Appendix 2

Summary of literature

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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:

- Epidemiology of WRMSDs among sewing-machine operators;
- Risk factors causative to WRMSDs in the working population; and
- 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

investigate differences and similarities ...ied populations and the South 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 opera[illegible]) 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[illegible]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 of the 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	• <u>Questionnaire:</u> 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%. • <u>Examination:</u> 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).	<u>Ergonomic analysis showed that operators:</u> • 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. <u>Interviews:</u> • 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:

- 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.
- National identification number: Captured as on the physical employee records at the company, physical patient records at the medical clinic and physiotherapy practice.
- Company identification number: Captured as on the physical employee records at the company, physical patient records at the medical clinic and physiotherapy practice.
- Job title: Captured as on the physical employee records at the company. Only data of the job title: “Sewing machine operator” were included
- Maternity leave dates: Captured as on leave records in physical employee records at the company only.
- Employment dates: Captured as on the physical employee records at the company.

Data from the company

Categorisation of data on *personal risk factors:*

- 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:*

- Force - material: Working with cloth/vinyl was indicated with a 0, and cloth/leather with a 1.
- 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.
- 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.
- 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:*

- Gender: As captured form the physical patient records. Male = 0, and female = 1.
- 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.

- Hypertension
- Arthritis
- Diabetes Mellitus

Data from the physiotherapy practice

Coding of data on *personal risk factors:*

- 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.

- Spinal - including cervical, thoracic, lumbar and sacroiliac areas,
- Upper limb - from the gleno-humeral joint to the fingers, and the
- 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: _____
Group Ergonomics Engineer

(Applies to Pre-Launch PEIL only)

Product Approved (Initial) ☐
Product Not Approved (Initial) ☐
(Applies to Pre-Launch PEIL only)

POTENTIAL ERGONOMICS ISSUES LIST (PEIL)

Basis/ Location Number _____
Customer/ Vehicle _____
Model Yr/ Platform _____
Product _____
Core Team _____

PEIL Date (Orig.) _____
Modified Date _____
Pre-Launch (Phase)/Post Launch **Post Launch**
Document ID _____

Created By _____
Modified By _____
Document Status _____
Revision Level/Version _____

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

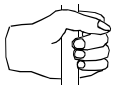
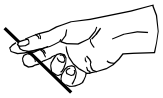
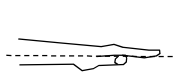
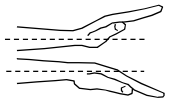
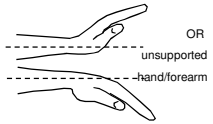
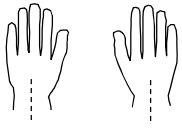
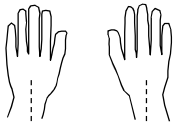
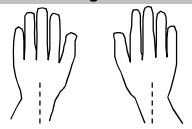
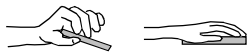
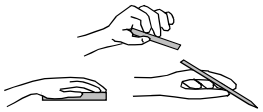
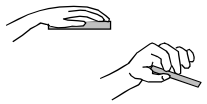
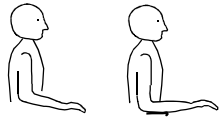
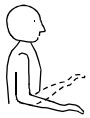
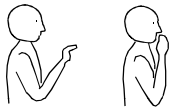
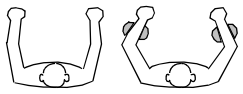
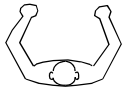
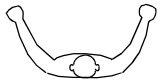
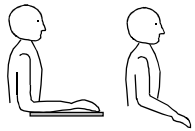
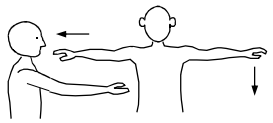
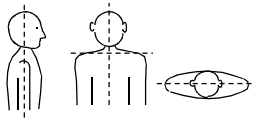
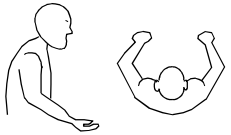
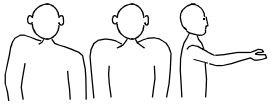
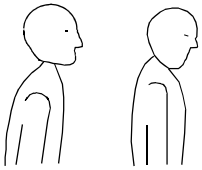
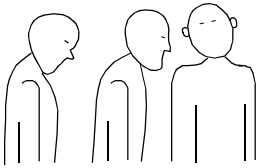
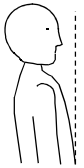
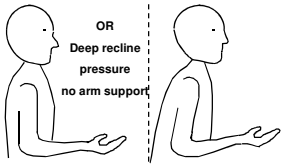
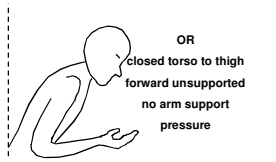
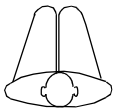
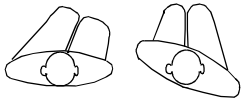
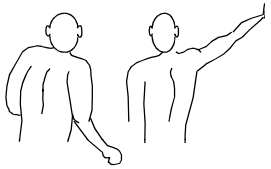
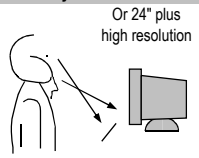
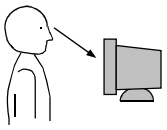
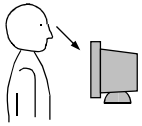
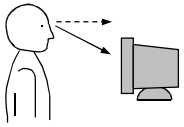
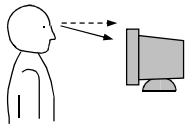
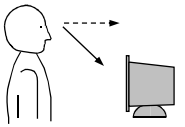
TYPE OF HANDLING	ILLUSTRATION	LOW	MODERATE	HIGH
POWER GRIP		< 14#	14# - 21#	21# - 48#
2 POINT PINCH		< 3#	3# - 4.5#	4.5# - 9#
3 POINT PINCH		< 4#	4# - 6#	6# - 14#
LATERAL PINCH		< 4#	4# - 6#	6# - 14#
THUMB PUSH		< 7#	7# - 10.5#	10.5# - 19#
PALM PRESS		< 10#	10# - 15#	15# - 35#
FOOT CONTROL		< 10#	10# - 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
			
	symetrical	twisted	bend/reach/lift
View Distance			
	15" - 24" to screen 14" - 16" to document	<16"	8" - 12"
View Angle			
	15 - 30 degrees	<15 or <30 degrees	>10 or <35 degrees