



# Work-related musculoskeletal disorders: Prevention report



European Agency for Safety and Health at Work  
*A EUROPEAN CAMPAIGN ON MUSCULOSKELETAL DISORDERS*



**Work-related musculoskeletal disorders:  
Prevention report**

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## FOREWORD



Musculoskeletal disorders (MSDs) are the most common work-related health problem in Europe, affecting millions of workers. Across the EU27, 25% of workers complain of backache and 23% report muscular pains. MSDs are the biggest cause of absence from work in practically all Member States. In some states, 40% of the costs of workers' compensation are caused by MSDs and up to 1.6% of the gross domestic product (GDP) of the country itself. They reduce company profitability and add to the government's social costs.

The challenge of work-related health problems, including musculoskeletal disorders, has been recognised and addressed at the European level by the adoption of a number of EU directives, strategies and policies, and by the establishment of dedicated EU bodies such as the European Agency for Safety and Health at Work to support occupational safety and health (OSH) activities across Europe. Creating more and better quality jobs is an important EU objective and was reinforced at the Lisbon Council in 2000. Successful prevention of MSDs - the most commonly reported and costly work-related health problem in Europe - would greatly contribute to achieving this objective. Community OSH strategies, European social partners, Member States and experts have also identified the prevention of MSDs as a priority area to improve workers' health and well-being. In general, there is a good momentum in Europe to tackle the problem.

Many problems can be prevented or greatly reduced through employers complying with existing safety and health law, and following good practice. However, there are specific actions that have to be taken if MSDs are to be tackled effectively. The Administrative Board of the European Agency for Safety and Health at Work therefore decided to dedicate the 2007 European Campaign ('Lighten the Load') for Safety and Health at Work to work-related musculoskeletal disorders.



'Lighten the Load' follows on from the first campaign run by the Agency in 2000, which focused on the same topic. Musculoskeletal disorders are complex work-related health conditions due to their multifactorial aetiology, various risk factors and their combinations, and the existence of numerous intervention methods. Therefore, it is difficult to communicate information about them to target audiences in a comprehensive way. In order to succeed, there is a need for continued, long-term efforts.

The European MSDs Campaign in 2007 seeks to promote an integrated management approach to tackling MSDs, embracing both elements - the prevention of MSDs and the retention, rehabilitation and reintegration of workers who already suffer from MSDs.

This report supports the Campaign by providing information on the first element of the above approach and is aimed at all those who have influence on the prevention of work-related MSDs. It evaluates the effectiveness of interventions in the workplace and provides practical examples illustrating successful prevention of MSDs.

I would like to take this opportunity to thank all our European partners as well as Agency and Topic Centre Working Environment staff who have contributed to the compilation of this report.

Jukka Takala  
Director

European Agency for Safety and Health at Work  
February 2008



## EXECUTIVE SUMMARY

Work-related musculoskeletal disorders (MSDs) are impairments of body structures such as muscles, joints, tendons, ligaments, nerves, bones or a localised blood circulation system caused or aggravated primarily by the performance of work and by the effects of the immediate environment where the work is carried out. Most work-related MSDs are cumulative disorders, resulting from repeated exposures to high- or low-intensity loads over a long period of time. The symptoms may vary from discomfort and pain to decreased body function and invalidity. Although it is not clear to what extent MSDs are caused by work, their impact on working life is huge. MSDs can interfere with activities at work and can lead to reduced productivity, sickness absence and chronic occupational disability.

The aim of this report is to evaluate the effectiveness of interventions at the workplace and to provide practical examples with respect to successful prevention of MSDs. It focuses mainly on the developments that have taken place since the previous European MSDs Campaign in 2000.



### Workplace Interventions

A systematic review of the scientific evidence on the effectiveness of preventive measures found that the number of good quality studies had increased during this period compared with the number found in reviews conducted in previous decades.

The main findings of the literature review were as follows.

- There is strong evidence that technical ergonomic measures can reduce the workload on the back and upper limbs without the loss of productivity and moderate evidence that these measures can also reduce the occurrence of MSDs.
- There is moderate evidence that a combination of several kinds of interventions (multidisciplinary approach) including organisational, technical and personal/individual measures is better than single measures. However, it is not known how such interventions should be combined for optimal results.





- There is some evidence that a participative approach which includes the workers in the process of change has a positive effect on the success of an intervention.
- Physical training can also reduce the recurrence of back pain and neck-shoulder pain. In order to be effective, however, the training should include vigorous exercise and be repeated at least three times a week.
- There is limited scientific evidence that a reduction in daily working hours can reduce MSDs and that extra pauses for recovery can often be added in an industrial setting without loss of productivity.
- There is strong evidence that training on working methods in manual handling is not effective if it is used as the only measure to prevent low back pain.
- There is no conclusive evidence to support back belt use to prevent work-related low back pain.
- No scientific studies have been found that conflict with the approach adopted by the EU Directives on manual material handling or on working with computers.

### Case studies

Fifteen case studies are presented from a range of occupations and sectors across Europe in order to share the good practice examples with respect to prevention of MSDs. Among others, the case studies cover the health care, pharmaceutical and construction sectors, and the sewing, waste and food industries.

The report shows that interventions to tackle the risks of work-related musculoskeletal disorders such as technical, organisational and behavioural measures can yield many benefits.



Not only can the working conditions and the satisfaction and motivation of workers improve and the rate of sick leave due to musculoskeletal disorders decline, there may also be a positive influence on overall safety, process capacity, production output, product quality, etc. In this regard, most of the case studies emphasise that

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the cost/benefit ratio of an ergonomic intervention is a crucial factor for its approval and success.

The case studies demonstrated that the principles that are important for successful implementation of workplace interventions include:

- participatory approach - the involvement of the workers and their representatives throughout the process;
- multidisciplinary approach - collaboration of people with expertise in different areas (e.g. ergonomics, engineering, psychology, etc.) when assessing and monitoring workplace risks, and searching for solutions;
- sponsorship from the management so that appropriate resources are made available to improve the working environment;
- if solutions proposed by good practice examples are used in another workplace they should be tailored to its specific conditions.





# 1.

## INTRODUCTION



Pain, discomfort and loss of function in back, neck and extremities are common among working people. These ailments are commonly termed musculoskeletal disorders (MSDs). For the purpose of this report, work-related MSDs are defined as impairments of bodily structures such as muscles, joints, tendons, ligaments, nerves, bones or a localised blood circulation system that are caused or aggravated primarily by the performance of work and by the effects of the immediate environment where the work is carried out.

Most work-related MSDs are cumulative disorders, resulting from repeated exposure to high- or low-intensity loads over a long period of time. However, MSDs can also be acute traumas, such as fractures, that occur during an accident. The symptoms may vary from discomfort and pain to reduced body function and invalidity.

MSDs cause harm and suffering to the worker as well as financial loss owing to invalidity, treatment costs and lost income. They also have an enormous negative impact on society as a whole. At the workplace level, the disorders result in costs due to reduced human capacity and disturbances to production. The costs to society are increased due to the need for treatment and rehabilitation, in addition to the compensation costs paid through social insurance.



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According to a European survey carried out in 31 countries in 2005, up to 25% of the workers in the EU27 reported back pain and 23% muscular pain (European Foundation for the Improvement of Living and Working Conditions, 2007). About 235 million people were employed in these 31 countries at the time of the survey, meaning that at least 60 million workers reportedly suffer from MSDs in Europe.

MSDs have commonly been associated with physically demanding working conditions. According to the survey, 62% of the workers reported that they were exposed to repetitive hand or arm movements and 46% reported working in painful or tiring positions for at least a quarter of their working time. There were large differences between the countries and sectors of working life. Of the blue collar workers, 18% had to move heavy

loads all or almost all of the time, whereas fewer than 5% of white collar workers did so. Exposure to all types of risks of MSDs (manual material handling, repetitive movements and constrained postures as well as vibration and working in low temperature) is highest in the construction sector and lowest in financial services. In all sectors and especially office work, however, the use of computers for long periods has increased leading to new kinds of risks for MSDs. According to the survey, 50% of women and 45% of men work on computers every day. Work with computers is physically light and the risk of upper limb disorders is low in comparison with the traditional occupations that involve repetitive work. However, the enormous numbers of computer workers makes the absolute number of workers with disorders large and a priority for European society.



The challenge of work-related health problems, including musculoskeletal disorders, has been recognised and addressed at the European level by the adoption of a number of EU directives, strategies and policies, and by the establishment of dedicated EU bodies such as the European Agency for Safety and Health at Work and the European Foundation for the Improvement of Living and Working Conditions to support occupational safety and health (OSH) activities across Europe.

Creating more and better quality jobs is an important EU objective, and was reinforced at the Lisbon Council in 2000.<sup>1</sup> Successful prevention of MSDs - the most commonly reported and costly work-related health problem in Europe - would contribute greatly to achieving this objective. The Community OSH strategy 2002-2006 identified MSDs as a priority area to improve the prevention of occupational illnesses (European Commission, 2002). The new OSH strategy for 2007-2012, which sets out the directions for future actions in Europe, reinforces the message and states that MSDs are a priority for improved risk prevention and research (European Commission, 2007). A similar position has been adopted by European social partners in order to stress the importance of preventing MSDs (ETUC, 2006; UNICE, 2006). In general, there is a good momentum in Europe to tackle the problem.

MSDs have been the focus of activities by the European Agency for Safety and Health at Work. The Agency's website contains a great deal of practical information on preventing MSDs and controlling risks in the workplace.<sup>2</sup> The theme for A European Campaign on Musculoskeletal Disorders in 2000 was 'Turn your back on musculoskeletal disorders'. In 2007 the theme is the prevention of MSDs and their consequences.

Between 2000 and 2007 much has happened in Europe and in working life. Much research has also been conducted since 2000. The aim of this report is to describe what we know about the prevention of MSDs today and the developments during the past years.



1 EU Presidency conclusions, Lisbon European Council, March 2000. Available at [http://www.consilium.europa.eu/ueDocs/cms\\_Data/docs/pressData/en/ec/00100-r1.en0.htm](http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/00100-r1.en0.htm)

2 <http://osha.europa.eu/topics/msds>



The focus of this report is on prevention: 'What can be done at the workplace level to manage the risks of MSDs?' Another Agency report (*Work-related MSDs: Back-to-work*) is oriented more to rehabilitation and the measures that can help people to return from sick leave. There is no strict cut-off line between the prevention and rehabilitation of MSDs, and therefore these two reports supplement each other. These reports will be complemented by two reports produced by the European Risk Observatory - *Thematic report on MSDs* and *Report on occupational exposure to vibration*. The former will include data and statistics.

This report has two parts. The first part is a state-of-the-art review of the research literature with respect to work-related interventions preventing MSD risks. It tries to answer the question: 'How much research-based evidence do we have to support practical solutions for prevention of MSDs?' The second part describes 15 case studies in which problems have been solved at the workplace level. Again we see that there are various ways of finding good solutions to manage the problems. There is a considerable variety of potential solutions depending on the problems in each sector of working life. Technical development is rapid and therefore the solutions presented have to be tailored for other workplaces. The report adds to the Agency's two previous reports concerning research on work-related neck and upper limb musculoskeletal disorders (WRULDs) (Buckle & Devereux, 1999) and lower back disorders (De Beeck et al., 2000).



# 2.

## **EVIDENCE ON THE EFFECTIVENESS OF WORK-RELATED INTERVENTIONS**





## 2.1. INTRODUCTION

### Risk factors

Hundreds of epidemiological studies have demonstrated clearly that a number of factors increase the probability of developing MSDs. A common way of classifying these **risk factors** has been to separate the individual factors from the external factors (**exposures**). Many of the external factors occur both at work and in leisure time activities. The biological processes leading from the risk factors to the MSDs are not well known, but it is obvious that the individual and external factors interact, i.e. the disorders are a result of several combinations of individual and external factors. Due to the wide individual variation it is difficult to make predictions on an individual level, though the relative magnitude of external risk can be assessed.



### Control of risks

Reducing the occurrence of risk factors should, in theory, lead to a reduction in MSDs even without knowing the exact process from the risk factors to the disorders. Based on epidemiological studies, it is possible to estimate how much each factor contributes to the origin of MSDs.

The **attributable fraction** of a risk factor describes the size of the proportional reduction in the occurrence of the disease when the risk factor is removed and with no change in the other risk factors. Table 1 gives the attributable fractions of the common risk factors for MSDs; the higher the attributable fraction, the greater is the potential for prevention by omitting the factor. The variation (range) of the attributable fraction is due to the differences in the populations and the factors investigated in individual studies.



Of the risk factors for low back pain, manual material handling includes several other factors included in Table 1 (frequent bending and twisting, heavy physical load, static postures and repetitive movements). In most epidemiological studies, disorders of the upper extremities have also been attributed to manual material handling and forceful repetitive movements.

Managing these risks would appear to have significant potential for prevention; omitting them might reduce the occurrence of the most common work-related disorders in the best case by up to two-thirds or three-quarters. In the worst case, the reduction should be 10-20%.

**Table 1. Work-related exposures and the estimated attributable fractions for disorders in the back and upper extremities**

Work-related risk factor	<i>n</i>	Range of attributable fraction (%) in different studies
<b>Back disorders</b>		
Manual material handling	17	11-66
Frequent bending and twisting	8	19-57
Heavy physical load	5	31-58
Static work posture	3	14-32
Repetitive movements	1	41
Whole-body vibration	11	18-80
High job demands	2	21-48
Low stimulus from work (monotony)	1	23
Low social support at work	3	28-48
Low job satisfaction	6	17-69
High perceived stress	1	17
<b>Upper extremity disorders</b>		
Manual material handling	17	11-66
Repetition	3	53-71
Force	1	78
Repetition and force	2	88-93
Repetition and cold	1	89
Vibration	15	44-95

*n* is the number of studies reviewed

Source: National Research Council and Institute of Medicine, 2001.

The relatively high attributable fractions in Table 1 imply that there is considerable potential to prevent the occurrence of MSDs through workplace interventions. Although the workplace cannot act directly on the individual factors (e.g. body build, gender, age), there remains the potential to act on some individual factors by promoting the healthy behaviour of workers.

In addition to back and upper limbs, the lower limbs can also be affected. The main risk factors of work-related lower limb disorders include squatting, kneeling, pushing on pedals and prolonged standing. However, scientific literature on work-related lower limb disorders is scarce.



## Scientific evidence

In theory, reducing the risk factors should lead to a reduction in MSDs. However, experience has shown that not all theoretically beneficial actions fulfil their expectations and the results can even be opposite to the expected results. Therefore, it is important to evaluate the actions (interventions) to see if the effects are the expected ones. There are several ways to do this. In daily life, the evaluation happens usually by direct experiences. However, formal evaluation asks for measurements showing that there is a difference in the outcomes measured before and after the intervention.

In real life, there are continuous changes in the environment. It is also well-known that a number of musculoskeletal symptoms may be alleviated without formal intervention. In experimental studies, there is always some bias, i.e. some systematic error in the measures or just random variation in the results. To be able to make general conclusions on the effects of interventions, it is important to make an evaluation in a valid test setting that will reduce the bias as much as possible. The best way to obtain generally valid evidence on the effects of interventions concerning health is to have a comparison group in addition to the intervention group. The most rigorous setting for the testing is a randomised controlled trial (RCT) - the 'gold standard' for the testing of health interventions.

Experience has shown that similar interventions can give different effects when repeated in the same population and that the difference can be even greater in another population. Today, the evaluation of interventions in medicine is based on systematic reviews that derive conclusions from the evidence on the basis of a number of original studies. The Cochrane Collaboration<sup>(3)</sup> has developed a standardised methodology to produce reviews in the most reliable way. The methodology includes:

- concise definition of the questions to be studied;
- procedures for systematic searching of studies in scientific databases;
- strict preset criteria for the assessment of data quality;
- inclusion and exclusion of the studies identified in the search.

Each included report is usually evaluated by several independent specialists to provide a more reliable interpretation.

In real life, evaluation of interventions with RCTs in a sophisticated scientific way is not always feasible. 'Evidence based' thinking in medicine admits this and therefore the evaluation of evidence can be based on a number of kinds of study settings. But when combining the results in the systematic review, the reports have to be evaluated for the scientific quality of the study with respect to the potential bias; i.e. how big is the possibility that the results are affected by factors other than the intervention studied. In the conclusions of the reviews, most weight is given to the most reliable studies with the lowest potential bias. If the scientific evidence is insufficient, the recommendations for good practice are based on the consensus of experts. History has shown that a number of good practice recommendations have been changed dramatically by the results of good quality studies; for example, a couple of decades ago the medical textbooks recommended bed rest as the treatment for low back pain - today there is strong evidence that bed rest will prolong the disorder.

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(3) <http://www.cochrane.org/index.htm>



## AIMS

# 2.2.

The aim of this report is to investigate the research on the prevention of work-related MSDs. In particular, it evaluates actions that can be performed in the workplace.

To help policy-makers and decision-makers at different levels (from the general policy-makers of the Member States to local workplace practitioners), the report aims to give the state-of-the-art answer to the following question: 'What is the scientific evidence on the effectiveness of different preventive actions at the workplace level on work-related MSDs?'

There are two main EU Directives that aim to reduce risks for work-related MSDs. Therefore this report gives special attention to the scientific evidence of the benefits while fulfilling the recommendations in these directives.

Directive 90/269/EEC <sup>(4)</sup> on manual handling gives advice to reduce accidents while handling heavy loads. The minimum safety requirements concern:

- material to be handled (e.g. weight, shape, ease with which to get a good grip);
- working environment (e.g. hazards for slipping, constrained postures due to limited space, temperature);
- individual worker (e.g. physical capacity and body build, adequate clothing, handling skills).

The basic recommendation is to avoid manual handling of heavy objects by employing technical solutions in the working process and, if it is not possible to avoid handling, there should be:

- adequate technical aids to reduce the loading of workers;
- training for workers on how to handle the loads.

Directive 90/270/EEC <sup>(5)</sup> on work with display screen equipment is related to a new epidemic of neck and upper limb disorders in working life. It sets out the minimum safety and health requirements with regard to:

- equipment (e.g. display screen, keyboard and work chair);
- environment (e.g. space requirements); and
- operator/computer interface.

The basic recommendation include that workstations have to meet the minimum requirements laid down in the Directive, workers should receive information on all aspects of safety and health relating to their workstation and daily work on a display screen should periodically be interrupted by breaks or changes of activity.

Today, more and more employees work with computers. Work with computers is physically light and the risk of upper limb disorders is slight in comparison with the traditional occupations with repetitive work. The enormous number of computer workers, however, makes the absolute number of workers with disorders large and a

<sup>(4)</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31990L0269:EN:HTML>

<sup>(5)</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31990L0270:EN:HTML>



priority for European society (in Europe tens of millions of people sit daily for several hours at a computer).<sup>(6)</sup>

A key component of both Directives is the requirement to carry out comprehensive risk assessment and to avoid or reduce workplace risks by putting in place appropriate preventive measures and training. Involvement of workers in the process is essential.

## Interventions included

This review report includes intervention studies on MSDs in all parts of the body. The definition of the health outcomes varies in the original reports from well-defined clinical diagnoses to the reported symptoms of pain or discomfort. In the results of this review, the findings are grouped according to the following anatomical areas:

- low back
- neck and upper limbs
- lower limbs.

To be selected, the interventions in the studies had to be targeted on the working system (e.g. ergonomic interventions on the physical environment, tools, methods, work organisation) or the mechanisms to handle the related problems at the workplace (e.g. training of workers, operational management of work). Interventions aimed at the treatment of individuals outside the boundaries of the working system are excluded.

The scope of the review is the prevention of MSDs. Therefore the outcomes of the included studies are related to the health of the musculoskeletal organs.

The concept of the prevention of diseases has three levels in the scientific literature.

- **Primary prevention** targets the first occurrence of the disease.
- **Secondary prevention** focuses on the recurrence of symptoms after the first occurrence.
- **Tertiary prevention** targets the reduction of the progression of the disease and is related more to treatment and rehabilitation.

With MSDs, this classification is problematic because the definition of disorders has usually been based on reported symptoms and there are no medical means to define exactly the onset of diseases related to degeneration (e.g. most of the adults without back pain had anatomic findings of disc degeneration when studied with the latest imaging methods). In the interventions performed at the workplace, it is difficult to exclude people with a history of past pain in order to study mechanisms for primary prevention because the proposed means will obviously also help to prevent the recurrence of pain. Therefore, this review has included studies on both primary and secondary prevention because most of the original studies included all workers within the workplaces investigated. There is also some overlap between secondary and tertiary prevention. Some of the studies included in this report are thus the same as those in the corresponding review being undertaken for the Agency's recent *Work-related MSDs: back-to-work* report (2007).

<sup>(6)</sup> This is an estimate, which was calculated based on data from the 4th European Working Conditions Survey (European Foundation for the Improvement of Living and Working Conditions, 2007)



Only those studies using valid study design are included in the review. Because there are few studies with a randomised setting, the minimum requirement to be included is that there was a comparison group in addition to the intervention group.

### Exclusion criteria

Case study reports have been excluded from this review. The number of case studies is large and some new experiences are described in the second part of this report. The trials that concentrate mainly on treatment or rehabilitation have also been excluded. They are reviewed in the *Work-related MSDs: back-to-work* report.



## 2.3. METHODS

### Materials

Systematic reviews and original studies cited in the reviews or published since the publication of these reviews were identified by systematic searches by one of the authors of this report in three databases - Medline, Embase and Cochrane Library. Keywords included anatomic terms ('musculoskeletal' OR 'back' OR 'neck' OR 'shoulder' OR 'elbow' OR 'wrist' OR 'forearm' OR 'hand' OR 'hip' OR 'knee' OR 'ankle' OR 'foot') combined with terms related to work ('occupational' OR 'workplace' OR 'ergonomic\*') and 'intervention'. The option of 'related studies' in the databases was also used.

These searches produced more than 760 titles. These were reviewed by the same author initially by titles, resulting in a reduction to 350 potential reports. Abstracts of this smaller group of reports were further screened using the inclusion and exclusion criteria; this yielded 56 reviews and original studies. The final set to be reviewed was made up of 28 reviews that had used systematic methodology and 26 original studies not included in these reviews.

The full papers of these reports were distributed to the six reviewers. In addition, an ongoing systematic review on the effectiveness of advice in manual material handling (Martimo et al., 2006) and a systematic review of the effectiveness of ergonomic interventions in office work published in Finnish (Takala, 2004) were included.

In the reviewing process, some of the reviews and studies were found not to be relevant to the aims of this report. Only those studies considered relevant are refereed and evaluated in the text.

### Methods of reviewing

Due to limited resources, each report was systematically reviewed by only one of the reviewers. There was no formal methodology with which to estimate the quality of the studies (e.g. by the determination of a quality score) because none of the different scoring systems used in the reviews has been shown to be superior to the other systems. The authors of this report tried to estimate potential bias and other factors reducing the validity of the studies in a qualitative manner, adding their personal opinion as a comment about each study.

Relevant data from each of the publications reviewed was extracted to summary tables as shown in Table 2.



**Table 2. Information included in the summary table of reviewed publications**

Reviews	Original studies
Types of intervention	• Types of intervention
Sector of work/ occupation	• Sector of work/ occupation
Types of studies and number of subjects/ intervention group	• Type of study and number of subjects/ group • Study period
Body area	• Body area
Health outcomes	• Health outcomes • Exposures and methods to get the information
Results	• Changes in exposures • Acute response • Documentation • Compliance • Intervention sustainability • Outcome sustainability
Conclusions by authors	• Conclusions by authors
Reliability of conclusions	• Reliability of conclusions
Comments	• Comments

For the original studies, the items are those proposed by Westgaard and Winkel (1997) in their review of ergonomic interventions on musculoskeletal health outcomes. No commonly used pattern for the data extraction relevant to occupational interventions was found.

The results in the report are given by body parts and type of intervention (modified from Zwerling et al., 1997) (Table 3).

**Table 3. Presentation of the results in the report**

Type of intervention	Prevention method
Organisational and administrative interventions	• Modified work (including working hours)
Technical, engineering or ergonomic interventions	• Redesign of physical environment • Adjusting tables and chairs • Redesign of working aids and tools • Lifting and transfer aids for manual material handling
Personal interventions (imposed on a group of workers)	• Protective equipment
Behavioural modification	• Working practices and personal habits • Health promotion: physical exercise

The conclusions are given according to the model adopted from the Cochrane reviews. Table 4 shows that the rating system summarising the strength of the scientific evidence about the effects is based on both the quality and outcome of the studies.





**Table 4. Rating system used in the report**

Rating	Description
Strong evidence	Consistent evidence in multiple high quality studies. New studies will probably not change the evidence.
Moderate evidence	Consistent findings in multiple low quality studies and/or one high quality study. Further studies could still change the evidence.
Limited evidence	One low quality study. Further studies could change the evidence.
Conflicting evidence	Inconsistent findings in multiple studies.
Lack of evidence	No studies found on the subject.



## RESULTS

# 2.4.

### Low back

#### *Organisational and administrative interventions*

Daily working hours were reduced from more than seven hours to six hours in physically demanding care work in three cities in Sweden and Norway (Wergeland et al., 2003). Reduced neck and shoulder pain was observed, but not low back pain.

#### *Technical, engineering or ergonomic interventions*

The effects of measures to reduce the physical load in manual handling have been well studied in the laboratory, but the number of field studies with comparison groups is small. In a critical review of 18 such studies by van der Molen et al. (2005a), seven out of eight studies involving only engineering controls (e.g. mechanical aids) found a reduction in physical work demands. Six studies that involved engineering and organisational controls also showed a decrease in workload. Ten studies that reported the effect on MSD symptoms did not show consistent results. One 'high quality' study reported a decline in the incidence of low back disorders. All four of the controlled field studies showed a significant reduction in physical work demands when lifting devices were part of the intervention. Two of these studies measured a significant reduction in low back disorders in the longer term.

Other recent studies confirm these findings. Working height adjustment and transport mechanisation resulted in lower physical loading and a reduction of back complaints without the loss of productivity in construction work (van der Molen et al., 2004). A new good quality study in the construction industry (Luijsterburg et al., 2005) showed that using a new bricklaying method reduced workload on the back and shoulders. The workers were satisfied with the new method, but there was no clear difference in the MSDs between the intervention and comparison groups. A slight decrease in sickness absence was seen in the intervention group. In a health care programme, introducing ergonomic consultation and financial support for purchasing ergonomic devices also resulted in decreased rates of MSDs, although the study had no control group (Fujishiro et al., 2005).

There appears to be strong evidence that the introduction of ergonomic improvements may reduce the physical workload.

#### *Personal protection: back belts*

Back belts have been recommended to be worn while handling heavy material. They are believed to give mechanical advantages to the worker by providing support to the trunk and increasing the intra-abdominal pressure. In addition, they may encourage the wearer to lift properly using biomechanically approved techniques.

Back belts have been evaluated in four reviews (Linton and van Tulder, 2001; Silverstein and Clark, 2004; Tveito et al., 2004; Ammendolia et al., 2005). Three of these reviews (Linton and van Tulder, 2001; Silverstein and Clark, 2004; Tveito et al., 2004) concluded that back belts appear to have no effect on the number of episodes of sick leave or the



costs associated with low back pain. The most recent review (Ammendolia et al., 2005) evaluated 10 epidemiological studies including those in the other reviews. Of five randomised controlled trials, three showed no positive results with back belt use; two cohort studies had conflicting results, and two non-randomised controlled studies and one survey showed positive results.

The conclusion from all these reviews is that there is no conclusive evidence to support back belt use to prevent or reduce lost time from occupational low back pain.

### **Behavioural modification**

'Back schools'

'Back schools' have trained workers in proper lifting techniques, the adoption of sound working postures and in strengthening exercises, and have been widely used for the treatment of back problems (see the Agency's *Work-related MSDs: back-to-work* report). There is moderate evidence that back schools are more effective for pain and functional restoration than other conservative treatments for patients with chronic low back pain (Heymans et al., 2004). No studies were found demonstrating that back schools can prevent the occurrence of low back pain.

Training on work methods and manual handling techniques

According to the European Directive on manual handling of loads (MHL), the problems should be managed by reducing the workload mainly by technical means. Training is also seen as a necessary element in the reduction of hazards.

In many occupations, it is difficult to avoid heavy loads on the back, e.g. in the handling of patients in health care. Therefore, training has been considered the main way to prevent back pain, combined with assistive devices or even without them.

A recent review aimed to determine the effectiveness of MHL advice and devices in preventing and treating back pain (Martimo et al., 2006). Six randomised trials (with a total of 17,720 employees) and five studies with a comparison group (772 employees) were included. In the randomised trials, training in MHL or the use of technical aids was no more effective than no intervention or minor advice, or physical training or back belt. The results in the comparative trials without randomisation were in line with these results.

Thus it appears that training in MHL, or in the use of technical aids, as the only intervention is not effective in preventing low back disorders. Previous reviews made similar conclusions (Linton and van Tulder, 2001; Tveito et al., 2004; Bos et al., 2006). A new randomised study also did not show any positive effect on low back pain of either a transfer technique or a stress management programme (Jensen et al., 2006). Thus, there is strong evidence that training as the main intervention is not effective in the prevention of low back pain.

Back pain and other musculoskeletal symptoms have been reduced in studies that combined training with ergonomic measures in order to reduce the load on the back (Bos et al., 2006). In these studies, mechanical aids are of benefit but no specific details can be given to compare the effects or to help with equipment provision.

Physical exercise

The risk of back pain increases if there is a discrepancy between the workload and the physical capacity of the person doing the work. This mismatch can also be reduced by improving the physical capacity of workers. Therefore, actions to promote health and physical activity have been advocated (Hayden et al., 2005). Physical training has also



been an essential part of the rehabilitation of patients with back pain (see the Agency's *Work-related MSDs: back-to-work* report).

In a review of interventions for low back in the workplace, six comparative studies on exercises were identified but all had potential bias (Tveito et al., 2004). In four of these reviews, positive effects were found on low back pain, new episodes of back pain, sick leave or economic savings. Another review made similar conclusions (Linton and van Tulder, 2001).

Thus there is moderate evidence that physical exercise is beneficial in the prevention of low back disorders.

## Neck and upper limbs

Disorders of neck and upper limbs are common in many manual tasks and in physically light office work with computers (see below under Office Work). The need for high muscular force in gripping as well as repetitive movements and poor postures have all been found to be work-related risk factors for the development of MSDs in manual work.

### *Technical, engineering or ergonomic interventions*

A critical review from 2001 considered conservative treatment (treatment not involving surgery) modalities in repetitive strain injuries, but no 'good quality' studies on ergonomics in manual work were found (Konijnenberg et al., 2001). Another review (Lincoln et al., 2000) identified only one study with a concurrent comparison group in aircraft manufacturing (Melhorn, 1996). Unfortunately, the report of this study does not give data on the occurrence of MSDs but only mathematically constructed figures describing risk.

Vibration of hand-held tools is another well-known risk for upper limb disorders. Standards regulating the manufacturing of tools have been introduced (e.g. ISO standards) while EC Directive 2002/44 (?) regulates the use of vibrating tools. A study followed the effects of a four-year intervention programme where new tools and anti-vibration gloves were introduced in a construction company (Jetzer et al., 2003). Measures related to the health effects of vibration were slightly more improved in the intervention groups than among the workers who did not use the new tools or gloves.

There are many laboratory studies on engineering interventions in the ergonomic literature. In laboratory studies, many technical tools and working techniques have shown benefits with respect to the loading on the musculoskeletal system. However, these studies have had very short periods of exposure duration and/or follow-up, possibly only a few hours or days. This limits the applicability of the study results to real life working situations.

In manual handling, reduction of the loads to be handled reduces the exposure of the back and also of the shoulders and upper limbs. The intervention studies on manual handling have concentrated mainly on reducing low back pain or have used general terms describing MSDs. No studies related to neck or upper limbs were found.

### *Protective equipment*

Splinting of the wrists has been proposed for the treatment of repetitive strain injuries (Lincoln et al., 2000; Konijnenberg et al., 2001; Verhagen et al., 2006). No studies were found concerning the preventive effectiveness of splints.

(?) <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:177:0013:01:EN:HTML>



### **Behavioural modification**

#### Physical exercises

Physical exercises have been recommended for the prevention and treatment of neck and shoulder disorders, although previous studies have not shown them to be effective (Linton and van Tulder, 2001; Verhagen et al., 2006). Strengthening of the muscles for 12 months was shown to be effective among women with chronic non-specific neck pain who were still working in an office despite their disorders (Ylinen et al., 2003). A similar effect was seen when the original comparison group repeated the programme after the end of the original trial (Ylinen et al., 2006). In another 'good quality' trial with a similar group of women, no effects of exercising were observed (Viljanen et al., 2003). However, there was a clear difference in the intensity of training between these two trials. In the one that was effective, the participants trained intensively for 30 minutes three times a week for 12 months, and an increase of muscle strength was seen. In the other trial, similar advice to train was given but most of the participants exercised much less. It would appear that the exercises have to be intensive enough (half an hour three times a week for several months) in order to effectively alleviate neck disorders.

### **Lower limbs**

Only one study on the prevention of disorders in lower limbs was identified (Larsen et al., 2002). When shock-absorbing and biomechanical shoe orthoses were tested in military service, users had less back and lower leg disorders than non-users. But because care-seeking for lower extremity problems is rare, the use of this kind of custom-made orthosis for prevention of MSDs in military conscripts would be too costly for wider application.

### **Office work**

MSDs of the neck, shoulders and upper limbs are common among workers using computers. Although the risk of well-defined disease is minor compared with the traditional occupations with repetitive manual tasks, the number of computer users is more than half the workforce in many countries. This results in a very large total number of workers with MSDs. (6) The EU Directive on computer work aims to reduce the risks. Its recommendations are to adjust the workstation and tools according to the needs of the users, and to train workers to use tools and software properly.

The effects of interventions in computerised work have been studied in numerous reports. General reviews on the effectiveness of interventions on MSDs of the neck and upper limbs have also evaluated interventions in an office environment (Lincoln et al., 2000; Verhagen et al., 2006).

A recent review evaluated over 350 reports related to computer work (Brewer et al., 2006). By including only those studies with a comparison group, conclusions were made based upon the findings of 31 studies. Improvement in musculoskeletal health was seen in some studies but in the other studies there was no difference between the intervention and comparison groups. By combining the results with the quality of the studies, it was concluded that there is moderate evidence for:

- a positive effect of alternative pointing devices;
- no effect of workstation adjustment;
- no effect of rest breaks and exercise.



For all other interventions, contradictory or insufficient evidence of effect was observed. It is important to note that none of the interventions led to an increase in, or worsening of, MSDs.

In an earlier systematic review (Takala, 2004), the information from other studies was included in addition to the 'high quality' studies. It was concluded that some benefits were gained by following the ergonomic guidelines such as those included in the EU Directive.

## Organisational and administrative interventions

### *Working hours, breaks*

In physically demanding care work, daily working hours were reduced from more than seven hours to six hours (Wergeland et al., 2003). The subjects were compared with workers in similar workplaces who did not benefit from a reduction in working hours. In all intervention groups, the occurrence of neck-shoulder pain was reduced by 15%. No reduction in pain was observed in the reference groups. The prevalence of back pain did not show the same consistent pattern.

Extra breaks within the working day have been introduced in some trials, although their long-term effects have not been studied. In a trial in a meat-processing plant, the introduction of four nine-minute breaks distributed evenly over the workday for a week were found to reduce the discomfort in the lower limbs but not in other body areas. The introduction of the breaks did not reduce productivity (Dababneh et al., 2001). In agricultural harvesting, five-minute rest breaks were introduced every working hour and workers in the experimental condition reported significantly less severe symptoms than workers in the control groups (Faucett et al., 2007).

## Implementation strategies

In addition to the ergonomic measures, intervention strategies (on how these measures are implemented) have been reviewed (van der Molen et al., 2005b). Of the 26 implementation strategies, 21 that measured an improvement in the process variables (e.g. positive changes in the worker's behaviour) used a participatory ergonomics approach, an education programme or both, with the direct involvement of workers. It was concluded that significant reductions in physical work demands and musculoskeletal symptoms were found when (mechanical) lifting devices were part of the intervention. The higher quality studies showed an improvement in workers' behaviour, thus indicating the importance of the use of facilitating and educational strategies in the implementation of ergonomic measures. It appears that the success of an intervention aimed at reducing the physical work demands associated with manual handling and musculoskeletal symptoms depends not only on the effectiveness of the ergonomic measures, but also on the implementation strategy.

Positive effects of using a participative approach in terms of greater comfort and higher productivity have been found in several reviews, although these reports do not fulfil the rigorous requirements of comparative trials (e.g. Hägg, 2003; Vink et al., 2006). A randomised comparative study in construction work was not able to show the benefits of a standardised participative programme when implementing ergonomic changes, but none of the companies in the intervention group completed all six steps of the intervention (van der Molen et al., 2005a).

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*A participatory approach that involves the workers seems to be beneficial for the prevention of MSDs.*

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## Health promotion and physical exercise

Epidemiological studies have shown that some personal risk factors for MSDs such as smoking, being overweight, or in poor physical shape are the same factors as those relating to poor general health. Therefore general health promotion at the workplace might be one option to prevent MSDs. A review of worksite health promotion programmes identified 13 relevant trials and there is moderate evidence that dietary habits can be modified by actions at the workplace (Engbers et al., 2005). The effectiveness of worksite physical activity interventions in 26 studies was reviewed in 1998 and no general effect on fitness was seen (Dishman et al., 1998). A subsequent review evaluated 15 randomised and 11 other trials with a comparison group (Proper et al., 2003). In seven studies, the prevalence of MSDs was also investigated and five studies reported a positive effect. In a recent review (Proper et al., 2006), the conclusion was that workers meeting the recommendations for vigorous physical activity (vigorous physical exercise at least three times a week) took significantly less sick leave, i.e. on average one day less over two months and four days less over a year.



## DISCUSSION

# 2.5.

During the past decade, many new intervention studies on work-related MSDs have been published and the research has been systematically and critically evaluated in a number of reviews. In general, the quality of studies has improved to leave less bias in the results. However, only a very low number of studies have shown a reduction in risk factors for MSDs. The reductions have mainly been shown in laboratory trials but not in the workplace. Even fewer studies have shown both a decrease in risks and a subsequent reduction in MSDs. It should also be stressed that information on workplace interventions focusing on reduction of work-related lower limb disorders is very scarce.

Generally, many reports have described benefits in laboratory or field trials after the interventions. The effects have been less in studies with a simultaneous comparison group without the intervention, and randomisation of groups before the intervention reduced the positive effects still further. Therefore, the critical reviews that give more weight to reliable studies have not found much scientific evidence that supports the effectiveness of workplace interventions in the prevention of MSDs.

Critical systematic reviews have tried to combine the evidence from a number of studies. There are enormous problems in attempting to combine studies because the measures describing interventions and MSDs are very different, making it very difficult to compare these studies. In addition, working life is changing continuously and rapidly, which makes it problematic to compare interventions carried out a few decades ago with those interventions that are made today. Conducting a 'good quality' intervention trial in the workplace usually takes several years and external changes may also happen during this time, making comparisons difficult even within a single trial.

'Evidence based' thinking comes from the health care setting, where some treatments can be dangerous. Should trials aimed at producing safety recommendations therefore have a different kind of criteria for evidence? Even though the reviewed results did not show many effects in favour of the interventions, no studies were found where the interventions had been harmful.

In epidemiological studies, the strongest predictors for the occurrence of MSDs have been the occurrence of previous symptoms. Traumas and accidents are probably one major cause behind the first symptoms for previously healthy people. Interventions aimed at preventing accidents are also probably beneficial in preventing MSDs. We found no studies with a focus on the general prevention of accidents that also examined the prevalence of the MSDs as an outcome. Perhaps the closest to this was the experiences of 'no lift' programmes in hospital work, but such trials have not had a comparison group. In occupational safety, several recommendations - such as the prevention of accidents - seem so self-evident that conducting systematic studies to investigate the effects have not been regarded as necessary. The results of this review do not conflict with the recommendations of the EU directives on manual material handling or on work with display screen equipment.





## Work-related musculoskeletal disorders: Prevention report

*A combination of several workplace measures gives a better result than one single measure.*

The literature evaluated is in line with previous reviews, which concluded that individual measures introduced at workplace level have little or no effect on improving musculoskeletal health but that combinations of several measures are needed if any significant improvements are to be found (National Research Council and Institute of Medicine, 2001; Silverstein and Clark, 2004). It is apparent that there is no one simple way to introduce the measures in an individual workplace but that the programmes must be tailored according to local needs. There is some evidence that a participative approach that includes the workers in the intervention process is beneficial.

In future studies, other outcomes in addition to the prevalence of MSDs should be investigated, such as improvements in production and cost/benefit analysis. Some studies of this type have been included in the 'Case studies' section of this report.



## CONCLUSIONS

# 2.6.

In this review, scientific studies on the prevention of work-related MSDs reported during recent years (2000-2006) have been systematically evaluated. The number of good quality studies has increased during this period compared with the number found in reviews conducted in previous decades. The number of studies, however, is still not very large and many reports do not describe or quantify how well the risk factors were reduced at the workplaces concerned.

It is possible to draw the following conclusions about the different types of interventions based on the randomised and non-randomised comparative studies in the workplace, trials without a comparison group, and laboratory studies:

### ***Organisational and administrative interventions***

There are few studies on these interventions. There is limited scientific evidence that a reduction in daily working hours from more than seven hours to six hours can reduce neck and shoulder disorders in physically demanding health care work. There is also evidence that it is possible to introduce additional breaks into repetitive work without loss of productivity. It is not known how the breaks should be organised in order to prevent the occurrence of MSDs most effectively.

### ***Technical, engineering or ergonomic interventions***

There is strong scientific evidence that technical measures can reduce the workload on the back without any loss in productivity. There is moderate evidence that these measures can also reduce low back disorders and sickness absenteeism.

There is strong evidence from laboratory studies that ergonomic hand tools can reduce the load on the upper extremities. There is also limited evidence that such measures can also reduce the MSDs associated with vibration or the manual tasks performed in computer work.

### ***Protective equipment***

The evidence of the effectiveness of back belts in the prevention of low back pain is conflicting. There is no conclusive evidence to support back belt use as a preventive measure for workers carrying out manual material handling. No evidence has been found to decide if other protective equipment such as splinting of the wrist is effective in preventing upper limb disorders.

### ***Behavioural modification***

There is strong evidence that training on working methods in material handling is not effective if it is used as the only measure to prevent low back pain.

There is moderate evidence that physical training can reduce the recurrence of back pain and neck-shoulder pain. In order to be effective, however, the training should include vigorous exercise, which should be repeated at least three times a week.



### ***Implementation strategies***

There is moderate evidence that interventions that are based on single measures are unlikely to prevent MSDs, but that a combination of several kinds of interventions (multidisciplinary approach) is needed, including organisational, technical and personal/individual measures. It is not known how such measures should be combined for optimal results. There is limited evidence that a participative approach that includes the workers in the process of change has a positive effect on the success of an intervention.

No scientific studies have been found that conflict with the approach adopted by the EU Directives on manual material handling or on working with computers. There is moderate evidence that following their recommendations will be beneficial in the prevention of MSDs.



## 2.7.

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# 3.

## EXAMPLES OF PRACTICAL WORKPLACE INTERVENTIONS





# 3.1. INTRODUCTION

This part of the report presents a sample of successful actions and interventions used to manage and prevent the risks of work-related MSDs. The 15 case studies are drawn from a range of occupations and sectors across Europe (14 from EU Member States and one from Switzerland). An overview of these case studies is presented in Table 5. The case studies are grouped according to their major type of intervention (see also the part of the report on the literature review), i.e.:

- technical interventions such as redesign of physical environment or working aids and tools, adjustment of tables and chairs, introduction of lifting and transfer aids, etc.;
- organisational and administrative interventions such as work modification, job rotation, etc.;
- behavioural modification such as training on work methods and manual material handling techniques, promotion of physical activity, etc.

**Table 5. Summary of the case studies**

Country	Title	Sector/occupation	Type of intervention
Austria	Ergo guide concept	Pharmaceutical industry	Organisational
Belgium	Redesign of a conveyor belt	Automotive industry	Technical
Denmark	Worksite physical activity intervention among male tax office employees	Office workers	Behavioural
France	Ergo sheets	Pharmaceutical industry	Administrative
Germany	Redesign of a crane operator seat	Waste incineration industry	Technical
Germany	Redesign of a sewing workplace	Sewing industry	Technical
Greece	Translation and cultural adaptation of a patient handling assessment tool	Hospital (health care)	Technical
Italy	Redesign of a demoulding workstation	Production of resin art statuettes	Technical
Luxembourg	Muscular fitness project	Chemical industry	Behavioural
Netherlands	Raised bricklaying	Construction	Technical
Portugal	Intervention at a hypermarket checkout line	Retail	Organisational
Portugal	Redesign of an ice-cream packing workstation	Food	Technical
Switzerland	Intervention in a distribution centre	Distribution	Organisational
UK	Ergonomic improvement team	Pharmaceutical industry	Organisational
UK	Redesign of a hand packing line	Pharmaceutical industry	Technical

The case studies are not intended to be definitive or to provide detailed technical guidance. They present some examples of what can work in practice and how this can be achieved.



Each case study is presented in the following structure:

- **Background** - an outline to the reasons for the action;
- **Action** - the action itself including a description of its aim, the assessment(s) applied, the solution(s) adopted and the results arising from the action;
- **Evaluation** - an evaluation of the action including a description of the problems faced, the identified success criteria and the possible transferability of the action;
- **Further contact** - contact details and sources of more information about the action.

The case studies add to other reported good practice by the European Agency for Safety and Health at Work. The report *Preventing MSDs in practice* (2000) includes 16 case studies. In addition, the Agency's 'good practice' website <sup>(8)</sup> contains much practical information about the prevention of MSDs and the control of risks in the workplace.

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<sup>(8)</sup> [http://osha.europa.eu/good\\_practice/risks/msd/](http://osha.europa.eu/good_practice/risks/msd/)



## 3.2. TECHNICAL INTERVENTIONS

### 3.2.1. Redesign of a conveyor belt in the automotive industry

#### *Background*

Tower Automotive is a worldwide company manufacturing body structures, lower vehicle structures, suspension components and modules for automotive manufacturers.

Tower Automotive Belgium applies Standardised Inspection Processes (SIPs) for the final quality inspection of the assembled end products. This inspection was originally as follows. Metal racks with various end products were supplied by forklift trucks and put on a conveyor belt (see Figure 1A). These metal racks were then manually pushed and pulled by operators to the end of the conveyor (see Figure 1B), over a length of 18 metres. Somewhere during this displacement, the end products in the racks received a visual inspection, scanning and labelling. Because the distance was covered in several phases, this meant the operators needed to initiate several push and/or pull forces. The weight of the full racks varies from 300 to 700 kg. The operators generally displaced several racks together, which meant that the total weight could amount to 2,000 kg.

**Figure 1. Manoeuvring the racks of end products for SIPs**



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During a shift of four hours, around 250 racks were moved and inspected by three operators. In total, seven operators were occupied with the tasks. Because of a growth in production, there was a need for a faster inspection at the SIPs. In addition, more and more physical complaints were reported among the operators, although the SIPs had only been in use for five months. To help solve these problems, Prevent, the Belgian Institute for Occupational Safety and Health, was contacted.

#### *Action*

##### Assessment

A safety coordinator at Tower Automotive Belgium and an ergonomist from Prevent carried out an assessment, including an evaluation of the workload experienced by the workers and an objective measurement of the activities (i.e. assessment of cardiovascular load, push and pull forces, noise and lighting).

The subjective workload evaluation of the seven operators involved was performed by means of a questionnaire (CERGO Prevent). This evaluation revealed that the operators' major concern was the safety risk, namely the possibility of being stuck or hit by a rack or forklift truck. Other important issues seemed to be 'fatigue', 'concentration' and 'rhythm of work' due to the irregular supply of racks by the forklift trucks, the constant attention required, and the frequent awkward and forceful movements (bending, reaching, pushing and pulling). The survey results also showed that four out of seven operators had complained of MSDs due to their work, which had developed only recently (the SIPs had only been in use for five months).

An assessment of the cardiovascular load (using a heart rate monitor) found that it involved semi-heavy to heavy work (around 60% CVL)<sup>(\*)</sup> (Mital et al., 1993).

Measurement of push and pull forces (registered by a dynamometer) revealed that the push forces were too high for all operators when pushing the racks rapidly and powerfully. When pushing more slowly, the push forces became acceptable. When pushing several racks at the same time, the acceptable limit values were exceeded even when pushing slowly. Pulling a rack with one hand was unacceptable for the majority of the workers.

The lighting level was too low (100-120 lux) for the quality control of the parts in the rack; 300-500 lux is recommended for such tasks.

#### Solution

Based on the results of this overall assessment and bearing in mind the available budget (EUR130,000), Tower Automotive Belgium decided on the following redesign of the SIPs (see Figure 2).

An automated conveyor was installed, which can be divided into three zones:

- input zone - where the racks are put on the conveyor by a forklift truck;
- inspection platform with two operators - one at both sides of the conveyor;
- output zone - where the racks are again taken away by a forklift truck.

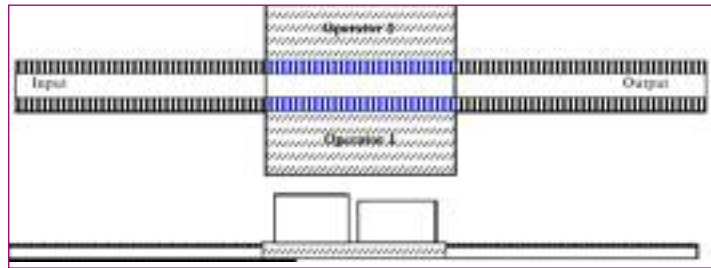
Instead of pushing and pulling the various racks along the conveyor, the operators are able to stay at the central platform. In this way, manual pushing and pulling of the racks by the operators is eliminated. Safety risks mean that the conveyor can be activated only if the two operators at both sides of the platform push a control button: the rack is then automatically brought (rolled) to the platform, where it can undergo inspection (see Figure 3). A pressure sensitive system between the rolls of the conveyor belt on the platform ensures the conveyor cannot be activated when someone is standing on the conveyor.

Moving the inspection task to a central platform meant that the lighting adaptation could be limited to above this zone instead of above the whole conveyor.

<sup>(\*)</sup> % CVL = 100 [(HRwork - HRrest) / (HRmax (8hr) - HRrest)]



**Figure 2. Upper and side view of the redesigned SIP**



**Figure 3. Operation of the new SIP**



© Tower Automotive Belgium

*Automation can improve working conditions, reduce risk of MSDs, increase capacity and improve workers' satisfaction.*

**Results**

By installing an automatic conveyor belt with one central inspection zone, the working conditions of the operators have improved significantly. As they do not have to push and pull the racks any more, the risk of MSDs has been reduced. In addition, the risk of getting hit or stuck by a rack is eliminated. Elimination of the pushing and pulling task also implies that the operators have more time for the inspection task. The capacity of the SIP has thus increased without putting an additional burden on operators.

**Evaluation**

**Problems faced**

Although the risk of MSDs has clearly been reduced, the operators still sometimes have to bend forward when inspecting the racks (which may, in particular, negatively affect their back). Therefore, they are taught the most ergonomic way to perform the task, i.e. using their knee or (even better) the rack as support when leaning forward (see Figure 4).

**Figure 4. Using the knee for support when leaning forward**



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Attention should also be paid to the fact that the operators are able to alternate their inspection job so that a situation of prolonged standing (without moving a lot) is avoided as much as possible.

**Success factors and transferability**

The automation of a conveyor belt can lead to:

- a reduction in the risk of musculoskeletal disorders and safety risks;
- an improvement in the working conditions and satisfaction of the operators;
- an increase in capacity of the process.

This technical measure is likely to apply to other processes where a similar conveyor and working method is in use.



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**3.2.2. Redesign of a sewing workplace****Background**

The German sewing industry has experienced elevated sickness levels with corresponding absenteeism for years. Most of this sick leave is caused by MSDs, particularly those affecting the spine and the upper limb (Ellegast et al., 2004). Numerous studies have highlighted the musculoskeletal risk factors associated with industrial sewing and garment making jobs (Blader et al., 1991; Westgaard & Jansen, 1992). One-sided, repetitive sewing work, which is often performed in awkward postures owing to poor workplace design, is mostly referred to as an important risk.

As there are few studies in which actual ergonomic interventions are evaluated at sewing workplaces, a research project was initiated under the mandate of the German Technical Committee 'Textile' and the German statutory accident insurance institutions for the leather and textile/clothing industry to assess MSD risk factors at different sewing workplaces. On basis of this risk assessment, ergonomic improvements of conventional sewing workplaces would be developed and field-tested in different sewing tasks. The research work was conducted by the BG Institute for Occupational Health and Safety (BGIA), the ergonomics department of Munich College of Higher Professional Training and the engineering consultant Schwan in Frankfurt. The project was financed by the German Federation of statutory accident insurance institutions for the industrial sector (HVBG).

**Action****Description**

The actions were conducted as an intervention study at a total of four businesses in the German sewing industry in the fields of footwear, technical textiles, soft toy production and clothing. These companies with their different sewing tasks were selected by experts in the statutory accident insurance in the leather and



textile/clothing industry. Altogether seven workplaces were analysed (two in footwear, two in technical textiles, two in soft toy production and one in the clothing area); a total of 11 female seamstresses participated in the study as voluntary test subjects.

The procedure of the study was as follows. First, risk factors such as repetitiveness, static posture, working at extreme joint angles and high exertion were measured over periods of three hours at the various workplaces. The evaluation phase then identified the main points of workload. On the basis of these analyses, the workplaces were ergonomically redesigned and installed in the companies. After a period of time for the seamstresses to adjust to the changes, they were studied once more during a normal work shift.

Assessment

*Kinematic measurements*

Postures and joint angles were measured using the CUELA (computer-assisted recording and long-term analysis of musculoskeletal loads) measuring system. This expert measuring system was developed by BGIA for the documentation and objective assessment of the load factors causing MSDs, and has been successfully used at a large variety of different workplaces (Ellegast and Kupfer, 2000).

Figure 5 shows a seamstress wearing the CUELA measuring system at the ergonomic sewing workplace.

**Figure 5. Seamstress wearing the CUELA system**



The person-centred measuring system is designed for long-term field measurements in the workplace and has a modular design. For the current project, a configuration was employed that permits kinematic measurements of the legs, back, shoulder-arm-hand system and head. The body angles and their degrees of freedom measured by the CUELA system with a sampling rate of 50 Hz are specified in Table 6.

The measurements are accompanied by video documentation, which can be synchronised with the measurement data to allow for a simple association of specific load points with related work situations.

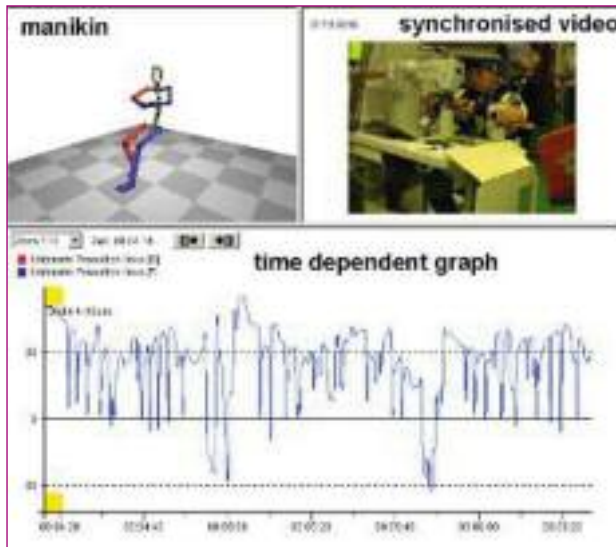
**Table 6. Body angles and degrees of freedom measured by the CUELA system**

Joint or body region	Degree of freedom
Head	Sagittal inclination
Cervical spine	Flexion/extension
Thoracic spine	Sagittal and lateral inclination at Th1
Lumbar spine	Sagittal and lateral inclination at L5
Hip joint	Flexion/extension
Knee joint	Flexion/extension
Shoulder girdle	Elevation/depression, anterior/posterior
Shoulder joint	Flexion/extension, ab-/adduction, inner/outer rotation
Elbow	Flexion/extension
Forearm	Pronation/supination
Wrist	Flexion/extension, radial/ulnar deviation



Once a measurement is taken, the readings are immediately available for display and further analysis with the internally developed CUELA software. In addition to several forms of statistical analysis, the software permits the graphic representation both of joint angle/time curves and a three-dimensional computer depiction of the postures and the corresponding work situation in the video (see Figure 6).

**Figure 6. Depiction of the measurement data using the CUELA software**



The measurement data were used in the following step to quantify the known risk factors for the musculoskeletal system. Each risk factor group was assessed according to international and European standards, and evaluation schemas selected from the literature.

#### *Physiological measurements*

Heart rate (HR) measurements were recorded with a sampling rate of 50 Hz using a data logger (<sup>TM</sup>Natic). The working heart rate was calculated as the difference between the measured heart rate during work and a defined resting period of each subject during sitting.

The electrical activity (EA) of the muscles has been analysed by electromyography (EMG). The EMG signals were detected using electrodes, pre-processed (band-pass filtered as well as integrated) in a data logger (<sup>TM</sup>Natic) and recorded with a sampling rate of 10 Hz. The EMG amplitudes were normalised to the measured minimum values of each test subject during the sedentary resting period and presented as a percentage of these minimum values.

#### *Questionnaires*

A standardised questionnaire was used to analyse the subjective perceived workloads of the seamstresses and their individual attitude to the conventional and new ergonomically designed workplaces.

#### *Solution*

The expected workload factors (e.g. awkward postures of the trunk and the upper limb) could be quantified before interventions in all the sewing tasks. The measurements obtained were employed initially in the development of a model ergonomic sewing workplace with:

- individual adjustability of the table and chair to the particular anthropometrics of the seamstress;



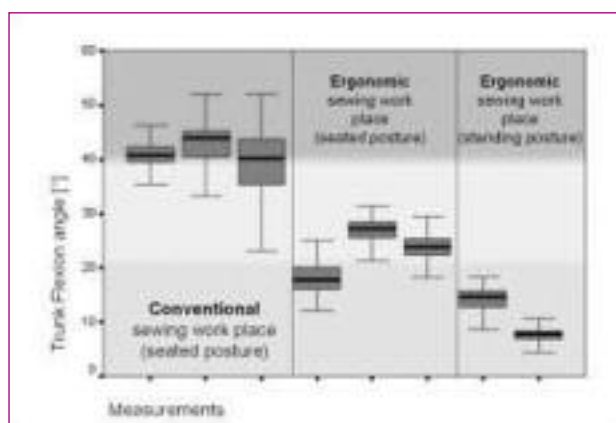


- tilt adjustment of the work surface;
- the option of working in a sitting or standing position (dynamic work);
- more extensive leg room;
- adjustability of the table surface to the weight and size of the piece(s) being sewn;
- creation of variably adjustable armrests;
- redesign of the operating pedal.

The ergonomic workplaces were installed in the sewing companies and the seamstresses were trained to use to them.

For work at the ergonomic workplace, comparison of the load and strain profiles yielded a significant improvement in spinal posture and the proportion of working hours spent with the shoulder-arm system in extreme angle positions. This result is exemplified by the results for the trunk flexion angle measured at the soft toy production sewing area before and after the ergonomic redesign (see Figure 7). The frequency distributions are depicted as box-plot diagrams.

**Figure 7. Box-plot diagram of the average flexion angle before and after redesign at sewing facilities for soft toy production**



Similar positive results were obtained for the postures of the cervical spine and the joints of the upper limb. No significant improvements could be identified for the risk factor 'repetitiveness', which is largely caused by the sewing tasks themselves.

Slight reductions in the working heart rate could be observed for the sedentary workplaces after intervention. After intervention, a major reduction in the EMG amplitudes can be observed. As part of the survey, 68% of the seamstresses reported that they had experienced muscular aches, pain and discomfort in the last year. The main body areas of concern were the upper limb and neck (56%) and the low back (31%).

After getting used to the new ergonomic sewing workplace, all seamstresses were very receptive to the ergonomic redesign of their workplaces and reported a reduction of the subjective perceived workloads after intervention.

The results of the actions confirm that seamstresses face a number of risks with respect to the musculoskeletal system. An ergonomic workplace design can lead to a considerable reduction in physiological workload and extreme postures in the area of the spinal column and the shoulder-arm system. In particular, the possibility of combining working in sitting and standing positions (dynamic work) seems to be a reasonable feature to reduce the known risk factors and therefore to prevent MSDs.



For the development process of the redesign, quantification of the physical workload before intervention turned out to be an important issue. With knowledge of the measurement results, some features of the new workplace (e.g. tilt adjustment of the work surface and the application of adjustable armrests) could be designed precisely for the specific sewing tasks.

The quantification of physical workloads after intervention was essential to assess the effectiveness of workload reduction. After the ergonomic workplace had proven effective in practice, all the findings were compiled in a set of instructions for industrial users for the ergonomic design of sewing workplaces (BGI 804-2) (TBBG and BG, 2005).

### **Evaluation**

#### Problems faced

It was planned to monitor sick leave rates at the four sewing companies during and after the intervention study as a measure of the effectiveness of the action. Although a decline in the rate of sick leave due to MSDs was observed in the sewing companies in which the workplaces had been ergonomically redesigned, it was not possible to attribute this to the change in ergonomic design as the economic situation in these businesses deteriorated during the course of the study and other factors such as fear of redundancy probably had a more pronounced effect on sick leave statistics.

#### Identified success criteria

- The workload reduction effect could be quantified after ergonomic interventions in all participating sewing companies.
- The seamstresses' acceptance of the ergonomic workplace was very high. Equally positive was the subjective assessment of the load-reducing effect of the new work situation.
- Several sewing companies in Germany have started to put these specific ergonomic design measures into effect on their premises. Demand for the model ergonomic sewing workplaces is also high.
- A decline in the rate of sick leave due to MSDs has been observed in sewing companies in which the sewing workplaces have been ergonomically redesigned, but it is not possible to attribute this only to the change in ergonomic design.
- A big demand for the ergonomic design instructions for companies is an indication that the target group has been reached.

#### Transferability

The strategic approach and the results can be transferred to other EU Member States. The procedure adopted for the case study is applicable in principle to other branches of industry. For example, an intervention study was launched in 2007 for the ergonomic design of assembly workplaces in which the methods from this case study have been adopted en bloc. A possible improvement could be close monitoring by occupational doctors and documentation of the study.

### **Further contact**



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*The improved ergonomic design of sewing workplaces serves as an example to other companies.*

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### 3.2.3. Redesign of a crane operator seat in the waste incineration industry

#### Background

**Figure 8. Crane operator in his cab before redesign**



After several years of work, the crane operators of a waste-to-energy facility complained about pain in the neck, shoulders and upper extremity. Their workplace was located in a special cab at the top of a so-called waste bunker, an enclosed receiving pit where waste is delivered by trucks. The crane operator sat in a simple, rotating seat using joysticks to operate a clamshell crane to mix and transport the waste into the incineration funnel (see Figure 8). To position the clamshell exactly, the crane operator had to look down into the waste bunker, partially through a vision panel in the floor of his cab.

The waste recycling company concerned was running several facilities in Germany. It was noticeable that the complaints were reported just when crane operators who had worked in facility (A) for years were delegated to help out in a newly built facility (N). As both facilities seemed to be almost identical in construction, the recycling company suspected there might be psychosocial causes of the disorders and contacted the responsible statutory accident insurance institution for the gas, district heating and water industry (BGFW) to identify the real cause of MSDs in facility (N). For this reason, the BGFW initiated a study and ordered the staff of BGIA to investigate the affected workplaces.

#### Action

##### Assessment

The BGIA started its assessment in 2001 by measuring the crane operator workplaces using the CUELA system (see previous case study from the German sewing industry). The measurements were performed in the affected facility (N) and, in order to draw a comparison, at two facilities where no complaints had been reported (A, B) (Herda et al., 2002).

After analysis of the results in 2001, certain actions were recommended to improve the situation and a redesign of the workplace took place. To evaluate the impact of the measures taken by comparing the situation before and after, the redesigned workplace in facility (N) was investigated again in 2004 (Ditchen et al., 2005).

The CUELA system enabled the continuous recording and analysis of the different body/joint movements (see Table 7).

**Table 7. Measurements made for the evaluation**

Joint or body region	Degree of freedom
Head	Flexion/extension
Cervical vertebrae	Flexion/extension
Trunk	Flexion/extension in lumbar spine and upper thoracic spine, torsion, lateral flexion
Pelvis	Inclination
Hip joint	Flexion/extension
Knee joint	Flexion/extension



The measurements were also documented on video.

Immediately after measurement, the data were entered into specially developed software and displayed. Using this software, it was possible to display:

- body posture at any given point with the aid of a three-dimensional computer-animated figure;
- a time-dependent graph of the measured body and joint angles;
- a video sequence showing the associated work situation.

As well as the measurements with the CUELA system and the video documentation, a questionnaire was used to document the crane operators' subjective assessment of the situation before and after the measurements were taken.

Features relating to the work environment were recorded using an 'all-in-one' measuring device for noise, temperature, humidity and intensity of light. Features relating to the work organisation were recorded by interviewing the staff and their supervisors.

At first sight, the workplaces in all the investigated facilities seemed to be almost identical. The work organisation (e.g. shift duration and shift schedule), work environment and work task were also the same. Nevertheless, complaints about musculoskeletal discomfort came only from crane operators in facility (N) even if these employees were working alternately in both plants (N) and (A).

The complaints were confirmed by the results of the body posture measurements with the CUELA system: in facility (N), crane operators were working most of their time in more extreme, unfavourable postures of head, neck, arms and shoulders than their colleagues in (A) or (B).

The difference between these facilities was found in the position of the crane operators' cab within the waste bunker: in (N) at the long side of the waste bunker, in (A) and (B) at the face side. This position of the cab was the cause of the problem whether the crane operators' main area of operation was in front of them or straight underneath the cab. If their area of vision was underneath their cab as in (N), they had to incline their heads and necks to an extreme degree. Furthermore, the installed non-adjustable seat and its instruments had been designed for working in an upright position, so that working in an extreme inclined position led to extremely unfavourable static arm postures.

The results of the assessment can be summarised as follows:

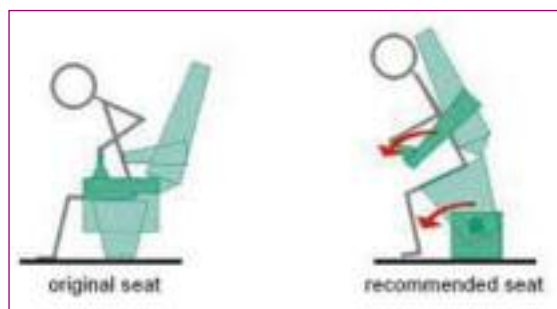
- The reported MSDs seemed to be caused by non-ergonomic static postures.
- The cause of the non-ergonomic postures was found in the construction of the building.
- The construction of the work seat and the crane operators' cab in all facilities was very similar, but the position of the cab in the waste bunker was quite different.

#### Solution

As redesign of the existing cab in facility (N) was out of the question, other possible measures of prevention had to be found. Apart from changing work organisation (e.g. job rotation) and individual prevention (e.g. physiotherapeutic exercises), technical measures were recommended. The most auspicious approach seemed to be a redesign of the seat as a means of improving body posture. To adapt the seat to the real working conditions, it was postulated that the ideal seat and associated instruments should tilt forward continuously and be individually adjustable as shown in Figure 9.



**Figure 9. Design of original and recommended seats**



The waste recycling company ordered a new seat incorporating the recommended features and installed it in facility (N). The new seat and the instruments were continuously adjustable by air pressure in three dimensions independently. After a short adaptation phase, the seat was well accepted by the crane operators.

*An ergonomically designed crane seat improved operators' postures and reduced MSD complaints.*

It was very important to evaluate the impact of the new seat and the new health situation of the crane operators who had formerly complained about MSDs. Therefore, the measurements of the redesigned crane operators' workplace in facility (N) were repeated in 2004, about six months after the introduction of the new seat. The result of this evaluation was a sharp decline in unfavourable body postures. This was documented by further measurements with the CUELA system, which yielded significantly improved working postures of the crane operators. The measurements showed a significant reduction in extreme flexion and bending of the trunk and the cervical spine, while the video documentation showed a significant improvement in upper arm postures.

### **Evaluation**

#### Problems faced

The standard CUELA measuring system features some sensors applied to the back of the test person to record, for example, the torsion of the trunk. In this case study, the test persons worked sitting down all the time and thus would have found sensors on their back disturbing. For this reason, a special version of the system adapted for sitting workplaces was used and measurement of the trunk's torsion was forgone.

#### Success factors

The success of the measures taken could be documented by different means of evaluation.

- The measurements after the installation of a new seat showed significantly improved body postures in the crane operators.
- A subjective assessment of the work situation by the crane operators 'before and after' yielded a real improvement.
- A survey of the workforce showed a sharp decline in MSDs.

#### Transferability

MSDs of neck and shoulders are a problem in many different occupational branches all over Europe. The method applied in this case can be transferred to similar workplaces to identify the cause of the problems and to take preventive actions such as as reconstruction of the workplace, change of work organisation, etc.



The ergonomic redesigned seat in this case may be an example worth considering in other industrial sectors where the area of vision is underneath the employees, e.g. crane operators in port facilities. The study shows the importance of an ergonomic design at the planning phase of a facility. Errors at this stage are hard to correct later on.

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## 3.2.4. Translation and cultural adaptation of a patient handling assessment tool

### Background

Work-related MSDs are common among health care professionals. Assisting patients in transfers is a work task in health care settings that has been considered hazardous and presumed to be a risk factor for the development of MSDs.

There are a number of methods for performing patient transfer tasks. Figure 10 shows some examples. The methods differ not only between countries, but also within countries. There is no consensus as to which method is preferable. Evaluation of a training programme for patient transfer tasks requires valid and reliable methods.

**Figure 10. Examples of patient transfer methods**



Source: [http://www.sjukvardsradgivning.se/handboken/06\\_article.asp?CategoryID=335&ParentId=335](http://www.sjukvardsradgivning.se/handboken/06_article.asp?CategoryID=335&ParentId=335)

A European Panel on Patient Handling Ergonomics was formed at the PREMUS conference <sup>(10)</sup> in 2004 from a collaboration of the International Ergonomics Association Technical Committees on Hospital Ergonomics and Musculoskeletal Disorders. The main purpose of this Panel is to share information and to develop ideas on patient handling for further European collaboration. Within this collaboration, the Hellenic Institute for Occupational Health and Safety conducted a pilot study in a Greek hospital using a direct observation instrument for assessment of the nurses' patient transfer technique (DINO), which has recently been developed in Sweden.

<sup>(10)</sup> <http://www.premus2004.ethz.ch/>



The DINO instrument consists of 16 items divided into three phases of a transfer (preparation, performance and result) plus an optional background description (characteristics of the nurse, the patient and the environment).

A definition of all 16 items, categories and the criteria for fulfilling or not fulfilling them, as well as a description of how the instrument is used, are provided in the 'Key to DINO instrument'. To quantify the items according to musculoskeletal health and safety, a scoring system has been constructed. The overall score can assume a value between zero and one. When the overall score is one, the work technique is regarded as safe.

### **Action**

#### Description

The instrument was translated from Swedish into Greek according to international guidelines for instrument translation. The same procedure was followed for the translation of the 'Key to DINO instrument'.

Apart from rigorous methods of translation and assessment for cultural equivalence, the psychometric properties of an instrument should be reassessed in each culture/country where the instrument is to be used. In this pilot study the inter-observer reliability of the Greek version of the instrument was tested. For this purpose, two physiotherapists used the final Greek version of the instrument to register a total of 36 patient transfers:

- 19 transfers in bed - from side to side, higher up in the bed, raising the upper part of the bed to take an X-ray, from lying to sitting;
- seven transfers from bed to bed;
- seven transfers from sitting to sitting;
- two transfers from sitting to standing;
- one transfer from standing to sitting.

In 13 transfers, the patients were intubated. Nurses, nurse's aides, porters and physiotherapists in an authentic clinical setting in the intensive care unit and wards of an acute hospital in Athens performed the transfers over a period of two weeks.

#### Results

The translation procedure resulted in a Greek version of both the DINO instrument and the 'Key to DINO instrument'. The assessments of both observers give us a description of the patient transfer technique used by the staff. For example, in the preparation phase both observers assessed that:

- in almost 50% of the transfers, the patient was encouraged to cooperate;
- in almost 80% of the transfers, there was enough space available for the transfer;
- in most of the transfers, there were enough nurses;
- in almost 50% of the transfers, the height of the bed was not adjusted;
- in more than 50% of the transfers, transferring aids were not needed and, in a third of the transfers, transferring aids were not available.

In the performance phase both observers assessed that:

- in most of the transfers, the nurse worked with good balance and good coordination;
- in most of the transfers, the nurse did not work with good movement economy;



- in most of the transfers, the load on the back and shoulders of the nurse was high;
- in a third of the transfers, the patients were not allowed to participate according to their ability to perform voluntary movements.

In the result phase both observers assessed that:

- in almost 80% of the transfers, the transfer technique chosen by the nurse did not cause any pain or feelings of fear to the patient;
- in most of the transfers, the patient was in a functional position at the end of the transfer.

The inter-observer reliability of the Greek version of the instrument was shown to be good. This indicates that the instrument produces similar results when used by different observers.

The overall score of the Greek version of the DINO instrument was found to be 0.5 for both observers. Thus the work technique used during the patient transfers cannot be regarded as safe.

### **Evaluation**

#### Problems faced

It was difficult to find bilingual people and experts in the field of patient handling in Greece. For better cultural adaptation of the instrument, the English version of the DINO instrument was therefore used.

In the Swedish study, video recordings of patient transfers were used to train the observers who participated in the reliability and validity process. In our study, the same physiotherapists involved in the translation procedure used the DINO instrument to assess the patient transfers at the hospital.

The author of the instrument suggested following the 'Key to DINO instrument' and assessing our own video films with authentic patient transfers in order to ensure a common understanding of the items and categories. The author also recommended carrying out some test assessments with the Greek version of the instrument before the final assessments. It was not possible to make video recordings of patient transfers or to borrow the Swedish video recordings in order to educate the Greek observers.

In order to have the same understanding of the items and categories of the instrument, the observers undertook four test assessments of authentic patient transfers with the Greek version of the DINO instrument. Differences in the registrations between the two observers were discussed in a consensus meeting. Questions regarding specific items were discussed further with the author of the instrument, who clarified the meaning of some items. This proved to be an essential step in the educational process of the observers, since some incorrect conceptions were discovered.

In conclusion, although assessments with this instrument can be performed without special equipment, specific training is needed to learn the items, definitions and the scoring system. A specific video with description of items and categories would be of great help for this purpose.

There were 13 intubated patients in this pilot study. Some items (1, 12, 13, 14 and 15) did not have an applicable answer for such patient transfer cases. Changes in the scoring system may be an issue for future use of the instrument.





#### Success factors

The two physiotherapists had experience in teaching patient transfer techniques both in Sweden and Greece. This meant they were both familiar with the Swedish approach to patient handling on which the DINO instrument is based. This facilitated communications with the principal author of the instrument as well as its use.

Furthermore, both physiotherapists had previously initiated and conducted ergonomic education for the personnel at the hospital where the study was conducted. They were familiar with the staff who performed the patient transfers. This in turn facilitated the staff's collaboration.

A major advantage was that a bilingual nurse with many years of experience in both Sweden and Greece was also available at the hospital. This contributed much to the translation and cultural adaptation of the DINO instrument, which is a prerequisite for its further use in Greece.

#### Transferability

The Greek version of the DINO instrument is easy to use, cost-effective and simple. Assessments with this instrument can be performed without special equipment, and thus the instrument can be used in both clinical and educational settings. For example, it can be used to:

- evaluate training programmes on patient transfer methods;
- assess compliance with the learnt patient transfer method in working life on the ward;
- assess nurses' work technique as one tool for measuring quality of care.

Furthermore, the instrument can also be used in epidemiological studies to explore the relationships between work technique and MSDs.

#### **Further contact**



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### **3.2.5. Redesign of a demoulding workstation in the production of resin statuettes**

#### **Background**

Manual handling of loads (MHL) is required at every step of the process in an Italian factory producing resin art statuettes. The working areas are located in two sheds. The first shed houses the casting department where the statuettes are manufactured. Finishing is performed in the second shed.



Processing in the casting department begins when resin is poured into the empty moulds on a moving pallet placed on a four-wheeled trolley. When this step is complete, the trolley and the moulds filled with resin are carried by two workers to the entrance of an aspirator for vacuum thermoforming. Workers push the pallet with the moulds off the trolley and into the aspirator. In the next step, the pallet is taken out of the aspirator and replaced on the trolley. This is pulled for at least 20 metres to move it into the storage area. From this area, the trolley is moved into the demoulding department where it is placed alongside a workbench. After demoulding, the empty moulds are put back on the trolley, which is moved again into the storage area.

### **Action**

#### Assessment

To assess each step in the MHL, the US National Institute for Occupational Safety and Health (NIOSH) equation (Waters et al., 1993) was used.

In the study, a preliminary inspection of the factory was scheduled to:

- capture photos and video of the different steps;
- assess the manufacturing process with descriptions of each task, the characteristics of handling of loads, the position and posture of workers;
- describe the characteristics of the working environment including an assessment of the microclimate, the characteristics of lighting and floors, and other factors;
- collect data to determine the Recommended Weight Limit (RWL) and the Risk Index (RI).

For each task, parameters and data on the handling of the different types of moulds were collected. Due to the vast range of weights and sizes, semi-moulds were classified into:

- small (up to 9 kg)
- medium (10-29 kg)
- large (30-55 kg).

For each step of processing in the examined department, the individual tasks were identified using collected data, but mainly by analysing videos. The variability in performing tasks from one individual to another was considered in order to assess any working procedure and/or behaviour that could be more dangerous.

To obtain a wider set of data and information on the total workload, the heart rate of workers while performing the different tasks was recorded using cardio frequency meters. Recorded data were processed using a computer with specific application software. The Net Heart Rate (NHR) and the Relative Heart Rate (RHR) were then calculated.

From the preliminary investigation, demoulding was identified as the operation with the highest workload. Items to be lifted consisted of two gesso or polyurethane resin semi-moulds which, when joined, form a rigid structure containing a silicone mould. This mould contained the product being processed. The solidified items within moulds and semi-moulds were carried on a trolley to the demoulding workbench. Each trolley could carry 30 small semi-moulds or 14 middle-size semi-moulds or one larger item. Workers completed the demoulding of items on a trolley in 40 minutes. The worker, located between two parallel worktops (see Figure 11), moved the semi-moulds manually from the trolley to the demoulding workbench.



The workers, with little movement and with no rotation of the trunk, usually performed the following actions: they lifted the semi-mould, took about two steps to move it, and left it on their workbench. Lifting was performed every 2.5 minutes, which is the average time required to free the solidified item from the semi-moulds and the mould.

High values of RI (>1) were recorded when handling a large number of small- and middle-size semi-moulds. The recording of the heart rate HR of workers in the different manufacturing steps in the casting department did not show a significant increase in the heart rate HR even when heavier operations were performed. In particular, for the worker performing the demoulding of heavier items (40-60 kg), the calculated values of NHR and RHR were equal to 8.7 and 11.4% respectively. These classified this job as 'light'.

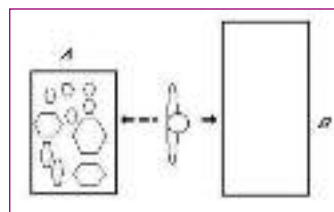
**Solution**

The first improvement suggested to the workers and the factory was to change the way in which semi-moulds were handled by trying a different position for the trolley: not alongside the workbench but perpendicular to it, thus reducing the workload because the small movement by the worker would no longer be required (see Figure 12).

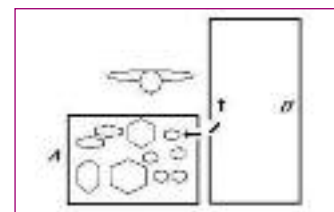
This solution eliminated the need to take the two steps from the trolley to the workbench necessary to move the semi-moulds. However, assessment of the RI showed even higher values than those recorded in the previous layout because it required workers to rotate their trunk by up to 90°. Due to the problems posed by the complete automation of the operation, which are further increased by the different sizes of the semi-moulds processed, and because this kind of organisation seemed to be ineffective, it was decided to redesign the the workbench for demoulding (see Figure 13).

The new demoulding workbench is no longer rectangular; it is 'U-shaped' so that the trolley can be placed inside. The new layout has produced remarkable changes in the performance of the basic tasks of workers. Once the trolley has been pushed inside the new workbench, the worker can perform demoulding by moving along the outer side of the workbench; thus, lifting and moving the semi-moulds are no longer required. Semi-moulds are moved from the trolley to workbench by overturning them and then drawing them on the rollers along the side of the workbench. When this step is complete, the trolley and the empty semi-moulds are brought back again in the storage area.

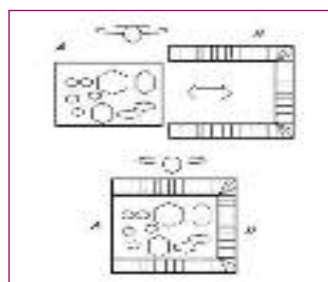
**Figure 11. Original layout**



**Figure 12. First suggested action**



**Figure 13. New layout**



**Key**

- A Trolley to carry moulds
- B Workbench



## Results

The changes have resulted in a clear improvement in working conditions because the need to lift and to handle loads manually has been eliminated. Overturning and drawing the semi-moulds on the rollers cannot be assessed using the NIOSH 1993 method, but the practice has been widely accepted by the workers. The factory's managers gave positive feedback on the new workplace because output did not change and they did not receive more complaints from workers. The HR was not assessed again because, even before this action, no remarkable conditions had been recorded.

The introduction of the new workplace and the elimination of lifting and handling of items from the trolley to the demoulding workbench, has enabled workers to take longer breaks than in the past. Workers in the demoulding department often now end their jobs more than 10 minutes earlier than other workers.

Using the NIOSH 1993 method to assess the MHL proved, in this case, to be useful in identifying conditions where ergonomic and corrective actions should be taken. Even though the assessment of HR at work and the calculation of the NHR and RHR did not show any major hazard, the RI - as determined using the NIOSH method - identified critical conditions that matched complaints reported by workers. As well as the meaning that could be given to the recorded RI values, it was possible to check that the NIOSH method allowed the determination of which factors, if changed, could have worsened the conditions of worker exposure.

## Evaluation

### Problems faced

Assessing the results of the ergonomic changes introduced was not easy. In fact, the NIOSH method could not be applied to assess these results and the assessment of HR, NHR and RHR did not show remarkable conditions or situations that required specific action. Thus, the satisfaction of management and workers was the only indicator proving the effectiveness of the action taken.

### Success factors

Opinions and suggestions from workers and factory technical staff were collected in individual interviews in the workplace and at general meetings - when planning the study, when the results of the action were presented and during the discussion of the ergonomic action taken.

The positive approach and attitude of all the social players during every stage of the ergonomic corrective action (from the analysis of the job to the identification of criticalities and possible solutions) were important to achieve positive results. The new workplace layout has not reduced the production output, but has significantly reduced risks, discomfort and complaints from workers.

### Transferability

The suggested method to study the risk factors for the musculoskeletal system integrates several investigation methods from different disciplines (engineering, biomedicine and social psychology). It may be useful in implementing programmes to identify risks and hazards, to find solutions and, most importantly, to assess, in the long run, if achieved results can be applied to working environments having characteristics similar to the one investigated in this study.

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*The positive approach and attitude of all players during ergonomic intervention, from the analysis of the job to the identification of criticalities and possible solutions, is important for achieving positive results.*

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### **Further contact**



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### **3.2.6. Raised bricklaying in construction**

#### **Background**

In the Netherlands, bricklayers comprise 20% of the total workforce in the construction industry. In general, bricklayers work in teams consisting of one assistant and three bricklayers. Assistants transport bricks and mortar to bricklayers, and bricklayers pick up these bricks and place them in the wall, together with mortar. Bricklaying is heavy work (Jørgensen et al., 1991), with bricklayers laying between 800 and 1,000 bricks every workday. Apart from the lifting, they work in an uncomfortable posture. Due to their position between the bricks and the wall that is being built, bricklayers need to bend and rotate the trunk frequently. It is known that frequent bending and rotation of the trunk and lifting are risk factors for MSDs (National Research Council and Institute for Medicine, 2001).

The heavy workload of bricklayers is not without consequences. Bricklayers report MSDs very frequently and the sickness absence among them is high. The unfavourable working conditions of the bricklayers called for action. Besides, a survey by Arbouw, a branch organisation in the construction sector, showed that bricklayers would welcome devices to lighten their burden.

#### **Action**

##### **Description**

To reduce the physical workload of bricklayers, a stepwise participatory approach was applied in a two-year project by research institute, TNO Construction (De Jong, 2002). The goal was to develop working methods that would reduce the flexion and rotation of the bricklayer's back.

As several companies have to cooperate in the bricklaying process and as they might have different and conflicting interests, their representatives were asked to participate in the project. This resulted in the cooperation of three Dutch organisations in this project:

- AVM - an organisation promoting the interests of bricklayers;
- KNB - an organisation promoting the interests of brick manufacturers;
- NVOB - an organisation promoting the interests of subcontractors in the construction industry.

In a first step, several committees were formed to develop and discuss solutions to reduce the workload of bricklayers. These committees consisted of executives of bricklaying companies, sector organisations, middle management of bricklaying companies, representatives of bricklayers and TNO.



Secondly, the major problems related to bricklaying work were determined. Previous analyses had shown that most complaints from bricklayers concerned the lumbar back. Therefore, it was decided to eliminate the most hazardous task for these complaints. In this context, bricklayers' most unfavourable posture during their work occurs when the bricks are located 0-50 cm above the work floor (see Figure 14).

In a third step, the committees suggested a number of solutions for this problem. After testing some solutions in practice, one functional concept was selected for further development. This concept should enable a higher placement of the bricks above the floor to prevent working 0-50 cm above the floor as much as possible. This is achieved by:

- scaffolding with split floors
- stools made of wood or aluminium
- height adjustable scaffolding floors.

All options enable the placement of bricks on a higher level than 0-50 cm above the floor.

In a fourth step, bricklayers tested prototypes of the devices at construction sites and, in a fifth step, preparations were made to produce the devices.

Finally the new working methods were introduced to the bricklaying sector via demonstrations, lectures, information days and articles in newspapers and magazines.

Results

**Figure 14. Traditional bricklaying**



*Effects of raised bricklaying*

The effects of the new method for bricklaying - the so-called raised bricklaying (see Figure 15) - were examined through a controlled intervention study with a follow-up period of 10 months (Luijsterburg et al., 2005). Moreover, a prospective cohort study evaluated the effect of changes in working conditions among bricklayers during a period of 4.5 years (van der Molen et al., 2006). The extent to which the new method for bricklaying was applied in the bricklaying sector was the objective of three other small studies (De Jong et al., 2003).

**Figure 15. Raised bricklaying**



Baseline measurements of the intervention study were taken in 1997 and 1998. The total study population consisted of 202 bricklayers from 25 bricklaying companies. Bricklaying companies that had no intention of implementing the new method served as the control group. The intervention group consisted of 44 bricklayers and



the control group of 158 bricklayers. Physical workload, musculoskeletal symptoms, sickness absence and job satisfaction were measured in both the intervention and control group before and after the introduction of raised bricklaying in the intervention group.

The results of this study show that most of the bricklayers strongly favoured the use of raised bricklaying devices. They perceived an increase in productivity and a reduction of physical load on the back. The physical workload (measured directly at the workplace and by means of video recordings) fell significantly in the intervention group as follows.

- The percentage of the workday spent with the trunk flexed more than 30° was reduced by 20% (from 60% to 40%).
- Time working with the trunk flexed more than 60° was reduced by 17% (from 38% to 21%).
- Time working with elevated arms was reduced by 8% (from 67% to 59%).
- No effect was found on the number of lifts. However, the vertical distance of lifting decreased, which reduced the amount of trunk bending.
- No effect was found on reported symptoms of back, shoulders or hands.
- Sickness absence decreased. During the intervention period, the number of bricklayers reporting sickness absence and the frequency of sickness absence for each employee was significantly lower in the group of bricklayers working with the raised bricklaying method. The two groups did not differ in terms of job satisfaction.

Baseline measurements of the longitudinal cohort study were taken in 2000 and a 4.5-year follow-up measurement was taken in 2005. During this period, activities were undertaken to encourage the use of ergonomic measures among Dutch bricklayers. These activities took place under the terms of a 4.5-year covenant between the Ministry of Social Affairs and Employment, employers' organisations and unions in the construction industry to reduce musculoskeletal complaints.

One of the objectives of the study was to examine the relation between an increased use of ergonomic measures and a decreased prevalence of musculoskeletal complaints in the low back and shoulders among bricklayers. The results showed that increased working height for picking up mortar significantly reduced the risk of low back complaints among bricklayers in the long term.

### *Adoption of this method by the bricklaying sector*

During the intervention study, interviews were held with employers in the bricklaying sector. From these interviews, it became clear the method was well-known in the sector. They had all heard about raised bricklaying - mostly through magazines, information days held by the sector organisation for bricklaying employers or from visits to other companies.

To determine if the working method has been adopted in the bricklaying sector, three independent studies have been carried out. Based on these studies it can be concluded that, six years after the start of the participatory project, more than half of the bricklaying sector is using the new working method. However, conclusions have to be drawn with care since these studies were small and all had methodological shortcomings.



## Evaluation

### Problems faced

Although the method of raised bricklaying was well-known in the sector, the study results are promising. But while the bricklayers are satisfied with this working method, the traditional working method is still used extensively. A number of reasons can be mentioned.

- **Cost of the devices.** Although the increased productivity and the decreased sickness absence will probably compensate for the cost of the devices, some companies are put off by extra costs.
- **Availability of the material.** Bricklaying is usually carried out by subcontractors. Subcontractors might be willing to use the devices needed for raised bricklaying, but they are dependent on contractors supplying the materials used. Often the communication between contractors and subcontractors is inadequate.
- **Lack of awareness.** Employers are often unaware of the risks of bricklaying according to the traditional working method.
- **Logistical problems.** There is often a lack of space on building sites, particularly in the centres of old cities and in renovation work, which complicates the use of stools or height-adjustable scaffolding floors.
- **Increase in the load of bricklayers' assistants.** Raised bricklaying is not favourable for the bricklayers' assistants as they have to lift the bricks higher than in the traditional situation.

### Success factors

An important reason given for adopting the method of raised bricklaying was its positive cost/benefit ratio. Employers also indicated that the investment not only concerned financial aspects, such as the purchase costs of the equipment, but also the time and knowledge necessary to implement the working methods in the production process. Another important reason for adoption concerned the improvements in work and health, and the increase in productivity. The employers that introduced raised bricklaying concluded the benefits outweighed the costs.

*The employers that introduced raised bricklaying concluded the benefits outweighed the costs.*

### Transferability

**Figure 16. A hoist-console scaffolding**



Raised bricklaying is easily transferable to other companies and to other countries. No extensive training of personnel is needed to introduce the method on-site. Moreover, the materials needed are easy to purchase.

The costs depend on the method chosen. Stools, placed on the scaffolding, are not expensive. Special hoist-console (HC) scaffolding demands a higher investment but has more advantages (see Figure 16), e.g. apart from the split floor, they offer the possibility of raising loads inside the scaffolding.

## Further contact

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### 3.2.7. Redesign of an ice-cream packing workstation

#### Background

Employees working in an ice-cream factory in Portugal were experiencing low back and shoulder pains. The tasks performed at the workstation involved packing ice-cream that was carried on a conveyor belt in front of the worker (see Figure 17A) into a box located between the conveyor and the worker (Figure 17B). The worker, who was seated, had to mount the cardboard box on the workstation, grasp five ice-creams with both hands and place them in the box. After four repetitions, the correct number of ice-cream units was inserted in the box. The worker then closed the box and lifted it to the second conveyor belt, which was located above shoulder height (Figure 17C). Full boxes weighed about 3 kg. The cycle was repeated approximately every 20 seconds. This was the main activity performed during the eight-hour shift.

Figure 17. Tasks performed at the workstation



In view of worker complaints, the head of the factory's safety and health department initiated the action. This involved a team of safety and health experts who performed a study on the target work situation.

#### Action

##### Assessment

After an ergonomic evaluation of the workplace, it was confirmed that MSD risk factors existed not only for the shoulders and back, but also for the wrist and neck. The activity produced an awkward posture in the neck, trunk and shoulder, and high repetition of forceful movements were performed above shoulder level. Furthermore, the handling of cold items with highly repetitive pinch motions presented a severe risk for wrist MSDs. This was particularly critical since the operators did not wear protective gloves.

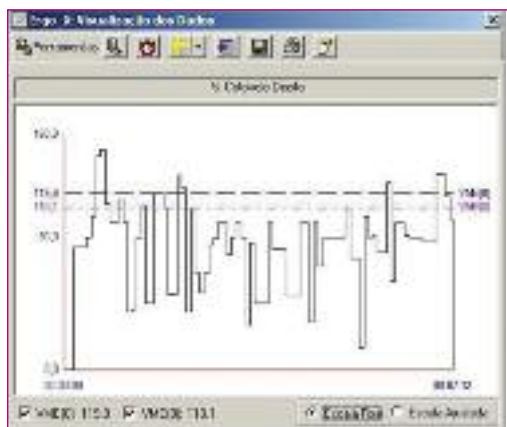
The evaluation was performed using the ERGO\_X system, based on objective and subjective data gathered by various means, including, video recordings and questionnaires. <sup>(1)</sup> The questionnaires were applied to all workers, while the videos were made at different packing workstations with different workers. The videos were analysed using ERGO\_X Tools software, an application of ERGO\_X that supports objective data collection based on images and video records. Figure 18 presents a screen showing the use of ERGO\_X Tools for the collection of postural data using a sample of video recording frames.

**Figure 18. Use of ERGO\_XTools to analyse worker movements**



Figure 19 shows a graph generated by ERGO\_X Tools which allows the extraction of different information regarding average posture angles, repetition rates or cycle duration.

**Figure 19. Graph generated by ERGO\_XTools**



The assessment concluded that workers were subject to a very high repetition rate of upper limb and wrist movements performed with a bent trunk. Basic ergonomic design principles were then checked in order to identify the corrective measures to implement.

<sup>(1)</sup> ERGO\_X is a patent-pending Fuzzy Expert System developed by Isabel Nunes to support ergonomic analysis and intervention in workplaces (e.g. regarding posture and MSDs).

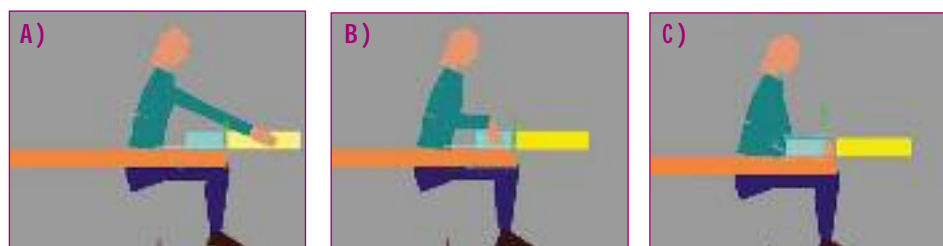


### Solution

The intervention focused on the redesign of the workplace using engineering measures.

The location of the upper conveyor belt was changed. It was placed perpendicular to the ice-cream conveyor between workers and at the same height as the bench where the boxes are filled. This allows the filled boxes to be slid onto the conveyor using rollers, thus avoiding the lifting of loads. Figure 20 shows the modified packing cycle resulting from the new workplace layout.

**Figure 20. Modified packing cycle**



At an organisational level, managers were advised to schedule the rotation of the workers two workstations each day. On other hand, packing operators were encouraged to alternate between seated and standing positions. Given that cold is a risk factor for some wrist and hand disorders, managers were advised to provide workers with thermal insulating gloves. These would also prevent the ice-creams slipping in their hands.

### Results

After the implementation of the measures, a reassessment was performed using the same methodologies. A significant improvement in working conditions had been achieved as there was no longer the need to lift the arms above shoulder level. There was also a reduction in the risk of wrist/hand MSDs due to the reduction in forceful exertion and exposure to cold. From the workers' side, there was a significant decrease in the number of complaints of shoulder and low back pain. Both results were good objective and subjective indicators of the success of the implemented measures.

### *Evaluation*

#### Problems faced

There were no major problems associated with the action. The modifications were performed during a factory maintenance stoppage and most of the equipment was reused. This meant there was no significant financial impact from the intervention.

#### Success factors

As mentioned above, the intervention did not result in significant financial costs because the main action was carried out during a production pause and the equipment was reused. The organisational modifications were also easy to implement because the factory has different workplaces that do not require particular skills. This rotation also has other advantages; it reduces repetition and monotony, promoting work variety and job enrichment.

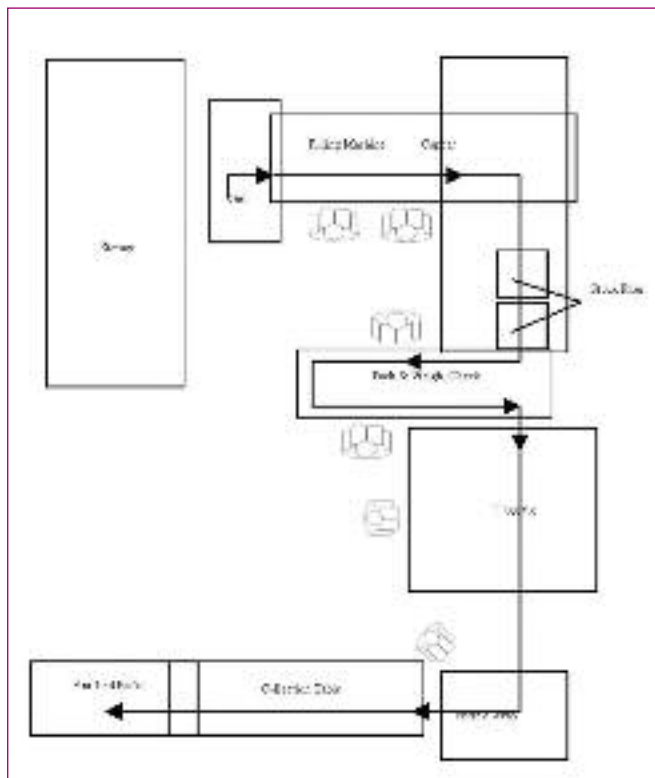


### 3.2.8. Redesign of a hand packing line in the pharmaceutical industry

#### Background

In a pharmaceutical plant in the UK, tablets were packed into vials by hand. Packing had been done this way for 10 years. Figure 21 shows the original layout of the packing area.

**Figure 21. Original layout of the packing line**



Orders for small quantities of tablets were packed by hand because this was more cost-effective than running the large capacity automatic packers.

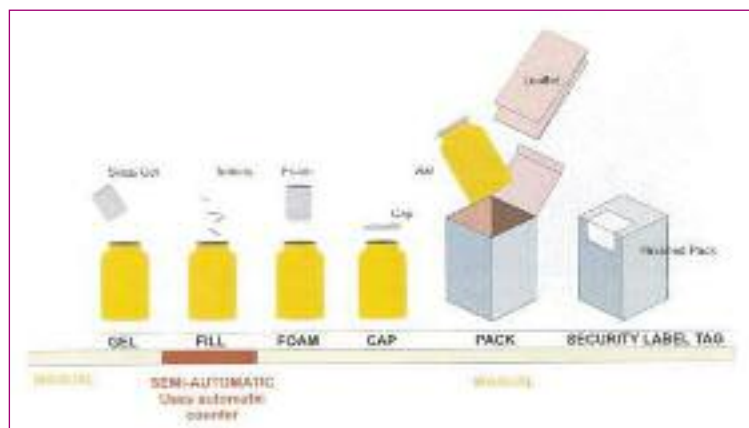
All stages of the process were undertaken manually except for the counting of tablets, which was performed by machine (see Figure 22). There were five stages to the process:

- inserting silica gel, tablets and foam (one operator);
- capping (one operator);
- packing and weighing (two operators);
- tagging (one operator);
- shrink wrapping and collating (one operator).

Once each operator had finished his/her part of the process, the vials were moved on to the next stage. Stockpiles of part-finished product built up as some stages were faster than others.



Figure 22. Stages in the packing process



However, there were ergonomic problems that made the job difficult to do and increased the risk of MSDs. The nature of the job meant that most activities were carried out sitting down and required repetitive movements of the upper limbs. Problems with the process arose because:

- most operators were not seated facing each other and they had to twist to communicate;
- a number of stages required the operators to twist to collect or move the vials;
- tables were at different heights and some were unstable, which made the transfer of materials more awkward;
- the tables tended to bow in the middle;
- some of the chairs were broken;
- most of the chairs were not adjustable;
- the work process appeared to be disorganised and was unclear;
- team morale was low.

It was evident that staff were at risk of developing upper limb disorders and back discomfort.

Operators worked a 7.5-hour day, with two 15-minute breaks and a 30-minute break in the middle of the day. Job rotation was practised to give operators some variety in their work and to allow different muscular activities to be carried out. Although it was considered to be of some benefit in reducing the risk of MSDs and fatigue, job rotation did not fully address these and other ergonomic problems associated with the work.

In addition to the risk of developing MSDs, the organisation of the working area resulted in the following problems.

- There was a long cycle time. It took over three hours for a pack to go from the start to the finish of the line. As a result, work-in-progress was often up to 1,500 packs part-finished.
- It was difficult to estimate how long jobs would take. Additional operators were brought in regularly to help clear backlogs and overtime costs were approximately £55,000 (~ EUR 82,000) per year.



- Inadequate storage for components resulted in operators having to collect supplies frequently.
- Working conditions were cramped because of the need to store items waiting to be progressed.
- Communication between operators was difficult because of the layout.
- Although staff worked continuously, production targets were frequently not met.

The company was aware of these problems and investigations into productivity levels established that morale within the team was low. The investigation also revealed that operators were working under pressure and frequently adopting poor postures. Both these factors are associated with increased risk of developing MSDs. Once these problems had been recognised, the company decided to act.

### **Action**

#### Description

It was accepted that the operation needed to be reorganised - based upon sound ergonomic principles - to improve the layout, storage facilities, flow of vials and transfer of items between operators.

The Kanban method of workflow analysis was employed to investigate the process and make it more efficient. The six-person team working at the hand packing line attended a training course to understand the principles underpinning Kanban and the system for continuous improvement.

Following their training, the team reorganised their work area in a series of trials to remove imbalances or 'bottlenecks' in the process. They held meetings to discuss their ideas to improve the layout and made video recordings so that they could gain an overview of the workflow.

The team aimed to design a layout that allowed the vials to be passed on by hand in a comfortable and efficient manner (i.e. with no extended reaching or twisting of the body). They also wanted to enhance communication between team members.

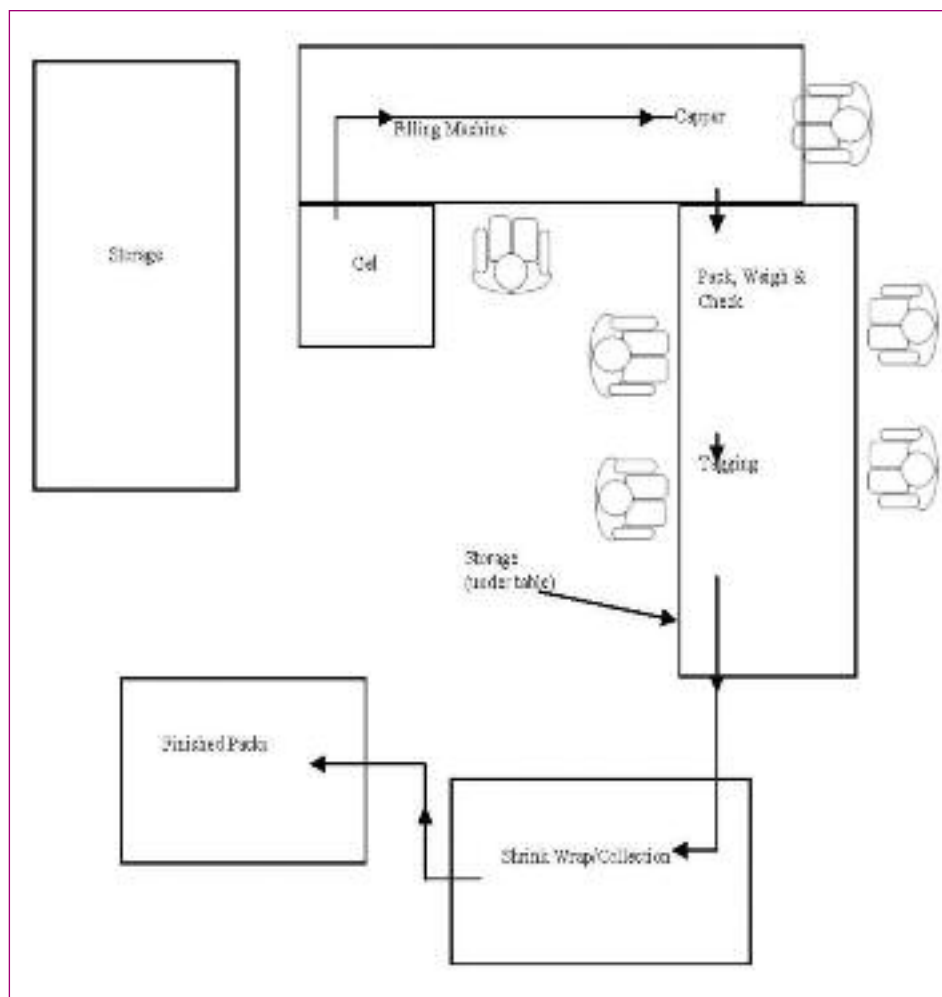
After considering straight line and U-shaped arrangements, the team decided that an L-shaped option would be best (see Figure 23). The other activities shown in Figure 23 (shrink wrapping, collation and storage tables) were located nearby. The L-shaped layout allowed all components to be passed by hand in a comfortable manner, without overreaching or twisting. Communication was found to be easiest with this layout.

The team presented its proposal to managers who agreed that a budget of £5,000 (~ EUR7,500) would be provided to implement the reorganisation. Quotes were obtained from local suppliers and a local company was engaged to install the new layout.

In addition to the new layout, better tables and chairs were purchased. The team specified that the tables should not have sharp edges or bow in the middle when loaded, and should be resistant to vibration (which affected the accuracy of the weighing scales). Adjustable chairs were selected, which all members of the team agreed could be used comfortably when performing their work.



Figure 23. Proposed new layout of the packing line



Mobile storage units were provided that fitted under the tables. These enabled operators to keep their work area tidy and reduced the number of trips made to retrieve components.

Other changes were made to the workstations and the area to improve the amount of space available, e.g. providing smaller boxes for components (see Figure 24) and allowing the waste bins to be stored under the tables (see Figure 25). An illustration of the new line layout is shown in Figure 26.

Operators rotated jobs every hour to provide some variety to the postures adopted and the range of movements made. This reduced the risk of fatigue associated with repetitive actions.



**Figure 24. Smaller boxes of caps increased the working area**



**Figure 25. Storage under table for waste bin**



**Figure 26. Packing line layout after the redesign**



## Results

The principal ergonomic benefits are summarised in Table 8.

**Table 8. Benefits of the ergonomic redesign**

Interventions	Benefits
Adjustable seating, better work surfaces	Operators can adapt the seating to suit their needs when performing the task rather than having to compromise their posture to fit the workplace.
Efficient use of space	The new layout reduced the need to adopt awkward postures and improved communication between workers.
Better work flow, layout and organisation	The risk of developing musculoskeletal disorders was reduced by: <ul style="list-style-type: none"> <li>• reducing the need to twist and stretch;</li> <li>• balancing the flow of work;</li> <li>• job rotation.</li> </ul>
All above	Improved morale. The working conditions were better and each team member made a significant contribution to improving his/her workplace.

In addition, the workflow and productivity benefits included the following.

- Cycle time was reduced from three hours to five minutes as stockpiling was avoided.
- Work in progress was reduced to 50 packs part-finished.
- Productivity targets were consistently met.
- There was a 25% increase in productive hours for the line.





*A participatory ergonomics approach is beneficial to both management and workforce.*

The financial benefits accruing from the intervention over the first two years following implementation are summarised in Table 9. The cost of the equipment, materials and installation amounted to £2,900 (~ EUR4,300), although £5,000 (~ EUR7,500) had been budgeted. The Kanban training was carried out in-house. The wages cost of the training and the subsequent project meetings were estimated at £9,000 (~ EUR13,400). The 25% increase in productive hours brought about a saving of nearly £55,000 (~ EUR82,000) in overtime payments during the following 12 months. The payback period therefore was approximately three months.

**Evaluation**

Transferability

The study demonstrates the benefits to both management and workforce in terms of reduced musculoskeletal pain and discomfort, improved well-being and job satisfaction, and considerable gains in economic productivity, of applying a participatory ergonomics approach to introducing changes on a hand packing line. It also demonstrates the benefits of encouraging the workforce to participate fully in the team given the task of designing and implementing the improvements required.

**Table 9. Summary of costs and benefits**

<b>Direct intervention costs</b>	
Staff time for Kanban training and implementation of proposals	£9,000
Purchase of equipment, tables and chairs	£2,900
	£11,900
<b>Annual pre-intervention costs</b>	
Overtime payments	£54,815
Work in progress costs - labour included in overtime payments	
Work in progress costs - materials (note 2)	£4,688
	£59,503
<b>Annual post-intervention costs</b>	
Overtime payments (note 1)	£5,000
Work in progress costs - materials (note 2)	£156
	£5,156
<b>Annual post-intervention cost savings</b>	
	£54,347
<b>Conclusion</b>	
The process lifecycle is assumed to be three years from the date of intervention.	
<b>Total cost of intervention</b>	£11,900
Net present value of post-intervention cost savings over the process lifecycle at an 8% discount rate, £59,347 per annum for three years	£151,262
<b>Net intervention benefit</b>	£139,362
	(~ EUR208,000)
<b>Payback period</b>	2.83 months
Base price year is 2000	



**Note 1**

**Overall reduction in overtime hours with no change in line output achieved from:**

**Reduction in WIP repackaging labour costs**

Overtime at £18.59 per hour (including overhead costs) cost 5% of the packs part-finished (1,500 to 50) over 250 days at 5.1 minutes per average repack

Hours	Cost
1,541	£28,647

**Increase in productive hours with an increase in line output**

Productive hours achieved pre-intervention  
 Productive hours achieved post-intervention  
 Increase in productivity at £12.39 per hour (including overhead costs)

8,448	
10,560	
2,112	£26,168

TOTAL

£54,815

**Note 2**

Work in progress costs

The additional labour cost is included within the overtime costs

Material wastage:

Repackaging costs estimated at:

5% of 1,500 packs part finished x 250 days x £0.25

£4,688

5% of 50 packs part finished x 250 days x £0.25

£156,000

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# 3.3. ORGANISATIONAL AND ADMINISTRATIVE INTERVENTIONS

## 3.3.1. Ergo Sheets in the manufacture of health care products

### Background

Figure 27. Ergo logo



Johnson & Johnson is a worldwide manufacturer of health care products as well as a provider of related services for the consumer, pharmaceutical, and medical devices and diagnostics markets. The Johnson & Johnson credo is to protect its employees. One way of attaining this is Ergo - Johnson & Johnson's Worldwide Ergonomics Initiative. Figure 27 shows the Ergo logo.

Ergo seeks to build an ergonomics culture by using various processes and tools. The Ergo Job Analyzer (EJA) is one of these tools. It is used to:

- evaluate ergonomic risks and improvement opportunities;
- assess the severity of risk;
- develop improvements;
- measure the effectiveness of improvements in a job.

All tasks within Johnson & Johnson have to be assessed and classified as high, moderate or low risk (HR, MR, LR) using the EJA. In this way, tasks can be prioritised according to risk, severity and frequency (as calculated by the EJA). Logically, tasks with the highest risk have to be addressed first.

### Action

#### Description

A technical solution has been identified for every high-risk task at the Global Pharma Supply Group at Val de Reuil (France) where pharmaceutical and cosmetic research, production and packaging are performed. While waiting for the implementation of these solutions, the company is introducing administrative controls to make sure the employees involved are protected. In addition to job rotation, one of the administrative controls is the so-called 'Ergo Sheets' (or 'Ergo Safety Sheets').

The Ergo Sheets are meant as an administrative control measure for high (and also medium) risk jobs. Each Ergo Sheet is a one-page information sheet that describes the safest and most ergonomic way to perform a certain task. An Ergo Sheet contains the following data (see Figure 28):

- identification (code) of the task/workstation and department
- reference number of the Ergo Sheet
- name of the workstation



- photo (or photos) of the workstation and its organisation, explaining the use of certain elements
- other pictures which demonstrate the best ergonomic way of working.

The Ergo Sheet covers all tasks with a residual Ergo risk or where an administrative solution is needed. At present, there are about 150 sheets in the company. All the Ergo team members and employees, as well as the medical and environment, health and safety (EHS) department, are involved in the process of producing an Ergo Sheet. This corresponds to an average of three people spending 20 minutes per sheet. The estimated cost per sheet is EUR50, which can be ascribed to the validation and in-the-field training by an ergotherapist.

The sheets can be found at the workstations concerned, nearest to the risk at the workplace (stuck on the wall in front of the risk). The sheets have also become part of the safety induction and the safe work permit for every employee, including temporary workers. Finally, the safe behaviour is observed on a regular basis according to the company's safe behaviour programme. Internal processes (e.g. cross-inspection, self-inspection, the internal Ergo audit and 5S inspection) provide opportunities for employees to check their knowledge about the Ergo Sheet(s).

Figure 28. Example of an Ergo Sheet



© Johnson & Johnson



**Figure 29. Johnson & Johnson Ergo award**



### Results

Ergo Sheets help the company to control high ergonomic risks for which the identified technical solutions have not yet been implemented. By introducing the Ergo Sheets, the French company won a Johnson & Johnson Ergo award (see Figure 29).

The introduction of the Ergo Sheets resulted in:

- a reduction in work-related health problems;
- an increase in awareness, practical safe behaviour and early recognition of ergonomic-related hazards.

*When there are many competing OSH priorities, it is possible to introduce temporary risk control measures while waiting for the implementation of definitive technical solutions.*

### Evaluation

#### Problems faced

No real problems were encountered regarding the deployment and employee participation. This can mainly be put down to the fact that:

- the action concerns a peer-to-peer message;
- the action explains and demonstrates to employees something for their own benefit, in the field and near to the risk (which makes it very real);
- the employees recognise themselves in the photograph (so it's not a message coming from the management or EHS department);
- the application and follow-up are observed by employees on their daily job.

#### Success factors

The Ergo Sheet concept helps to achieve a real, shared Ergo cultural approach, deployed and maintained in the field, in the heart of the job, within a complex organisation that incorporates:

- different business cultures (pharmaceutical and cosmetic);
- different activities (warehouse, production, packaging, labs, computer workstation, etc.);
- diverse categories of employee (temporary workers, employees, contractors, etc.).

#### Transferability

The idea and format of the Ergo Sheet have already been introduced in other companies of the Johnson & Johnson Global Pharma Supply Group. As it concerns an administrative prevention measure, the idea of the Ergo Sheets is easily transferable to other industries and countries. However, attention should be paid to the fact that these sheets are not the ultimate preventive solution for ergonomic (MSD-related) problems: they are only a mechanism for controlling high risks when waiting for the implementation of definitive technical solutions. It should also be stressed that the Ergo Sheets are a small part of a whole ergonomics culture.

### Further contact

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### 3.3.2. Ergo Guide concept in the pharmaceutical industry

#### **Background**

An occupational safety and health management system was implemented at Baxter AG Vienna several years ago. In spite of this, the annual accident rate of 40 (with at least one day's absence) with 1,900 employees was still not satisfactory for a health-conscious company. Thus, it seemed necessary to take further action to improve both the behaviour of the employees and their working conditions.

Actions were integrated into a strategy and a programme for safety and health was developed. An important part of this programme is the Ergo Guide Concept (EGC). Other elements include periodical employee surveys, inclusion of safety and health as issues for QLP (Quality Leadership Process Teams), and safety training for the first line management.

The Ergo Guide Concept was developed in cooperation with the Austrian Worker's Compensation Board, human-ware GmbH (Institut für Gesundheit, Sicherheit und Ergonomie im Betrieb), the company physician and the company's internal safety expert.

#### **Action**

##### Description

The aim of the EGC is to give all employees who are involved directly or indirectly in workplace design (e.g. workplace designers, members of the purchasing department, members of the IT department and at least one member of each other department) basic knowledge about:

- ergonomics (stress and strain, unfavourable strain, effects of bad and good working conditions, approaches to prevention);
- different types of unfavourable strain;
- methods of analysis and assessment;
- the scope for improvement and how improvement actions can be made accessible in a systematic way.

The EGC is not an isolated training course. The participants obtain improved awareness of the working conditions within the company and become competent to put the taught knowledge into practice, particularly during the planning of new workplaces and modifications.

The core of the EGC is a three-stage workshop process:

- basic workshops
- two workshops covering topics in more depth
- annual follow-up workshops.

Table 10 summarises the scope of the various workshops.



**Table 10. Outline of the workshop sequence**

Type	Description
1. Basic workshops (1 day)	During this workshop, the participants get a general idea of the field of ergonomics in theory, supplemented with active exercises.
2. Two in-depth workshops for office and manufacturing/laboratory (2 days)	<p>Those attending these workshops are assumed to have been to the basic workshop. In these longer workshops, information is given on assessment methods in the workplace and possibilities for improvements. The splitting of office ergonomics and manufacturing/laboratory ergonomics enables a specific deepening of knowledge. Exercises, group work, in-company examples and lectures are offered. On the second day, the participants work on ergonomic projects in groups. They have to assess the workplace of a group member, develop improvements and present the project to the other workshop participants.</p> <p>Those attending the basic workshop and the in-depth workshops receive a certificate as an 'Ergo Guide'. They are now competent to carry out an ergonomic workplace analysis and to develop and evaluate improvements on their own. 'Ergo Guides' have to be sensitive to ergonomic problems in their own department and develop improvements with assistance from the environment, healthy and safety (EHS) department and the company physician.</p>
3. Annual follow-up workshops (1 day)	The core of these workshops is the exchange of experiences among the 'Ergo Guides'. Implemented projects (best practice) are presented by the 'Ergo Guides' and discussed. Special ergonomic issues can be presented on request.

During all workshops, seven issues of ergonomics are dealt with:

- postures and movements at the workplace
- measurements at the workplace and work equipment
- working time
- work-related psychological stress
- climate and indoor air
- light and lighting
- noise.

These issues also feature in real in-company examples.

#### Results

From the start in 2000 till the end of 2005, more than 170 Ergo Guides from over 60 departments of Baxter AG were trained. Overall, more than 10 major projects and a multitude of smaller projects were initiated and carried out by Ergo Guides (see the example below). Many projects resulted in additional benefits such as improvements in the working process and/or quality or environmental improvements. The Ergo Guides also became competent in project management and presentation skills.

During the first three years of the EGC, the accident rate fell by about 29% and sick days decreased by about 50%. These figures are consequences not only of the EGC but also of other projects such as a 'Safety Behaviour Training'.



*Example of an Ergo Guide project: manipulation of a 23 kg heavy centrifuge rotor*

Before:

The movement of the rotor was performed manually. The first step was to pull the rotor out of the centrifuge and carry it to a work bench. Then the fluid content of the rotor was drained into a container manually (working posture, movements, effort).

**Figure 30. Pulling out the rotor with a ceiling-mounted lifting tool**



After:

The rotor is lifted using a ceiling-mounted lifting tool (see Figure 30) and placed on a special trolley. Up to eight rotors can be transported and manipulated with this trolley (see Figure 31). The rotors can also be drained by pivoting the upper part of the trolley with the rotors without awkward postures and movements (see Figure 32). The effort necessary is a fraction of that with manual handling.

**Figure 31. Transport of eight rotors using the trolley**



**Figure 32. Draining the rotors with the pivoted trolley**



**Evaluation**

A project to evaluate the effects of the EGC began in July 2006 and the final results were foreseen to be available in spring 2007. Preliminary results from a survey of executives about the Ergo Guides show that they are well-known as consultants for ergonomic workplace design and that the ergonomic improvements also lead to an optimisation of tasks.

**Transferability**

The EGC can be used in an adapted form in all companies with ergonomic needs. The main reason for the success of the concept is the direct reference to the company and the integration of the suggestion system. Necessary adaptations for other companies are made according to the seven ergonomic issues. All photos and examples must be adapted to the company concerned.

**Further contact**

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*Training the employees involved in workplace design in OSH helps to improve working conditions.*





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### 3.3.3. Intervention at a hypermarket checkout line

#### *Background*

A hypermarket in the Lisbon area of Portugal has a checkout line with 80 terminals. Each terminal includes an optical bar code reader located in a frontal position by the side of a keyboard which includes the magnetic card reader and a printer. The top cover of the cash drawer is the desktop of the checkout terminal. The checkout has two side conveyor belts; one to feed the terminal and the other to take the articles to the packing zone. Terminals are paired using a layout where the operators are stationed back to back. This way, half the terminals are right-side fed and the other half are left-side fed.

The checkouts employ about 250 workers, which is approximately 30% of the hypermarket workforce. The majority (84%) of operators are females. Most of the workers (78.2%) have worked for the company for less than three years.

Despite the youth of workers and the short time they have spent performing the task, the occupational physician frequently received complaints about wrist, shoulder and back pain on the checkout sector. Based on the occupational health records, about 15% of the checkout operators were affected by MSDs, mostly in the shoulder (shoulder tendonitis) and wrist (carpal tunnel syndrome and De Quervain's disease), but also in the neck (tension neck syndrome) and back (low back pain).

The information about the worker complaints and already diagnosed MSDs was the trigger for action. A team of safety and health experts, together with the occupational physician and some workers, performed a study on the target work situation. As the company has several hypermarkets nationwide that share the same checkout layout and organisational procedures, the study had an impact on the company throughout Portugal.

#### *Action*

##### Assessment

An initial ergonomic evaluation of the workplace confirmed the presence of MSD risk factors for upper limb disorders and back. The evaluation was performed using the ERGO\_X system, based on objective and subjective data gathered by means, for instance, of video recordings and questionnaires respectively. <sup>(1)</sup>

The videos were taken on different checkouts with different workers and were used, for example, to evaluate postural angles, number of repetitions and cycle times. The



videos were analysed using ERGO\_X Tools - an application of ERGO\_X that supports objective data collection based on images and movies. Figure 33 presents a screen demonstrating the use of the ERGO\_X Tools for the collection of postural data using samples of video recording frames.

**Figure 33. Use of ERGO\_X Tools to analyse worker movements**



Questionnaires were given to a group of 34 workers with two or more years of service. This group corresponded to 42% of the total of checkout operators (102 workers) who fulfilled the selection criteria.

The assessment concluded that workers were subject to a very high repetition rate of shoulder and wrist movements performed with a bent and twisted trunk. On the other hand, checking out products involved lifting some heavy loads with a pinch grasp, while rotating the body and twisting the wrists.

Basic ergonomic design principles were then used to identify the corrective measures to implement.

#### Solution

No major engineering actions were identified since, as mentioned above, the checkouts had conveyer belts, the workers operate on the normal work zone, and the displays and keyboards were in front of the workers. Within this area of ergonomic intervention, however, the workstations were provided with anti-fatigue mats to improve comfort while workers are standing.

Therefore, the main corrective intervention was based on organisational measures. The first one was to perform a daily task rotation from left-feeding checkouts to right-feeding checkouts in order to distribute the workload on the joints more evenly. In fact, it was observed that the exertion was not symmetrical on both side joints, particularly when the workers are seated.

Workers were encouraged to alternate between seating and standing positions. Working in a seated position increases the muscular strain on the shoulders and back because the upper limbs are working at a greater height and the trunk rotation is high. When standing, the load on the neck and back is increased since the operators look downwards most of the time and bend frequently.

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*A participatory approach raises awareness of the problem, facilitates finding an adequate solution and improves compliance with the proposed actions.*

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## Work-related musculoskeletal disorders: Prevention report

Education and training were provided on how to handle materials during scanning in order to avoid lifting loads.

Another measure was to promote the workers' awareness about the risk factors that lead to MSDs by means of education sessions and the display of posters.

### Results

After a six-month period following the implementation of the identified measures, there was a significant decrease in the number of complaints. The feedback obtained on the follow-up of the actions also demonstrated an increase in the level of workers' satisfaction. Both results were good objective and subjective indicators of the success of the implemented measures.

### *Evaluation*

#### Problems faced

No major problems were encountered during the action. The workers adhered to the intervention and participated actively in the analysis of the workstations, and in the identification and implementation of the intervention measures.

#### Success factors

The intervention did not require financial support since the main action focused on adequate tasking of the workers to the checkout terminals. The adoption of a participatory ergonomics approach involved:

- the workers gaining awareness about the problem;
- finding an adequate solution;
- complying successfully with the implemented procedural changes and the behavioural change recommendations.

Another success factor was the common view shared by all the participants on the process.

#### Transferability

The identified intervention is applicable to all the company's other shops and to other checkout terminals that share an identical layout configuration.



### 3.3.4. Intervention in a distribution centre

#### Background

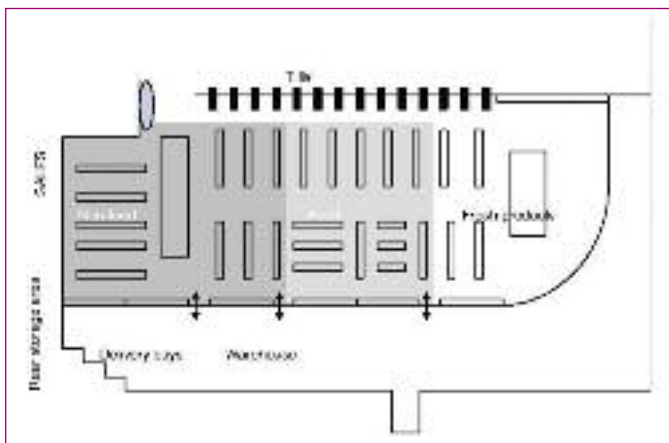
Ergonomic measures were introduced at one of the outlets of a major Swiss store chain with a view to preventing back pain. The initial application followed a study of the causes of sick leave in the chain. The business employs 45,000 people and includes production, warehousing and retailing units. As chronic back pain proved to be a major cause of absences in the company, in particular among sales staff, the management decided to introduce certain ergonomic changes in one of the company's shops in order to identify and prevent risk factors for back pain among sales staff.

#### Action

##### Description

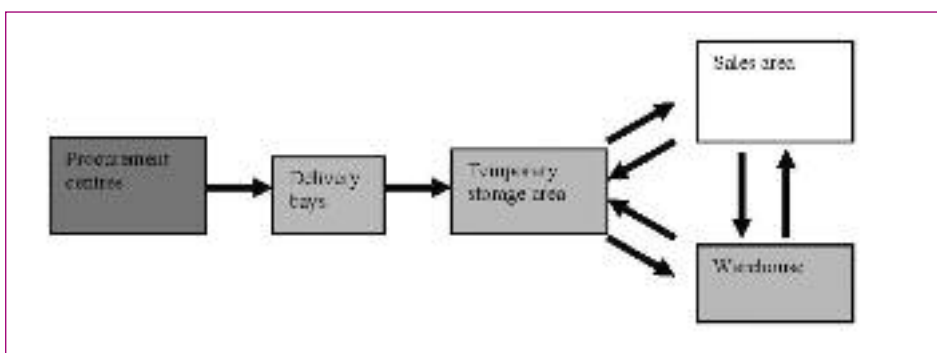
The shop employs 200 people and is split into a storage area for goods and a sales area organised into three departments (food, non-food and fresh products) (see Figure 34). The sales staff is divided into teams for each department.

Figure 34. Layout of store



Preliminary analysis revealed problems in the cooperation between the different trades and it proved essential to carry out a workflow analysis. The goods flow is shown in Figure 35.

Figure 35. Goods flow



Orders for goods are prepared on pallets in the procurement centres. The goods are then taken by lorry to the shop's delivery bays. Warehouse staff unload the lorries and put the goods in the temporary storage areas using fork-lift trucks. Sales staff then manually take charge of the goods for which they are responsible and arrange them either in the warehouse or directly in their sales departments.

### Assessment

The work of the different trades was analysed following the workflow by which goods were dealt with. An examination of instructions, observations recorded in writing and in photographs, and interviews conducted at the same time generated an understanding of the constraints upon, and resources available to, the different trades and the way in which activities at different stages of the goods flow are interdependent. The work of about 15 people during a very busy period of approximately 150 hours was analysed from the beginning to the end of their shifts.

This analysis revealed the following diagnostic elements, which can influence the emergence of back pain.

- The mixing of goods on the pallets arriving from the procurement centres hindered sales staff in the sorting and handling of goods when they took charge of them.
- The small size of the storage area at the back of the shop relative to the volume of goods handled considerably limited the room for manoeuvre available to warehouse staff and sales staff in storing the goods. Items had to be repeatedly rearranged, resulting in considerable loss of time and waste of energy.
- The procurement centres and, to a lesser extent, the sales staff were not fully informed of delivery times and what would be delivered. This meant the warehouse staff could not plan their work in advance and organise the temporary storage of goods better so as to facilitate the work of the sales staff. This general lack of organisation impacted in turn on the work of the sales staff.
- There was a lack of equipment to assist in warehousing and shelf filling, which meant sales staff were compelled to work in awkward positions and to carry out repetitive actions.
- Staff were unable to turn their hand to a variety of tasks, which meant extra work when replacements are required.

Problems relating to space, equipment, shelf-filling aids and, above all, a lack of communication and collaboration between the different trades constitute risk factors for back pain among the sales staff.

The work analysis revealed that insufficient weight was given to interaction between the work of the different trades in the course of the goods flow. Work was not organised in terms of communication and collaboration. The absence of either a spatial or organisational interface, and a lack of knowledge about the work of others, made exchanges between the different stages of the process difficult. The result was limited room for manoeuvre on the part of workers, a disorganised process and additional work and awkward working positions for sales staff.

### Solutions

Working groups drew up proposals for changes which were then discussed with management.

- Certain high areas in the warehouse were used illegally during very busy periods. It was agreed that these areas should officially be arranged in such a way as to allow



warehouse staff to use them properly, and thus to increase and optimise options for storage and for organising goods in the temporary storage areas.

- Storage solutions and shelf-filling equipment were suggested to sales staff to allow them to organise, regroup and arrange goods more easily - both in the warehouse and in their departments.
- Knowledge transfer (mini training schemes) between the different trades was proposed to improve versatility, understanding and collaboration between those working at different stages of the work flow.
- A daily exchange of information (meetings, verbal and written communications) regarding delivery hours, content and changes, and thus the preferred place of storage would allow the work of the warehouse staff to be planned better, which in turn would facilitate the work of the sales staff.

Unfortunately, reorganisation of the procurement centre so as to avoid the mixing of goods on pallets appeared difficult to negotiate at this level.

#### Results

It is too soon to measure the effects of these changes on the rate of absences caused by back pain.

### **Evaluation**

#### Problems faced

The work analysis was carried out during a very busy period and the problems appeared worse than during the rest of the year.

#### Transferability

This action illustrates the importance of exchanges between different trades and between the different stages in the work process from beginning to end: work in practice transcends the boundaries defined by the prescribed organisation of the work. The workload of staff is increased by their lack of room for manoeuvre, which in turn stems from the inadequate collaboration and communication between the different stages of the process and from the absence of any kind of interface.

The action was taken in a major company which covers all stages in the process from production to sales. It proved relatively easily to demonstrate the considerable interdependence which exists between the different stages in the work flow. Such interaction is more difficult to define and manage in smaller companies where subcontracting segments the work flow more. Nonetheless, where tools exist to manage inter-company flows, it is important that they are used and developed in such a way as to facilitate communication and collaboration between the different trades. However, the growing trend for subcontracting means it will become more and more difficult to take action in such an organisational context.

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*Communication and collaboration between the different trades/ departments of a company is beneficial for optimising working conditions.*

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### 3.3.5. Ergonomic Improvement Teams in the pharmaceutical industry

#### **Background**

GlaxoSmithKline (GSK) is a world-leading research-based pharmaceutical company. All lost time incidents in the previous year at a particular GSK site were caused by work-related MSDs. The site employs approximately 1,400 staff working in product laboratories and offices, site maintenance, warehousing and plant rooms.

An intervention programme was set up based on the following key business drivers:

- the increasing number of musculoskeletal injuries resulting in absence
- the costs associated with the injuries
- regulatory compliance and the reduction of enforcement action
- the reduction of product cycle waste
- the improvement of efficiency in the workplace
- to support the UK Health and Safety Executive's programme to reduce MSDs.

#### **Action**

##### Description

In 2001, managers at GSK implemented their first Ergonomic Improvement Team (EIT) at a UK manufacturing site. The objectives of the EIT were to:

- investigate the increasing numbers of lost time MSDs;
- identify and assess associated risk factors;
- achieve operational excellence.

Sponsorship for this initiative was obtained from senior management to ensure that appropriate resources would be made available. The use of an EIT enabled employees to participate in the improvement process by identifying ergonomic hazards and seeking solutions to reduce the risk of MSDs. End user involvement in work system interventions had been recommended in a review of work-related neck and upper limb musculoskeletal disorders published by the Agency (Buckle & Devereux, 1999).

Representatives from across the site were carefully selected to join the EIT on the basis of their positive attitude, good communication skills and prior experience. The team had a relatively small number of members in order to facilitate good communication and effective management. A site champion was appointed to lead the initiative and an external ergonomics expert engaged to help the team focus on, and address, the most significant work issues.

The EIT members participated in an initial two-day training programme based upon their needs which focused on the specific ergonomics issues commonly found at work in the pharmaceutical industry. The training ensured that team members understood:

- the overall strategy;
- the importance of interactions between work system factors;
- how to perform ergonomic risk assessments accurately;



- how to facilitate changes to equipment;
- the processes to reduce exposure levels to multiple MSD risk factors.

Each team then began the systematic assessment of work systems to reduce risk factors associated with:

- the organisation of work;
- the work environment;
- the workplace or tool design;
- the technology used or the training provided;
- the risks from individual worker behaviour.

The ergonomic improvement strategy employed is illustrated in Figure 36.

**Figure 36. Ergonomic improvement strategy**



The level of occupational injuries and illness cases within each work system were investigated and the tasks known to be at higher risk identified. Each EIT member also held discussions with employees about the tasks they perceived as exposing them to the greatest risk, or imposing the greatest physical or mental demands within their work area.

Appropriate risk assessment methods were chosen for the EIT members that:

- were straightforward to use;
- identified the relevant risk factors for the type of ergonomic problems being addressed;
- allowed accurate identification of risk factors and assessment of exposure levels.

For example, a discomfort form was used to gather information from employees, which was re-administered after the intervention to verify the reductions in intensity, frequency and duration of discomfort and symptoms of MSDs.

In some circumstances, the analysis of exposure levels to MSD risk factors required the use of advanced methods, e.g. video observation analysis, or biomechanical modelling to evaluate spinal compression forces. These methods were used only by





the expert ergonomist, who provided the data to the EIT to assist members in their evaluation of the tasks concerned.

The results of the risk assessments enabled potential solutions to be identified. The same risk assessment methods were used subsequently to conduct post-intervention assessments to verify the effectiveness of the solutions found.

In addition, EIT members played a critical role in ensuring 'early reaction' to reports of individual MSD cases. An assessment was conducted to identify and address the causes of an injury when it was presented to medical staff. The EIT worked closely with medical and safety personnel, and the area supervisor, to determine:

- if the injury was work-related;
- the aspects of the task or equipment that may have contributed to the injury;
- the changes necessary to eliminate or reduce exposure to MSD risk factors.

Employees were included in the development of any potential improvements. Trials and mock-ups of the proposed improvement were constructed before decisions were made; this allowed 'in place' testing to determine whether the solution was viable. Employee feedback on any trials or mock-ups was recorded using a simple survey or questionnaire. If any new mechanical devices were proposed, it was found to be essential to train the users so that they were fully conversant with them prior to the trial to ensure a realistic evaluation of the device concerned.

The EIT worked in partnership with staff from engineering, maintenance and operations to identify and agree project plans for interventions. Following their introduction, the EIT monitored the change and verified that the risk reduction solutions remained in place.

### Results

Twelve months after the participatory ergonomics programme was initiated at the site, 31 work system improvements had been implemented.

- One intervention involved automation and thus eliminated human involvement.
- Two interventions mechanised the work process and thus eliminated the risk, though human involvement remained.
- Three interventions used administrative controls involving changes to job design or work policy.
- Twenty-five interventions reduced exposure to multiple risk factors for MSDs by introducing new equipment, repositioning or modifying existing equipment, and introducing new ways of working.

In addition, there was a 40% reduction in MSDs attended to on-site by the company physician during the year. No reduction in MSDs was observed over the same time period at a similarly sized GSK manufacturing site that did not initiate an EIT.

Within three years, the EIT was considered a resounding success having resulted in the following additional improvements:

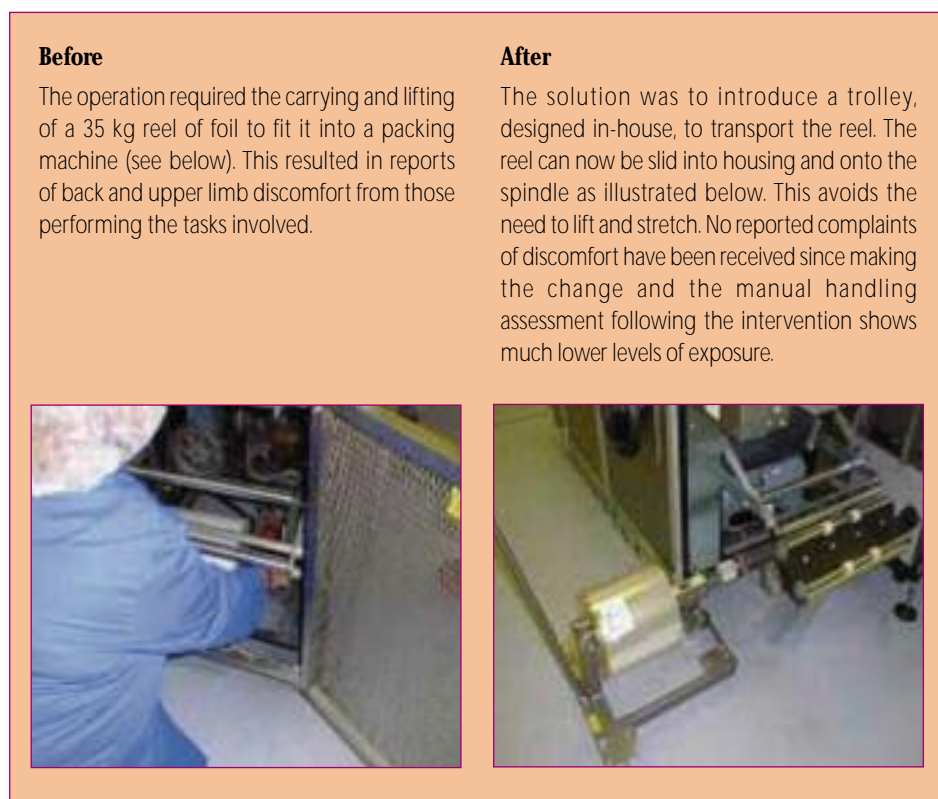
- 65 ergonomic improvements implemented and evaluated in total
- 160% increase in ergonomic hazards reported
- efficiency savings and reduced cycle times of up to 40%



- best ever employee health and safety performance - 3.4 million hours work free of lost time illness and injury achieved in 2003
- improved manual handling assessment and training for the site
- development of a standardised site ergonomic awareness training package
- the delivery of an ergonomic design course
- a seating at work policy implemented
- development of a display screen equipment assessment tool for non-user workstations.

Figure 37 shows a successful example from the programme.

**Figure 37. Example: changing cellophane reels**



The total cost of implementing the EIT was approximately £20,000 (~EUR30,000) per annum at the site. This figure was derived from costs based on:

- meeting attendance times;
- design course attendance time and fees;
- materials for training;
- consultant fees.



However, the EIT programme was viewed as a significant cost/benefit in relation to the costs of incident investigations, claims, compliance, etc.

**Evaluation**

Success factors

Obtaining sponsorship from senior management was found to be essential so that appropriate resources were made available to set up the EIT and to provide ongoing support. A proposal was developed that established the need for reducing occupational injury, illness and poor productivity. The work conducted by the EIT was also integrated with other site teams focusing on operational excellence. Figure 38 illustrates the support infrastructure needed to deliver the strategy.

*Sponsorship from senior management is essential for the successful implementation of workplace interventions.*

**Figure 38. Infrastructure needed to develop the EIT programme**



Ergonomics solutions that required a substantial capital investment needed to be justified to senior management. Necessary analyses including the proposed reduction in risk, reduction in cycle times or throughput, a return on investment solution and feedback from employees regarding satisfaction with the proposal were found to be essential to gain the required level of support. It was also found to be essential to communicate the results and benefits of the EIT intervention in appropriate detail across all levels of the organisation.

Transferability

Two other Ergonomic Improvement Teams have been piloted at other GSK sites and have been successful in improving work processes and reducing risk for MSDs. As a result of the success of these three programmes, Ergonomic Improvement Teams are to be established worldwide across the business. This is a major success for ergonomics and hopefully the lessons learnt can be used by other organisations in a wide range of industries.

GSK has set up an intranet site on ergonomics good practice so that problems and solutions can be shared across its 85 manufacturing sites spread over 37 countries.

The use of Ergonomic Improvement Teams enabled employees to participate in the improvement process by identifying ergonomic hazards and seeking solutions to reduce the risk of MSDs. The introduction and use of the EIT also improved familiarity with the work systems, workstations and tasks that were evaluated and



helped significantly in identifying practical and effective solutions. In addition, it was found to be much easier to gain employees' acceptance of workplace changes if they knew that they had come from other staff members performing the same or similar tasks.

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## 3.4. BEHAVIOURAL MODIFICATION

### 3.4.1. Worksite physical activity intervention among tax office employees

#### *Background*

Approximately 70% of the population report problems with upper limb and neck disorders, particularly female computer workers (Jensen et al., 2002). The increased use of computers in the workplace means this is likely to be a growing problem. Little is known how best to prevent MSDs arising from computer use. Previous studies have pointed about towards physical exercises relieving neck and shoulder disorders. However, documentation is lacking regarding the effect of worksite activities.

Inactivity and subsequent impaired muscle strength and general function may be the underlying mechanisms for upper limb and neck disorders. There is a general trend in society to relate physical activity to improved health outcome. But knowledge regarding musculoskeletal health is limited. This study from the Danish tax office aimed to shed light on this issue. The tax office employees were very keen to participate. Their organisation offered exercise facilities, but little was offered regarding professional instruction.

#### *Action*

##### Description

The general approach included first awareness building at the top level of the organisation, then communication with the different local work sites about the study, and finally provision of external funding to the organisation for training programmes and instructors.

Screening questionnaires<sup>(12)</sup> were sent out to 2,163 workers (approximately 33% male) with information and questions regarding interest in participating. Of these, 862 agreed to participate. Subsequent inclusion criteria allowed 616 workers to be included. These workers were randomised into three different intervention groups (see below). The study design followed the timeline below.

Professional instructors were allocated to the participants in three groups as follows.

- Strength training group. Strength training for the upper limb and neck area was performed with an instructor twice a week and once by self-training.<sup>(13)</sup> Training took place three times a week for 20 minutes each time.

<sup>(12)</sup> Screening questionnaires are available in Danish. Many of these correspond to the questionnaire used in the NEW European EC shared-cost RTD actions (QRLT 2000 00139), which can be downloaded in several European languages at:  
<http://www.ami.dk/Aktuel%20forskning/NEW.aspx>

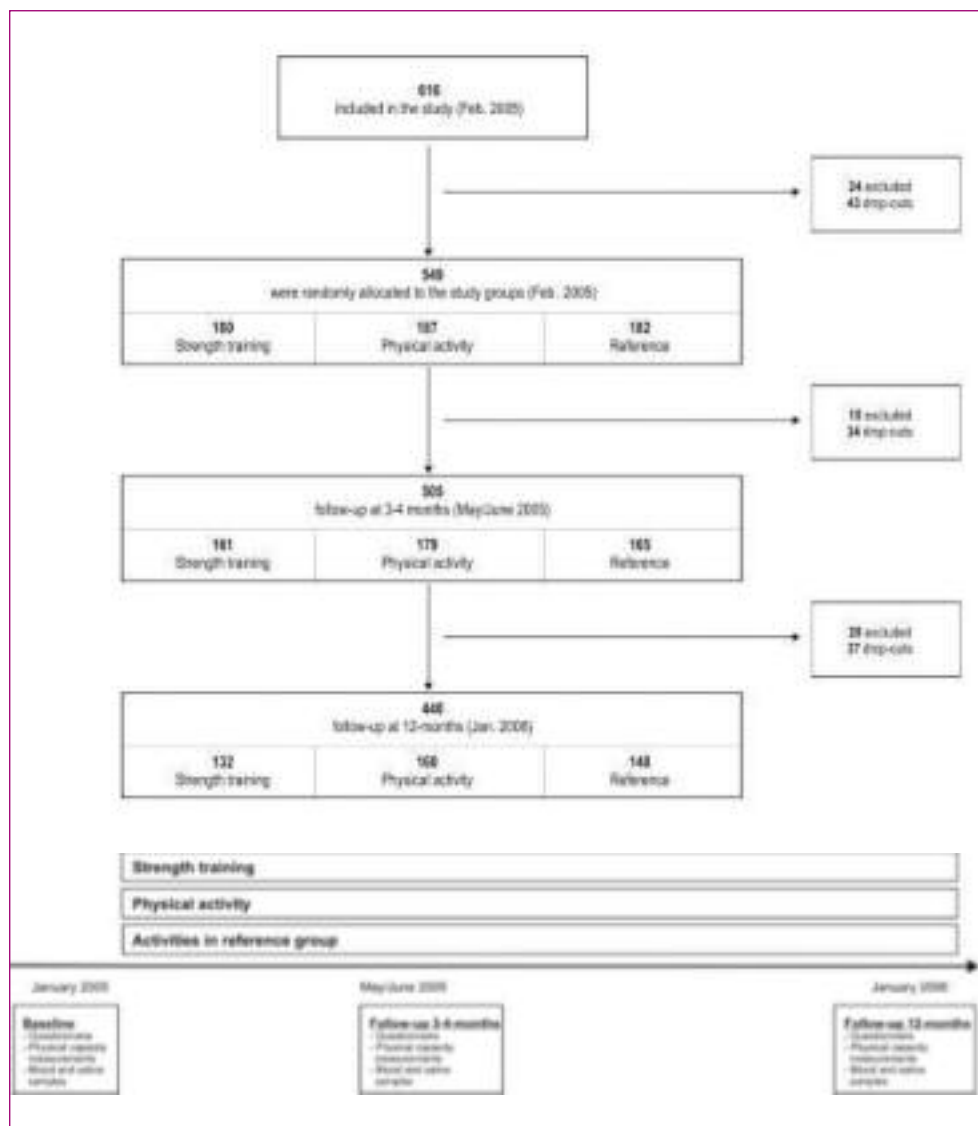
<sup>(13)</sup> The specific instructions given to the strength training group are available as video clips at:  
<http://www.arbejdsmiljoforskning.dk/Aktuel%20forskning/SPA/Videoklip.aspx>



- General physical activity. General physical activities such as gymnastics, walking, stretching, etc. were performed. The instructor came approximately every second week to introduce new activities. Alerts were given by e-mail.
- Information only. Participants were offered information on health promotion via lectures, working groups, etc.

The organisation sponsored one hour a week for each participant to perform physical activity during working hours for one year. Financial support was given by the National Institute of Occupational Health and the Directorate for Health Promotion. DFIF, a company promoting physical activity at the workplace, supported the project by giving instruction for free. Scientists from the University of Copenhagen worked together with the whole team. Figure 39 provides a timeline of the study and the numbers participating at each stage, including the follow-up.

**Figure 39. Overview of the study**

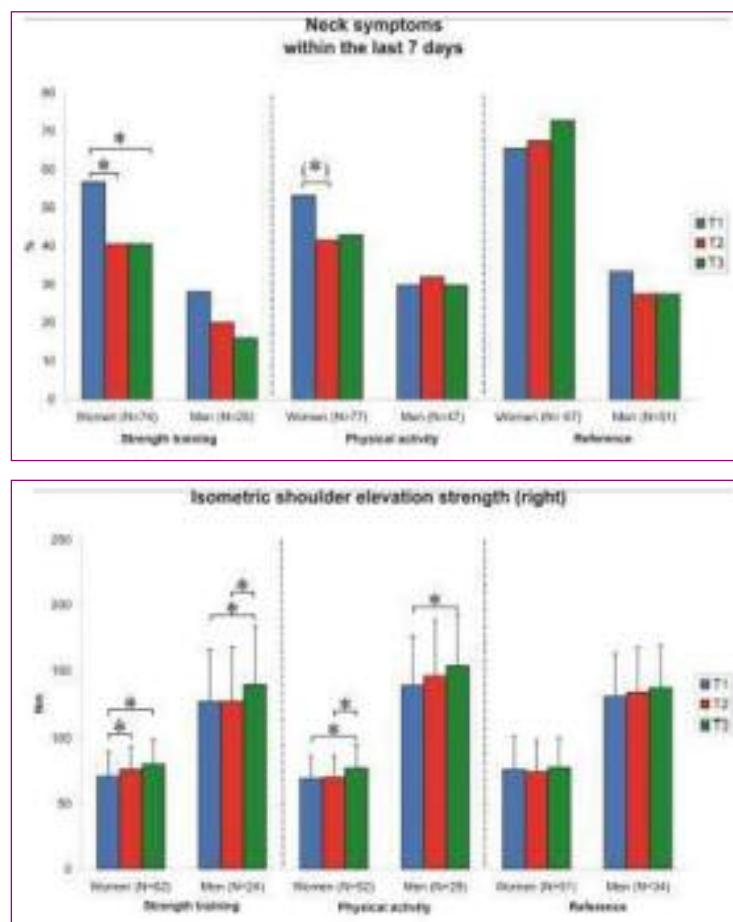


Results

The results <sup>(14)</sup> of the project can be divided into:

- qualitative results - the participants were very satisfied, especially those in the group receiving the largest number of instructor hours;
- quantitative results - members of the strength training group increased their shoulder muscle strength and reduced their neck disorders (see Figure 40).

**Figure 40. Quantitative results obtained with the strength training group**



**Key**  
 T1 = baseline testing  
 T2 = follow-up test 3-4 months later  
 T3 = follow-up test 12 months later

*Cultural changes are required in the workplace before benefit can be gained from physical exercise programmes offered there.*

**Evaluation**

The following problems were faced.

- The major problem was that participants in the study did not find time during working hours to take part in the physical activity programmes even though their employer granted them one hour per week to participate for one full year. This indicates that cultural changes are required before benefits can be gained from physical exercise programmes offered at the workplace.
- There were practical problems in attracting enough support from the management of the organisation to demonstrate their sincerity regarding compliance with the project.

<sup>(14)</sup> A comparison of the situation before and after the action is presented in a report in Danish and is available at [http://www.arbejdsmiljoforskning.dk/upload/spa\\_ramin/rapport\\_20061011.pdf](http://www.arbejdsmiljoforskning.dk/upload/spa_ramin/rapport_20061011.pdf)



- Hostility to the study was rare, but some people initially tried to boycott the project. Personal dialogue with the project leaders minimised this problem.
- Negative side effects were not encountered.

#### Success factors

The study documented goals achieved compared with goals intended, particularly regarding the strength training programme in relation to reducing neck trouble. More general physical activity was less successful in this respect. Furthermore, the pattern was more scattered in terms of the beneficial effects regarding other body regions. However, the project was considered successful from all viewpoints (initiators, organisation, target groups).

#### Transferability

Specific and transferable elements include the strength training programmes, which are available as video clips (<http://www.arbejdsmiljoforskning.dk/Aktuel%20forskning/SPA/Videoklip.aspx>). Training diary books are also available. The knowledge that training only 20 minutes three days a week is successful in reducing neck trouble among computer workers can be used in all EU Member States.

Necessary adaptations include gaining full and active support from the leadership of an organisation in order that the physical activity programmes at the work site are completely successful.

For dissemination and more details of the study, please consult:  
<http://www.ami.dk/spa>

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*Strength training appeared to be beneficial for reducing neck symptoms.*

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### 3.4.2. Muscular fitness project in the chemical industry

#### **Background**

Some diseases linked to physical inactivity have a strong negative impact on an employee's health and performance. While companies currently invest in machines to make them more ergonomic, people also need to be made aware of the benefits of being active and helped to make exercise a part of their everyday life. To improve employee health and performance, DuPont Luxembourg started a 'Muscular Fitness Project' in October 2002.

#### **Action**

##### Description

The project consisted of a number of action steps through which the Six Sigma Methodology was applied. These were:

- build up of a project team involving different competencies, including experts in the Six Sigma tool;





- installation of muscular training equipment at the plant (two sets of four machines) in January 2003;
- holding site-wide meetings with employees and handing out questionnaires in order to identify the issues (with the possibility of volunteering for a pilot test);
- selection of two groups of 20 volunteers for the pilot test by the project supervisor and plant physician;
- execution of a large-scale test with 35 people during six months from January to July 2003 supported by a fitness training consultant from Kieser Health Systems;
- analysis and evaluation of data (December 2003);
- defining the 'Vital Few' parameters - back strength, leg strength, body weight, flexibility and presence at work;
- opening in May 2004 of a plant fitness centre with seven muscular training machines, attended twice a week during four hours by trained personnel;
- development of a management system to include especially affected employees in a health programme.

The company is covering all costs related to the project, which have been about EUR 2,200 per month since January 2003. Figure 41 shows some of the participants using the equipment in the plant fitness centre.

**Figure 41. Physical training of workers**



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### Results

The pilot test proved that muscular training was effective in addressing the issue of employee health. In this case, the use of the Six Sigma statistical tool made it possible to convince people with a technical and scientific background that muscular training can have statistically significant results.

The plant fitness centre is attended regularly by 220 employees (close to 20% of the workforce). This intervention demonstrates the beneficial effects on workers' health. More than 10 cases of back problems followed up by the plant medical service were effectively addressed. In addition, employees became more aware that physical activity is useful and has a positive effect on their health.

### **Evaluation**

#### Problems faced

The goal of 30% of the workforce training regularly in the site fitness centre has not yet been met.



Success factors

These included:

- the corporate vision to increase employees' health and fitness by preventive action;
- a win-win-win solution for the employer, the employees and public health;
- the determination of plant management, facilitated and supported by the medical service;
- good communication within the organisation;
- the mental aspect of the action - change of paradigm, change of mindset.

Transferability

Muscular fitness programmes can be successfully applied to any organisation for people of any age.

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## 3.5. CONCLUSIONS

*Job satisfaction, motivation and acceptance of workplace changes can be enhanced when all players are involved in every stage of the ergonomic actions - from the risk assessment to the identification, try out and implementation of solutions.*

The case studies presented in this report provide real examples of how companies and organisations have made interventions and sought to manage and prevent the risks of musculoskeletal disorders at work.

The approaches applied to MSD risks described in each case study can be adopted in other situations and sectors, and in other EU Member States. This applies equally to the various solutions resulting from these case studies: most of the design or organisational ideas presented in this report are transferable to other instances. For example, the ergonomic principles and redesign of a conveyor belt in the automotive industry are likely to apply to other processes where a similar conveyor and working method are in use. Yet these solutions have to be matched to the particular situation, as each type of industry and workplace has its own conditions, which in addition can vary between Member States. This can be done by carrying out an assessment of the risks at the actual workplace concerned. One of the case studies explains, for example, how a Swedish patient handling tool has been translated and adapted to the Greek context.

In some of the case studies, the companies developed their own solutions using their own expertise, while other interventions were achieved with the aid of an expert ergonomist. In any case, experience shows that the collaboration of people with expertise in different areas (e.g. engineering, psychology, human relations) is advantageous as it allows MSD-related issues to be approached in a global (multidisciplinary) way.

To succeed in such a holistic approach and, moreover, in creating a culture where ergonomics and the prevention of MSDs are embedded in every part of the process, the involvement and participation of all employees and their representatives is crucial. Case studies such as the Ergo Guide Concept and Ergonomic Improvement Teams demonstrate that job satisfaction, motivation and acceptance of workplace changes can be enhanced when all players are involved in every stage of the ergonomic actions - from the risk assessment to the identification, try out and implementation of solutions.

The case studies show that interventions to tackle the risks of MSDs can yield many benefits. Not only can working conditions and the satisfaction and motivation of workers improve and the rate of sick leave due to MSDs decline, there may also be positive influences on overall safety, process capacity, production output, product quality, etc.

In this regard, most of the case studies point out that the cost/benefit ratio of an ergonomic intervention is a crucial factor in its approval and success (see, for example, 'Redesign of a hand packing line'). A report published by the UK Health and Safety Executive (HSE), *Cost Benefit Studies that Support Tackling Musculoskeletal Disorders* (HSE, 2006), illustrates ways in which investments in reducing musculoskeletal risks have resulted in financial benefits to the company through cost savings, or increased productivity and quality of output.

If interventions require a substantial capital investment, it becomes essential to obtain sponsorship from management in order that appropriate resources can be made



available. However, ergonomic interventions do not only imply major (engineering) investments. This is, for example, demonstrated by cases where the main intervention is of an organisational kind such as the case studies featuring job rotation on a hypermarket checkout line and the improvement of collaboration and communications in a distribution centre.

It should be stressed that, when an attempt is made to resolve a particular MSD problem, a wide range of solutions (technical, organisational, administrative, etc.) need to be considered and a hierarchy of prevention principles (based on Article 6.2 of Directive 89/391/EEC<sup>(15)</sup>) have to be respected (see the box below). The Ergo Sheet example shows how residual risks can be managed temporarily by applying administrative controls such as job rotation, training and information sheets.

#### Hierarchy of prevention principles

- Avoid MSD risks.
- Evaluate MSD risks that cannot be avoided.
- Combat the MSD risks at source.
- Adapt the work to the individual - especially the design of workplaces, the choice of work equipment and the choice of working and production methods - with a view to alleviating monotonous work and work at a predetermined work-rate, and to reduce their effect on health.
- Adapt to technical progress.
- Replace the dangerous with the non-dangerous or less dangerous.
- Develop a coherent overall prevention policy that covers technology, organisation of work, working conditions, social relationships and the influence of factors related to the working environment.
- Give collective protective measures priority over individual protective measures.
- Give appropriate instructions to workers.

<sup>(15)</sup> <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31989L0391:EN:HTML>



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# 4.

## OVERALL CONCLUSIONS





The figures and facts show that MSDs are still one of the major work-related health problems in Europe. The high prevalence of MSDs among workers, together with their consequences for the individual and their economic costs, compels action at the workplace. In the first part of this report, an account is given of a literature review concerned with work-related interventions aimed at the prevention of MSDs. In the second part of the report, examples of workplace interventions that have proved successful in practice are described.

## Scientific evidence on preventive measures

Scientific reviews and original studies on the prevention of work-related MSDs reported during recent years (2000-2006) were systematically evaluated. The number of good quality studies increased during this period compared with the number found in reviews conducted in previous decades.

### *Organisational interventions*

Studies on organisational interventions are few in number. There is limited scientific evidence that a reduction in daily working hours from more than seven hours to six hours can reduce neck and shoulder disorders in physically demanding health care work. There is also evidence that it is possible to introduce additional breaks into repetitive work without loss of productivity. It is not known how the breaks should be organised in order to prevent the occurrence of MSDs most effectively.

### *Technical interventions*

There is strong scientific evidence that technical measures can reduce the workload on the back without any loss in productivity. There is moderate evidence that these measures can also reduce low back disorders and sickness absenteeism.

There is strong evidence from laboratory studies that ergonomic hand tools can reduce the load on the upper extremities. In addition, there is limited evidence that such measures can also reduce the MSDs associated with vibration or the manual tasks performed in computer work.

### *Personal interventions*

The evidence on the effectiveness of back belts in the prevention of low back pain is conflicting. This means that back belts cannot be recommended as the only preventive measure for workers carrying out manual materials handling. No evidence has been found to decide if other protective equipment, such as the splinting of wrists, is effective in preventing upper limb disorders.

### *Behavioural interventions*

There is strong evidence that training on working methods in material handling is not effective if it is used as the only measure to prevent low back pain.

There is moderate evidence that physical training can reduce the recurrence of back pain and neck-shoulder pain. In order to be effective, however, the training should include vigorous exercise, which should be repeated at least three times a week.

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*There is some evidence that a multidisciplinary approach and worker involvement is beneficial for preventing MSDs.*

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### Implementation strategies

There is moderate evidence that interventions that are based on single measures are unlikely to prevent MSDs, but that a combination of several kinds of interventions (multidisciplinary approach) is needed, including organisational, technical and personal/individual measures. It is not known how such measures should be combined for optimal results. There is limited evidence that a participative approach that includes the workers in the process of change is beneficial.

No scientific studies were found that conflict with the approach adopted by the EU Directives on manual material handling or on working with computers. There is moderate evidence that following their recommendations is beneficial in the prevention of MSDs.

### Examples of work-related interventions

Even without scientific evidence, workplaces have to manage the risks and try to prevent health hazards. Fifteen case studies have been drawn from a range of occupations and sectors of work across Europe. The approaches applied to the prevention of MSD risks described in each case study can be adopted in similar situations and sectors, and in other EU Member States. This also applies to the various solutions resulting from these case studies: most of the design or organisational ideas presented in this report are transferable to other situations. Yet these solutions have to be matched to the particular situation, as each type of industry and workplace has its own conditions which, in addition, can vary between Member States.

In some of the cases, the organisations involved developed their own solutions using their own expertise, while other interventions were achieved with the services of an expert ergonomist. Practice shows that the collaboration of people with expertise in different areas (e.g. engineering, psychology, human relations) is advantageous as this allows MSD-related issues to be approached in a global way. However, the involvement and participation of all employees and their representatives is crucial to success in such a holistic approach and, moreover, in creating a culture where ergonomics and the prevention of musculoskeletal disorders is embedded in every part of the process.

The case studies show that interventions to tackle the risks of MSDs can yield many benefits. Not only can working conditions and the satisfaction and motivation of workers improve and the rate of sick leave due to MSDs decline, there may also be positive influences on overall safety, process capacity, production output, product quality and other issues. In this regard, most of the case studies point out that the cost/benefit ratio of an ergonomic intervention is a crucial factor for its approval and success.

*The solutions described are transferable to similar situations. However, they always have to be adapted to the particular conditions.*





European Agency for Safety and Health at Work

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In order to improve the working environment, as regards the protection of the safety and health of workers as provided for in the Treaty and successive Community strategies and action programmes concerning health and safety at the workplace, the aim of the Agency shall be to provide the Community bodies, the Member States, the social partners and those involved in the field with the technical, scientific and economic information of use in the field of safety and health at work.

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