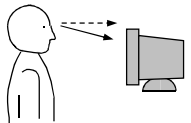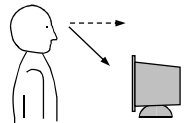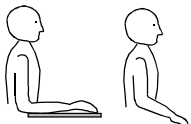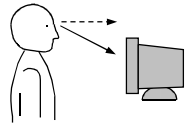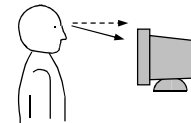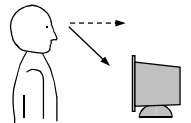
TYPE OF HANDLING	ILLUSTRATION	LOW	MODERATE	HIGH
POWER GRIP		< 14#	14# - 21#	21# - 48#
2 POINT PINCH		< 3#	3# - 4.5#	4.5# - 9#
3 POINT PINCH		< 4#	4# - 6#	6# - 14#
LATERAL PINCH		< 4#	4# - 6#	6# - 14#
THUMB PUSH		< 7#	7# - 10.5#	10.5# - 19#
PALM PRESS		< 10#	10# - 15#	15# - 35#
FOOT CONTROL		< 10#	10# - 16#	16# - 37#
OTHER		NO EFFORT NEEDED		GREATEST EFFORT POSSIBLE

Table C - Posture Benchmarks

	Low Risk	Moderate Risk	High Risk
Hand/ Wrists	0-15 degrees Extention	15 - 30 deg. extention >0, <15 deg. flexion	30 deg. extention >15 deg. flexion
	0-15 deg. ulnar dev.wrist	5-15 deg. ulnar deviation	>15 deg. deviation
	neutral & relaxed finger grip	tensed/awkward finger grip	tensed/awkward finger grip
Arm/ Shoulder	relaxed or supported elbow	<45 deg. extended >70 deg. flexion elbow	<70 deg. flexion elbow
	neutral or supported forearm	unsupported forearm	reach & unsupported forearm
	supported or neutral upper arm	reaching/shoulder <60 deg. flexion	reaching/shoulder >60 deg. flexion
	neutral shoulders	slouched/forward shoulders	assymetrical/tensed shoulders

	Low Risk	Moderate Risk	High Risk
Head/ Neck	neutral	<15 degree flexion & chin in	>15 degree flexion or chin protrude
Torso	recline	vertical	flexed
View Distance	symetrical Or 24" plus high resolution 15" - 24" to screen 14" - 16" to document	twisted < 16"	bend/reach/lift 8" - 12"
View Angle	15 - 30 degrees	<15 or <30 degrees	>10 or <35 degrees

Appendix 6

Power point presentation on basic back care

Posture in front of TV

2005 5 17

2005 5 17
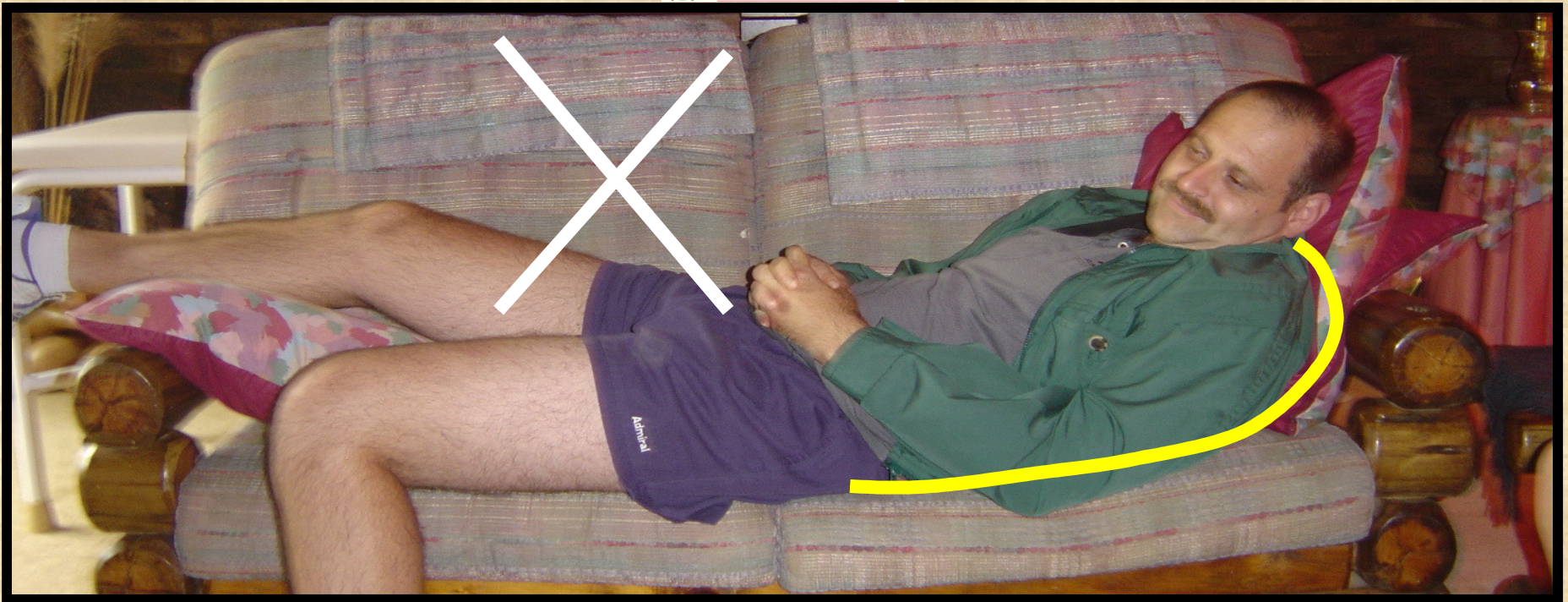
Carrying and picking up children

The principles for picking up objects also apply when picking up children. Resist the temptation to simply lean over and lift. Instead, with your feet placed slightly apart, bend your knees into a squat that will bring you closer to the level of the child A. Wrap one arm around the child's body and use the other arm to support him or her from underneath B. Slowly straighten into a standing position C, keeping your abdominal stabilizers contracted throughout.

Carrying your child in this manner is acceptable for short periods, for example, if you want to take the child indoors or to bed. However, carrying children for extended

Lifting a child
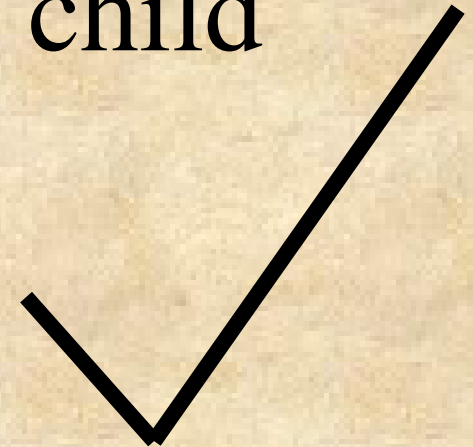
Fehrsen-du Toit, R; *The Good Back Book*, New Holland Publishers, 2002

When to go to the doctor or physio?

- Severe pain not resolved after 2 days of self-management
- Numbness, P&N's and/or weakness in legs or arms
- Difficulty passing/controlling urine
- Unsteadiness on feet/clumsy hands
- Dizziness
- Frequent; recurring attacks
- Traumatic Injury d.t. a fall/ accident
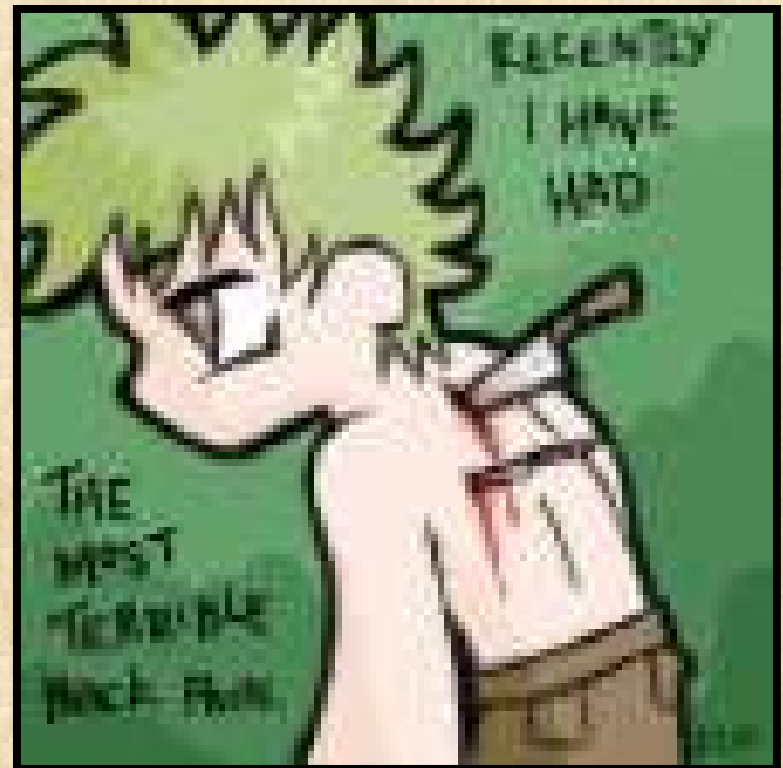
To exercise or not to exercise?

Appendix 7

Power point presentation of TRIM training

Ergonomics training for TRIM team leaders & coordinators

Johnson Controls Watloo, Pretoria

Presented by Susan Grobler

Physiotherapist

3/2006

What do you see?

His chair is too low/his table is too high.
Reason: ?

My definition of ergonomics:

- Ergonomics is the science to design the job according to the human, to enable the human to be more productive.

- Productivity = <u>Money received from customer</u>
  Expenses due to sick leave/material/etc

- Ergonomics should: <u>Increase productivity (Better work-flow, Less mistakes)</u>
  Decrease labor costs (Less sick leave)

Performance equation

Performance = $\boxed{\text{capability}}$ x $\boxed{\text{commitment}}$

capability:
- Know how
- Knowledge

commitment:
- Willingness
- Persistence

How Do You Measure Up?
The Answer Does Not "Add Up"...
IT MULTIPLIES!

Why is it hard work to work in a static posture?

The 6 reasons are:

Reduce the harmful effects of a static job by attending to:

1. Work place design
2. Job design
3. Training

1. Work place design

Proper back support   Don't reach   Space under the table

3. Training: Job rotation: Why?

Prevent injury by:

- Using different muscles in different time slots during the day to minimize the overuse effect on a specific muscle group.

- E.g. Rotate between:

  locking down and top stitch

3. Training: Job rotation in standing

Table too low   Table too high

Tables should be height adjustable

3. Training: Job rotation in sitting

- Each work station should be adjustable regarding the chair, and table height
- It is very complicated to design this in our own environment
- Alternative: Rotate the job between the workers, except for:
- Top stitch

What are the most common overuse injuries?

- Carpal tunnel syndrome
- Tennis elbow
- Neck & back spasm
- De Quervian tendonitis

Appendix 8

Exercises

GROBLER AND MABENA PHYSIO'S
Personal Exercise program
FORD Medical Center Tel: (012) 8422556

PR 0720000212679

Date: 2007/01/18

Provided for : 1 min During work   Stretch & improve blood circulation in legs

Provided by : Susan Grobler
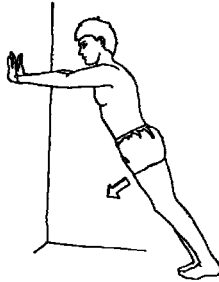
---

Stand with your feet together on the yellow line of the mat behind you. Take support from your table. Lean forward while you KEEP YOUR HEELS ON THE FLOOR, AND YOUR KNEES STRAIGHT.

You should feel the stretching in your calves. Hold approx. 10 secs - relax.

Repeat once every hour (09h00, 11h00, 12h00, 14h00, 16h00) - both legs at the same time.

© PhysioTools Ltd
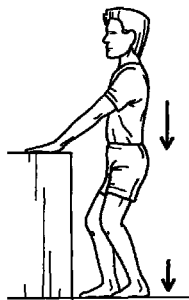
Stand with your feet together on the yellow line of the mat behind you. Take support from your table. Bend knees while you KEEP YOUR HEELS ON THE FLOOR.

Feel the stretching in your calves. Hold 10 sec. - relax.

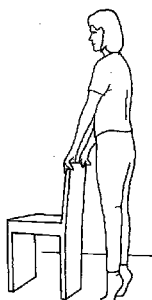Repeat once every hour (09h00, 11h00, 12h00, 14h00, 16h00) - both legs at the same time.

© PhysioTools Ltd
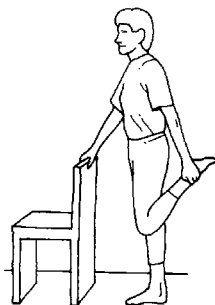
Stand holding on to your table with one hand, and one forefoot in the other hand. Pinch your buttocks. Do not lock the knee of the leg you are standing on. Draw your heel towards your buttock. Feel the stretch in the front of your thigh, and front shin. Hold 10 sec.

Repeat once every hour (09h00, 11h00, 12h00, 14h00, 16h00) -one leg at a time.

© PhysioTools Ltd

Stand. Keep your balance by holding lightly onto your table. Raise yourself on your toes. Do not push yourself up on your hands. Hold 2 sec.
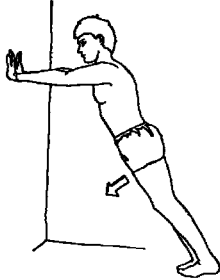
Repeat 5 times every hour (09h00, 11h00, 12h00, 14h00, 16h00) - both legs at the same time.

© PhysioTools Ltd

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Tools RG
Know how to show how

Provided for : Date: 2005/06/03   Recommended table height: _____
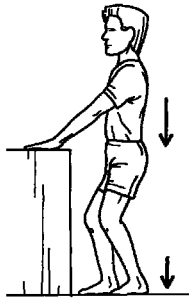Provided by : Susan Grobler

---

Stand with your feet together, fore feet on the yellow line of the Ergobuddy behind you. Take support from your table. Lean your body towards while you KEEP YOUR HEELS ON THE FLOOR.

Feel the stretching in your calves. Hold 10 secs - relax.

Repeat once every hour (09h00, 11h00, 12h00, 14h00, 16h00) - both legs at the same time.
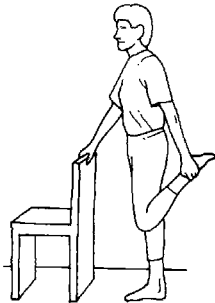
© PhysioTools Ltd

Stand with your feet together, fore feet on the yellow line of the Ergobuddy behind you. Take support from your table. Bend your knees while you KEEP YOUR HEELS ON THE FLOOR.

Feel the stretching in your calves. Hold 10 secs - relax.

Repeat once every hour (09h00, 11h00, 12h00, 14h00, 16h00) - both legs at the same time.

© PhysioTools Ltd

Stand holding on to your table with one hand and the fore foot in the other hand. Pinch your buttocks.

Pull the forefoot towards your bottom, and hold for 10 sec. You should feel the stretch in your upper thigh, as well as your front shin.

Repeat once every hour (09h00, 11h00, 12h00, 14h00, 16h00) - with each leg.

© PhysioTools Ltd

Stand with one leg in front of the other, and take the front foot in your hand.
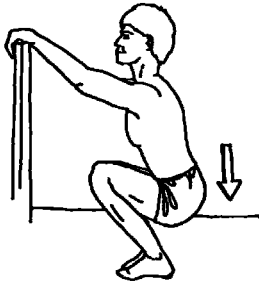
Then bend your upper body forwards from your hips keeping your back straight, and try to put your fore head on your knee. You should feel the stretching behind your knee and thigh. Hold 10 sec.

Repeat once every hour (09h00, 11h00, 12h00, 14h00, 16h00) - with each leg.

© PhysioTools Ltd

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Susan Grobler
Physiotherapist PR 7223447

FORD Motor Co of S.A., Waltloo, Pretoria

Tel: (012) 842 2556 (am)/083 415 2008

Ease down from high heeled shoes to flat shoes.

Date: 2005/06/06

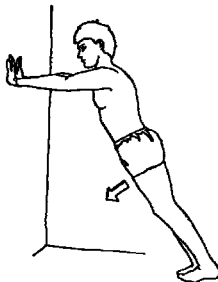Provided by : Susan Grobler

---

Stand in front of a table or chair holding on to the support with both hands.

Slowly crouch keeping your back straight and heels on the floor. Stay down for approx. 20 secs. and feel the stretching in your buttocks and the front of your thighs.
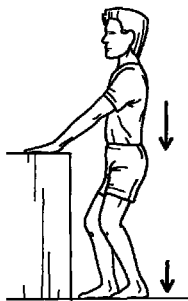
Repeat 30 times.

© PhysioTools Ltd

Stand with your feet together, fore feet on the yellow line of the Ergobuddy behind you. Take support from your table. Lean your body forwards while you KEEP YOUR HEELS ON THE FLOOR.

Feel the stretching in your calves. Hold 20 secs. - relax.
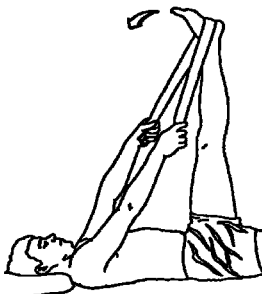
Repeat 30 times.

© PhysioTools Ltd

Stand with your feet together, fore feet on the yellow line of the Ergobuddy behind you. Take support from your table. Bend your knees while you KEEP YOUR HEELS ON THE FLOOR.

Feel the stretching in your calves. Hold 20 secs. - relax.

Repeat 30 times.

© PhysioTools Ltd

This exercise will mobilise the neural tissue (nerves) coming from your spine - and running down to your toes. It is NOT recommended that you do this exercise into any pain with a new back injury - but a bit of discomfort (stretch) is OK in the "maintenance & prevent recurrence"-phase.

Lying on your back with a cushion under your head. Put a band/towel under the sole of your fore foot and hold onto the band/towel with both hands.
Lift your leg up, with a bent knee. Gently straigthen your knee, while you maintain the tension in the band/towel. Pull the straight leg now further up - if possible. Hold approx. 20 secs. - relax. Repeat to the other side.
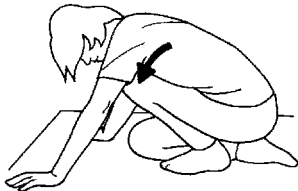
© PhysioTools Ltd

Stand on a step with both heels over the edge. Hold on to a support.

Let the weight of your body stretch your heels towards the floor. Hold 20 sec.
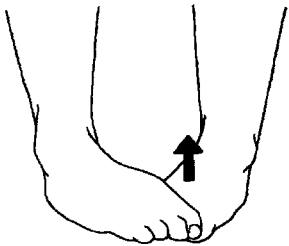
Repeat 30 times.

Half kneeling. Place your hands on the floor. Bring the ankle to be stretched close to your bottom keeping the sole of your foot on the floor.

Bring your chest forwards and shift your weight over the sole of your foot. Keep your heel on the floor during the exercise. Hold approx. 20 secs.

Repeat 30 times.

Sit on a chair or on the floor. Put one foot on top of the other foot.

Try to lift the foot that is under while preventing any movement with the foot that is on top. Hold approx. 5 secs.
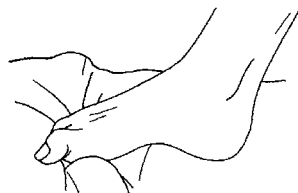
Repeat 30 times.

Stand with your back against a wall and your knees slightly bent.

Lift your toes and front of feet of the floor. Keep your heels on the floor. You should feel your shin muscles working. Hold 5 sec.

Repeat 30 times.

Stand or sit with your foot on a towel on a slippery surface (eg. tray/tiled floor).

KEEP YOUR TOES STRAIGHT, and lift the middle part of your foot to crumple up the towel under the middle part of your foot. DON'T curl your toes and crimple the towel under your toes.
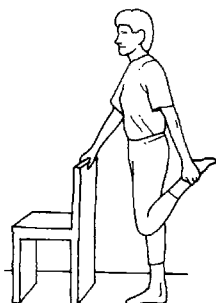
Repeat 30 times & do often during the day in your shoes.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Tools RG
Know how to show how

Provided for : Trim Ladies

Provided by : Susan Grobler
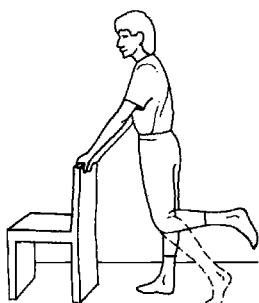
Date: 2008/08/22

Stand holding on to a support. Bend one knee and take hold of the ankle. Do not lock the knee of the leg you are standing on.

Draw your heel towards your buttock. Tilt your hip forwards so that your knee points towards the floor. Feel the stretch in the front of your thigh. Hold 20 secs.

Repeat 10 times with each leg.

© PhysioTools Ltd

Stand. Hold onto a support and bring one leg slightly backwards.

Bend your knee and lift your foot off the floor. Keep your knees next to each other. Hold 5 secs.

Repeat 50 times with each leg.
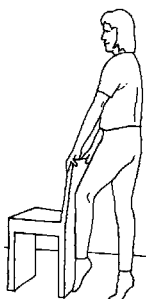
© PhysioTools Ltd

Stand on one leg.

Push up on your toes.

Repeat 50 times with each leg.

© PhysioTools Ltd

Stand on a step with both heels over the edge. Hold on to a support.

Let the weight of your body stretch your heels towards the floor. Hold 30 sec.

Repeat 10 times.

© PhysioTools Ltd

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Stand in a walking position with the leg to be stretched straight behind you and the other leg bent in front of you. Take support from a wall or chair.

Lean your body forwards and down until you feel the stretching in the calf of the straight leg. Hold approx. 30 secs. - relax. KEEP YOUR HEEL ON THE FLOOR AND YOUR KNEE STRAIGHT.
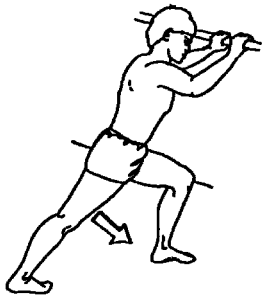
Repeat 10 times with each leg.

© PhysioTools Ltd

Half kneeling.

Tighten your stomach muscles to keep your back straight. Rotate the heel behind you outwards while pushing your hip forwards. Hold approx. 20 secs. - relax.

Repeat 10 times with each leg.
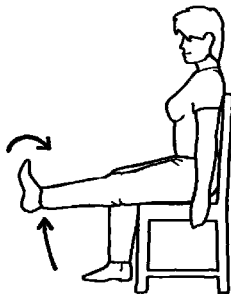
© PhysioTools Ltd

Sit on a chair.

Pull your toes up, tighten your thigh muscle and straighten your knee. Hold approx. 5 secs. and slowly relax your leg.

Repeat 50 times with each leg.
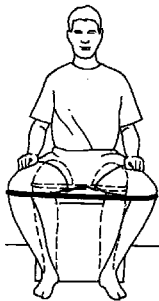
© PhysioTools Ltd

Sit on a chair/lay down. Put a non-elastic band/belt around your knees. Feet together.

Spread knees apart. Hold 6 sec.

Repeat 30 times.

© PhysioTools Ltd
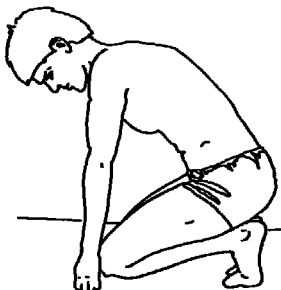
Kneeling with your heels off the floor and both arms on the floor as shown.

Sit on your knees and stretch your calves. Hold approx 20 secs.- relax.

Repeat 10 times.

© PhysioTools Ltd
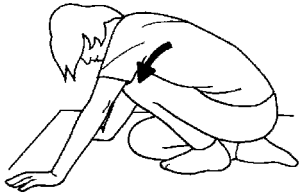
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Half kneeling. Place your hands on the floor. Bring the ankle to be stretched close to your bottom keeping the sole of your foot on the floor.

Bring your chest forwards and shift your weight over the sole of your foot. Keep your heel on the floor during the exercise. Hold approx. 30 secs.

Repeat 10 times with each leg.
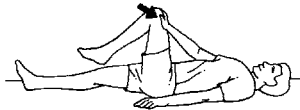
Lying on your back.

Bend your leg and resist the movement with your hand. Hold 6 secs. Repeat with other leg.

Repeat 30 times with each leg.
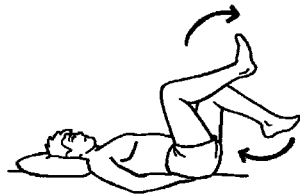
Lying on your back with hands supporting pelvis.

Make a cycling movement with both legs for 10 min.
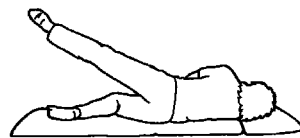
Sidelying. Keep the leg on the bed bent and the upper leg straight.

Lift the upper leg straight up with ankle flexed and the heel leading the movement.

Repeat 30 times with both legs.

Lying face down with a band around your ankle.

Tighten your stomach muscles to keep your lower back straight. Bend your knee and pull the band with both hands until you feel tightness on the front of your thigh. Hold approx. 5 secs. - relax.

Repeat 10 times with each leg.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Lying on your back with one leg straight and the other leg bent. (You can vary the exercise by having your foot pointing either upwards, inwards or outwards).

Exercise your straight leg by pulling the toes up, straightening the knee and lifting the leg 20 cm off the bed. Hold approx 5 secs. - slowly relax.

Repeat 50 times with each leg.

© PhysioTools Ltd
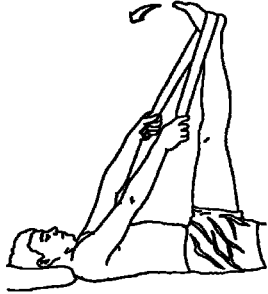
Lying on your back with a cushion under your head. Put a band under the sole of your foot and hold onto the band with both hands.

Lift your leg straight up. Pull the band flexing the ankle and stretching the back of your thigh. Hold approx. 20 secs. - relax. Stop if you feel any pain in your lower back.

Repeat 10 times with each leg.

© PhysioTools Ltd

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Appendix 9

Approval from ethics committee

Faculty of Health Sciences Research Ethics Committee

17/02/2012

Number	:	S157/2011
Title	:	Retrospective study of a physiotherapy and ergonomics programme on work-related musculoskeletal disorders in sewing machine operators
Investigator	:	Susanna Helena Grobler, Department of Physiotherapy, University of Pretoria (SUPERVISOR: Ms Karien Mostert-Wentzel)
Sponsor	:	None
Study Degree:		M.PhysT

This Student Protocol was reviewed by the Faculty of Health Sciences, Student Research Ethics Committee, University of Pretoria on 17/02/2012 and found to be acceptable. The approval is valid for a period of 3 years.

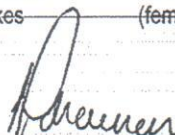|	
Prof M J Bester	BSc (Chemistry and Biochemistry); BSc (Hons)(Biochemistry); MSc (Biochemistry); PhD (Medical Biochemistry)
Prof R Delport	(female)BA et Scien, B Curationis (Hons) (Intensive care Nursing), M Sc (Physiology), PhD (Medicine), M Ed Computer Assisted Education
Prof J A Ker	MBChB; MMed(Int); MD – Vice-Dean (ex officio)
Dr NK Likibi	MBB HM – (Representing Gauteng Department of Health) MPH
Dr MP Mathebula	Deputy CEO: Steve Biko Academic Hospital
Prof A Nienaber	(Female) BA (Hons) (Wits); LLB (Pretoria); LLM (Pretoria); LLD (Pretoria); PhD; Diploma in Datametrics (UNISA)
Prof L M Ntlhe	MBChB(Natal); FCS(SA)
Mrs M C Nzeku	(Female) BSc(NUL); MSc Biochem(UCL,UK)
Snr Sr J. Phatoli	(Female) BCur (Et.Al); BTech Oncology
Dr R Reynders	MBChB (Pret), FCPaed (CMSA) MRCPCH (Lon) Cert Med. Onc (CMSA)
Dr T Rossouw	(Female) MBChB.(cum laude); M.Phil (Applied Ethics) (cum laude), MPH (Biostatistics and Epidemiology (cum laude), D.Phil
Mr Y Sikweyiya	MPH (Umea University Umea, Sweden); Master Level Fellowship (Research Ethics) (Pretoria and UKZN); Post Grad. Diploma in Health Promotion (Unitra); BSc in Health Promotion (Unitra)
Dr L Schoeman	(Female) BPharm (NWU); BAHons (Psychology)(UP); PhD (UKZN); International Diploma in Research Ethics (UCT)
Dr R Sommers	**Vice-Chair (Female)** - MBChB; MMed (Int); MPharMed.
Prof T J P Swart	BChD, MSc (Odont), MChD (Oral Path), PGCHE
Prof C W van Staden	**Chairperson** - MBChB; MMed (Psych); MD; FCPsych; FTCL; UPLM; Dept of Psychiatry

Student Ethics Sub-Committee

Prof R S K Apatu	MBChB (Legon,UG); PhD (Cantab); PGDip International Research Ethics (UCT)
Mrs N Briers	(female) BSc (Stell); BSc Hons (Pretoria); MSc (Pretoria); DHETP (Pretoria)
Prof M M Ehlers	(female) BSc (Agric) Microbiology (Pret); BSc (Agric) Hons Microbiology (Pret); MSc (Agric) Microbiology (Pret); PhD Microbiology (Pret); Post Doctoral Fellow (Pret)
Dr R Leech	(female) B.Art et Scien; BA Cur; BA (Hons); M (ECI); PhD Nursing Science
Dr S A S Olorunju	BSc (Hons). Stats (Ahmadu Bello University –Nigeria); MSc (Applied Statistics (UKC United Kingdom); PhD (Ahmadu Bello University – Nigeria)
Dr L Schoeman	CHAIRPERSON: (female) BPharm (North West); BAHons (Psychology)(Pretoria); PhD (KwaZulu-Natal); International Diploma in Research Ethics (UCT)
Dr R Sommers	**Vice-Chair (Female)** MBChB; M.Med (Int); MPhar.Med
Prof L Sykes	(female) BSc, BDS, MDent (Pros)

DR L SCHOEMAN; BPharm, BA Hons (Psy), PhD; Dip. International Research Ethics
CHAIRPERSON of the Faculty of Health Sciences Student Research Ethics Committee, University of Pretoria

DR R SOMMERS; MBChB; M.Med (Int); MPhar.Med.
VICE-CHAIR of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

Faculty of Health Sciences Research Ethics Committee

28/03/2013

Approval Notice
Amendment

Ethics Reference No.: S157/2011

Title: The impact of a change in work posture on work-related musculoskeletal disorders among sewing-machine operators, managed within a physiotherapy and ergonomics programme

Dear Susanna Helena Grobler

The **Amendment** as described in the documents dated 1 March 2013 and that we received on 1 March 2013 was approved by the Faculty of Health Sciences Research Ethics Committee on the 27/03/2013.

Please note the following about your ethics amendment:
- Please remember to use your protocol number (S157/2011) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committe may ask further questions, seek additional information, require further modification, or monitor the conduct of your research.

Ethics amendment is subject to the following:

Standard Conditions:
- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

The Faculty of Health Sciences, Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

We wish you the best with your research.

Yours sincerely

DR L SCHOEMAN; BPharm, BA Hons (Psy), PhD;
Dip. International Research Ethics
VICE-CHAIR of the Faculty of Health Sciences
Research Ethics Committee, University of Pretoria

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH GCP guidelines and has US Federal wide Assurance.
- FWA 00002567, Approved dd 22 May 2002 and Expires 20 Oct 2016.
- IRB 0000 2235 IORG0001762 Approved dd 13/04/2011 and Expires 13/04/2014.

☎ 012 354 1677   📠 0866516047   ✉ deepeka.behari@up.ac.za   🖥 http://www.healthethics-up.co.za
✉ Private Bag X323, Arcadia, 0007 - 31 Bophelo Road, HW Snyman South Building, Level 2, Room 2.33, Gezina, Pretoria

Appendix 10

Medical surveillance forms

OCCUPATIONAL HEALTHCARE

COMPANY _Express_   DIVISION _____

Surname _____   Initials _____   Employee No. _____

Date of Birth. dd/mm/yy _____   Department _C & S_   Code _01_

Address :

Zone 16

Ga-rankuwa

Job Title _Sewer_

Date Engaged dd/mm/yy _08.08.2000_   I.D.Number _____

Medical Aid   Y   [N̸]

Surveillance Required

Hospital Folder Numbers.

Known Allergies. _None_

Chronic Medical Conditions _None_   Date diagnosed

Chronic Medicatiions _None_   Supplied by.   Date started / changed

Comments : _____

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Ref A2

Occupational Health

Form AB

PRIVATE & CONFIDENTIAL

Name _____

Company _Johnson Controll_

No. _____

Consent for taking of Specimens

This is to acknowledge that I, _____ Co. No._____

Agree to undergo medical examinations / consent to the collection of biological specimens (as required for medical surveillance)

This document is confidential and relevant finding's about occupational exposure may need to be divulged to the appropriate authorities.

_____   23/08/06
Signature   Date

Form AB

A. PRE-EMPLOYMENT MEDICAL EXAMINATION

Occupational Health

HEALTH CARE

1. Full Names, including Surname	
2. Home Address	3. Telephone Numbers
Postal Code	048109000 (Work)

4. Date of Birth (DD-MM-CCYY)	5. Age	6. Sex	7. Marital status/children

8. Occupation	9. Business Unit	10. Section
Sewer,	Tin	Ford

11. ID/Passport Number	12. Company No.

CLINICAL HISTORY

13. Occupational History and Hazard Exposure (in chronological order)

Dates From	To	Organisation	Location	Occupation	Hazard Exposure (Radiation, Noise, Asbestos, etc.)
1987	1998	Ford	wattoo	Sewer	o
1998	–	John Sai Ceith	4	Sewer	–

14. Medical History: If YES please provide complete details below (if space is insufficient, add supplementary notes on separate sheet) (N = No, Y = Yes)

Family History of:	N	Y	Have you ever had or do you now have	N	Y	Have you ever had or do you now have	N	Y
1. Heart disease or high blood pressure	X		13. Head injury/concussion/unconsiousness	X		27. Stomach, liver or intestinal trouble	X	
2. Epilepsy or convulsions	X		14. Epilepsy or fits of any kind	X		28. Unexplained weight-loss or gain	X	
3. Glaucoma or blindness	X		15. Any other neurological disorder	X		29. Bleeding from the rectum	X	
4. Diabetes Mellitus (sugar sickness)	X		16. Any mental/psychological disorder/phobia	X		30. Kidney stone or infections	X	
5. Cancer/Blood diseases	X		17. Suicide attempt	X		31. Sugar Blood or protein in urine	X	
6. Hereditary diseases/Congenital abnormalities	X		18. Eye or vision trouble (except glasses)	X		32. Diabetes Mellitus (sugar sickness)	X	
Have you ever been	N	Y	19. Hearing or speech disorders	X		33. Prostate/Gynaecological problems	X	
7. Refused work on medical grounds	X		20. Allergies: Resp./Skin/Medicines	X		34. Any blood or thyroid disorder	X	
8. Refused/Loaded for insurance	X		21. Asthma/lung disease/chronic cough	X		35. Malignant tumours or cancer	X	
9. Treated for alcohol or drug addiction	X		22. Tuberculosis or pneumonia	X		36. Skin disorders (psoriasis, eczema, acne)	X	
10. A smoker (expanded in section 45)	X		23. Heart disease or high blood pressure	X		37. Diseases of muscle, bone, joints, back	X	
Have you ever had, or do you now have	N	Y	24. Chest discomfort, pain or palpitations	X		38. A positive HIV test	X	
11. Frequent or severe headaches/migraine	X		25. Heart murmur, or valve problems	X		39. Admission to hospital (for any reason)	X	
12. Dizziness or unsteadiness	X		26. Heartburn, frequent indigestion	X		40. Any other illness or injury	X	
						41. Are you pregnant or planning to be so		

42. Sports and Hobbies	43. Alcohol consumption: Type/Quantity
Dr Naita — Church	N.O

44. Name and Address of usual medical practitioner

45. Smoking No. of packs per day _____
If stopped, what date? _____ When smoking started _____

46. Medical Treatment within the last three (3) years which required sick leave > 7 days or hospitalisation

Date	Name of Medical Practitioner, Specialists, etc.	Diagnosis/Treatment
2006	Dr, Naita	Medical Condition

47. Medications:

No Medication

15. REMARKS (To be completed by Medical Examiner. Comment in full on all items marked YES.)

Signature of Applicant

Signature of Med. exam

23/0 90 6

Date (DD-MM-CCYY)

Occupational Health
HEALTH CARE

B. PHYSICAL EXAMINATION

1. Mass (kg)	2. Height (m)	3. Pulse rate	4. Blood pressure			5. Urinalysis						
100 kg	155cm		100	Lying	Sitting							
BMI m/ht² 41.7		76 /min	/ 60 mm Hg				Appearance	pH	Protein	Glucose		Blood
						Normal ⨯	clear	7	Nil	0.2		Ni
						Abnormal						

Mark each item in the appropriate column	NAD	ABN	Mark each item in the appropriate column	NAD	ABN
6. Head, face, scalp and neck	⨯		12. Genito-urinary system (external and rectal)	⨯	
7. Ears, nose and throat	⨯		13. Neurological system (cranial nerves, motor, sensory, reflexes)	⨯	
8. Lungs, chest and breast	⨯		14. Upper and lower limbs (strength, range of motion)	⨯	
9. Heart (size and sounds)	⨯		15. Spine and musculoskeletal (cervical, thoracic and lumbar)	⨯	
10. Vascular system and lymphatics (pulses/glands)	⨯		16. Skin and appendages	⨯	
11. Abdomen (viscera and hernia)	⨯		17. Psychological evaluation report/impressions	⨯	

SPECIAL MEDICAL INVESTIGATIONS To be conducted as prescribed by the OREP

18. Vision examination

Corrective lenses used			(Yes) No
Ophthalmoscopy			(NAD) ABN
Cornea/Lens/Fundi			

Visual acuity (corrected)	R	L	B
Far (6 m)	6/	6/	6/
Near (50 cm)	6/	6/	6/
Night vision	6/	6/	6/
Visual fields	R	L	B
Stereopsis			%

Colour vision (State method)

- (Orthorator)
- Ishihara
- Colour wires
- Practical test

Other comments:

19. Initial Screening Audiometry (Attached Audiogram)

Frequency (H₃)	R	L
500		
1 000		
2 000		
3 000		
4 000		
6 000		
8 000		
PBI	PLH	

21. BASELINE

Frequency (H₃)	R	L
500		
1 000		
2 000		
3 000		
4 000		
6 000		
8 000		
PBI	PLH	

20. Special examinations (Attach reports)

	NAD	ABN
Lung function test (spirometry)		
FVC ___% FEV₁ ___% FEV₁/FVC ___%		
Chest X-ray (attach report)		
Peak Flow		
Rest ECG (attach ECGs)		

Lab analysis (Attach reports)	Y	N
Hematological (FBC, Hb)		
Liver functions (GGT, ALT, AST)		
Lipogram (cholesterol, HDL, LDL, TG)		
Toxicology (lead, PCB, cholinesterase, etc.)		
HIV		
Other		

DECLARATION BY MEDICAL EXAMINER

I hereby certify that I personally examined the applicant and this report and attachments embody my findings completely and correctly.

The applicant (Full name): _____   Company no: _____ is

Fit	⨯	as	Occupation	Seual	for
Temporary unfit					
Unfit					

and | Recommended | Not recommended |

A: (signature) DOH.

Telephone no. 0810900   Signature _____   Name and Qualifications Rosa Molelamaba   date 23.08.06