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.

- 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:

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

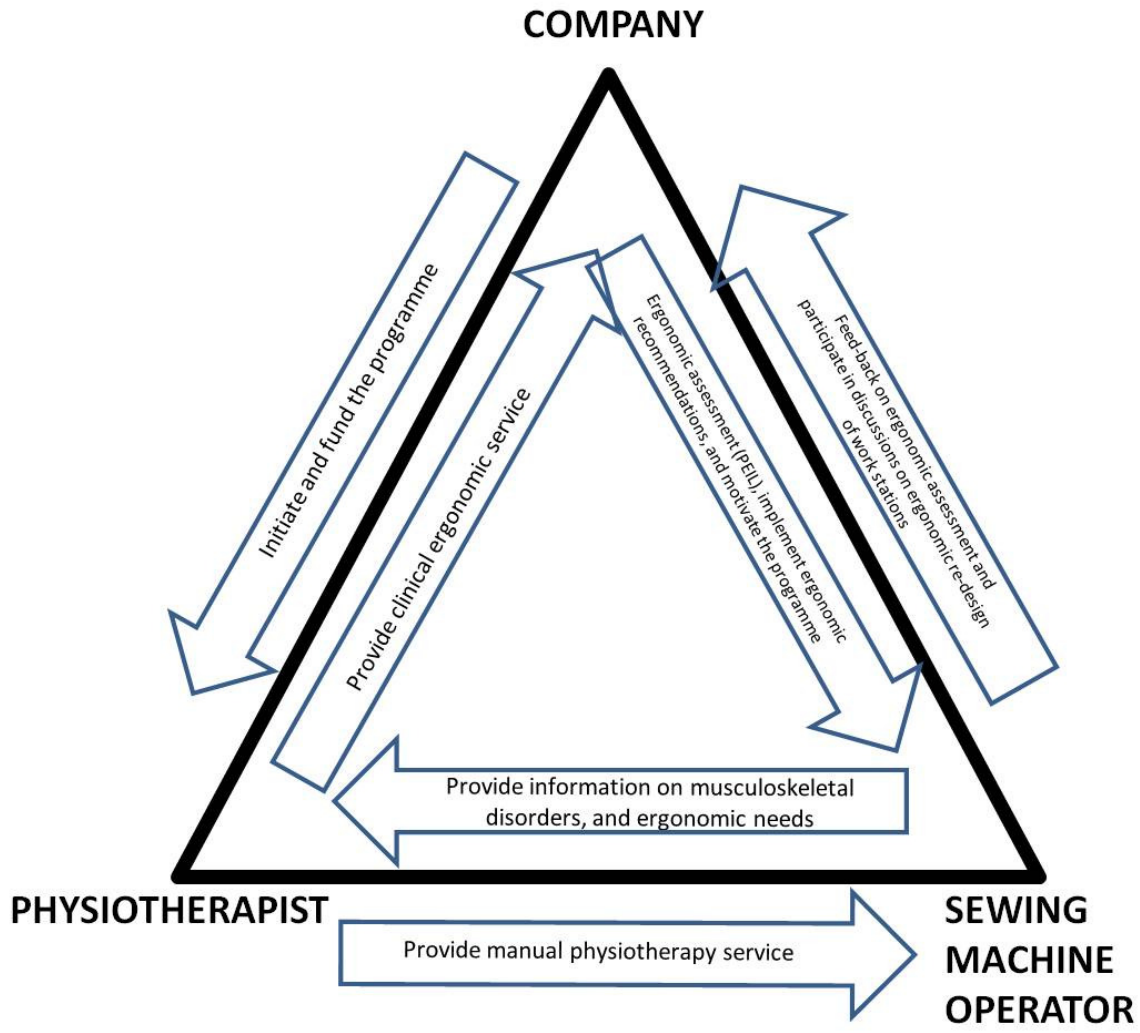

Figure 3.1 A graphic description of the programme (Source: Developed by the researcher)

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:

- 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.

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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:

- Optimised storage-heights for both seated and stand-up work stations to minimise regular, excessive reaching;
- Optimised work station layout regarding the floor plan and work flow for both seated and stand-up work stations to minimise regular, excessive reaching;
- 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;
- 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

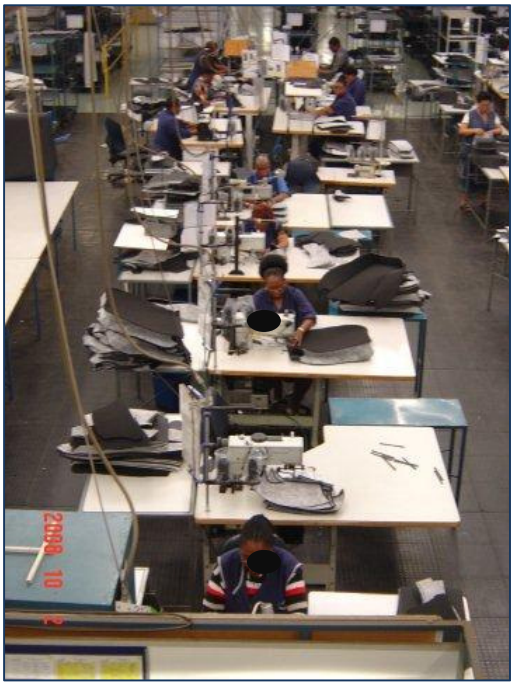
Picture 3.3 demonstrates the unilateral reaching above shoulder-height in the seated work posture compared to the relatively easily accessible storage height in the stand-up work station shown in Picture 3.4.

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

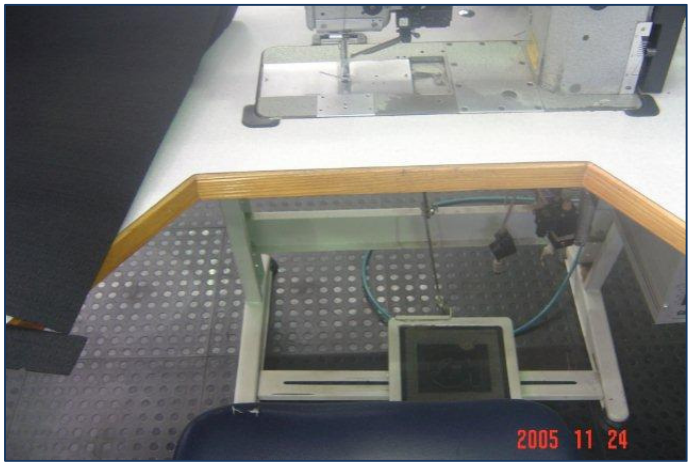
Picture 3.6 The floor layout of stand-up work stations

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

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:

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

Continuous training to sewing-machine operators addressed:

- 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);
- 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);
- Basic functional anatomy regarding hand work posture (Picture 3.17);
- Increase fitness;
- Decrease overweight;
- Stop the excessive use of stimulants for pain relief;
- Awareness regarding domestic ergonomic exposure;
- Basic back care;
- Guidelines of purchasing supportive footwear, inserting silicone innersoles, and wearing compressive stockings when sewing in the stand-up posture started (Picture 3.18);
- Alteration in weight bearing when working in the stand-up work posture;
- 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.

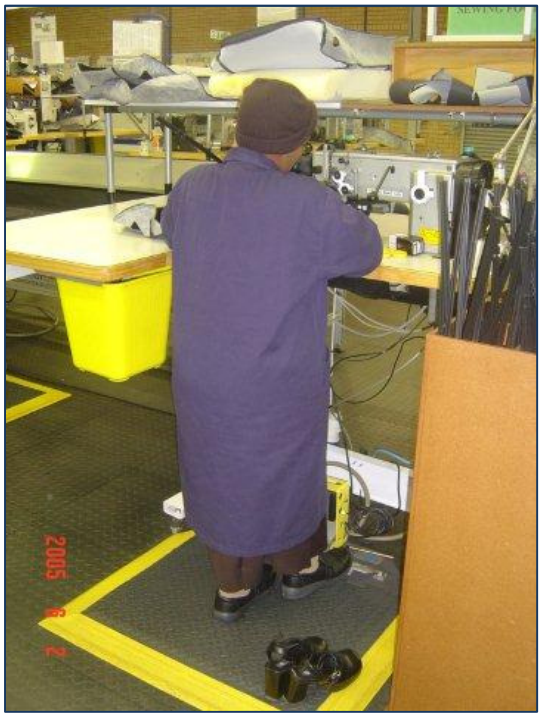
Training on the use of the chair

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.

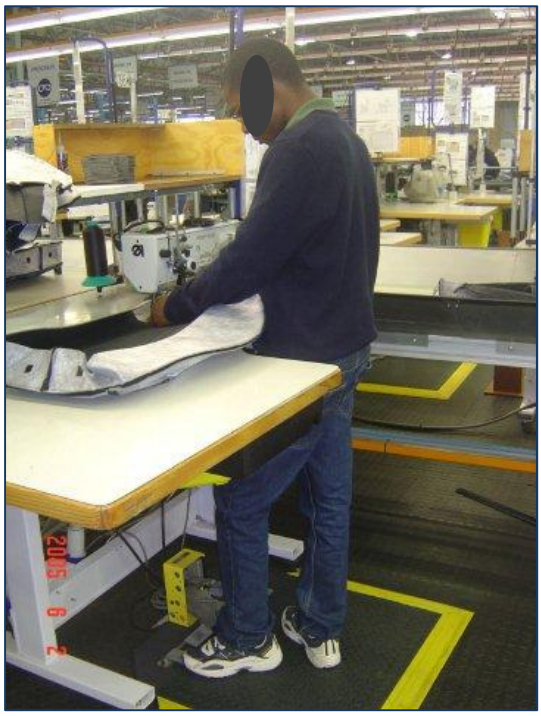
Picture 3.14 The back rest of the chair is supporting the sewing-machine operator's back

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

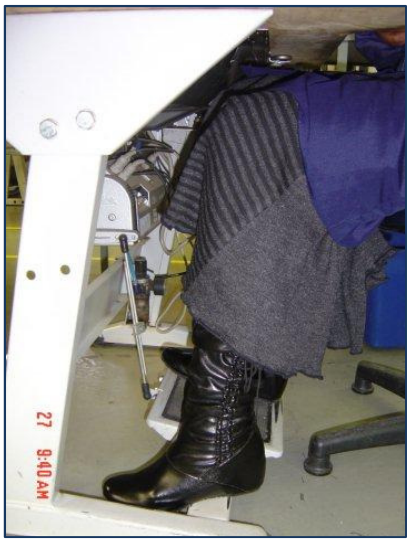
The aim of health education was to ensure that the environment for prevention and recovery of WRMSDs was optimised. Initially, the physiotherapist's training was designed to address the musculoskeletal needs of the seated sewing-machine operator. As the production lines were re-designed by the company 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

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

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

- Fitness level
- Length of employment
- 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

- Posture: Working in a seated or stand-up posture
- Force: Working with cloth/vinyl or cloth/leather
  Straight stitching or precision stitching
- 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.