# Effect of a work-based physiotherapy and ergonomics programme on work-related upper-extremity musculoskeletal disorders in car-seat seamstresses

K Mostert-Wentzel (M PhysT, MBA (UP))[1], SH Grobler (B PhysT (UP), Dip. Ergonomics)[1], R Moore (B PhysT (UP))[1], N Ferreira (B PhysT (UP))[1], M Lumley (B PhysT (UP))[1], K Burelli (B PhysT (UP))[1]

[1] Department of Physiotherapy, University of Pretoria

Corresponding author: K Mostert-Wentzel, Department of Physiotherapy, University of Pretoria, PO Box 223, Newlands 0049. E-mail: karien.mostert@up.ac.za Tel: +27 (0)12 354 2023

## Abstract

***Introduction:*** **Although evidence for the effectiveness of single physiotherapy modalities in treating work-related upper-extremity musculoskeletal disorders (WRUEMDs) exists, only limited effectiveness has been shown for integrated physiotherapy intervention programmes.**

***Methods:*** **A retrospective study 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 over a three-year period was conducted (N = 43). The intervention comprised ergonomic adaptations, health education and conventional physiotherapy.**

***Results:*** **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.**

***Conclusion and recommendation:*** **The findings provided weak evidence that this integrated programme was effective but further research with larger samples is recommended.**

***Key words:*** musculoskeletal disorders, upper extremity, carpal tunnel syndrome, work-related, work-based physiotherapy, ergonomics, seamstresses

## Introduction

Work-related upper-extremity musculoskeletal disorders (WRUEMDs), the most common occupational conditions in industrialised countries, are increasing in developing countries like South Africa.[1-3] WRUEMDs is a "collective term for a group of occupational diseases that comprise musculoskeletal disorders caused by exposure in the workplace . . . with characteristic symptoms and physical signs".[4] Consequences include fatigue, pain and decreased job satisfaction[5] as well as workers' compensation claims, and loss of productivity and profit.[6,7,8]

An integrated case-management approach, consisting of ergonomic adaptations and measures to prevent WRUEMDs is appropriate in a factory setting.[1] Physiotherapists, as part of a multidisciplinary team, assist with preventing (e.g. by suggesting changes in work demands and implementing sound ergonomics) and treating musculoskeletal injuries.[9,10] Other possible team members would include ergonomics experts, design engineers, operations managers, technical workers responsible for building and machine maintenance, factory-line supervisors and workers. Although evidence of single effective physiotherapy modalities in treating such WRUEMDs, such as electrotherapy[11,12] exists, only limited effectiveness of such integrated physiotherapy programmes has been demonstrated.[13] A Cochrane review concluded that "[t]here is limited evidence for the effectiveness of keyboards with alternative force-displacement of the keys or an alternative geometry, and limited evidence for the effectiveness of exercises compared to massage; breaks during computer work compared to no breaks; massage as an add-on to manual therapy; and manual therapy as an add-on to exercises."[13] A review of non-surgical treatment for carpal tunnel syndrome (CTS) found ultrasound, yoga, carpal tunnel mobilisations and insulin and steroid injections for diabetics effective.[14] Rehabilitation ergonomics, referring to ergonomics requiring knowledge of anatomy, physiology, biomechanics and anthropometry,[15] versus traditional physiotherapy includes Physical Demand Assessments and Functional Capacity Evaluation to determine and evaluate work modifications.[15]

Only three studies relating to integrated physiotherapy programmes were identified from a search of CINAHL, Medline (Ovid), Academic Premier, Health Source: Nursing/Academic Edition, TOC Premier, Academic Search Premier, Africa-Wide Information, E-Journals, Humanities International and the Cochrane Library.

In Pillastrini et al.'s[16] five-month follow-up randomised controlled trial with video-display terminal (VDT) workers the intervention group (n = 100) received personalised preventive ergonomics and the control group (n = 200) an information brochure on ergonomics. Overall posture measured by the Rapid Entire Body Assessment improved significantly in the group whose workstations were assessed and modified. In the intervention group, discomfort depicted in pain drawings decreased significantly in the spine, but not in the upper limb. The authors concluded that for the upper limb, clinical physiotherapy in addition to ergonomics is advisable.

Fabrizio[17] described an intervention where ergonomics followed traditional physiotherapy in a case study with a single female computer worker. He did a work-risk analysis using the QuickDASH, the Rapid Upper Limb Assessment (RULA), a visual analogue scale and the Work Shortform Survey that included the OSHA Workstation VDT list to assess the client at baseline and post intervention. The intervention, a work risk analysis and workstation modification after a series of traditional physiotherapy interventions, was effective in decreasing pain levels, improving the RULA and Workstyle scores.

Sadi et al.[18] reported on a longitudinal cohort of an on-site occupational physiotherapy clinic. They found such a clinic in the Canadian automotive industry feasible.

Although three work-related studies were published in the South African Journal of Physiotherapy since 2002, an intervention study of a Back School, a retrospective injury profile[19] and an observational study in a beverage factory of compliance with safety measures,[20] none were on this topic.

Therefore, a retrospective study 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 was conducted.

## Methodology

### Design and setting

A retrospective longitudinal design using a record review to investigate a work-based physiotherapy and ergonomics occupational programme that was introduced in a car-seat manufacturing factory by the second author in June 2004. The factory had three production divisions, respectively responsible for cutting the car-seat parts, sewing the seats, and assembling seats.

### Population and sampling strategy

The population was people working as seamstresses in the factory from June 2004 to September 2007. The number varied for each period (see Table 1).

Exclusion criteria were workers with:

- a reported history (recorded in the physiotherapy files) of associated non-work-related accidents and surgery to the upper limb;
- other disorders directly affecting the upper limb;
- co-morbidities that could influence the incidence of WRUEMDs like diabetes, pregnancy, arthritis[21];
- back and neck pain and fibromyalgia (usually affecting amongst others the posterior and upper thorax) if these symptoms occurred before the onset of the WRUEMDs, because the spine, shoulder girdle and upper limbs form such an integrated biomechanical system; and
- more than five days sick leave for medical or mental conditions.

Workers' physiotherapy files were checked to exclude workers with the first four criteria, whilst the Human Resources (HR) Department records were scrutinised to exclude workers with the fifth criterion. WRUEMDs in workers without the exclusion criteria and who consulted the physiotherapist for the study period formed the sample. This resulted in a sample of 38 workers who experienced 43 WRUEMDs for which they consulted the physiotherapist between June 2004 and September 2007. Some workers experienced more than one injury. For the period October 2004 to September 2007 (the period during which the programme was implemented) there were 27 workers with 32 WRUEMDs (see Table 1).

### Intervention – the work-based physiotherapy and ergonomics programme

The physiotherapist treated workers with WRUEMDs in her on-site rooms using physiotherapy modalities like ultrasound, laser, strengthening exercises, mobilisation and customised health education, based on the client's individual assessment. She continuously gave educational talks and preventive group classes about ergonomic principles and protecting one's body to all the seamstresses.

The physiotherapist, who has a Certificate in Ergonomics, completed the ergonomic analysis of the workstations and the first factory floor analysis sheet by December 2004. Based on these, she recommended ergonomic improvements, most of which were implemented in collaboration with management and line supervisors. Some workstations were supplied with adjustable-height working surfaces. Most seamstresses' working position was altered from sitting to standing. To prevent fatigue and associated risk of injuries, job rotation was introduced. Workers rotated between workstations with different levels of physical demand, and/or between those which loaded different parts of the body.

### *Measures*

Figure 1 shows the framework for selecting the variables.

### *Biographic measures*

Two biographic variables were noted i.e. gender and age. Being a female and of older age is a risk factor for upper-extremity injury.[18]

### *Outcome measures – programme effect*

Despite the availability of production output in terms of the number of completed car-seats, this could not be used as a proxy for the seamstresses' output as other production-line factors could influence output.

The sum of the number of hours absent from the factory floor due to sick leave and attendance of physiotherapy were considered absenteeism. The cost of absenteeism was calculated by multiplying the hourly salary of the participant by the number of absent hours. The total cost of WRUEMDs to the factory was calculated by adding the cost of absenteeism to the cost of the physiotherapy treatment and ergonomic consultation.

The incidence of WRUEMDs, defined as the number of new WRUEMDs in workers who consulted the physiotherapist in a certain period, was used to measure the effect of the programme. The prevalence rate (the number WRUEMDs in workers who consulted the physiotherapist over a specific period compared to the total number of workers in the division during that same period) was also calculated.

### *Data collection and capturing process*

The sources and the data they contained were:

1. factory floor analysis sheets – working position, intensity of the work, name of the worker at each workstation and stations where workers were involved in job rotation;
2. physiotherapy files – biographic data (gender and date of birth), diagnoses of injuries seen by the physiotherapist, clients' work position (sitting or standing), job rotation, and dates, number and cost of physiotherapy sessions.
3. HR manager data – dates when workers were absent due to injury or illness, reason for their absence and their hourly salary rate, factory temperature and number of days of legal worker strikes.

The four junior authors screened the files to select the sample, and checked each other. Data were captured into a Microsoft Excel spreadsheet. The first author did spot checks during data collection. The second author (owner of the practice) was not involved in data collection. The first author controlled the integrity of the data by comparing the spreadsheets with source documents.

### *Data analysis*

The period from June to September 2004, during which time the programme was being introduced, was designated Period 0. This period was not used for determining effectiveness as the programme was incomplete. Periods 1, 2 and 3 each started from October till the following September, respectively ending in 2005, 2006 and 2007. The second author was not involved in the analysis of the data, but was consulted for clarification of detail about practical elements, when necessary.

Workstations were categorised into levels of demand according to the strain of the job: A (easy; straight stitching along one line only), B (moderately difficult; curved stitching involving complex upper-extremity movements) and C (difficult; manoeuvring tough material or precise stitching causing strain on the upper-extremity joints).

Analyses were carried out in the STATA 10.0 program (2008). Descriptive statistics were conducted. The Analysis of Variance (ANOVA) was applied to compare the WRUEMDs over the four time periods taking their age, gender, working position and workstation level of demand categories into account. Bartlett's test for equal variances indicated that the groups were similar ($p > 0.05$). The association between variables was tested with the Pearson chi-square and the Kruskall Wallis tests. These non-parametric statistical techniques were selected because of the small sample size, and for not meeting pre-conditions like normal distribution of the data. The associations between the type of injury (CTS or not) and age and number of physiotherapy treatments were investigated.

A Poisson regression was applied to determine whether the incidence of WRUEMDs had decreased over the time periods P1, P2 and P3, comparing each one with every other one (level of significance of $p = 0.01$). Testing was done in both directions. In each case the incidence risk ratio, standard error, $z$-statistic, $p$-value and 95% confidence interval were calculated.

The two-sample test of proportion was applied to the mean prevalence of each of the diagnostic groups, again comparing each period with every other one (P1, P2 and P3). The mean, standard error, $z$-statistic, $p$ value and 95% confidence interval were calculated for each comparison.

### *Ethical aspects*

The Ethics Committee, Faculty of Health Sciences, approved the study (S32/2008). The South African and European company boards of the factory gave written permission. Participants gave written consent for access to specified personal information having been informed by trained shop stewards about the nature of the study, their rights, possible risks and benefits, and confidential measures.

## RESULTS

The sample of 38 participants had 43 WRUEMDs.The mean ages of the sample (in years) were 44 (± 11) in Period 0; 46

(± 8) in Period 1; 43 (±10) in Period 2, and 43 (±11.55) in Period 3. The mean age of the CTS group was 44 (± 10). The injured cohort had one male and the rest were females.

Table 1 indicates that the incidence of CTS decreased over the period. The incidence of other diagnoses increased over the first three periods and decreased in the last period. The cohort showed a dependence of disease over period, decreasing significantly (Pearson chi-square = 17.67, $p > 0.001$). Tables 2 and 3 give the results from the two-sample test of proportion applied to the mean prevalence rate of those with CTS and others conditions respectively. Although the prevalence rate over P1, 2 and 3 decreased (Table 1), the difference was not significant (Tables 2 and 3).

Apart from CTS, WRUEMDs experienced were muscle spasm (thumb, triceps muscle) (n = 6), tennis and golfer's elbow (n = 6), finger injuries (e.g. tendonitis of the indicis muscle) (n = 5), tendonitis of the biceps muscle (n = 3), de Quervain tendonitis (n = 3), tenosynovitis (shoulder) (n = 2) and tendonitis of forearm muscle tendons (n = 2).

Table 4 provides summary statistics for the incidence, prevalence rate and total cost for the duration of the study (P1 to P3). Workers took a mean of 0.19 days of sick leave per diagnosis. In Period 1 one worker with CTS was absent from work due to the condition. Thereafter no-one was absent because of CTS. The mean cost of absence from work per diagnosis was R109.19. The mean cost of ergonomic consulting was R38 000 per annum.

Job rotation was implemented in Period 2 and maintained in Period 3 (see Table 5). One workstation had a standing machine from Period 0. The date of change from sitting to standing differed from worker to worker depending on when the standing machine was obtained. The position of work and job rotation could therefore not be analysed to explain changes in incidence of WRUEMDs over time.

Those with CTS tended to be older. In Period 2 the carpel tunnel group was significantly different from the non-CTS group when controlling for age ($F = 12.21$; $p < 0.01$).

The physiotherapy files were screened to identify and exclude workers with risk factors for CTS. However, data on the sick notes gathered later indicated that 19 of the 32 workers with WRUEMDs during Periods 1 to 3 experienced one or more factor before or after the physiotherapy visit. The risk factors were pregnancy, gynaecological conditions, hypothyroidism, diabetes, arthritis, anxiety and similar musculoskeletal disorders.

No other comparisons and relationships reached levels of statistical significance. This finding was supported by the confidence intervals.

The factory temperature was maintained at 25°C, by using fans in summer and heaters in winter. Working time lost due to strike action was negligible, i.e. 12 of 260 annual workdays (0.05%).

## Discussion

We investigated the effect of a work-based programme that combined individualised physiotherapy with ergonomic interventions and group training. The incidence of WRUEMDs decreased significantly over the duration as did the incidence of CTS. However, the incidence of other WRUEMDs initially increased before decreasing. This finding suggests that the programme may have been relatively effective.

The initial increase in non-CTS injuries may be because the physiotherapy service was offered for the first time. Previously, these types of injuries were possibly present but without the participants seeking treatment they remained unknown to the factory medical system. This might have changed once physiotherapy treatment became available during working hours. The incidence during the Period 2 is therefore probably a more accurate picture of the real baseline incidence than that for Period 1. The subsequent decrease in incidence may have been due to the ergonomic interventions[10] combined with therapy.

Although there was no significant decrease in the prevalence rate, this is not surprising as such injuries can have a duration longer than one year and so changes in prevalence as a result of the programme may take longer than three years to manifest.

The prevalence rate of MSD of the arm, and the subgroup with carpal tunnel syndrome is similar to those found in other studies.[7,24] As expected the CTS group tended to be older. Increasing age is a well-established risk factor. Not only is the incidence of WRUEMDs higher, but pain perceptions also become more intense with increased age.[22,23] Special care should be given to workers from their fifth decade.[7] Since all but one were female, gender as an increased risk[18] could not be investigated.

Most of the workers with CTS also presented with other risk factors for the conditions such as diabetes and gynaecological disorders. The existence of these co-morbidities may have increased the incidence.[21] Sick leave for CTS occurred only once, and that was in the first six months of the study. The number of treatment sessions when patients are already sick-listed with an MSD arm disorder, without the ergonomic intervention, were higher in another study.[25] As electrodiagnostic testing, the gold standard in addition to physical examination,[10] was not used to confirm the condition, it may have been over-diagnosed. Also, the cases may not have been only work-related, as postulated by Derebery.[21] There is a possibility that the tendency for CTS was latent and was triggered by work conditions. Only a short intervention to address inflammation was needed.

As no other studies examining costs of an integrated work-based programme in South Africa were located, the data relating to costs provide a baseline for comparisons with future studies.[7]

This investigation of the effectiveness of a factory-based physiotherapy and ergonomics programme appears to be the first in South Africa known to the authors. One of the study's strengths is that it combined clinical and ergonomic intervention at the work-place.

A limitation of the study is its non-experimental design and small sample size. The potential for a conflict of interest by the involvement of the practice owner may have introduced bias, but she did not collect or analyse the data, so that this could be curtailed. Furthermore, the organisational and psychosocial environments,[26,27] both influencing factors for occupational injuries, were not taken into account. The influence of other risk factors such as increased body mass index, longer and previous exposure to a physically demanding job, a history of ill health and behavioural elements were not investigated due to the absence of available information.[14]

The study cannot be reproduced in the sense that the interventions were not described in detail or in a standard way. However, the customised nature of the intervention may rather have been a strong point. One would expect a different person with the same education and training to be able to assess and intervene similarly.

## Conclusion and recommendations

The study provided weak evidence that an integrated physiotherapy programme of education on sound body mechanics, the introduction of work rotation and ergonomically improved workstations, and physiotherapy treatments reduced the incidence of WRUEMDS overall and CTS in seamstresses in this car-seat manufacturing factory. However, this tentative support must be tested prospectively with larger samples over a longer period of time in studies with a control group. The effect could also be investigated in more diverse production lines. The effect of the availability of on-site physiotherapy on quality of work life and other subjective experiences could also be investigated quantitatively and qualitatively.

## Lessons learned

- An integrated physiotherapy clinical service, health education and ergonomic interventions appear to reduce the incidence of WRUEMDs.
- Ergonomic interventions to prevent WRUEMDs in such settings should include workstation analysis and adaptation, and job rotation.
- Electro-diagnostic testing, the gold standard in addition to physical examination, should be done in addition to physical tests to confirm CTS.
- Older workers tend to be more at risk of WRUEMDs.
- A physiotherapy service within walking distance from the factory floor increases access to workers and facilitates prevention and treatment of WRUEMDs.

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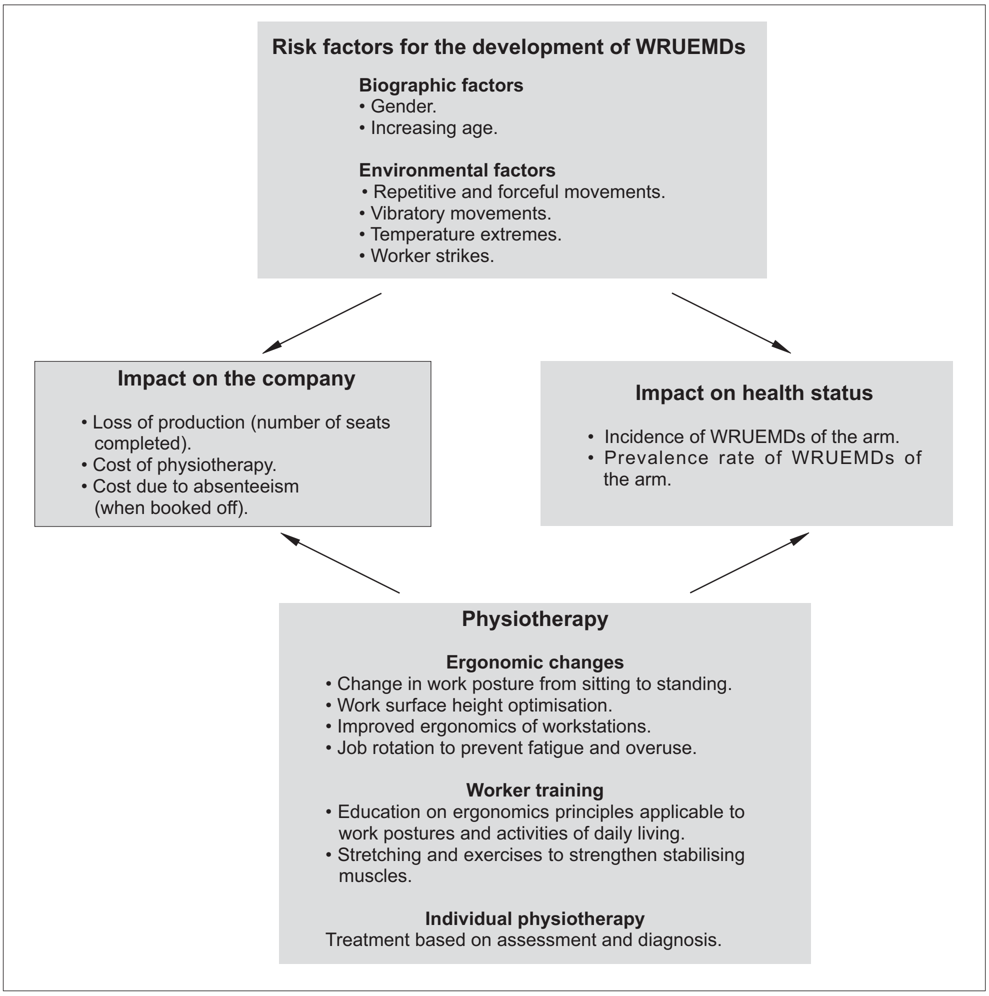


**Figure 1. Framework of the variables considered in the study**

**Table 1. Incidence and prevalence rate of WRUEMDs over time and population**

| | Period 0 | Period 1 | Period 2 | Period 3 | Total |
|---|---|---|---|---|---|
| Incidence of WRUEMDs | | | | | |
| CTS | 11 | 5 | 3 | 2 | 21 |
| Others | 0 | 5 | 12 | 5 | 22 |
| Total | 11 | 10 | 15 | 7 | 43 |
| Frequency of workers with injuries* (difference from incidence)** | 11 (0) | 7 (3) | 14 (1) | 6 (1) | 38 (5) |
| Prevalence rate (95% Confidence Interval) | Cannot calculate without population size | 0.06 (0.01 - 0.10) | 0.03 (-0.00 – 0.06) | (0.02) (-0.01 – 0.04) | N/A |
| Population** | Unknown | 89 | 108 | 103 | N/A |

* A worker could present with >1 WRUEMD per period

** Total number of seamstresses in the car-seat line.

**Table 2. Results from the two-sample test of proportion applied to the mean prevalence rate of those with CTS**

| Periods compared | Mean | Standard error | *z* = value | *p* = value | 95% Confidence Interval |
|---|---|---|---|---|---|
| P1 and P2 | 0.03 | 0.03 | 1.01 | 0.32 | -0.29 - 0.09 |
| P1 and P3 | 0.04 | 0.03 | 0.36 | 0.18 | -0.02 - 0.09 |
| P2 and P3 | 0.01 | 0.02 | 0.40 | 0.70 | -0.03 - 0.05 |

**Table 3. Results from the two-sample test of proportion applied to the mean prevalence of those with conditions other than CTS**

| Periods compared | Mean | Standard error | *z* = value | *p* = value | 95% Confidence Interval |
|---|---|---|---|---|---|
| P1 and P2 | -0.05 | 0.04 | 1.37 | 0.17 | -0.13 - 0.02 |
| P1 and P3 | 0.01 | 0.03 | 0.24 | 0.81 | -0.06 - 0.07 |
| P2 and P3 | 0.06 | 0.04 | 1.67 | 0.10 | 0.01 - 0.13 |

**Table 4. Summary statistics for incidence, prevalence rate and total cost for the duration of the study (P1 to P3)**

| Variable | Mean | ± SD | Minimum | Maximum | Range |
|---|---|---|---|---|---|
| Incidence | 10.67 | ± 4.04 | 7 | 15 | 8 |
| Prevalence rate | 0.11 | ± 0.36 | 0.07 | 0.14 | 0.07 |
| Number of treatments per condition | 3.74 | ± 2.39 | 1 | 12 | 11 |
| Total cost | R8 229 | ± R4 215 | R5 017 | R13 003 | R7 986 |
| Opportunity cost † | R1 165 | ± R407 | R695 | R1427 | R731 |
| Clinical physiotherapy cost | R7 065 | ± R3 981 | R4 321 | R11 631 | 7 309 |

† Cost due to sick leave and time attending physiotherapy

**Table 5. Work position, workstation demand and job rotation by time period**

| | Period 0 June to September 2004 | Period 1 October 2004 to September 2005 (n = 10) | Period 2 October 2005 to September 2006 (n = 15) | Period 3 October 2006 to September 2007 (n = 7) |
|---|---|---|---|---|
| **Category of workstation demand (level of physical strain)** | | | | |
| A Low | –* | 0 | Job rotation implemented | Job rotation maintained |
| B Medium | –* | 3 | | |
| C High | –* | 7 | | |
| **Working in a standing position** | | | | |
| Proportion | –* | None | 25% | 60% |

* Initial assessments and recommendations being made during this period

**This chair provided proper back support**

**A common problem: Tall tibias caused the knee caps to bump into the belly of the sewing machine underneath the table. To prevent this discomfort, the operator will sit farther from the machine – as the pedals are fixed – causing her to reach forward. This posture change leads to back and upper-extremity muscle discomfort**

**The solution for the leg space problem underneath the table was to ask the maintenance team to increase the table height. This would enable the operator to sit closer to the table, but might also lead to upper shoulder muscle spasm**

**Visual means was used to teach the basic postural principles to prevent over-use injuries**

This chair did not provide proper back support

The pedals were all fixed onto the tables. The position of this pedal caused the operator to sit far from the machine and lean forward to sew. This would lead to increased strain on the upper extremities and back muscles

**This is "sit-down-sewing": The tables were not height-adjustable, and a lot of reaching was involved to pass the covers on to each other**

**This is "stand-up-sewing": The tables were height-adjustable, and the conveyor-belt decreased the need for reaching. Note the racks for parts above the machines. The musculoskeletal strain on the upper body here was much less than on the "sit-down-sewing line"**

**This table was not height-adjustable. The preferred height for precision work is elbow height.**