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PARTICIPATORY ERGONOMICS TO PREVENT LOW BACK PAIN AND NECK PAIN AT THE WORKPLACE Maurice Driessen

Body @ Work

Maurice Driessen

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VRIJE UNIVERSITEIT

PARTICIPATORY ERGONOMICS TO PREVENT LOW BACK PAIN AND NECK PAIN AT THE WORKPLACE

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General introduction

Case description

A manager of a large road building company wonders what he can do to prevent low back pain and neck pain among workers. He realises that the workers at his company are at risk for developing these symptoms since they perform heavy physical work, lift and carry heavy loads, and do shift work. In the past months, the production levels of the company increased with approximately 20%. To keep up with the high production levels, the manager realises that his workers need to stay healthy. However, the manager is sceptical about low back pain and neck pain prevention programmes. A few years ago he implemented several costly lifting devices in order to reduce the workers' workload. However, only a handful of workers used the lifting devices. Some workers told the company manager that they were not interested in using the lifting devices because they never have had low back pain or neck pain. Workers with a history of low back pain or neck pain were interested in using them, but they did not know how to use the lifting devices. During a congress on Human Resource management, the manager took notice of participatory ergonomics. By involving both management and workers in the development and the implementation of ergonomic measures, participatory ergonomics may not only increase the workers' acceptance but may also increase workers' adherence to the ergonomic measures. The manager decides to phone an ergonomist to obtain information about the possibilities to prevent low back pain and neck pain by implementing participatory ergonomics at the departments of his company. The ergonomist remembers that participatory ergonomics is an effective return to work intervention for workers sick-listed due to low back pain. However, he does not know whether participatory ergonomics is effective to prevent low back pain and neck pain. The ergonomist decides to call a friend who is a researcher in the field of occupational health, and asks him whether participatory ergonomics is effective to prevent low back and neck pain. The researcher answers that he currently investigates the effectiveness of participatory ergonomics in a large cluster randomised controlled trial. As the study results are expected to come soon, the researcher promises that he will inform the ergonomist, the company manager and the workers about the study outcomes.

Low back pain* and neck pain* are prevalent.[1;2] Lifetime prevalences of these symptoms are high and vary from 49%-70% for low back pain[3] to 14%-71% for neck pain.[1] These prevalence rates indicate that up to almost two of every three persons will experience low back pain and neck pain at a certain time during his/her working life.

* In this thesis low back pain and neck pain refer to the term non-specific low back pain and neck pain. Non-specific low back pain and neck pain indicate that pain and functional disability are present without a specific cause (e.g. hernia nuclei pulposi, fracture, inflammation or infection).

One-year prevalence rates for low back pain range from 25-42%[3], whereas for neck pain similar ranges are found.[4] Symptoms have unfavourable consequences for the individual worker in terms of pain and disability. As a result of their symptoms, health care professionals may be visited, such as a general practitioner, a physiotherapist, or a neurologist.

In the Netherlands, the total health care costs in 2005 for the treatment of low back pain and neck pain are estimated at € 867 million.[5] Moreover, workers with low back pain and neck pain are less productive compared to workers without symptoms.[6] Furthermore, low back pain and neck pain are a common source of sick leave from work. The costs due to sick leave from work and the costs due to disability pensions are high and comprise the nine fold of the total health care costs.[5;7] In view of the major personal and financial impact of low back pain and neck pain, the prevention of these symptoms has become an important goal for governments and companies. Few interventions have shown proven effectiveness to prevent low back pain and neck pain. In this perspective, the development of (cost-)effective interventions is warranted.

Therefore, the primary objective of this thesis was to investigate the (cost-)effectiveness of a participatory ergonomics programme to prevent low back pain and neck pain among workers.

Questions asked:

By the ergonomists and the workers: What is the effectiveness of the interventions we often use to prevent low back pain and neck pain?

Before introducing a new intervention at the workplace, it is worthwhile to investigate the effectiveness of commonly used interventions to prevent low back pain and neck pain. By providing an overview of the results obtained from various studies on a certain topic, a systematic review can provide researchers and/or health care professionals insight into the effectiveness of an intervention.

For low back pain and neck pain prevention, the effectiveness of various interventions have already been evaluated in systematic reviews. For example, physical exercise programmes may improve a worker's strength/work capacity and thereby improve a worker's ability to deal with the exposure to work-related risk factors. Previous systematic reviews have shown that physical exercise programmes were effective to prevent low back pain.[8;9] Evidence obtained from a Danish randomised controlled trial showed that physical exercise programmes have the potential to prevent neck pain.[10;11] However, due to the general lack of high quality studies, systematic reviews on neck pain prevention could not draw any conclusions about the effectiveness of physical exercise programmes.[4;12;13]

Other commonly implemented preventive strategies are the individual worker interventions, such as instruction sessions about proper working methods and lifting techniques with or without lifting devices, education on ergonomics, back belts or lumbar supports.

Systematic reviews showed that individual worker interventions were not effective to prevent low back pain.[9;14-17] Also, physical ergonomic interventions (i.e. new equipment or workplace adjustments) have been frequently used to prevent low back pain and neck pain at the workplace. Nonetheless, there is insufficient evidence available to determine the effective-ness of physical ergonomic interventions to prevent low back pain.[9] Regarding neck pain prevention, the evidence to support the use of physical ergonomic interventions is ambiguous. For example, whereas two systematic review concluded that a new mouse and an alternative keyboard were effective to prevent neck pain among office workers[12;13], another systematic review found evidence for no effect.[4] A final strategy to prevent low back pain and neck pain at the workplace is by implementing organisational ergonomic interventions (i.e. job redesign, modifications to the production system, and job enlargement). However, systematic reviews concluded that there was insufficient high quality evidence available to either support or reject the use of these type of interventions to prevent low back pain and neck pain.[9;12;13]

In the past years, randomised controlled trials on the effectiveness of physical and organisational interventions to prevent low back pain and neck pain have become available. An up to date systematic review is warranted. To evaluate the effectiveness of the physical and organisational ergonomic interventions to prevent low back pain and neck pain, we therefore conducted a systematic review of these studies (chapter 2).

As pointed out in our case description, the use of participatory ergonomics may be a promising approach to prevent low back pain and neck pain. In a systematic review by Rivilis et al. (2008) it was concluded that participatory ergonomics was effective to prevent musculoskeletal disorders, including low back pain and neck pain.[18] However, the review included also studies using study designs susceptible for bias (i.e. pre-post studies and controlled trials). The only cluster randomised controlled trial in the review that was aimed on musculoskeletal disorder prevention, concluded that participatory ergonomics was not more effective than the control group to prevent musculoskeletal disorders among Norwegian aluminium industry workers.[19] Not included in the review by Rivilis et al. (2008) was the recently conducted cluster randomised controlled trial among Finnish kitchen workers. In this study by Haukka et al. (2008) it was concluded that participatory ergonomics was not more effective compared to the control group to prevent musculoskeletal disoders.[20] Since these two randomised controlled trials were conducted among blue collar workers only, it is important to investigate the effectiveness of participatory ergonomics among a heterogeneous working population. Moreover, no randomised controlled trial on participatory ergonomics has been specifically aimed to prevent low back pain and neck pain. Also, no randomised controlled trial has investigated the cost-effectiveness and cost-benefit of participatory ergonomics when used as a strategy to prevent low back pain and neck pain.[21]

The current cluster randomised controlled trial will address these topics, and will compare the effects of participatory ergonomics with the control group (no participatory ergonomics).

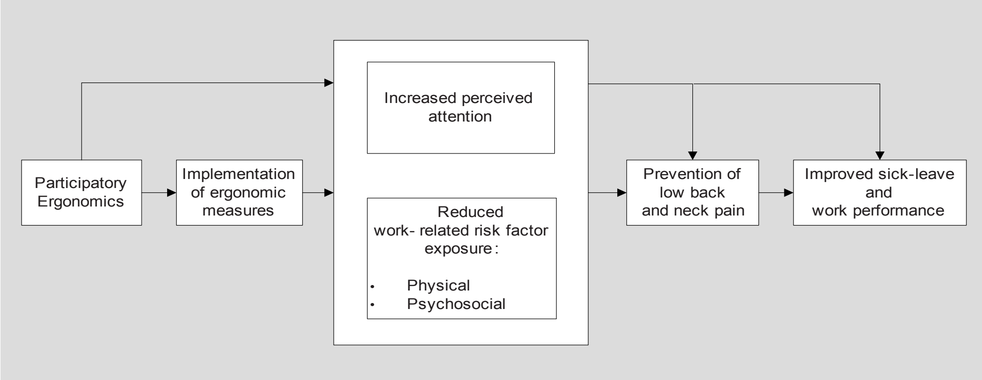
By the researchers: What are important aspects in the design of a participatory ergonomics programme aimed at preventing low back pain and neck pain among workers?

One of the main characteristics of participatory ergonomics is the formation of a working group consisting of both workers and management.[22] Each department allocated to the intervention group forms a working group. Workers in the working group represent the co-workers of their department. Whereas the department manager, who also participates in the working group, is responsible for the financial and organisational aspects that are accompanied with the ergonomic measures. Under guidance of an ergonomist, the working group follows the steps of participatory ergonomics during a six hour working group meeting. In this meeting, the working group identifies risk factors at the department and prioritise the most important risk factors for low back pain and neck pain. Subsequently, the working group lists ergonomic measures and prioritises the most adequate ergonomic measures to solve the prioritised risk factors. After the meeting, the working group starts with the implementation of the ergonomic measures at the department. The prioritised ergonomic measures have to be implemented within three months.

In the Stay@Work model (figure 1), we outline the possible working mechanism of participatory ergonomics. This model, which is largely based on the model by Westgaard and Winkel (1997)[23], illustrates how participatory ergonomics may result in the implementation of ergonomic measures at the workplace. In turn, the ergonomic measures may reduce the workers' exposure to work-related physical risk factors (i.e. manual lifting of heavy loads, non-neutral trunk postures, or whole body vibration)[4;24;25] and/or work-related psychosocial risk factors (i.e. high work demands, low support, or poor job satisfaction).[26;27] As a result of reduced exposure to risk factors, low back pain and neck pain may be prevented. Preventing low back pain and neck pain may result in decreased sick leave and improved work performance[6;28], and consequently may result in the savings of costs. The Stay@Work model also incorporates the option that participatory ergonomics neither leads to the implementation of ergonomic measures nor to a reduction of the exposure to the work-related risk factors, but still manages to prevent low back pain and neck pain. In this option, the obtained results may be caused by an increased level of attention in the perception of the workers (Hawthorne effect).

Chapter 3 describes the Stay@Work study, in which the (cost-)effectiveness of participatory ergonomics is compared to a control group to prevent low back pain and neck pain among a heterogeneous working population. In addition, chapter 3 provides information about the recruitment of the study population, the intervention, the control group, the study outcomes, and the outcome assessments as used in the Stay@Work study.

Figure 1. The Stay@Work model.



By the employers: Are my workers satisfied with participatory ergonomics? By the ergonomists: What is the applicability of participatory ergonomics and does participatory ergonomics lead to the implementation of ergonomic measures?

A process evaluation can shed light on whether participatory ergonomics was delivered as intended.[29] This information can be used to draw conclusions about the applicability of participatory ergonomics as a strategy to prevent low back pain and neck pain among workers. For this purpose, aspects to be considered are the adherence to the working group meetings, compliance to the study protocol, satisfaction towards the quality of the working group meetings, and satisfaction towards the prioritised risk factors and prioritised ergonomic measures.[30] participatory ergonomics should be beneficial for the workers at the departments. Therefore, information about workers' satisfaction with the use of participatory ergonomics, the use of other implementation strategies (i.e. flyers, posters, presentations and ergocoaches), and satisfaction with the prioritised ergonomic measures is also needed to make judgements about the deliverance of the intervention. Information about implementation is needed to determine whether the prioritised ergonomic measures were delivered as intended to the department and its workers. If this is not the case, one needs to investigate what factors played a role during the implementation.[31]

Chapter 4 evaluates the process and implementation of participatory ergonomics. Chapter 5 explores what factors negatively or positively occurred during the implementation of the prioritised ergonomic measures.

By the ergonomists and the workers: Is participatory ergonomics more effective than the control group (no participatory ergonomics) to reduce the exposure to work-related risk factors for low back pain and neck pain?

Studies found that a number of work-related physical risk factors and psychosocial risk factors present at the workplace can contribute to the occurrence of low back pain and neck pain.[4;24;26] In the Stay@Work model, we illustrated how participatory ergonomics may reduce worker's exposure to these risk factors. Nonetheless, the large cluster randomised controlled trial conducted on Finnish kitchen workers, showed that participatory ergonomics was neither more effective than the control group to reduce physical workload[20] nor to reduce psychosocial workload.[32] The within-group comparisons performed in the cluster randomised controlled trial by Morken et al. (2002) found that participatory ergonomics slightly improved social support among operators in the 'shift group without a supervisor'. Other psychosocial risk factors including job demands and control did not improve by participatory ergonomics.[19] A small Japanese cluster randomised controlled trial on assembly line workers showed that mental health outcomes remained at the same level in the lines that received participatory ergonomics, while the mental health outcomes significantly decreased in the control lines (no participatory ergonomics).[33] Another small randomised controlled trial among office workers concluded that participatory ergonomics was not more effective to reduce psychosocial work stress than a group receiving education on ergonomics.[34]

These results are too sparse and too conflicting to draw final conclusions on the effectiveness on workload reduction. Therefore, chapter 6 presents the results of participatory ergonomics on the exposure to work-related physical and psychosocial risk factors for low back pain and neck pain among a heterogeneous working population.

By the researchers and by the ergonomist: Is participatory ergonomics more effective than the control group (no participatory ergonomics) to prevent low back pain and neck pain?

Two cluster randomised controlled trials concluded that participatory ergonomics was not effective to prevent musculoskeletal disorders.[19;20] However, the effectiveness of participatory ergonomics specifically targeted on the prevention of low back pain and neck pain has not been established in a cluster randomised controlled trial yet. More evidence obtained from high quality studies is needed to draw conclusions about the effectiveness of participatory ergonomics.

Chapter 7 presents the 12-month follow-up results on the effectiveness of participatory ergonomics to prevent low back pain and neck pain, as well as the results of participatory ergonomics on the reduction of pain intensity and pain duration. It is known that low back pain and neck pain follow an episodic course.[35;36] Therefore, chapter 7 also shows the effects of participatory ergonomics on the course of low back pain and neck pain (transitions from no episode to an episode and from an episode to no episode).

By the employers and by the ergonomists: Does participatory ergonomics reduce sick leave and improve work performance? Is participatory ergonomics cost-effective and /or cost-beneficial?

In economic evaluations the value for money of occupational health care interventions is assessed. The costs and effects derived from the intervention under study are compared with the costs and effects derived from the alternative intervention. This comparison gives insight into whether an intervention is worth performing or whether similar effects can be derived by the less expensive alternative. Moreover, it is needed to investigate the return on investment of an intervention. For employers this information is essential in order to decide whether or not to undertake a new intervention.[37;38] However, no randomised controlled trial on participatory ergonomics aiming at the prevention of musculoskeletal disorders (including low back pain and neck pain) conducted an economic evaluation.[21]

In chapter 8, the effectiveness of participatory ergonomics on sick leave and work performance is investigated. Furthermore, from a societal perspective, chapter 8 presents the results of the cost-effectiveness analyses. The cost-effectiveness analyses compares the differences between the intervention and the control group in effects (on low back pain and neck pain prevalence, sick leave, and work performance) with the differences between the intervention and the control group in total societal costs (including the costs due to health care consumption, intervention costs, and costs due to productivity loss).

Chapter 8 provides information about the costs regarded from the perspective of the employer by presenting the results of a cost-benefit analysis on participatory ergonomics. In the cost-benefit analysis the differences in intervention costs between the intervention and the control group are compared to the differences in lost productivity costs between the intervention and the control group.

Finally, chapter 9 of this thesis includes the general discussion. In chapter 9, the main research findings, overall evidence on the effectiveness of participatory ergonomics and ergonomic interventions, methodological considerations are discussed, and recommendations for research and practice are provided.

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2

The effectiveness of physical and organisational ergonomic interventions on low back pain and neck pain: a systematic review

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Abstract

Objective: Ergonomic interventions (physical and organisational) are used to prevent or reduce low back pain and neck pain among workers. We conducted a systematic review of randomised controlled trials on the effectiveness of ergonomic interventions.

Methods/Results: A total of 10 randomised controlled trials met the inclusion criteria. There was low to moderate quality evidence that physical and organisational ergonomic interventions were not more effective than no ergonomic intervention on short and long term low back pain and neck pain incidence/prevalence, and short and long term low back pain intensity. There was low quality evidence that a physical ergonomic intervention was significantly more effective for reducing neck pain intensity in the short term (i.e. curved or flat seat pan chair) and the long term (i.e. arm board) than no ergonomic intervention.

Conclusions: The limited number of randomised controlled trial included make it difficult to answer our broad research question and the results should be interpreted with care. This review, however, provides a solid overview of the high quality epidemiological evidence on the (usually lack of) effectiveness of ergonomic interventions on low back pain and neck pain.

Introduction

Low back pain (LBP) and neck pain (NP) are major health problems in the working population and have considerable consequences for workers, employers, and society.[1;2] Prevention of these symptoms is imperative. Prevention of LBP and NP can be categorised into primary, secondary and tertiary prevention. The aim of primary prevention is to prevent the onset of symptoms in a healthy working population, while secondary prevention seeks to aid recovery from early symptoms and reduce the risk of symptom recurrence.[3] However, due to the high lifetime prevalences of LBP and NP, it is difficult to discriminate between primary and secondary prevention.[4] Tertiary prevention is targeted at reducing and assisting the patient to cope with consequent disabilities.[3]

Because the development of LBP and NP is assumed to be multifactorial (i.e. individual, psychosocial, and physical risk factors play a role)[5;6], preventive strategies vary widely. The common strategy of ergonomic intervention is targeted at occupational risk factors such as lifting, physically heavy work, a static posture, frequent bending and twisting, repetitive work, and exposure to vibration[4], and can be divided into individual worker interventions, physical ergonomic interventions, and organisational ergonomic interventions.[3]
Prevention through individual worker interventions mostly consists of 1) physical exercise programmes to improve strength/work capacity, 2) education, instruction or advice on working methods or lifting techniques, or 3) lumbar support or back belts.[6] Systematic reviews have shown that with the exception of exercise programs[7-9], none of these strategies are effective in preventing LBP.[8-12] Evidence on the effectiveness of training to prevent neck pain is inconclusive.[13;14] Prevention through physical ergonomic interventions consists of redesigning the workplace (i.e. providing lifting aids and new equipment, and modifying workstations), while prevention through organisational ergonomic interventions encompasses more changes at the system level (i.e. job rotation, modifications to the production system, and job enlargement).[6]

Previous reviews have shown that there is insufficient evidence of the effectiveness on LBP prevention of the application of physical or organisational ergonomics.[5;15;16] Regarding the effectiveness of physical and organisational ergonomics to prevent neck pain, Brewer et al. (2006) found mixed evidence for the effectiveness of arm supports, alternative keyboards, and rest breaks.[14] Boocock et al. (2007) concluded that there was moderate evidence that workstation equipment (mouse and keyboard design) and workstation adjustments were effective (i.e. modified lighting, new workplaces, changed office lay out and new software application led to positive health benefits among video display unit workers with NP. Despite the promising results on video workers, insufficient evidence was found to support the use of ergonomic equipment among manufacturing workers with NP.[13]

In recent years, several randomised controlled trials (RCTs) on the effectiveness of physical and organisational ergonomics on LBP and NP have been conducted and so an up to date systematic review seems warranted.

The objective of this systematic review is to investigate the effectiveness of ergonomic interventions (physical and organisational) in reducing the incidence/prevalence and intensity of LBP and NP among non sick listed workers.

Methods

Search strategy

With the help of an experienced librarian, the medical electronic databases Pubmed, EMBASE, PsychINFO and the Cochrane Central Register of Controlled Trials, and the database of the Cochrane Occupation Health Field between 1988 and September 2008 were searched. The sensitive search for RCTs and the search terms for LBP and NP used terms recommended by the Cochrane Back Review Group for searching Pubmed and EMBASE.[17] Search strategies in other databases were as close to the sensitive strategy as possible. Verbeek et al. found that no single search term was available to adequately locate occupational health intervention studies.[18] Because the terms of ergonomic interventions also vary largely, no search term for ergonomic interventions was added to the search. 'Musculoskeletal disorders' was included as search term as this term may incorporate LBP and NP. Because 'intensity of discomfort' is frequently used to assess the prevalence of LBP and NP, the term was also added to the search. Two reviewers (MTD and KIP) independently screened the obtained titles and abstracts for eligibility. Studies were eligible when all four inclusion criteria (see below) were met.

Inclusion criteria

Inclusion criteria were as follows:

- The study was an RCT;
- The study population involved a non-sick listed working population;
- The intervention met the definition of a physical or organisational ergonomic intervention, that is: the intervention is targeted on changing the biomechanical exposure at the workplace or on changing the work organisation;
- The outcome measure included non-specific LBP or NP incidence/prevalence or intensity of pain. Studies on neck/shoulder pain were considered as NP studies.

Exclusion criteria

The exclusion criterion was as follows:

- Individual worker interventions.

When inclusion or exclusion of a study could not be decided on reading the title and abstract, the full article was retrieved and checked for inclusion. A consensus meeting with a third reviewer (AJvdB) was arranged to sort out disagreements between both reviewers.

Finally, the reference lists of eligible RCTs and relevant review studies were checked for relevant citations.

Risk of bias assessment

Using the 12 criteria list of the Cochrane Back Review Group, two reviewers (MTD and KIP) independently assessed the risk of bias of the included RCTs.[17] The list and the operationalisation of the criteria are described elsewhere.[17] The criteria were scored as 'yes/no/ don't know'. If necessary, a consensus meeting with a third reviewer (AJvdB) was arranged to sort out disagreements between the first two reviewers. Subsequently, results of the risk of bias assessment were sent to all first authors and they were asked to provide additional information on the criteria scored as 'don't know'. The first authors were also asked to provide additional information on positive or negative scores they disagreed with. RCTs were considered as having 'low risk of bias' when at least 50% (six) of the 12 criteria were met, otherwise they were considered as having a 'high risk of bias'.[17]

Data extraction

One reviewer (MTD) extracted the data by using a standardised data extraction form.[17] Information on study design, randomisation level, population, follow-up period, measurement tools, statistical analyses, outcomes, and effect sizes was extracted. The second reviewer (KIP) checked all data extracted. In case of disagreements, a third reviewer (AJvdB) was consulted. If data were missing, first authors of the studies were contacted and additional information was requested.

Data analysis and the GRADE approach

A meta-analysis was performed among studies that reported on the same outcome and had a similar duration of follow-up, that is, short term (closest to 6 months) or long term (closest to 12 months). For studies with a follow-up period of more than 12 months, the final measurement was used in the meta-analysis. If studies compared more than one ergonomic intervention with a control, each ergonomic intervention was analysed separately. To avoid double-counting of studies, only the effects of the ergonomic intervention with the largest effect size were included in the meta-analysis. For comparisons of dichotomous data (eg, incidence/prevalence), if not provided, risk ratios (RR) with a 95% CI were calculated. For comparisons of continuous data (e.g. pain intensity) standardised mean differences with a 95% CI were calculated. The random effects model was used. All analyses were conducted using the RevMan 5 software.

The GRADE approach was used to classify the overall quality of the evidence.[19;20]

For each specific outcome the quality of the evidence was based on five factors: 1) limitations of the study referring to the risk of bias for the results across all studies that measure that specific outcome, 2) consistency of results, 3) directness (generalisability), 4) precision (sufficient data), and 5) the potential for publication bias. The overall quality of evidence was considered to be high if multiple RCTs with a low risk of bias provided consistent, generalisable results for the outcome. The overall quality of evidence was downgraded by one level if one of the factors described above was not met. Likewise, if two or three factors were not met, then it was downgraded by two or three levels, respectively. Thus, the GRADE approach resulted in four levels of quality of evidence: high, moderate, low, and very low. In case of only one study measuring an outcome, data were considered to be sparse and inconsistent and the evidence was labelled as 'low quality evidence'.

Results

Study selection

The computer generated search resulted in 2654 references in Pubmed, 404 in EMBASE, 62 in PsychINFO, 206 in the Cochrane Central Register of Controlled Trials, 23 in the Cochrane Occupational Health Field. After exclusion of the duplicated references, both reviewers (MTD and KIP) read 3067 titles and abstracts. Disagreements were resolved in a consensus meeting. The most important reasons for exclusion were: the study design was not an RCT, the study population consisted of sick listed workers, and outcome measure was not LBP or NP incidence or intensity. Hand searching of the reference lists of relevant review articles did not result in any new articles. Finally, 10 studies were included in this systematic review (figure 1).

Risk of bias assessment

Before contacting the authors, 52 risk of bias criteria were scored 'don't know'. After authors had provided additional information, 16 risk of bias criteria were still scored 'don't know'. Table 1 shows the risk of bias assessment scores for the included studies. Seven studies were classified as 'low risk of bias' and three as 'high risk of bias'. Few studies were able to keep the participants blinded for the intervention (criterion C), and only one study was able to successfully blind the care provider (criterion D). Some studies did not report at all or reported insufficiently on these criteria. Blinding in workplace settings is not really possible[21], so there is always a potential risk of bias in this field. No study blinded the outcome assessor (criterion E) seeing that self-reported subjective experience of pain was the outcome. Further, most studies did not report on the use of co-interventions or compliance with the intervention.

Figure 1. Flow chart of selection process.

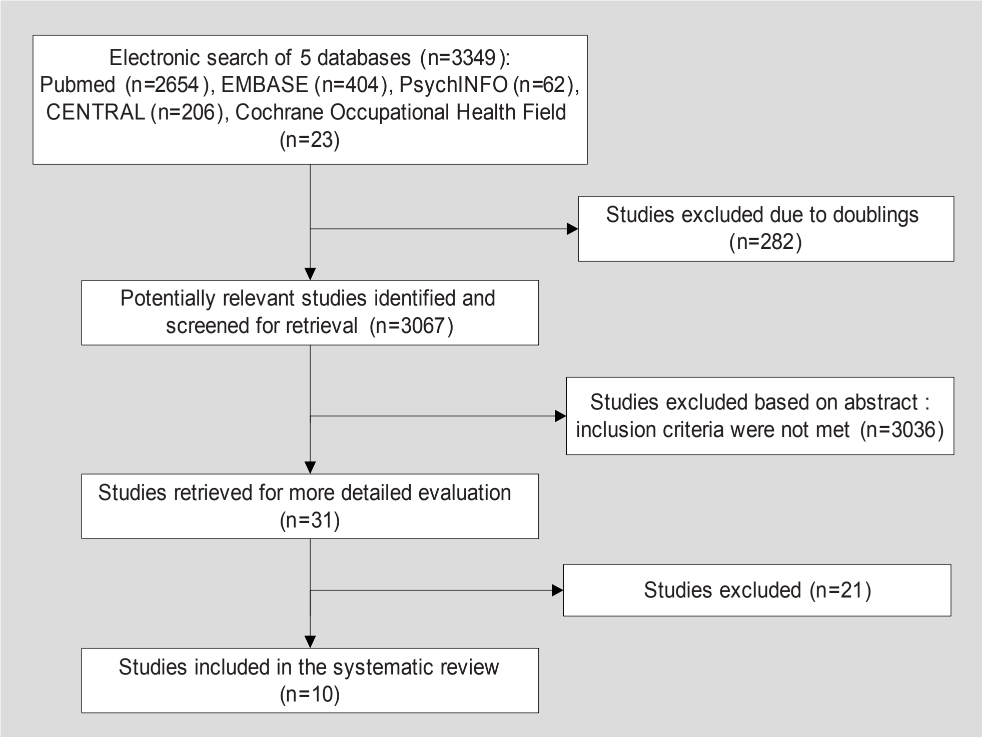


Table 1. Characteristics of included studies.

Criterion	A	B	C	D	E	F	G	H	I	J	K	L	
	Randomisation	Concealment	Patient blinded	Care provider blinded	Outcome blinded	Drop-out	Intention to treat	Selective report	Baseline	Co-interventions	Compliance	Timing	Total score
Haukka et al.[24]	1	1	0*	0*	0	1	1	1	1	1*	1	1	**9**
Lengsfeld et al.[28]	1*	1*	1	1	0	1	1	1	1	0*	0*	1	**9**
Brisson et al.[22]	1*	?	0*	0*	0	1	1*	1	1	1*	0*	1	**7**
Heuvel et al.[26]	1	1*	0*	0*	0	1	1*	0	0	1*	1*	1	**7**
Gerr et al.[30]	1	?	?	?	0	1	1	1	1	?	0	1	**6**
Rempel et al.[31]	1	1*	0*	0*	0	0	1	1	1	?	0*	1	**6**
Rempel et al.[25]	1*	1*	0*	0*	0	0	1	1	1	?	0*	1	**6**
Conlon et al.[27]	1	1*	0*	0*	0	0	1	1	0	?	?	1	**5**
Cook et al.[23]	1	0*	0*	0*	0	1	1	1	0	0*	0*	1	**5**
Mekhora et al.[29]	?	?	0	?	0	1	?	1	?	?	?	1	**3**

* Before contacting the first authors, items were scored "don't know".

Study characteristics

Table 2 shows the characteristics of the studies included. The number of participants varied from 59 to 627.[22;23] All studies, except two, were conducted in an office environment.[24;25] Nine interventions were classified as physical ergonomic interventions, and one as an organisational ergonomic intervention.[26] The study of Haukka et al. (2008) was classified as a physical ergonomic intervention, because the participatory ergonomic programme predominantly resulted in adjustments to the workplace or new equipment.[24] Five studies were conducted on workers with and without symptoms[22-25;27], three on workers with symptoms[26;28;29], and two on workers without symptoms.[30;31] The duration of follow-up among studies varied from 6 weeks[23] to 2 years.[24-28] One study reported on LBP only[28], five studies on NP only[25-27;30;31], and four studies reported on both LBP and NP.[22-24;29]

Measurements used to determine incidence/prevalence among studies varied, and included using a manikin to identify the body region[24], the use of medication for symptoms, cut-off points on self-reported discomfort or pain intensity scales, and/or subsequent diagnosis by a healthcare provider.[22;27;30;31] Measurements on pain intensity also varied, and some studies used a visual analogue scale (VAS)[26;28;31], a 5-point Likert scale[25], or a 10-point discomfort scale.[29] One high risk of bias study (n = 85) showed that a physical ergonomic intervention (i.e. workstation intervention) was not effective in reducing LBP and NP intensity in the short term.[29] However, the study only performed within-group comparisons and did not perform any between-group comparisons. The authors did not respond to our request to provide additional information on between-group comparisons, this study was excluded from the analyses of this review.

Table 2. Characteristics of included studies.

Study, country	Participants randomised	Intervention(s)	Control intervention	Follow-up duration	Outcome	Results intervention vs. control	Risk of bias
Brisson et al.(1999), Canada[22]	627 university workers with and without LBP and NP at baseline	Ergonomic training: two sessions of 3 hours on workplace adjustments workplace (postural and visual components), and work organisation	No ergonomic training	6 months	Prevalence of LBP and NP Having pain 3 days or more in past 7 days greater than >5 on a VAS (0-10) were referred to an occupational therapist for diagnosis. Prevalence is determined by a positive diagnosis	LBP: 22/283 vs. 24/339*; NS NP: 36/282 vs. 46/341*; NS	7
Cook et al.(2004), Australia[23]	59 call centre workers with and without LBP and NP at baseline	Adjustments to the desk surface to support the fore-arm, and adjustments on keyboard and mouse position	Workplace adjustments according to Australian standards	6 weeks	Presence of LBP and NP (Nordic questionnaire)	LBP: 4/30 vs. 8/29†; NS NP: 5/30 vs. 8/29†; NS	5
Haukka et al.(2008), Finland[24]	504 kitchen workers with and without LBP and NP at baseline	Participatory ergonomic programme: on the basis of active group work, workers identified problems, evaluated changes, and implemented them in collaboration with management and technical staff	No participatory ergonomics programme	24 months	Prevalence of LBP and NP (manikin illustration)	a. LBP: 126/263 vs. 111/241†; NS b. LBP: 145/241 vs. 135/241†; NS a. NP: 176/263 vs.174/241†; NS b. NP: 184/263 vs. 159/241†; NS	9
Rempel et al.(2007), USA[25]	480 garment workers with and without neck/shoulder pain at baseline	1. Curved seat pan chair plus miscellaneous items 2. Flat seat pan chair plus miscellaneous items	Miscellaneous items: footrest, storage box, side table, task lamp, and reading glasses	4 months	Neck/shoulder pain intensity Pain intensity in the past month (5 point scale: 1 "little painful"- 5 "very painful")	1. Difference in slope (intervention-control) of NP score for change over time = -0.34 (95% CI -0.41 to -0.28)**; p= not reported 2. Difference in slope (intervention-control) of NP score for change over time: -0.14 (95% CI -0.22 to -0.07)**; p= not reported	6
Van den Heuvel et al.(2003), Netherlands[26]	268 office employees with neck/shoulder pain at baseline	Computer software stimulating 5-minutes computer breaks after 35 minutes computer usage. 7 seconds break after using the computer for 5 minutes, a booklet and a neck and upper-limb disorder risk test	Booklet with information on neck and upper limb disorders and a neck and upper-limb disorder risk test	8 weeks	Neck/shoulder pain severity (VAS 1-10)	NP: 3.00 (SD 2.33)* vs. 3.14 (SD 2.52); NS	7

Table 2. Continued.

Study, country	Participants randomised	Intervention(s)	Control intervention	Follow-up duration	Outcome	Results intervention vs. control	Risk of bias
Conlon et al.(2008), USA[27]	206 (supportive) engineering staff with and without neck/shoulder pain at baseline	1. Alternative mouse: vertical handle for grapping, flat base to support ulnar side of the hand and a roller ball for tracking 2. Fore arm board plus conventional mouse 3. Fore arm board plus alternative mouse	Conventional mouse: hand in almost fully pronated posture and an optical LED for tracking	12 months	Incidence of neck/shoulder pain Workers with discomfort rates of >5 (0-10 scale) in the past 7 days or used medication for upper body discomfort were referred to an occupational physician for diagnosis. Incidence of NP is a positive diagnosis	1. NP: 4/52 vs. 3/52; NS 2. NP: 8/51 vs. 3/52; NS 3. NP: 3/51 vs. 3/52; NS	5
Lengsfeld et al.(2007), Germany[28]	280 office workers with chronic recurrent LBP at baseline	Office chair with micro rotation function underneath the seat to prevent long term sitting	Office chair without micro rotation function	24 months	Lumbar Pain score (VAS 0-100mm)	a. LBP: 39.75 (SD 17.79) vs. 38.53 (SD 17.46); NS b. LBP: 34.56 (SD 18.41) vs. 33.32 (SD 19.39); NS	9
Mekhora et al.(2000), Thailand[29]	85 office workers with tension neck symptoms at baseline	Workstation intervention: Using a software program, advices on computer workstation adjustments were given on monitor and keyboard height and the use of foot stools and document holders	Use of unadjusted workstation	Cross-over design after 14 weeks, intervention becomes own control	Discomfort of LBP and NP (VAS 0-10, "no pain-extreme pain")	LBP: change score from baseline: -1.436; NS (within group comparison) NP: change score from baseline: -1.197; NS (within group comparison)	3
Gerr et al.(2005), USA[30]	356 computer workers without neck/shoulder pain at baseline	1. Alternate intervention: postural intervention with workplace changes based on results from a prospective study on MSD 2. Conventional intervention: postural intervention with workplace change based on OSHA, NIOSH and private industry rules	No intervention: continue keying in usual posture and no workstation changes	6 months	Incidence of neck/shoulder pain Discomfort score of >=6 (0-10 discomfort scale) or medication use for musculoskeletal discomfort on any day of the week	NP: 38/114 vs. 33/109; NS NP: 36/116 vs. 33/109; NS	6

Table 2. Continued.

Study, country	Participants randomised	Intervention(s)	Control intervention	Follow-up duration	Outcome	Results intervention vs. control	Risk of bias
Rempel et al.(2006), USA[31]	182 customer service operators without neck/shoulder pain at baseline	1. Ergonomic training and trackball 2. Ergonomic training plus arm board 3. Ergonomic training plus trackball plus arm board	Ergonomic training: erect sitting posture, adjustments on the height of the chair, arm supports, work surface, monitor, and adjustments of mouse and keyboard location	12 months	Incidence of neck/shoulder pain Pain intensity scores >5 (VAS 0-10) OR pain medication for two days or more per week due to neck/shoulder/upper extremity complaints) were referred to occupational physician for diagnosis. Incidence of NP is a positive diagnosis	1. NP : 6/35 vs. 19/43 2. NP : 6/40 vs. 19/43 3. NP : 8/40 vs. 19/43	6
					Neck/shoulder pain intensity (VAS 0-10)	1. NP: 2.2 (SD 2.2)* vs. 1.8 (SD 1.9)* 2. NP: 2.6 (SD 2.8)* vs. 1.8 (SD 1.9)* 3. NP: 2.0 (SD 2.4)* vs. 1.8 (SD 1.9)*	

Abbreviations: LBP, low back pain; NP, neck pain; MSD, musculoskeletal disorders; SD, standard deviation; NS, not significant; VAS, visual analogue scale.
* information not reported in study and provided by first authors on request.
** unadjusted estimates.
a. results at short term follow-up.
b. results at final follow-up measurement.
†: frequencies derived from percentages.

LBP incidence/prevalence

Short term

Two studies with low risk of bias (total n = 1131)[22;24] and one study with high risk of bias (n = 59) evaluated the effectiveness of an ergonomic intervention on LBP prevalence. The participants included in these studies consisted of workers with or without LBP at baseline. The physical ergonomic interventions included an ergonomic training incorporating workplace adjustments for university employees[22], a participatory ergonomics programme instituting workplace changes for kitchen workers[24], and computer workplace adjustments for call centre workers.[23]

The quality on LBP prevalence was downgraded with two levels. The results were inconsistent because in one study the LBP prevalence decreased[23], while in the two other studies the LBP prevalence remained the same.[22;24] The results of the pooled data were indirect, because the effect was largely determined by the high weight (87.7%) in the meta-analysis of one study conducted on kitchen workers.[24]

Therefore, there is low quality evidence from three studies (N = 1190) that there is no statistically significant difference in the reduction in LBP prevalence in the short term (RR 1.03; 95% CI 0.86-1.22) between groups that received a physical ergonomic intervention compared to groups receiving no such intervention (figure 2a).

Long term

One low risk of bias study (N=504) evaluated the effectiveness of a physical ergonomic intervention on LBP prevalence in the long term among kitchen workers with and without LBP at baseline. A participatory ergonomic programme was no more effective than no intervention on 2-year prevalence of LBP.[24] There is low quality evidence that a physical ergonomic intervention is no more effective than no such intervention at reducing LBP prevalence in the long term.

NP incidence/prevalence

Short term

Three low risk of bias studies (total n = 1487)[22;24;30] and one high risk of bias study (n = 59)[23] compared the effectiveness of a physical ergonomic intervention to no intervention on NP incidence/prevalence. The study of Gerr et al. (2005) was evaluated as regards NP free workers[30], while the three other studies included workers with and without NP.[22-24] Ergonomic interventions included ergonomic training incorporating workplace adjustments for university employees[22], an alternate or conventional postural intervention with workstation changes for computer workers[30], computer workplace adjustments for call centre workers[23], and a participatory ergonomic programme consisting of workplace changes for kitchen workers.[24] The quality of evidence on this outcome was downgraded with one level. The results were indirect, because the pooled effect was largely determined by the high weight (84.7%) in the meta-analysis of one study that was conducted on kitchen workers.[24]

Therefore, there is moderate quality evidence from four studies (n = 1546) that there is no statistically significant difference in the reduction of NP incidence/prevalence at the short term (RR 0.93; 95% CI 0.84-1.03) between groups that received a physical ergonomic intervention compared to groups receiving no such intervention (figure 2b).

Long term

Two RCTs with low risk of bias (n = 686)[24;31] and one high risk of bias RCT (n = 206)[27] were identified. All the interventions under study were classified as physical ergonomic interventions and were conducted on workers with and without NP at baseline. Rempel et al. (2006) compared the effectiveness of three ergonomic interventions among customer service operators (ergonomic training and trackball, ergonomic training plus arm board and ergonomic training plus trackball plus arm board) to ergonomic training[31], and found that an ergonomic training plus an arm board, even when combined with a trackball, was significantly more effective than the ergonomic training only. Among engineering staff, Conlon et al. (2008), however, did not find any significant differences when an alternative mouse; an arm board combined with an alternative mouse or an arm board with a conventional mouse were compared to a conventional mouse.[27] Haukka et al. (2008) showed that a participatory ergonomic programme was no more effective than no intervention among kitchen workers regarding 2-year prevalence of NP.[24] The quality of evidence on this outcome was downgraded with two levels. Results were inconsistent and pooled data were imprecise, meaning that the width of the confidence interval of the pooled data made it impossible to support or refute the effectiveness of physical ergonomic interventions.

Therefore, there is low quality evidence from three studies (n = 892) that there is no statistically significant difference in the reduction of NP incidence/prevalence at the long term (RR 0.79; 95% CI 0.41-1.53) between groups that received a physical ergonomic intervention compared to groups that received no such intervention (figure 2c).

Figure 2a. Meta-analyses of three studies on physical and organisational ergonomic interventions compared to a control intervention in the reduction of short term LBP prevalence.

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Brisson 1995	22	283	24	339	9.8%	1.10 [0.63, 1.92]
Cook 2007	4	30	8	29	2.6%	0.48 [0.16, 1.43]
Haukka 2008	126	263	111	241	87.7%	1.04 [0.86, 1.25]
Total (95% CI)		**576**		**609**	**100.0%**	**1.03 [0.86, 1.22]**
Total events	152		143			

Heterogeneity: Tau² = 0.00; Chi² = 1.93, df = 2 (P = 0.38); I² = 0%
Test for overall effect: Z = 0.28 (P = 0.78)

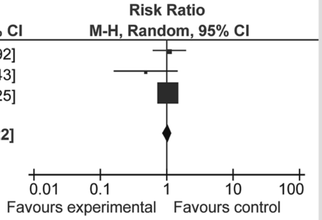


Figure 2b. Meta-analyses of four studies on physical and organisational ergonomic interventions compared to a control intervention in the reduction of short term NP incidence/prevalence.

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Brisson 1995	36	282	46	341	6.8%	0.95 [0.63, 1.42]
Cook 2007	5	30	8	29	1.1%	0.60 [0.22, 1.63]
Gerr 2005	36	116	33	109	7.3%	1.03 [0.69, 1.52]
Haukka 2008	176	263	174	241	84.7%	0.93 [0.83, 1.04]
Total (95% CI)		**691**		**720**	**100.0%**	**0.93 [0.84, 1.03]**
Total events	253		261			

Heterogeneity: Tau² = 0.00; Chi² = 0.97, df = 3 (P = 0.81); I² = 0%
Test for overall effect: Z = 1.33 (P = 0.18)

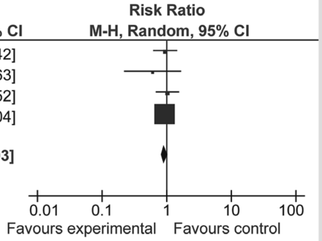
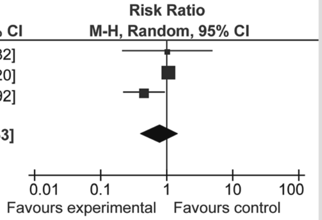


Figure 2c. Meta-analyses of three studies on physical and organisational ergonomic interventions compared to a control intervention in the reduction of long term NP incidence/prevalence.

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Conlon 2008	3	51	3	52	13.5%	1.02 [0.22, 4.82]
Haukka 2008	184	263	159	241	53.2%	1.06 [0.94, 1.20]
Rempel 2006	8	40	19	43	33.4%	0.45 [0.22, 0.92]
Total (95% CI)		**354**		**336**	**100.0%**	**0.79 [0.41, 1.53]**
Total events	195		181			

Heterogeneity: Tau² = 0.21; Chi² = 5.76, df = 2 (P = 0.06); I² = 65%
Test for overall effect: Z = 0.69 (P = 0.49)



LBP intensity

Short and long term

One low risk of bias study (N = 157) investigated the effects of a physical ergonomic intervention on the reduction in LBP intensity at the short and long term. Using a 2-year follow-up period, Lengsfeld et al. (2007) showed that a new office chair, with an electric motor underneath the seat to prevent prolonged sitting, was no more effective than the same chair without an electric motor.[28] There is low quality evidence that a physical ergonomic intervention is no more effective than no such interventions in reducing LBP intensity at both the short and long term.

NP intensity

Short term

Two low risk of bias studies (total n = 748) evaluated an ergonomic intervention.[25;26] One study investigated the effectiveness of an organisational ergonomic intervention among office workers, but found that rest breaks were no more effective than an informative brochure to reduce NP intensity.[26] A study of garment workers evaluated two physical ergonomic interventions: a chair with a curved seat and miscellaneous items, and a chair with a flat seat and miscellaneous items. Compared to a group with miscellaneous items (e.g. a footrest, storage box, side table, task lamp and reading glasses), both chairs were significantly more effective in reducing NP intensity.[25] The garment study showed, on a 5-point Likert scale, that the curved seat pan chair reduced NP intensity by 0.34 points, while the flat seat pan chair reduced NP intensity by 0.14 points. It should be noted that these significant results were found in a subgroup of 277 workers with NP at baseline, while a total 480 workers were randomised to one of the three groups. The garment study did not describe the intervention effects among the excluded subgroup (n = 203, without NP at baseline) or among the entire study population (n = 480). The use of two different pain scales (continuous and categorical) and the use of different types of ergonomic interventions among the studies made a meta-analysis on this outcome impossible.

In summary, there is low quality evidence from one study (n = 268)[26] that an organisational ergonomic intervention is no more effective than no such intervention in reducing NP intensity in the short term. Based on the significant reduction in NP intensity found in the garment study (n = 277)[25], there is low quality evidence that a physical ergonomic intervention (i.e. curved and flat seat pan chair) is significantly more effective for reducing NP intensity in the short term than no ergonomic intervention.

Long term

One study with a low risk of bias (n = 182) evaluated the effectiveness of three physical ergonomic interventions among customer service operators (ergonomic training and trackball, ergonomic training plus arm board and ergonomic training plus trackball plus arm board) to no ergonomic training.[31] Ergonomic interventions that combined the use of an arm board support and an ergonomic training were significantly more effective in reducing NP intensity than ergonomic training only. As regards the use of a trackball, no significant effects were reported on NP intensity.

Based on the significant reduction in NP intensity found in this single study, there is low quality evidence that a physical ergonomic intervention (i.e. arm board support) is significantly more effective in reducing NP intensity in the long term than no ergonomic intervention.

Discussion

This review investigated the effectiveness of physical and organisational ergonomic interventions on the prevention and reduction in LBP and NP among non-sick listed workers. The findings of this review showed that there is low to moderate evidence that ergonomic interventions were no more effective than control interventions on short and long term LBP and NP incidence/prevalence, LBP intensity and short term NP intensity. However, we found low quality evidence that in the short term a physical ergonomic intervention (i.e. curved and flat seat pan chair) was significantly more effective in reducing NP intensity than no ergonomic intervention. There was also low quality evidence that in the long term a physical ergonomic intervention (i.e. arm board) was significantly more effective in reducing NP intensity than no ergonomic intervention. However, these findings were obtained from two studies only.[25;31]

The results of the current review have to be interpreted with caution because of the limited number of studies per outcome and the heterogeneity in populations (symptomatic and non symptomatic), interventions, controls and outcomes. The generalisability of the results to the entire working population is low, because populations studied only consisted of office workers, garment workers, and kitchen workers. Further, the results of the pooled data on short-term prevention of LBP and NP were dominated by a large study that was conducted among kitchen workers.[24] Moreover, almost all other studies were on NP and were conducted in an office setting evaluating physical ergonomic interventions (i.e. workstation adjustments). At present, RCTs on organisational ergonomic interventions to prevent and reduce LBP and NP are lacking. Despite the limited number of included RCTs, this review provides solid epidemiological evidence of the effectiveness of ergonomic interventions on LBP and NP.

Findings compared to other reviews

The conclusions of the current review differ somewhat compared from those of other reviews.[5;13-15] Compared to previous reviews, this one specifically focussed on LBP or NP, while others included a larger variety of symptoms (i.e. neck/upper extremity pain, upper extremity musculoskeletal disorders or visual symptoms). Further, this review excluded study designs other than RCTs and excluded individual worker interventions. Moreover, none of the other reviews performed a meta-analysis and none used the GRADE classification system for levels of evidence.

Explanation of the findings

A number of factors may explain the results found in most studies. Due to the small sample sizes, there is a lack of power to detect positive effects. A meta-analysis was conducted that increases the power, but the results of the meta-analysis showed no statistically significant differences in effect. Six studies used relatively short follow-up periods that varied from 6 weeks to 6 months and found no effect. This might indicate that follow-up periods shorter than 6 months are too short to measure an effect. Furthermore, longer follow-up periods make it possible to measure intervention sustainability[16] and enable identification of delayed intervention effects. More measurements during follow-up may also be needed as LBP and NP are both marked by periods of remission and exacerbation.[32;33] By using one or two follow-up points only, the incidence/prevalence of LBP and NP may be over-or underestimated. Therefore, more advanced study designs and statistical methods are recommended, for example study designs with repeated measurements.[34] Furthermore, a considerable number of studies in this review included both workers with and without symptoms at baseline, and as a consequence may suffer from prevalence-incidence bias. Symptomatic workers at baseline may recover during follow-up, while workers without symptoms at baseline may in time develop LBP and NP. Further, because baseline pain intensity scores were low, little room was left for improvement on pain intensity scores.[35;36]

Another reason that no effect was found may be related to the exposure to occupational risk factors for LBP and NP. In their conceptual model, Westgaard and Winkel (1997) hypothesised that the implementation of an ergonomic intervention may change the workers' mechanical exposure and/or may affect the physical or psychosocial risk factors for musculoskeletal health, which in turn would lead to improved outcomes on musculoskeletal health.[16] In the current review, eight out of 10 studies were conducted among office workers. All but two[26;28] ergonomic interventions were aimed at optimising the workers' mechanical workload which in turn would reduce the physical risk factors for NP. The most important physical risk factor for NP and upper limb symptoms is repetitiveness combined with forceful exertions.[37-39] However, the exposure to such a physical load among office workers is very small. Psychosocial factors may also play a role in the onset of NP among office workers[5], however, none of the ergonomic interventions were targeted at the psychosocial workload.

Another possibility is that the ergonomic interventions did not target the most important risk factors. However, the issue of risk factors for LBP and NP is still poorly understood, particularly which risk factors are most likely to change through ergonomic interventions. In addition, risk factors outside the workplace may not be affected by ergonomic interventions.[40] Despite the fact that an RCT should control for unforeseen factors, according to some researchers, the work life environment may be too complex for such control. Although we agree that other study designs can add to our knowledge of the mechanisms of ergonomic interventions, in our opinion the RCT design is the gold standard to evaluate the effectiveness of ergonomic interventions. The view that RCTs are only applicable in occupational health settings and to ergonomic interventions is debatable because contamination between workers in the intervention and control groups can easily occur. To avoid contamination, randomisation at the workplace level (department or firm) is recommended.[41] In our review, only two studies performed a so-called cluster randomisation procedure.[24;26]

Finally, it may be that workers were not compliant with the ergonomic intervention. An intervention may be perfectly designed, but high compliance is still very important for its effectiveness.[42] From the scoring of the methodological quality criteria, it appeared that most studies had either insufficient levels of compliance or did not report on compliance at all. Reporting on this criterion is, therefore, strongly recommended. To increase worker's compliance, the use of an appropriate implementation strategy may be beneficial.[43] For instance, among floor layers an adequate implementation strategy was effective in reducing severe knee problems.[44] Furthermore, to improve interventions, authors mentioned that the combination of quantitative studies with qualitative studies would be worthwhile in order to examine participant's experiences with the intervention and the intervention effects on different subgroups and settings.[21] Subsequently, the new insights into the working mechanism of an intervention can be used for the development of new ergonomic interventions.

Strengths and limitations of the review

One of the main strengths of this review is that we only included RCTs, which are the studies least susceptible to bias. Furthermore, this review performed a meta-analysis on the results of the ergonomic interventions.

The present review has some limitations. The aim of this review was to summarise the existing knowledge and evidence concerning the effectiveness of ergonomic interventions on LBP and NP. A systematic review is a form of observational research and, therefore, selection bias may have occurred. Even though a highly sensitive literature search was conducted, it is still possible that studies were missed in this review. Three studies evaluated more than one ergonomic intervention. To avoid double counting of these studies, we chose to include the most effective intervention from these studies in the meta-analyses. This may have influenced the results, leading to an overestimation of the intervention effect. If studies did not report risk ratios, we calculated them using uncorrected study data. This also may have led to an overestimation of the effect size. However, because we did not find a statistically significant difference in effectiveness, these biases can be excluded.

Conclusion

This review showed low to moderate quality evidence that physical and organisational ergonomic interventions were not more effective on short and long term LBP and NP incidence/prevalence, on short and long term LBP intensity than no ergonomic intervention. In the short term, a physical ergonomic intervention (i.e. curved and flat seat pan chair) was significantly more effective in reducing NP intensity than no ergonomic intervention. There was also low quality evidence that in the long term a physical ergonomic intervention (i.e. arm board) was significantly more effective in reducing NP intensity than no ergonomic intervention. However, these findings were obtained from two studies only. In conclusion, ergonomic interventions were usually not effective in preventing or reducing LBP and NP among non-sick listed workers.

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3

Stay@Work: participatory ergonomics to prevent low back pain and neck pain among workers: design of a randomised controlled trial to evaluate the (cost-)effectiveness

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Abstract

Objective: Low back pain and neck pain are a major public health problem with considerable costs for individuals, companies and society. Therefore, prevention is imperative. The Stay@Work study investigates the (cost-)effectiveness of participatory ergonomics to prevent low back pain and neck pain among workers.

Methods: In a randomised controlled trial, a total of 5759 workers working at 36 departments of four companies is expected to participate in the study at baseline. The departments consisting of about 150 workers are pre-stratified and randomised. The control departments receive usual practice and the intervention departments receive participatory ergonomics. Within each intervention department a working group is formed including eight workers, a representative of the management, and an occupational health and safety coordinator. During a one day meeting, the working group follows the steps of participatory ergonomics in which the most important risk factors for low back pain and neck pain, and the most adequate ergonomic measures are identified on the basis of group consensus. The implementation of ergonomic measures at the department is performed by the working group. To improve the implementation process, so-called 'ergocoaches' are trained. The primary outcome measure is an episode of low back pain and neck pain. Secondary outcome measures are actual use of ergonomic measures, physical workload, psychosocial workload, intensity of pain, general health status, sick leave, and work productivity. The cost-effectiveness analysis is performed from the societal and company perspective. Outcome measures are assessed using questionnaires at baseline and after 6 and 12 months. Data on the primary outcome as well as on intensity of pain, sick leave, work productivity, and health care costs are collected every 3 months.

Discussion: Prevention of low back pain and neck pain is beneficial for workers, employers, and society. If the intervention is proven (cost-)effective, the intervention can have a major impact on low back pain and neck pain prevention and, thereby, on work disability prevention. Results are expected in 2010.

Introduction

In the Netherlands the most common musculoskeletal disorders (MSD) are low back pain (LBP) and neck pain (NP).[1] Surveys among the Dutch working population showed that the one year prevalence of LBP is 44.4% for men and 48.2% for women[2], and the prevalence of neck and shoulder pain is 28%.[3] These symptoms may lead to medical consumption[1;4], sickness absenteeism or disability claims.[5-8] In 2003, the estimated total health care costs of LBP and NP were 761 million Euros.[9] However, the annual costs of sick leave and loss of productivity due to LBP and NP are estimated to be nine times the health care cost.[10] The consequences and the costs of LBP and NP are a burden to society and companies. Therefore, prevention of these symptoms is imperative. LBP and NP are assumed to be of multifactorial origin.[11] Several systematic reviews showed that the work-related risk factors for LBP are heavy physical workload, whole body vibration, frequent bending and twisting, and heavy (manual) lifting.[12-16] The main risk factor for NP is neck flexion.[17] High prevalence rates of LBP and NP and the presence of the risk factors in the working population indicate the need for prevention at the workplace. Workplace interventions, such as ergonomics (i.e. education on lifting techniques or postural instruction) have been frequently used. However, the evidence to recommend ergonomics for the reduction of the prevalence of LBP is not sufficient and inconsistent.[18] The evidence for preventing neck and upper extremity pain using ergonomics is also limited.[19;20] Another approach to prevent LBP and NP may be participatory ergonomics. Supported by the management, participatory ergonomics empowers workers to design and change the worksite.[21] A recent randomised controlled trial (RCT) indicated that participatory ergonomics was not effective to prevent MSD among kitchen workers[22;23], whereas other studies indicated that the use of participatory ergonomics reduces MSD among workers.[24-29] However, most of the studies lacked a randomisation procedure, had no control group, assessed no other health outcomes (i.e. pain, quality of life, general health status, and costs), and studied homogeneous study populations only (blue or white collar).[30] Moreover, a RCT conducted in Sherbrooke Canada, indicated that participatory ergonomics induced a 1.9 faster (i.e. 42 days) return to work (RTW) in patients suffering from sub acute LBP.31 In the Netherlands, the Dutch participatory workplace intervention[32] which was derived from the Sherbrooke model[33], resulted in 30 days earlier RTW and was cost-effective when compared to usual practice.[34-36]

Although participatory ergonomics was (cost-)effective as a return to work RTW intervention, no RCT has been conducted to evaluate the (cost-)effectiveness of participatory ergonomics to prevent LBP and NP among a large and heterogeneous population of workers (blue and white collar). Therefore, the main objective of this study, called the Stay@Work study, is to evaluate the effectiveness of participatory ergonomics compared to usual practice (no participatory ergonomics) to prevent an episode of LBP and NP among workers. Secondary objectives of this study are: 1) to compare the effectiveness of participatory ergonomics on the secondary outcome measures (i.e. actual use of ergonomic measures, physical workload, psychosocial workload, intensity of pain, general health status, sick leave and work productivity); and 2) to evaluate the cost-effectiveness and cost-utility of participatory ergonomics compared to usual practice.

Methods

Study design

The Stay@Work study is a two-armed randomised controlled trial. Workers of the departments allocated to the intervention group receive the participatory ergonomics programme; departments allocated to the control group receive usual practice (no participatory ergonomics programme). Data on all outcome measures are assessed at baseline and after 6 and 12 months. Data on the primary outcome (an episode of LBP and NP), as well as on intensity of pain, sick leave, work productivity, and health care costs are collected retrospectively every 3 months. The data collection started in November 2007.
The study protocol was approved by the Medical Ethics Committee of the VU University Medical Center. Because departments are included as a whole, the Medical Ethics Committee decided that participants did not have to sign an informed consent form.

Study population and setting

Participants are workers, both blue and white collar workers, recruited from the departments of four large Dutch companies with at least 3000 workers each. The companies included are a railway transportation company, an airline company, a university including its university medical hospital, and a steel company. In order to successfully accomplish a participatory ergonomics programme, strong management support and participation at all company levels (high, middle, low management, as well as worker level) is essential.[21] Therefore, a top-down and bottom-up strategy is applied.
Prior to the study, the company's higher management confirmed participation by signing a letter of intent and agreed that their workers at certain departments are allowed to spend working time to participate in the study. In their letter of intent, the higher management also agreed with the financial and organisational consequences of the intervention. Then, the higher management sent all managers of potential departments an information letter containing information about the study design and the intervention, and requested cooperation. The researchers informed the department managers in detail during an oral presentation, and then asked for the participation of the department. After the department manager agreed to participate, he or she informed the lower level management of the department about the study. The stakeholders involved with workers' health (i.e. human resource management, workers union, and occupational physicians) are also informed by the researchers about the study design.

Although all workers within the participating departments are invited to participate, workers have to meet the following inclusion criteria to be included in the data analyses: 1) aged between 18 years and 65 years; 2) no cumulative sick leave period longer than 4 weeks due to LBP or NP in the past 3 months before the start of the intervention; and 3) not pregnant.

Sample size

The one-year incidence of LBP and NP in a general working population are 12-14% and 6%, respectively.[37;38] However, LBP and NP are episodic in nature. Therefore, repeated outcomes assessments are performed. Based on the results of the study of IJmker et al. (2006) an intra-class correlation coefficient (ICC) of 0.73 is estimated.[39] By using the ICC, the power analysis revealed that a sample size of 1662 workers (2 groups of 831 workers) is needed to detect a 25% decrease of an episode of LBP and NP among the intervention group compared to the control group.[40] This difference can be detected with a power of 80% and an alpha of 0.05. Expecting a dropout rate of 20% an initial study population of 2076 workers is needed (see figure 1).

Randomisation

Each department consists of approximately 150 workers. If necessary, to obtain a 'department' size of approximately 150 workers, departments are clustered to one department using the revised version of the Dutch Classification of Occupations 1984 (e.g. mentally demanding work, mixed mentally or physically demanding work, light physically demanding work, and heavy physically demanding work).[41] All departments are pre-stratified using this classification. Randomisation is performed at the level of department, in order to avoid contamination from workers allocated in the intervention to those in the control group. Using a computer-generated randomisation (Random Allocation Software, version 1.0, May 2004, Isfahan University of Medical Sciences, Iran), the randomisation is performed by an independent researcher (e.g. research assistant), who has no prior information about the departments. For practical reasons, the randomisation is performed before baseline measurements.

Blinding

Obviously, as a result of the participatory ergonomics intervention it is impossible to blind researchers, ergonomists, and department managers. However, workers of the departments randomised to the intervention or the control group are not aware of the study design. Only the department managers are informed about the study design and the randomisation outcome and are asked not to communicate to workers about the study design. Moreover, to further blind the workers for the study design, both groups watch a movie with ergonomic instructions which is used as a sham intervention.

Study groups

Control group

To the workers allocated to the control departments are asked to watch three short (45 seconds) web-based educative movies about the prevention of LBP and NP at the campaign website of 'Lighten the load, a European Campaign on Musculoskeletal Disorders' developed by the European Agency for Safety and Health at Work. The movies show certain risk factors at work (i.e. lifting too heavy loads, frequent twisting of the lower back, holding the neck in a fore ward bent position for a prolonged time) for LBP and NP as well as (ergonomic) strategies to avoid these risk factors and, thereby, prevent LBP and NP. The movie is used as a sham intervention and is considered as a educative strategy, which showed to be ineffective to prevent LBP.[42]

Intervention group

Workers allocated to the intervention departments watch the same movies about the prevention of LBP and NP as the control group. In addition, they receive the Stay@Work participatory ergonomics programme (see below).

Intervention

One of the main characteristics of participatory ergonomics is the formation of a 'working group' in which both workers and management participate as members.[21;43] The six steps of the Stay@Work participatory ergonomics programme are followed during two meetings with the working group. The first working group meeting is obligatory, and the second meeting is optional. The first meeting is guided by an ergonomist. During a 6-hour training session, which was held one month before the start of the intervention and consisted of a theoretical and a practical part, the participating ergonomists are trained in the protocol.

Each working group is formed by the department manager of each intervention department and consists of a maximum of 10 members; each member has his or her own role during the working group meetings. The working group includes:

Eight workers who are representatives for the main job tasks performed at the department, who have worked for at least 2 years in the current job, and who work more than 20 hours per week at the department. Workers have to identify risk factors for LBP and NP and have to define adequate ergonomic measures for these risk factors.

One department manager (or a representative) having decision authority and who knows whether the ergonomic measures suggested are feasible on organisational and financial criteria.

One occupational health and safety coordinator who judged to what extent the ergonomic measures fit in the health and safety policies measures.

After forming the working group, the researchers plan a date for the first and second working group meeting and instruct the working group in the six steps of participatory ergonomics and their specific roles during the meeting. In case a member of the working group is unable to attend the working group meeting him or herself, the department manager selects and asks a substitute. If the department manager or the occupational health and safety coordinator is not able to attend the working group meeting, a representative is asked to take their place.

The Stay@Work participatory ergonomics programme consists of the following six steps:

Step 1 The inventory of the workplace

As part of the preparation of the first working group meeting, an inventory of the workplace is conducted one month prior to the meeting consisting of the following sub steps:

1. Pictures of risk factors for LBP and NP are made: each worker of the working group is equipped with a photo camera and is instructed to take at least 10 pictures of risk factors for LBP and NP at the worksite.
2. Data of all workers of the department are obtained from the baseline questionnaire, and is used to obtain information on psychosocial risk factors for LBP and NP present at the department.
3. The ergonomist conducts a worksite observation at the department by using a checklist. The ergonomist observes activities relevant for LBP and NP at work (e.g. type of work performed, lifting heavy loads (> 20 kilograms), frequent bending and rotating the lower back or neck). Furthermore, the ergonomist collects information about co-worker support, job organisation, job planning, instructions, skills, management styles, materials, and equipment.

According to a fixed format, all information is summarised in a document by the research assistant for each department, and serves as a starting point for the first working group meeting. One week before the first working group meeting, the document is sent to the ergonomist and all members of the working group.

In the first meeting lasting six hours, the working group follows steps 2-4 of the Stay@Work participatory ergonomics programme. The meeting is guided by the ergonomist and takes place in one of the regular conference rooms of the department.

Step 2 Analysis of risk factors

All members of the working group discuss and if necessary adjust risk factors for LBP and NP summarised in the document, and a brainstorm session is performed to add possible other risk factors (individual, physical, mental, and organisational). Then, the frequency and the severity of the risk factors is evaluated by rating them according to a criteria list. The most frequent and severe risk factors are written down on a flap-over and are prioritised by all members of the working group. Subsequently, each member of the working group is asked to award his or her three most important risk factors by adding a sticker. On the basis of consensus, the three risk factors with the highest number of stickers are considered as the three most important risk factors.

Step 3 Finding of ergonomic measures

According to the nominal group technique[32] the working group performs a brainstorm session about different types of ergonomic measures (individual, physical, mental, and organisational) to reduce the prioritised risk factor. The ergonomic measures are evaluated using a criteria list, considering the problem solving capability, costs, compatibility, complexity, and feasibility of the ergonomic measures.[44] The manager decides whether the costs for the ergonomic measures are feasible. Furthermore, the ergonomic measures are judged whether they can be implemented within three months. Prioritisation of the ergonomic measures is performed similarly to step 2, resulting in the three most adequate ergonomic measures on the basis of consensus.

Step 4 Preparation of an implementation plan

The working group writes down the prioritised three most adequate ergonomic measures for the three most important risk factors for LBP and NP in an implementation plan. The plan describes who is responsible for the implementation of the ergonomic measures; what type of activities need to be performed by who, how, and when a test phase is needed; and whether an appointment for a second meeting to evaluate the implementation plan is required (see step 6). After finishing the first meeting, all members of the working group receive a copy of the implementation plan.

Step 5 Implementation of ergonomic measures

In the weeks following the first meeting, the working group informs the co-workers about the ergonomic measures, motivates and instructs them on how to use the ergonomic measures. The occupational health and safety coordinator or the department manager is the central person for coordinating and facilitating the implementation process. Studies on participatory ergonomics report difficulties towards the implementation of ergonomic measures[25] and the actual use of ergonomic measures.[45] Therefore, to further improve the implementation process and the actual use of the ergonomic measures, two or three workers are trained to be a 'Stay@Work ergocoach'. During a four hour training session, they are instructed about implementation strategies that can be used to inform, motivate, and instruct the co-workers about the selected ergonomic measures, and to learn how to deal with co-workers' resistances against the ergonomic measures. At the end of the training session they receive the 'Stay@Work ergocoach toolkit', which includes formats of e-mails, posters, flyers, and digital presentations. The toolkit is used as an instrument to inform the co-workers at the department about the prioritised ergonomic measures.

Step 6 Evaluation and control of the ergonomic measures

In step 4, the working group decides whether the second meeting (one hour) is needed to evaluate the status of the implementation plan or the test phase. The ergonomist does not attend the second meeting, unless he or she is asked by the working group. The rationale is that the implementation should be the responsibility of the department and the working group.

Use of co-interventions

In both the intervention group and the control group, the use of co-interventions are registered. Using a questionnaire, the department managers are asked about all other ongoing studies, planned reorganisations and other innovations or company health interventions (i.e. fitness programmes, back schools, chair massages, and lifestyle programmes).

Data collection procedure

Depending on the availability of an e-mail account supported by the company, outcome measures are collected either by online questionnaire or by hard copy questionnaires. If companies prefer online questionnaires, an e-mail is sent to the workers containing a link to the online questionnaire. If companies prefer hard copy questionnaires, the questionnaires are sent to the department managers, who hand out the questionnaires to the workers. The completed questionnaires are collected by the researchers. Approximately, one month before the first working group meeting, all workers of the intervention departments of concern and those of the matched control departments, receive the baseline questionnaire. To reduce loss to follow-up, a maximum of three reminders are sent and each department manager is asked to encourage all workers to complete the questionnaires. Subsequently, at each measurement, the researchers visit the participating departments before, during baseline and during follow-up measurements to encourage workers to fill out their questionnaires. Additionally, incentives (e.g. gift vouchers and pie) are used.

Primary outcome measure

An episode of LBP and NP

Every 3 months, the primary outcome measures, an episode of LBP and NP, are assessed using a modified version[46] of the Nordic Questionnaire.[47] LBP and NP are episodic and recurrent. This implies that one may have more than one episode of LBP and NP during follow-up. An episode of LBP and NP is defined by the presence of LBP and NP during a recall period of 3 months followed and preceded by a recall period of 3 months without LBP and NP. The transition from a symptom free period to a new episode of LBP and NP is modelled as the outcome variable.

Secondary outcome measures

Actual use of ergonomic measures

After 6 and 12 months, the researchers monitor whether the ergonomic measures are implemented or not, and classify the ergonomic measures according to the Stapleton classification scheme for ergonomic measures.[48] It is known that the actual use of ergonomic measures is positively and significantly associated with behavioural change phases.[49] Therefore, the behavioural determinants Attitude-Social influence- self-Efficacy (ASE)[50] needed to measure determinants for (the intention to perform) the desired behaviour (actual use of ergonomic measures) are asked using five questions at baseline, after 6 months and 12 months.

Physical workload

Data concerning the physical workload is obtained from the Dutch Musculoskeletal Questionnaire (DMQ)[46]. Proven physical risk factors are assessed: heavy physical workload, whole body vibration, frequent bending and twisting, and heavy (manual) lifting[12-16] for LBP, and neck flexion for NP.[17]

Psychosocial workload

Data on psychosocial workload are assessed by means of a Dutch version of the Job Content Questionnaire[51] using the following indices: skill discretion, decision authority, psychosocial job demands, supervisor support, and co-worker support. These indices have shown moderate to good reliability (0.65-0.81).[52] The psychosocial stressors and perceived stress are assessed using the 11-item 'need for recovery scale' from the Dutch version of the Questionnaire on the Experience and Evaluation of Work (Dutch abbreviation VBBA), which has shown to be valid and reliable (0.86).[53;54]

Intensity of pain

The intensity of pain (i.e. pain at the moment of filling out the questionnaire, average pain and most severe pain experienced in the past 3 months), and the pain duration (total days of pain experienced in the past 3 months) due to LBP and NP is measured using von Korff scales, which have shown acceptable to good test-retest reliability.[55;56]

General health status

The Dutch version of the EuroQol is used to assess the patient's general health status. The questionnaire describes the general health status in five dimensions: mobility, self-care, usual activities, pain/discomfort and anxiety/depression.[57] Furthermore, one question is adopted from the Dutch ShortForm-36 questionnaire, which has shown satisfactory validity and reproducibility.[58]

Sick leave and work productivity
Self-reported all cause sick leave is measured using a single item question asking the workers about their full days of absence from work due to sick leave in the past 3 months. The same question is used to assess sick leave due to LPB or NP in the past 3 months. These questions have shown acceptable specificity and sensitivity levels.[59] Additional data on days of sick leave and diagnoses are collected from the records of the Occupational Health Service and Human Resource department of the participating companies. Work productivity is measured using a single item question from the WHO Health Productivity Questionnaire[60;61] asking participants to report their overall work productivity on a 10-point scale in the past three months.

Other variables
Sociodemographic
At baseline, sociodemographic data, (i.e. age, gender, level of education, workingdays per week, working hours per week, nationality, body height, and body weight) are assessed using the DMQ.[46]

Physical Activity
Lack of physical activity might be a risk factor for LBP and NP.[62;63] Therefore, physical activity (during work, sports, during other leisure-time pursuit, and in total) is assessed using the Baecke questionnaire[64;65], which has shown acceptable reliability and validity.[66]

Cost data
A cost-effectiveness analysis (CEA) and a cost-utility analysis (CUA) of the Stay@Work participatory ergonomics programme is performed. The CEA is performed using both a company and a societal perspective. The company perspective compares the intervention costs paid by the company with 1) the effect on the prevalence of LBP and NP; 2) the effect on sick leave (in days)[67]; and 3) work productivity. Intervention costs include costs for the development of the intervention, the implementation of the intervention (i.e. materials needed for the working group meetings, the Stay@Work ergocoach training, and costs of the ergonomists).
Next to the costs relevant for the employer, the societal perspective takes into account all costs (i.e. direct and indirect costs, and costs within and outside the health care). Direct health care costs include costs of the visits to health care providers, diagnostic examinations, and prescribed medication due to LBP and NP. Direct non-health care costs are costs outside the formal health care system due to LBP and NP and include costs of the ergonomist, time loss of workers in the working group, and over-the-counter medication. Both direct health care cost and direct non-health care cost are measured every three months by using retrospective cost questionnaires.[68;69] The indirect non-health care costs are the costs of

production losses due to sick leave, reduced productivity while at work, and work disability of the worker. The CUA estimates the incremental costs per Quality Adjusted Life Year. Utilities are measured by the EuroQol.

Process evaluation

The process of the intervention is evaluated in four ways:

First, the working group is asked for their opinions on: 1) the content and process of the working group meeting as a whole; 2) the ergonomist's competences; and 3) their expectations towards the implementation and the effectiveness of the ergonomic measures on the prevention of LBP and NP.

Second, working group members who followed the Stay@Work ergocoach training are asked their opinions about: 1) the training as a whole; and 2) the added value of the training to improve the implementation process and to improve the actual use of ergonomic measures.

Third, all workers of the intervention and control departments are asked: 1) if they are aware of prioritised ergonomic measures and whether the ergonomic measures are implemented at the department; 2) if they actually use the ergonomic measures; and 3) about the perceived effectiveness of the implemented ergonomic measures on LBP and NP prevention.

Fourth, all members of the working group are sent a questionnaire and are asked: 1) whether he or she implemented the ergonomic measure(s) for which he or she is responsible; and 2) to identify and describe possible barriers or facilitators during the implementation of the ergonomic measure(s). One worker of the working group is invited for a semi-structured interview in which the implementation process is discussed. The content and structure of the interview is based on the answers given in the questionnaires of all working group members. Furthermore, the manager is sent a questionnaire and is also invited for a semi-structured interview.

Statistical analyses

All analyses are performed according to the intention to treat principle. The most important analyses are performed at worker level. Two analyses are performed: 1) a crude analysis with the outcome variable measured at follow-up as the dependent variable adjusted for the outcome, measured at baseline; and 2) an analysis as above but adjusted for potential covariates (e.g. gender, age, type of work, history of LBP and NP, and physical and psychosocial workload). Effects of the intervention will be checked for effect modification (gender, type of work, number of ergonomic measures implemented). For the purpose of primary prevention a subgroup analysis is performed among workers without LBP and NP in the month prior to the start of the intervention.[70] Generalised estimation equations (GEE) are used to analyse long-term results (i.e. 12 months after baseline) and to investigate the transition of no episode to an episode of LBP and NP during a 3-month period. Furthermore, analyses at department level are performed by the use of multilevel analysis. For all analyses a two-tailed significance level of <0.05 is considered statistically significant. The multilevel statistical analyses are performed with MlwiN 2.0; linear and logistic regression analyses is performed with SPSS 14.0 (SPSS Inc. Chicago, Illinois, USA), and GEE analyses is performed with STATA version 7.0, College Station, TX).

Cost-effectiveness analysis

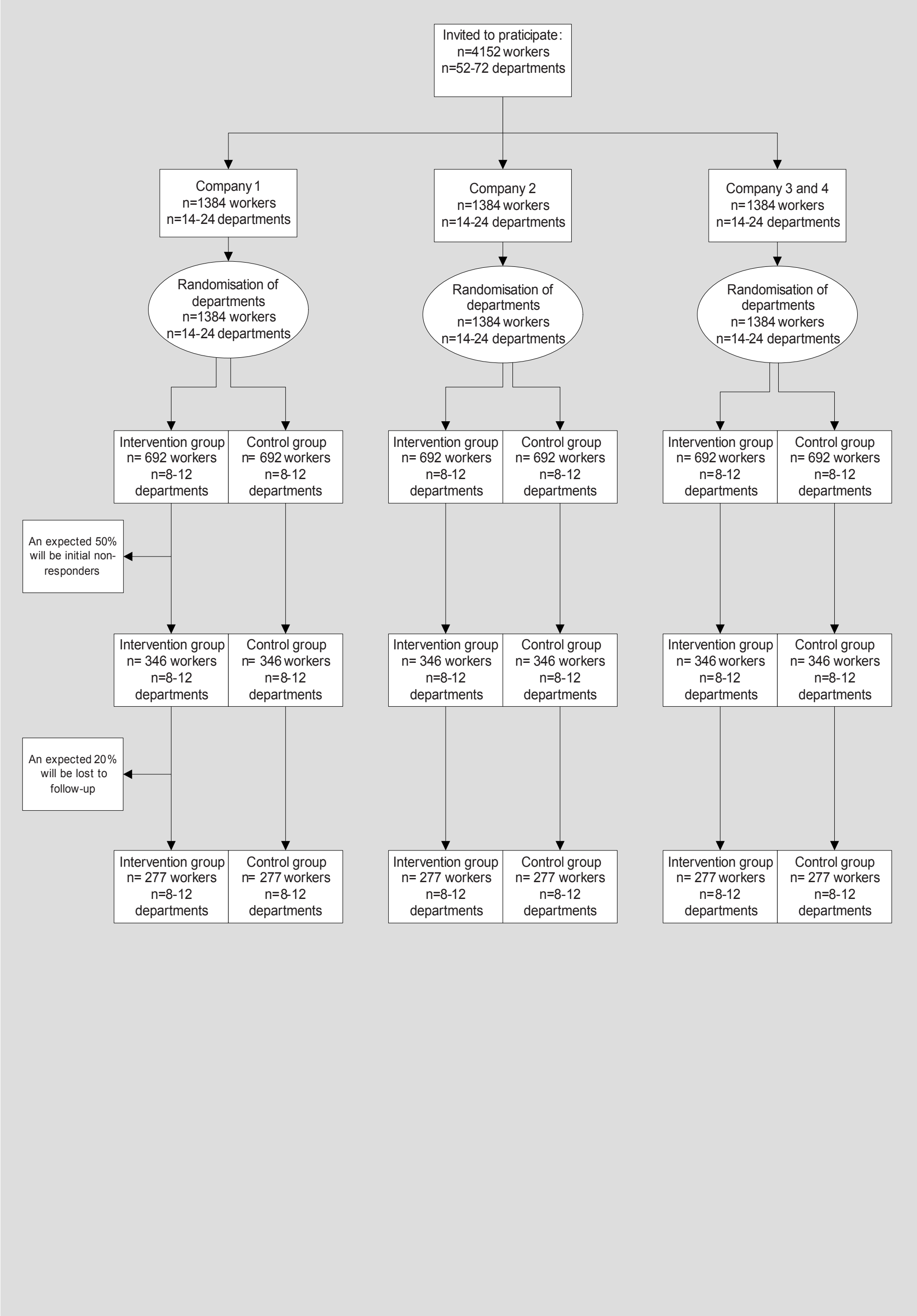
The indirect costs for production losses due to sick leave are calculated by using the Friction costs method.[71] For this method, the Dutch guidelines for economic evaluation is used.[72] The direct health care costs are calculated by using tariffs for the costs of health care professionals and market prices for the value of medication. Costs for the ergonomists are calculated by using the hourly wages. The direct non-health care costs, are calculated by using the information obtained from the cost questionnaires and shadow prices. Bootstrapping is used for comparison of mean direct, indirect and total costs between the two groups. Confidence intervals are obtained by bias corrected and accelerated bootstrapping. Cost-effectiveness ratios are calculated by dividing the difference between the mean costs of the interventions by the difference between the mean effects of the interventions. The bootstrapped costs effects pairs are graphically presented on a cost-effectiveness plane. Acceptability curves are calculated in order to show that the probability of the intervention is cost-effective at a specific ceiling ratio. Furthermore, sensitivity analyses are performed.

Discussion

Prevalence of LBP and NP among Dutch workers is high and the financial consequences are a considerable burden to companies and society.[2;3;9] In previous studies participatory ergonomics has been applied to prevent MSD; however, most studies lacked a randomisation procedure or a control group. One of the main strengths of Stay@Work is that this study is one of the few RCT's that evaluates PE aimed at the prevention of an episode of LBP and NP. Moreover, this study evaluates the (cost-)effectiveness of participatory ergonomics, and investigates other important health outcomes among a large heterogeneous population of workers. To date, research populations are consisting of construction workers, cleaners, glaziers, and manufacturing workers. In this study also health care workers, industrial and white collar workers are studied. A second strength is that the participants are blinded to the study design and the randomisation outcome, which minimises the chance that they undertake actions that may interfere with the experimental study design. A third strength is the use of an appropriate implementation strategy. Van der Molen et al. (2005) reported that the use of facilitation and educational strategies in the implementation of ergonomic measures lead to higher completed behavioural change phases and increased use of ergonomic measures.[73] This is confirmed by Jensen and Friche (2008), who used an implementation strategy that increased the use of ergonomic measures and successfully reduced severe knee problems among floor layers.[26] To our knowledge, this is the first study that trained ergocoaches to improve the implementation of the ergonomic measures and stimulate the co-workers to use the ergonomic measures. A fourth strength is that Stay@Work evaluates the effectiveness of participatory ergonomics under routine department circumstances and does not optimise the study conditions (i.e. stopping with co-interventions). In other words, it is an effectiveness study and not an efficacy study.

There are also some limitations. First, selection bias due to a selective response may occur. Workers with LBP and NP could be more likely to fill out the questionnaires compared to workers without complaints. Second, due to the maximum size of the working group (10 persons), the department manager selects representatives of the largest and most important task groups to participate in the working groups. Therefore, very small task groups may not be represented in the working group. The ergonomic measures are developed for the department as a whole, consequently, the non-representation of the smallest task groups might lead to a lower actual use of the ergonomic measures among workers from these groups. Third, although the randomisation and the deliverance of the intervention are carried out at the level of the department, the main statistical analyses are performed at worker level. However, based on the example described in the book, we expect that by using multilevel analysis the differences and equalities between the analyses performed at department level and analyses performed at worker level are comparable to the differences of studies in which the randomisation was carried out at worker level.[74] Studying the effects of this intervention is important, as it aims to prevent a major occupational health problem. If proven (cost-)effective, the companies will benefit from a bottom-up method to prevent LBP and NP among their workers. Occupational Health Services or managers may incorporate this method in their usual prevention management.

Figure 1. Participants flow chart (numbers are expected to vary in the actual study).



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Process evaluation of a participatory ergonomics programme to prevent low back pain and neck pain

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Abstract

Objective: Both low back pain and neck pain are major occupational health problems. In the workplace, participatory ergonomics is frequently used on musculoskeletal disorders. However, evidence on the effectiveness of participatory ergonomics to prevent low back pain and neck pain obtained from randomised controlled trials is scarce. This study evaluates the process of the Stay@Work participatory ergonomics programme, including the perceived implementation of the prioritised ergonomic measures.

Methods: This cluster randomised controlled trial was conducted at the departments of four Dutch companies (a railway transportation company, an airline company, a steel company, and a university including its university medical hospital). Directly after the randomisation outcome, intervention departments formed a working group that followed the steps of participatory ergonomics during a six-hour working group meeting. Guided by an ergonomist, working groups identified and prioritised risk factors for low back pain and neck pain, and composed and prioritised ergonomic measures. Within three months after the meeting, working groups had to implement the prioritised ergonomic measures at their department. Data on various process components (recruitment, reach, fidelity, satisfaction, and implementation components, i.e. dose delivered and dose received) were collected and analysed on two levels: department (i.e. working group members from intervention departments) and participant (i.e. workers from intervention departments).

Results: A total of 19 intervention departments (n = 10 with mental workloads, n = 1 with a light physical workload, n = 4 departments with physical and mental workloads, and n = 4 with heavy physical workloads) were recruited for participation, and the reach among working group members who participated was high (87%). Fidelity and satisfaction towards the participatory ergonomics programme rated by the working group members was good (7.3 or higher). The same was found for the Stay@Work ergocoach training (7.5 or higher). In total, 66 ergonomic measures were prioritised by the working groups. Altogether, 34% of all prioritised ergonomic measures were perceived as implemented (dose delivered), while the workers at the intervention departments perceived 26% as implemented (dose received).

Conclusions: Participatory ergonomics can be a successful method to develop and to prioritise ergonomic measures to prevent low back pain and neck pain. Despite the positive rating of the participatory ergonomics programme the implementation of the prioritised ergonomic measures was lower than expected.

Introduction

The prevalence of low back pain (LBP) and neck pain (NP) among workers is high.[1;2] To prevent or reduce these symptoms, ergonomic interventions are commonly applied.[3] However, ergonomic interventions appeared to be most often not effective in the prevention of LBP and NP.[2;4-6] An important reason for finding no effects on LBP and NP might be due to the inadequate implementation of ergonomic measures (i.e. compliance, satisfactions and experiences) and the lack of using adequate implementation strategies.[7]

Participatory ergonomics is a noted implementation strategy to develop ergonomic measures from the bottom up.[8-10] According to the stepwise participatory ergonomics method, ergonomic measures are developed by working groups (consisting of workers, management, and other important stakeholders).[8;10-12] By using this bottom up approach, the acceptance to use the ergonomic measures may become more widespread among end-users (i.e. workers). To inform, educate, and instruct workers on the participatory ergonomics process, other supportive implementation strategies, such as distribution of brochures and flyers, providing training, and capitalising on opinion leaders are used.[13;14] The actual implementation of ergonomic measures is considered as a (possible) consequence of the participatory ergonomics process and can be enhanced by the use of additional strategies (e.g. use of opinion leaders).

The effects of participatory ergonomics on the reduction of musculoskeletal disorders (MSD) have shown to be promising.[15-21] However, it should be noted that most studies on the effectiveness of participatory ergonomics were of low quality and were conducted in a working population with heavy workloads. Studies directly assessing the prevention of MSD are rare, especially those using a randomised study design. The only randomised controlled trial (RCT) in the area of participatory ergonomics and the prevention of MSD has been conducted by Haukka et al. (2008). They showed that participatory ergonomics was not effective to prevent MSD among kitchen workers.[22] More high-quality studies (RCTs) evaluating the effectiveness of participatory ergonomics are needed. Therefore, the Stay@Work study currently investigates the effectiveness of a participatory ergonomics programme on the prevention of LBP and NP among a heterogeneous population of workers.[23]

In the past years, the conduct of process evaluations alongside RCTs has been recommended, because they can facilitate the interpretation of the findings.[24] For example, a process evaluation can shed light on whether the intervention was delivered as intended (i.e. compliance, adherence, satisfaction, and experiences) as well as the success and failures of the intervention programme.[25-28] Moreover, the information obtained from a process evaluation can be used to further improve the intervention[26;29], and to enable the transition of research evidence into occupational health practice.[30]

Therefore, this study evaluated the process of the Stay@Work participatory ergonomics programme, including the perceived implementation of the prioritised ergonomic measures.

Methods

This process evaluation was performed alongside a RCT on the effectiveness of a participatory ergonomics programme on the prevention of LBP and NP among workers, called Stay@Work. The Medical Ethics Committee of the VU University Medical Center approved the study protocol. Detailed information on the methods, randomisation procedure, and intervention can be found elsewhere.[23] The departments of four large Dutch companies (a railway transportation company, an airline company, a university including its university medical hospital, and a steel company) were invited to participate in the study. The higher management of all companies agreed with the financial and organisational consequences of the intervention.

Based on their main workload, participating departments were classified into: mental, physical, mix mental/physical, or heavy physical departments.[31] Within each company, one randomisation pair of two departments with comparable workloads was randomly allocated to either the intervention group (Stay@Work participatory ergonomics programme) or the control group (no Stay@Work participatory ergonomics programme).

All workers at the departments of both groups received the baseline questionnaire and watched three short (45 seconds) educative movies about the prevention of LBP and NP.

The Stay@Work participatory ergonomics programme

In short, the intervention comprised a 6-hour working group meeting, in which the steps of the Stay@Work participatory ergonomics programme were followed. Each intervention department had to form a 'working group', in which both workers and management participated as members.[8;11] Each working group consisted of at least one manager with decision authority, a maximum of eight workers who were a solid representation of the largest and most important task groups at the department. If available, an occupational health and safety coordinator was incorporated in the working group as well. Working group members had to have worked at least two years in their current job, worked for more than 20 hours per week at the department, had responsibilities within his/her own task group, was a role model for his/her co-workers, and was motivated to participate as a member in the working group.[23]

During the first meeting, the working group discussed a document containing infor mation on risk factors on LBP and NP present at the department, which were obtained from the ergonomist workplace visit (which was mandatory for each intervention department), pictures made by the working group members, and baseline questionnaire information (step 1). Then, the working group could add other risk factors of LBP and NP, and judged all mentioned risk factors as to their frequency and severity. Based on the perceptions of the working group, the most frequent and severe risk factors were prioritised, resulting in a top three of risk factors (step 2). Subsequently, the working group held a brainstorming session about different types of ergonomic measures targeting the prioritised risk factors, evaluated the ergonomic measures according to a criteria list considering: relative advantage, costs, compatibility, complexity, visibility, and feasibility within a time frame of three months.[32] On a consensus basis, the working group prioritised the three most appropriate ergonomic measures (step 3). Finally, the prioritised risk factors and the prioritised ergonomic measures were written down in an implementation plan (step 4). The implementation plan described for each ergonomic measure which working group members were responsible for its implementation. Based on their interests in the projects, the prioritised ergonomic measures were divided among the members of the working group. Working group members who had a responsibility towards implementation of a prioritised ergonomic measure were called the 'implementers'. At the end of the meeting, the working group was requested to implement the ergonomic measures (step 5) and was asked whether an appointment for a second, optional, meeting was necessary to evaluate or adjust the implementation process (step 6).

During the implementation process, all working groups were allowed to ask help from other professionals (i.e. technicians, engineers, or suppliers) or services (i.e., equipment or health services). To improve the implementation process, two or three working group members from each working group were asked to voluntarily follow a training programme to become a Stay@Work ergocoach. In this additional four-hour implementation facilitation training, workers were educated in different implementation strategies to inform, motivate, and instruct co-workers about the prioritised ergonomic measures.

Moreover, the ergocoaches were equipped with a Stay@Work toolkit consisting of flyers, posters, and presentation formats about the prioritised ergonomic measures. According to the Attitude - Social influence - self–Efficacy (ASE) behavioural change model that was applied during the participatory ergonomics programme, dissemination of information about ergonomic measures may increase worker's self-awareness of their own behaviour and increase knowledge about possible ergonomic solutions. Thus informing workers can be regarded as a first step in order to induce a behavioural change.[13;33]

The process evaluation

An adapted version of the Linnan and Steckler framework, which has been recommended to be a useful guide for the conduct of a process evaluation, was used.[34;35] Table 1 presents the components that were addressed; recruitment, reach, fidelity, satisfaction, and implementation components (i.e. dose delivered and dose received).

Data collection

The process evaluation was conducted for the intervention departments only. The participatory ergonomics programme is a complex intervention, containing components that may affect different levels. Therefore, if appropriate, data on the components were collected on two levels (see table 2): department level (i.e. working group members from intervention departments) and participant level (i.e. workers from intervention departments).

Recruitment

Department level recruitment

The department level was defined as the number of intervention departments that agreed to participate in the study and the number of working groups formed. Managers who formed the working group had to send a list with names of the working group members to the principal researcher. At the end of each working group meeting, two or three members were recruited for the additional Stay@Work ergocoach training.

Table 1. Process evaluation components and their definitions.

Component	Definition
Recruitment	- Number of intervention departments that agreed to participate - Number of working groups formed - Number of working group members recruited for additional ergocoach training - Number of workers who responded to the baseline questionnaire
Reach	- Number of worksite visits by ergonomist - Number of working group members who attended working group meeting - Number of working group members who attended the Stay@Work ergocoach training
Fidelity	- The extent to which the steps of the participatory ergonomics programme were delivered as intended
Satisfaction	- Satisfaction of working group members towards the prioritised risk factors and ergonomic measures, the ergonomist's competences, and duration of the working group meeting - Satisfaction of working group members who followed the Stay@Work ergocoach training towards the course leader's competences, and the duration of the training - Satisfaction of workers at the department towards the perceived implemented ergonomic measures and towards the intervention method (participatory ergonomics) that was used to develop the ergonomic measures
Dose delivered	- Perceived implementation of the ergonomic measures according to the implementers
Dose received	- Perceived implementation of the prioritised ergonomic measures according to the workers at the departments - Workplace implementation of the prioritised ergonomic measures according to the workers at the departments

Table 2. Process evaluation data collection: main levels and methods.

Component	Department level	Participant level	Data collection tool
Recruitment	X	X	Checklist and baseline questionnaire
Reach	X		Checklist
Fidelity	X		1 to 10 scale (very bad to very good)
Satisfaction	X	X	1 to 10 scale (very unsatisfied to very satisfied)
Dose delivered	X		Questionnaire assessing for each prioritised ergonomic measure the perceived implementation (yes/partly/no)
Dose received		X	Questionnaire assessing for each prioritised ergonomic measure the: 1) Perceived implementation (yes/no/don't know) 2) Workplace implementation (yes/no)

Participant level recruitment

The level of the participant was defined as the number of workers who filled out the baseline questionnaire.

Department level reach

At the level of the department, 'reach' was defined in two ways. First, reach was defined as the number of worksite visits conducted by the ergonomists. During a worksite visit, the ergonomist observed activities or situations that were considered relevant for LBP and NP. Information on the workplace visits was sent to the principal researcher. Second, reach was defined as the number of workers that attended the working group meeting and the number of working group members that attended the Stay@Work ergocoach training. Before the start of each session, all working group members had to sign a list to confirm their attendance. Reasons for not attending were registered.

Department level fidelity and satisfaction

Directly after finishing the working group meeting, all working group members were asked to report on the components fidelity and satisfaction: at the level of the department, 'fidelity' was defined as the extent to which the steps of the participatory ergonomics programme were delivered as intended, and was rated on an 1-10 point scale (very bad to very good); at the level of the department, 'satisfaction' was rated on an 1-10 point scale (very unsatisfied to very satisfied) and encompassed satisfaction towards the outcomes (risk factors and ergonomic measures prioritised), the ergonomist's competences, and the duration of the meeting was assessed. By using the same components (fidelity and satisfaction) and measures (1-10 scale), the Stay@Work ergocoach training was evaluated.

Participant level satisfaction

At the level of the participant, satisfaction could only be measured among workers who perceived at least one ergonomic measure as implemented. By using an 1-10 point scale (very unsatisfied to very satisfied), satisfaction with the perceived implemented ergonomic measure(s) was assessed; likewise, satisfaction with the intervention method (participatory ergonomics) used to develop ergonomic measures was measured. These workers were also asked on how they took notice of the supportive implementation measures (i.e. e-mail/poster/flyer).

Implementation

Department level dose delivered

Four months after finishing the working group meeting, the implementers - working group member(s) responsible for the implementation of one or more prioritised ergonomic measure(s) - received a short questionnaire. Implementers were asked whether the prioritised ergonomic measures for which he/she was responsible for were realised (implemented) at the department as described in the original implementation plan. The perceived implementation was assessed separately for each ergonomic measure. For each ergonomic measure, the implementers could choose from three answer categories:

1. yes, implemented: the prioritised ergonomic measure was realised as described in the implementation plan.
2. yes, partly implemented.
3. no, not implemented: the prioritised ergonomic measure was not realised as described in the implementation plan.

This method enabled the investigators to calculate for each ergonomic measure of interest a percentage of the perceived implementation. The implementation percentage was derived by summing the frequencies of each of the three answer categories (yes, implemented/ yes, partly implemented/ no, not implemented). By summing all implementation percentages and dividing by the total number of prioritised ergonomic measures, an overall implementation percentage for all departments could be calculated.

Participant level dose received

All information on the participant level was obtained from workers who responded to the six-month follow-up questionnaire, and addressed information on:

1. The perceived implementation of the ergonomic measures was measured by means of a separate question that asked workers whether the prioritised ergonomic measure was implemented by the working group at their department. For each ergonomic measure, three answers were possible: yes/no/don't know. By using a procedure similar to the one for dose delivered, an overall perceived implementation percentage was calculated.
2. The workplace implementation was assessed among those workers who perceived an ergonomic measure as implemented. By means of another question they were asked whether the ergonomic measure was applicable to their workplace (yes/no). The percentage of implemented measures at their workplace was derived by dividing the number of 'yes actually implemented' by the number of 'yes perceived as implemented'.

Results

Recruitment and reach

Department level

In total, 37 departments were included in the randomisation procedure with 19 departments randomised to the intervention group. Among the intervention departments, 10 departments were characterised by mental workloads, one department had a light physical workload, four departments had mixed workloads (physical and mental), and four departments had heavy physical workloads.

One department with a mixed workload (n = 103 workers) dropped out of the study due to a sudden reorganisation, and no working group was formed at that department. Further, as the department managers of four departments with a 'mental workload' were not able to select a sufficient number of workers to participate in the working group, it was decided to form two working groups instead of four.

Thus, out of 18 departments, 16 working groups were formed. In total, 113 working group members were invited to participate. All working groups held a working group meeting, which was attended by 98 working group members (87%). Of the 15 non-attending members six were on sick leave, seven were too busy, one had a regular day off, and one was no longer working at the department.

Eight Stay@Work ergocoach training sessions were held and were attended by 40 working group members. The number of members per working group that followed the training varied from one to six.

Participant level

The baseline questionnaire was sent to 5695 workers, of whom 3232 (57%) responded. A total of 185 workers did not meet the inclusion criteria for data analyses, which were: 1) aged between 18 years and 65 years; 2) no cumulative sick leave period longer than four weeks due to LBP or NP in the past three months before the start of the intervention; and 3) not pregnant.23 Hence, at baseline 3047 (53%) workers were included. Among them, 1472 workers were working at intervention departments. Compliance to watching the movies on LBP and NP prevention in the intervention group was 67%.

Fidelity and satisfaction

Department level

Six trained ergonomists conducted the worksite visits (n = 18) and guided the working group meetings. The number of working groups that each ergonomist guided varied from one to five. All 16 working groups completed the first working group meeting according to the study protocol and developed an implementation plan. Three working groups, all characterised by heavy physical workloads, planned the second (optional) working group meeting. Working group members (n = 98) rated the quality of the participatory ergonomics steps performed between 7.32 (SD 1.02) and 7.59 (SD 0.99), and were satisfied with the risk factors and ergonomic measures prioritised (7.30, SD 1.15), the ergonomist's competences (7.70, SD 0.92) and the 6-hour duration of the meeting (7.06, SD 1.30).

In total, 40 working group members (25 men and 15 women) followed the Stay@Work ergocoach training and were positive about the quality of the training (7.67, SD 0.48), were satisfied with the course leader's competences (8.03, SD 0.70), and with the four-hour duration of the training (7.53 (SD 1.15)).

Participant level

Workers at the departments who perceived at least one of the ergonomic measures as implemented were informed about the ergonomic measure(s) by poster/flyer/e-mail (55%), by a presentation provided by a working group member (41%), or by their supervisor (24%). Workers rated their satisfaction towards the ergonomic measures as prioritised by the working group (5.72, SD 2.39) and the method (participatory ergonomics) used to develop and prioritise the ergonomic measures (5.59, SD 2.29). In case the ergonomic measures were implemented at their workplace, satisfaction towards the ergonomic measures was 6.02 (SD 2.31). For the method used to develop and prioritise the ergonomic measures their satisfaction was 5.82 (SD 2.23).

Implementation

Department level: dose delivered

In total, the working groups prioritised 66 ergonomic measures. The number of ergonomic measures per working group varied from three to six. The 66 prioritised ergonomic measures were classified by two researchers independently from each other into three categories: individual, physical, and organisational ergonomic measures.[36] The classification resulted in: 32 individual, 27 physical, and 7 organisational ergonomic measures (see table 3).

Table 3. Types and targets of the prioritised ergonomic measures (n = 66).

Type of ergonomic measure	Target of ergonomic measure	N
Individual (n = 32)	Improving awareness regarding ergonomics	21
	Worksite visits by an expert	2
	Physical activity programmes	5
	Training in working techniques, (*i.e.* lifting technique)	3
	Personal protective equipment (*i.e.* kneepads)	1
Physical (n = 27)	Ergonomic redesign and/or workstation modifications	18
	Manual handling aids (*i.e.* lifting devices)	5
	Equipment and/or tools	4
Organisational (n = 7)	Installation of pause software	2
	Develop protocol to improve worker's health	1
	Restructuring management style	2
	Job rotation	2

To investigate whether the 66 prioritised ergonomic measures were actually implemented at the departments, the 81 implementers were sent a short questionnaire. A total of 65 of the implementers responded (80%). From the questionnaire, it appeared that the implementation status of three prioritised ergonomic measures was unknown (n = 1 individual, n = 2 physical). Therefore, this study evaluated the perceived implementation of 63 prioritised ergonomic measures (n = 31 individual; n = 25 physical; n = 7 organisational). Implementers reported that altogether 34% of the prioritised ergonomic measures was implemented, 26% was partly implemented, and 40% was not implemented at the 18 departments. From the answers on the questionnaire, it was shown that within working groups implementers sometimes disagreed on the implementation status of the prioritised ergonomic measure. That is, one implementer perceived the measure as implemented, whereas another implementer within the same working group perceived the measure as not implemented.

Table 4 presents the percentages of the perceived implementation stratified by type of ergonomic measure and department workload. In general, highest implementation rates were found for individual ergonomic measures (53%), and lowest implementation rates for organisational ergonomic measures (28%). At the light physical workload department, the implementation was 100%, but these results were obtained from only one department. Organisational ergonomic measures were most common at the departments with a mental workload and were in most cases 'partly' implemented (47%). Departments with a heavy physical workload most often prioritised physical ergonomic measures (n = 12), but the perceived implementation was low (16%). Departments with a mixed workload, and departments with a mental workload, most often prioritised individual ergonomic measures (n = 11). The perceived implementation between these two department types, however, varied largely (26% to 79%).

Table 4. Perceived implementation of the prioritised ergonomic measures according to the implementers (n = 65).

Ergonomic measures perceived as implemented	**Type of ergonomic measure**		
All departments	Individual	Physical	Organisational
(n = 18)	(n = 31)	(n = 25)	(n = 7)
Yes (%)	53	30	25
Partly (%)	21	26	47
No (%)	26	44	28
Mental workload departments	Individual	Physical	Organisational
(n = 10)	(n = 11)	(n = 7)	(n = 5)
Yes (%)	26	33	15
Partly (%)	32	41	46
No (%)	42	26	39
Light physical workload departments	Individual	Physical	Organisational
(n = 1)	(n = 1)	(n = 2)	(N/A)
Yes (%)	100	100	N/A
Partly (%)	0	0	N/A
No (%)	0	0	N/A
Mixed workload departments	Individual	Physical	Organisational
(n = 3)	(n = 11)	(n = 4)	(N/A)
Yes (%)	79	31	N/A
Partly (%)	17	13	N/A
No (%)	4	56	N/A
Heavy physical workload departments (n = 4)	Individual (n = 8)	Physical (n = 12)	Organisational (n = 2)
Yes (%)	44	16	50
Partly (%)	18	26	50
No (%)	38	58	0

Participant level: dose received

According to the 833 workers who responded to the perceived implementation questions in the six-month follow-up questionnaire, 26% perceived the ergonomic measures as implemented, 36% as partly implemented, and 38% as not implemented at the departments. Table 5 presents the percentages of the perceived implementation of the ergonomic measures stratified by type of ergonomic measure and department workload. Among the 26% of the workers who perceived the ergonomic measures as implemented at the departments, the ergonomic measure was in 69% of the cases implemented at their workplace.

Table 5. Perceived implementation of the prioritised ergonomic measures according to the workers at the departments (n = 833).

Ergonomic measures perceived as implemented	Type of ergonomic measure		
All departments	Individual	Physical	Organisational
(n = 18)	(n = 31)	(n = 25)	(n = 7)
Yes (%)	28	26	19
No (%)	37	38	38
Don't know (%)	35	36	43
Mental workload departments	Individual	Physical	Organisational
(n = 10)	(n = 11)	(n = 7)	(n = 5)
Yes (%)	21	30	18
No (%)	44	42	52
Don't know (%)	35	28	30
Light physical workload departments	Individual	Physical	Organisational
(n = 1)	(n = 1)	(n = 2)	(N/A)
Yes (%)	40	32	N/A
No (%)	32	44	N/A
Don't know (%)	28	24	N/A
Mixed workload departments	Individual	Physical	Organisational
(n = 3)	(n = 11)	(n = 4)	(N/A)
Yes (%)	31	36	N/A
No (%)	36	37	N/A
Don't know (%)	33	27	N/A
Heavy physical workload departments (n = 4)	Individual (n = 8)	Physical (n = 12)	Organisational (n = 2)
Yes (%)	35	20	20
No (%)	29	36	67
Don't know (%)	36	44	13

Discussion

The Stay@Work study investigated whether participatory ergonomics is an effective method to prevent LBP and NP among workers. The aim of the current study was to evaluate the process of the Stay@Work participatory ergonomics programme implementation including the perceived implementation effectiveness of the prioritised ergonomic measures. The results of this process evaluation showed that almost all department managers formed a working group and that a meeting was held with all working groups. Attendance rates of the working group meetings were good, and all working groups were successful in developing an implementation plan with prioritised risk factors for LBP and NP and prioritised ergonomic measures to prevent LBP and NP. Working group members were positive about the quality of the participatory ergonomics steps performed during the meeting, meeting duration, and the prioritised ergonomic measures. These opinions were not shared among the remaining workers at the departments. Attendance rates of the Stay@Work ergocoach training and the quality of the training were good.

Workers at the departments were not satisfied with the implementation strategy used. Dissatisfaction may have occurred because workers at the departments were kept blind as to the study design and were thereby only marginally informed about the participatory ergonomics programme content and its aims. It is plausible that workers at the departments did not link the prioritised ergonomic measures to the participatory ergonomics programme and were therefore not sufficiently able to rate their satisfaction with the used method. Moreover, dissatisfaction among workers might have occurred because they were asked to report on the implementation of ergonomic measures that were not (always) applicable to their workplace. However, workers' satisfaction towards both the prioritised ergonomic measure and the method that was used to develop the ergonomic measures increased somewhat when the ergonomic measures were implemented at their workplace.

Overall, it can be concluded that the Stay@Work participatory ergonomics programme is a successful and feasible strategy to develop an implementation plan with prioritised risk factors for LBP and NP and prioritised ergonomic measures to prevent LBP and NP. It is more difficult, however, to draw conclusions regarding the implementation rates as there is no cut-off point to determine whether implementation was successful or has failed. Regarding the prevention of LBP and NP it can be suggested that every (extra) ergonomic measure implemented might be profitable[3;37;38], even when perceived implementation rates of 34% and 26% are derived. Future research should investigate whether the implementation rates found in this study are sufficient to reduce workload and thereby reduce LBP and NP prevalence among workers.

The perceived implementation rates found in our study differed from other studies on participatory ergonomics. For example Haukka et al. (2008) conducted a RCT on participatory ergonomics and MSD prevention and reported a perceived implementation rate of 80% (402 ergonomic changes)[22;39], although it remained unclear how they assessed whether an ergonomic measure was implemented. There are several explanations for the different implementation rates found in our study compared to other participatory ergonomics studies like the Haukka study.

In our study, individual ergonomic measures were prioritised most often, especially among departments with a mixed workload. The choice to prioritise and implement individual ergonomic measures seemed plausible, since the ergonomic measures were evaluated according to a set of common implementation criteria: low initial costs, not complex, compatible, visible, and feasible within three months. In line with other studies on participatory ergonomics, physical ergonomic measures were also prioritised frequently. However, other studies also found higher frequencies on organisational ergonomic measures.[16;17;22;39;40] The reason why fewer organisational ergonomic measures were prioritised in this study may be a result of the implementation criteria that were probably less applicable to evaluate organisational ergonomic measures. In addition, the implementation of physical or organisational measures is more complex, expensive, and time consuming to perform compared to individual ergonomic measures.[30]

Another possible explanation involves the inconsistent answers on the implementation status of the prioritised ergonomic measure (yes/no/partly implemented). For example, within the same working group, two out of the five implementers reported that the prioritised ergonomic measure was implemented, whereas the remaining implementers reported that the ergonomic measure was not implemented. Such inconsistencies often made it impossible for the researchers to decide whether a measure really was implemented. More knowledge about the implementers' reasons for choosing a certain implementation status may have helped the researchers to make decisions about the implementation status of the prioritised ergonomic measures. However, due to the purpose of this study, no information on such reasons was collected.

Furthermore, inconsistency may have been caused by the high number of 'yes, partly implemented' answers. In our questionnaire that was sent to the implementers, we did not specifically define the term 'yes, partly implemented'. However, from the information obtained from the questionnaire we suspect that some implementers chose 'yes, partly implemented' when they discovered that it was more beneficial to implement a prioritised ergonomic measure for only a subgroup of workers rather than for all workers at the intervention department. Other implementers appear to have chosen 'yes, partly implemented' when the implementation of the prioritised ergonomic measure was in progress but had not been completely realised yet. For example, in case of the implementation of a lifting device, implementers ordered the device; however, the lifting device was not yet being used at the workplace.

Finally, although several explanations for the modest implementation have been discussed, it is possible that other unmeasured factors might have occurred during the implementation period (e.g. hierarchy, poor management support, lack of assistance, or financial problems) thereby hampering implementation.[41] For example, it is plausible that a lack of financial resources may have hampered the implementation of ergonomic measures. This is because most working groups were conducted in 2008 - a time when many Dutch companies experienced the consequences of the international financial downturn.

Different implementation factors may be present or absent at different stakeholder levels (i.e. individual professional, worker, societal, or organisational level).[14] More in-depth knowledge on implementation factors and their stakeholder level can help researchers to improve ergonomic interventions. Therefore, to further improve the implementation of this or future participatory ergonomics programme(s), it may be helpful to explore what factors hampered or facilitated the implementation of ergonomic measures.

Strengths and weaknesses of the process evaluation

No other study implemented participatory ergonomics on such a large scale and among departments with different type of workloads. Furthe more, this process evaluation study collected extensive data on the perceived implementation. In doing so, this study attempted to estimate the efficiency of the participatory ergonomics programme and the implementation strategies. The existing literature suggests that the use of informational material alone is not sufficient to induce a behavioural change (i.e. use of ergonomic measures). More active strategies such as toolkits and local opinion leaders should be used to disseminate information.[13] Therefore, a strength of this study was that not only informational materials but also ergocoaches (opinion leaders) trained to inform, motivate, and instruct their co-workers on the ergonomic measures. Furthermore, data were collected from different stakeholders at different levels which provided a better understanding of how the different stakeholders experienced the participatory ergonomics programme and the implementation strategies.

A weakness of this study is that selection bias may have occurred because not all implementers and not all workers at the department responded to their questionnaires. Furthermore, the accuracy of the method that was used to measure implementation is debatable. All workers at the department were asked whether the prioritised ergonomic measures were implemented. Due to the variety of task groups within departments, it may be that some workers were asked to report on implementations that were not meant for their workplace. The same goes for the implementers, who during the implementation of the ergonomic measures may have discovered that a prioritised ergonomic measure was more beneficial for a subgroup of workers rather than for the whole department. This may have led to misinterpretations of the concept of implementation and may have resulted in inconsistent answers on the questionnaires. A possible solution to overcome such inconsistencies and to increase the validity of the answers provided by the implementers is to arrange control visits by an ergonomist.[42] Finally, the role of the ergonomist in the current study was restricted to guiding the working group meeting. In line with the participatory ergonomics literature[43], working group members themselves were responsible for the implementation of the prioritised ergonomic measures. Although working group members were allowed to seek help from other professionals during the implementation period, no information on which professionals were consulted was collected. It is, however, plausible that more assistance and cooperation from the ergonomist, other professionals (i.e. suppliers, technicians, and purchase) and the management to realise implementation, might indeed have led to higher implementation rates.

Conclusion

The results of this process evaluation showed that participatory ergonomics can be a feasible and successful strategy to develop an implementation plan with prioritised risk factors for LBP and NP and prioritised ergonomic measures to prevent LBP and NP. Moreover, recruitment, reach, fidelity, and satisfaction towards the participatory ergonomics programme were good. The same was found for the Stay@Work ergocoach training. Despite the positive rating of the participatory ergonomics programme and the ergocoach training, the implementation of the prioritised ergonomic measures was lower than expected. Further research is needed to develop and test ways to more optimally implement participatory ergonomics programmes in order to reduce work-related injuries and to promote worker well-being.

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What are possible barriers and facilitators to implementation of a participatory ergonomics programme?

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Abstract

Objective: Low back pain and neck pain are common among workers. Participatory ergonomics is used as an implementation strategy to prevent these symptoms. By following the steps of participatory ergonomics, working groups composed and prioritised ergonomic measures, and developed an implementation plan. Working group members were responsible to implement the ergonomic measures in their departments. Little is known about factors that hamper (barriers) or enhance (facilitators) the implementation of ergonomic measures. This study aimed to identify and understand the possible barriers and facilitators that were perceived during implementation.

Methods: This study is embedded in a cluster randomised controlled trial that investigated the effectiveness of participatory ergonomics to prevent low back pain and neck pain among workers. For the purpose of the current study, questionnaires were sent to 81 working group members. Their answers were used to make a first inventory of possible barriers and facilitators to implementation. Based on the questionnaire information, 15 semi-structured interviews were held to explore the barriers and facilitators in more detail. All interviews were audio taped, transcribed verbatim, and analysed according to a systematic approach.

Results: All possible barriers and facilitators were obtained from questionnaire data, indicating that the semi-structured interviews did not yield information about new factors. Various barriers and facilitators were experienced. The presence of implementation plans for ergonomic measures that were already approved by the management facilitated implementation before the working group meeting. In these cases, participatory ergonomics served as a strategy to improve the implementation of the approved measures. Furthermore, the findings showed that the composition of a working group (i.e., including decision makers and a worker who led the implementation process) was important. Moreover, stakeholder involvement and collaboration were reported to considerably improve implementation.

Conclusions: This study showed that the working group as well as stakeholder involvement and collaboration were important facilitating factors. Moreover, participatory ergonomics was used as a strategy to improve the implementation of existing ergonomic measures. The results can be used to improve participatory ergonomics programmes, and thereby may contribute to the prevention of low back pain and neck pain.

Introduction

The lifetime prevalence rates of low back pain (LBP) and neck pain (NP) in western countries are high (90%), indicating that almost every person will experience an episode of LBP and NP during his/her life.[1;2] Furthermore, LBP and NP have considerable consequences for workers, companies, and society.[3;4] Therefore, preventing these symptoms at the workplace is imperative.

To prevent LBP and NP among workers, ergonomic measures are frequently implemented at the workplace. The findings of a recent systematic review, however, showed that the implementation of physical and organisational ergonomic interventions alone were not effective to prevent LBP and NP.[5] Therefore, the use of an adequate strategy to implement ergonomic measures, such as participatory ergonomics has been recommended. Participatory ergonomics has already shown promising results in preventing of musculoskeletal disorders (MSD)[6]; however, the positive effects on MSD have not been confirmed by large randomised controlled trials (RCT).[7]

Another large cluster RCT, the Stay@Work study, evaluated the effectiveness of a participatory ergonomics programme as an implementation strategy to prevent LBP and NP among workers.[8] As part of the participatory ergonomics programme, working groups had to implement ergonomic measures in their department. The process evaluation of this RCT has shown that one-third of the proposed ergonomic measures were implemented in the intervention departments.[9] From the literature it is known that various factors can positively or negatively influence implementation[10-12], including ergonomic measures derived from a participatory ergonomics programme.[13;14] Moreover, it has been postulated that factors for implementation can be present at different levels (i.e. individual professional, worker, societal, or organisational).[15] Knowledge on the barriers and facilitators about their presence in the different levels of the occupational context is crucial to improve the implementation of ergonomic interventions, thereby contributing to the reduction of LBP and NP among workers.[16;17] Nevertheless, the reporting on barriers and facilitators for implementation is lacking in most ergonomic intervention studies.[18]

Therefore, embedded in a RCT, this study aimed to identify possible factors that hampered (barriers) and/or enhanced (facilitators) the implementation of the prioritised ergonomic measures when using the PE programme as an implementation strategy. It also aimed to understand how these barriers and/or facilitators influenced the implementation.

Methods

More details on the methods of the Stay@Work participatory ergonomics programme, evaluation of the participatory ergonomics programme, and the perceived implementation have been published elsewhere.[8;9] The study protocol was approved by the Medical Ethics Committee of the VU University Medical Center.

Study setting and intervention

Stay@Work was designed as a cluster RCT to investigate the effects of a participatory ergonomics programme to prevent LBP and NP among workers. Based on their workload, 37 departments from four Dutch companies (a railway transportation company, an airline company, a university including its university medical hospital, and a steel company) were classified into: mentally, mixed mentally and physically, light physically, or heavy physically demanding work.[19] To avoid contamination from workers allocated in the intervention group to those in the control group randomisation was performed at a departmental level. Within each company, pairs of departments with comparable workloads were randomly allocated to either the participatory ergonomics intervention group or the control group (no participatory ergonomics). By using a computer-generated randomisation programme, 19 departments were allocated to the intervention group and 18 to the control group.

Each intervention department formed a working group, consisting of eight workers and one (department) manager. Workers invited for the working group had to have worked at least two years in their current job, and for more than 20 hours per week in the department. The (department) manager in the working group, had to have decision authority on organisational and financial aspects.

Under the guidance of an ergonomist, 16 working groups (for 19 intervention departments) followed the steps of the Stay@Work participatory ergonomics programme during a 6-hour working group meeting. In this meeting, working group members added risk factors of LBP and NP, and judged all mentioned risk factors on their frequency and severity (step 1). Based on the perceptions of the working group, the most frequent and severe risk factors were prioritised, resulting in a top three of risk factors (step 2). Subsequently, the working group held a brainstorming session about different types of ergonomic measures to target the prioritised risk factors and evaluated the ergonomic measures according to a criteria list considering: relative advantage, costs, compatibility, complexity, triability, feasibility, and visibility.[20] Further, the ergonomic measures had to be implementable within a timeframe of three months. On a consensus basis, the working group prioritised the three most appropriate ergonomic measures (step 3). An implementation plan was formed containing information on the prioritised risk factors for the development of LBP and NP and the prioritised ergonomic measures to prevent LBP and NP (step 4). The implementation plan also described which working group member(s) was/were responsible for the implementation of the prioritised ergonomic measure(s); these working group members were called 'implementers.' At the end of the meeting, the working group was requested to implement the ergonomic measures (step 5) and was asked whether an appointment for a second, optional meeting was necessary to evaluate or adjust the implementation process (step 6).

Altogether the working group meetings resulted in 66 prioritised ergonomic measures. According to the classification by van Dieën and van der Beek (2009) the prioritised ergonomic measures were classified into three categories.[21] Individual ergonomic measures that were aimed at the individual worker (i.e. improving awareness regarding ergonomics, worksite visit, physical activity programs); physical ergonomic measures that were aimed at redesigning the workplace (i.e. ergonomic modification, new equipment, or manual handling aids), and organisational ergonomic measures that were aimed at changing the system level (i.e. pause software installation, job rotation, or restructuring management style). Most of the prioritised ergonomic measures addressed either individual (n = 32) or physical (n = 27) ergonomic measures, whereas organisational ergonomic measures (n = 7) were less prevalent.[9]

To improve the implementation process, two or three implementers from each working group were asked to voluntary follow a training programme to become a Stay@Work ergocoach. A total of 40 implementers attended the ergocoach training.[9] In this additional 4-hour implementation training, they were educated in different implementation strategies to inform, motivate, and instruct their co-workers about ergonomic measures. Moreover, ergocoaches were equipped with a toolkit consisting of flyers, posters, and presentation formats. These types of implementation strategies have been recommended to induce behavioural change.[22;23]

Data collection and analyses

Data were collected from the so-called 'implementers,' who were working group members responsible for the implementation of one or more prioritised ergonomic measure(s).

Questionnaires

To identify barriers and facilitators to implementation, all implementers (n = 81) received a questionnaire four months after finishing the first working group session. By means of open questioning, the implementers were asked to report on the perceived barriers and/or facilitators to those ergonomic measures he/she was responsible for. To assist the implementers, researchers provided several examples of barriers in the questionnaire. Furthermore, to understand 'how' the barriers and facilitators influenced implementation, the implementers were asked to provide a brief explanation for each barrier or facilitator.

A total of 65 implementers (80%) responded on the questionnaire. Among the responders were 35 males (54%) and 30 females (46%); 52 of the responders (80%) were workers, whereas 13 had a management function (20%). Moreover, most responders worked in a department characterised by either a mental workload (42%) or a heavy physical (30%) workload (see table 1).

Questionnaire data analyses

First, an inventory of possible barriers and facilitators for each working group was made. This was performed by two researchers (MTD and KG), who independently extracted all possible barriers and facilitators for implementation from the questionnaires. During a consensus meeting, the two researchers discussed whether all possible barriers and facilitators were obtained.

Based on the inventory, the semi-structured interviews were developed to explore the barriers and facilitators in further detail, and potential participants for the interviews were selected.

Semi-structured interviews

The aim of the semi-structured interview was to: verify the correctness of barriers and facilitators derived from the questionnaires; gain in-depth understanding as to 'how' the barriers and facilitators influenced implementation; and gather new barriers and facilitators. The interview was held only among implementers from those working groups that had finished the implementation period (n = 9 working groups). To acquire a broad overview of implementation factors, from each working group we intended to interview one implementer who participated as a manager and one implementer who participated as a worker. Moreover, we tried to select implementers who fulfilled a key role in the implementation process of their working group (i.e. had to implement most of the prioritised ergonomic measures). Furthermore, we intended to select the implementers from different departments (i.e. mental or heavy physical) and different companies (see table 1).

Potential participants for the semi-structured interview were selected among the implementers who responded to the questionnaire. Implementers were contacted by the principal researcher (MTD) by telephone and were invited to a face-to-face interview. One week before the start of the interview, the implementer was emailed an overview of the perceived barriers and facilitators (with explanation) that were reported by the other implementers from his/her working group. During the interview a guide was used to ensure that the same semi-structured questions were addressed. All interviews were conducted by the principal researcher and took place in person with only the researcher and the implementer present. The interview had a mean duration of 30 minutes, and all interviews were recorded on a digital voice recorder. No more than two interviews were held on the same day. All interviewed implementers provided informed consent.

Table 1. Characteristics of the participating implementers.

	Questionnaire responders (n = 65)	Interviewed implementers (n = 15)
Male/Female	35/30	8/7
Worker/Manager	52/13	8/7
Heavy physical demanding work	20	2
Light physical demanding work	4	2
Mental demanding work	27	6
Mix mental/physical demanding work	14	5

Semi-structured interview data analyses

First, all interviews were transcribed verbatim. Two researchers (MTD and KG) independently extracted all possible barriers and facilitators to implementation from the transcripts.

Data extracted from the transcription sets was subsequently analysed using the constant comparison process.[24;25] By following this process, the two researchers independently checked whether all possible barriers and facilitators that were obtained from the questionnaires were also obtained from the semi-structured interviews. Moreover, it was checked whether new barriers and facilitators were derived from the semi-structured interviews. To ensure uniformity on the identified barriers and facilitators, a consensus meeting between the two authors was held.
For all data extracted, a qualitative software program (ATLAS.ti version 5.2) was used to electronically code and manage data, and to generate reports of coded text for analysis. To illustrate the meaning of the perceived barriers and facilitators, quotations that were considered representative for each barrier or facilitator were reported in the text. Quotations were derived from the semi-structured interviews and were translated from Dutch.

Classification of perceived barriers and facilitators into implementation levels

After reaching consensus on the barriers and facilitators for implementation obtained from the questionnaires and the semi-structured interviews, the researchers (MTD and KG) classified the perceived barriers and facilitators into different implementation levels by using the 'implementation model' of Grol and Wensing (2004).[15] By classifying the implementation factors into implementation levels more specific recommendations to improve implementation can be formulated. The model was originally used in the healthcare setting and distinguished six implementation levels in which barriers and facilitators for implementing an innovation could be perceived: the innovation itself (i.e. feasibility, accessibility, and advantages in practice); the individual professional (i.e. awareness, motivation to change, and routines); the patient (i.e. knowledge, skills, and attitude); the social context (i.e. culture of network, opinions of colleagues, and leadership); organisational (i.e. staff, capacities, and resources); and economical and political context (i.e. regulations, policies, and financial arrangements).[15]

Results

All barriers and facilitators were derived from the questionnaire data; that is, the interviews did not yield any additional barriers or facilitators. Table 2 presents the perceived barriers and facilitators from the perspective of the implementers and stratified for the four implementation levels. Because the original implementation levels used by Grol and Wensing (2004) were based on the healthcare setting, some of the levels were not applicable to the workplace in which our study was conducted.

Adjustments were made to create more context-specific levels. The 'economic and political context,' 'patient,' and 'individual professional' levels were excluded because no barriers and facilitators were identified on these levels. In the model by Grol, the social context is a rather wide perspective including the culture and existing values of the network, perceived patients expectations and behaviour, and collaboration between healthcare teams. In the current study, the social context encompassed only the implementers' co-workers, and therefore the 'social context' was replaced by a co-worker level. The working group level was introduced because the working group itself is a specific characteristic of a participatory ergonomics programme, and referred to the barriers and facilitators perceived by the implementers at the level of the working group. Because in the current study the innovations encompassed the implementation of ergonomic measures, the term 'innovation' was replaced by an ergonomic measure level.

Table 2. Perceived barriers and facilitators to implementation by the implementers.

Implementation level	Factor	Explanation(s) of factors
Organisational	Management commitment	- (No) agreement or (no) support from management to implement prioritised ergonomic measure (**b+f**)
	Resources	- (Lack of) financial resources **(b+f)** - (Lack of) personnel resources (**b+f**)
	Collaboration	- Implementation process was delayed or accelerated by persons/ structures/ services within or outside the department (**b+f**)
Co-worker	Culture	- Prioritised ergonomic measure did not fit in the department culture (**b**)
Working group	Composition	- (No) leading person in the working group (**b+f**) - Members dropped out from or stayed in the working group (**b+f**) - Members had (no) time for implementation (**b+f**) - No decision maker in working group (**b**) - Efforts made by working group members (**f**)
Ergonomic measure	Relative Advantage	- Prioritised ergonomic measure did (not) improve the situation when compared to the current situation (**b+f**)
	Difficulty	- Prioritised ergonomic measure were easy/difficult to implement (**b+f**)
	Compatibility	- Prioritised ergonomic measure did not fit the workplace (**b**)
	Complexity	- Prioritised ergonomic measure was not direct practicable for all workers (**b**)
	Approved	- The plans for implementing the prioritised ergonomic measure were already made and approved before the working group meeting took place (**f**)

b+f: explanation could be both a barrier and a facilitator; b: explanation of a barrier; f: explanation of a facilitator.

Table 2 presents the explanations of the perceived barriers and facilitators to implementation. While some factors were perceived as either a barrier or facilitator, most of the factors were experienced as being both a barrier and a facilitator. Most factors (n = 5) for implementation were found at the level of the ergonomic measure.

Organisational level

At the organisational level, three factors appeared to be perceived as both a barrier and facilitator. The three factors were 'management commitment,' 'resources,' and 'collaboration.'

Management commitment

The factor 'management commitment' referred to whether the management supported or did not support the implementation of the prioritised ergonomic measure. Despite a (department) manager or its representative attending the working group meeting and approving the implementation of the prioritised ergonomic measure, the implementers still reported this factor as being important for implementation. Management commitment was in most cases mentioned as a facilitator. During the interview one of the implementers said:

> 'There were, of course, the managers at the department but they were fine with it [the prioritised ergonomic measure] and supported the initiative to be more aware on work and health. They [the managers] were happy with it. So from that point everybody was enthusiastic!'

Resources

At the organisational level, the factor 'resources' had two meanings. Most frequently, implementers reported that implementation was hampered due to insufficient financial resources. Insufficient financial resources most often played a role during the implementation of physical ergonomic measures (i.e. new chairs). During the interview one implementer explained the financial resources as:

'Our management reserved an implementation budget to implement the new chairs.' Other implementers mentioned that it was a lack of personnel resources that ham pered implementation. This problem most often occurred when organisational ergo nomic measures such as job rotation had to be implemented. Regarding the personnel resources implementers said:

> 'There are many practical factors which make it impossible to do something with this ergonomic measure. At this moment this is mainly caused by the enormous lack of personnel resources.'

Collaboration

The factor 'collaboration' referred to the collaboration with persons, structures, or services within or outside the department during the implementation process, and was mostly experienced as a barrier. Implementers blamed the bureaucracy of their firm or their own department, and reported that key persons for implementation (i.e. engineers, technicians, or suppliers) or other services (i.e. equipment or health services) were too busy to help them with implementing the ergonomic measures. Other implementers had positive experiences with collaboration and reported that collaboration facilitated the implementation of the ergonomic measure. One of the implementers said:

> 'We received good help [from two persons of the occupational health services]. They knew our department very well, and very soon we had all information for our training available.'

Co-worker level

Culture

At the level of the co-worker, only the implementation factor 'culture' was identified. The factor 'culture' referred to which extent the prioritised ergonomic measure fit within the culture of the department. One implementer reported that the reactions and opinions of some co-workers were so negative that he decided to stop with the implementation of the ergonomic measure. During the interview he said:

> 'So, drawing attention to each other's working posture [the prioritised ergonomic measure] is not really incorporated into our department culture. They [the co-workers] find that annoying and it bothers them. The same goes for the managers. Sometimes they [the co-workers] say things to me like: 'what is your problem?' or 'leave it, it's my body!' So, that's why I stopped doing it.'

Working group level

Composition

At the level of the working group, the only factor for implementation that was identified was 'composition' and was experienced by many implementers in different working groups. The factor was experienced as both a barrier and a facilitator, and can have different explanations.

According to many implementers, 'composition' was facilitating if there was one imple-menter in the working group who played a leading role during the implementation process, while not having such a leader was experienced as a barrier. During the interview one implementer said:

> 'In my opinion this is because she spent all her efforts on the implementation and if she wants something then it has to be done. She doesn't stop before she's reached her goal, and that was a really important factor for this measure.'

With special emphasis towards the implementation of individual ergonomic measures, implementers from departments characterised by a mental workload reported that 'composition' hampered implementation because of the high number of dropouts in their working group. As a consequence, too few persons were left in the working group to implement all prioritised ergonomic measures.

Some implementers had too many other work-related tasks and thereby lacked the time to play an active role in the implementation process. Others reported that 'composition' hampered implementation, because their working group lacked a person who was entitled to make decisions at departmental level. Consequently, the decisions had to be approved by another (higher) management level.

Ergonomic measure level

The following factors for implementation were reported at the level of the ergonomic measure: 'relative advantage,' 'difficulty,' 'compatibility,' 'complexity,' and 'approved.'

Relative advantage

The factor 'relative advantage' was defined as the possible effects that the ergonomic measure could have in terms of LBP and NP prevention among workers at the department compared to the current situation. According to some implementers, this factor was a facilitator if during the implementation they remained convinced of the relative advantage of the prioritised ergonomic measure. However, with special regard to physical ergonomic measures, most implementers reported that during the implementation they discovered that the relative advantage of the prioritised ergonomic measure was little compared to the current situation. In these cases, little relative advantage was perceived as a barrier. One of the implementers said during the interview:

> 'We thought that five patients a day would be transferred by using this lifting device [the prioritised ergonomic measure], however, in practice this is not true [more than five patients]. OK, the lifting device costs some money but that is not the problem, the most important point is its advantage. Regarding its advantage, I'm still not convinced.'

Difficulty

The factor 'difficulty' was defined as to the extent to which the ergonomic measure was difficult to implement. Some implementers reported that implementation was hampered because the ergonomic measures were too difficult to implement within three months. Most implementers experienced easy implementations as a facilitator:

> 'It was a really simple task, and yes that was important. Some things you just have to do quickly and I think that these quick successes are important.'

Compatibility

The factor 'compatibility' referred to the extent to which the ergonomic measure was compatible with the present norms and practises in the department. In other words, how well the innovation 'fit' into the department. Compatibility is positively related to the rate of implementation. However, in this study a few implementers reported that the prioritised ergonomic measure was not very compatible at the department and implementation was hampered. One of these implementers said:

> 'I collected information on this, but it [screensaver with ergonomic advices] was not compatible on the computers, so it could not be implemented. That was to my opinion a technical problem.'

Complexity

The factor 'complexity' referred to the extent to which the workers were able to understand and use the ergonomic measure after it had been implemented. Less complex ergonomic measures are positively related to the rate of implementation. Nevertheless, in this study 'complexity' was only perceived as a barrier when the ergonomic measure appeared to be too complex for the workers to immediately understand and to use it. During the interview one of the implementers said:

> 'In addition, if we would have implemented the carts, workers had to follow special training sessions on how to use them.'

Approved

The factor 'approved' referred to the extent to which plans for implementing the ergonomic measure were already present and approved by the (department) management before the working group meeting was held. Many implementers of different working groups mentioned that this was the case for some of the ergonomic measures they prioritised and experienced that this facilitated the implementation process. One of the implementers said:

> 'Well, the plans to implement new chairs were already made, even before the working group meeting was held. So, when the working group prioritised to implement the new chairs, it was not so difficult to order them.'

Discussion

The aim of this study was to identify possible factors that hampered or facilitated the implementation of the prioritised ergonomic measures that were derived from a participatory ergonomics programme. The findings of this study suggested that various barriers and facilitators to implementation were perceived at four implementation levels. Insight into the barriers and facilitators to implementation is useful, because it shows what kind of (sometimes unforeseen) factors may occur when implementing ergonomic measures. Moreover, the results may contribute towards the improvement of participatory ergonomics programmes as an implementation strategy. As a consequence of improved implementation, LBP and NP among workers may be reduced.

Comparison with other studies

Previous studies have reported on the barriers and facilitators that were experienced during a participatory ergonomics programme. For example, the participatory ergonomics framework by Haines et al. (2002) described important implementation dimensions (i.e. level of influence of the working group, guiding role of ergonomist, and direct involvement of workers) that should be considered during the development a participatory ergonomics programme.[26] Moreover, a systematic review by van Eerd and colleagues (2008) identified barriers and facilitators for the process and implementation of a participatory ergonomics programme and classified them into 19 categories (e.g. resource availability, creation of an appropriate team, and sufficient resources).[27] Many similarities were found when comparing our main findings with the study findings of Haines et al. (2002) and van Eerd et al. (2008).[26;27] It was found that almost the same definitions were used to point out the meaning of the barriers and facilitators. However, due to the use of a different framework or model, the labelling of the barriers and facilitators slightly differed between the studies. For example, Haines et al. (2002) used the label 'mix of participants' to address the importance of incorporating a mixed group of participants in the working group (i.e. operators, supervisors, technical staff, and management) while we named this 'composition' at the working group level.

Furthermore, the implementation levels or dimensions that were used to classify barriers and facilitators differed between studies. Because our study aim was to identify all possible barriers and facilitators on implementation, we used the implementation model by Grol and Wensing (2004) in which not only contextual levels were incorporated but also the level of the ergonomic measure was considered.

Our findings were in concordance with the results of other participatory ergonomics studies that used qualitative research methods. Factors that hamper implementation have included high production pressures, not securing employees' time to carry out ergonomic changes, lack of management commitment, insufficient financial resources, and workers' frustration due to implementation delays.[13;14;28]

Although most of the barriers and facilitators obtained from other participatory ergonomics studies were in line with our findings, caution is needed when comparing the results. This is because heterogeneity existed regarding the study design, study population, outcome measures, type of ergonomic changes, the timing, and methods used to assess barriers and facilitators for implementation (mix of questionnaires and semi-structured interviews).

Implications

The findings of this study offered new information on factors to implementation of ergonomic measures using the participatory ergonomics implementation strategy. It appeared that implementation was facilitated if plans for implementing the ergonomic measure were already present and were approved by the management before the working group meeting took place. This may indicate that the participatory ergonomics implementation strategy can not only be used to develop new ergonomic measures, but also to improve the implementation of the already planned ergonomic measures in a department. This finding is not surprising because it is known that most ergonomic measures are implemented without using an adequate implementation strategy.[29]

Despite all of the prioritised ergonomic measures meeting the implementation criteria (i.e. low initial costs and less complex, large relative advantage, compatible, good triability, visible, and feasible)[20], our findings show that meeting these criteria alone does not guarantee implementation. With special regard to physical ergonomic measures, some implementers discovered during the implementation process that it was too costly to order the measure for the whole department and consequently the implementation was reconsidered. To avoid these types of problems, we included a manager in the working group who had sufficient decision authority to facilitate implementation. However, this seemed not to be sufficient. Our findings show that the involvement of stakeholders may improve implementation since these professionals have more knowledge on the costs and/or the working mechanisms of ergonomic measures. Therefore, incorporating important stakeholders (such as technicians, engineers, suppliers, or occupational health experts) into the working group or consulting them during the implementation process is recommended.[30]

Furthermore, we found that it was important to create an enthusiastic and sustainable working group that is supported by its management and supplied with sufficient resources (i.e. time and money).

Strengths and limitations

The factors for implementation were obtained from a heterogeneous working population; therefore, the findings represent a broad overview of possible barriers and facilitators. Furthermore, few studies on the factors for implementation of ergonomic interventions have used qualitative research methods.[31] The use of qualitative research techniques can result in a better understanding of the meaning of the factors for implementation.[25] Further strengths of this study were that data were analysed using a systematic approach[24;25] and an adapted version of the well-known theoretical implementation model by Grol and Wensing (2004) was used to classify the barriers and facilitators into levels.[15]

However, there were also some limitations in our study. A selected group of implementers was interviewed - only implementers from working groups that had finished the full implementation period. The selection of this group of implementers may have influenced the representativeness of this study. We do not believe that this selection resulted in less communication of barriers, because all barriers and facilitators were derived from the questionnaire data. Bias may have occurred because the interviews were conducted by the principal researcher. Moreover, implementers knew the researcher and were familiar with the position of the researcher in the research project[32], which could have sometimes resulted in 'socially accepted answers.' Another limitation is that the barriers and facilitators were obtained from the implementers' point of view, whereas other persons from different levels (i.e. management, health services, or co-workers) were involved during the implementation as well. It would be informative to gain insight into which barriers and facilitators to implementation these persons experienced.

Conclusion

In summary, the findings show that participatory ergonomics can be used for both the development and implementation of new ergonomic measures as well as to improve implementation of already planned ergonomic measures. Furthermore, the working group composition was important for implementation, meaning that a manager who is entitled to make decisions at the department level and working group members who can play a leading role during the implementation process should be included. Stakeholder involvement can considerably facilitate implementation; therefore, it is recommended that they are involved in the working group or consulted during the implementation process. The results of this study can be used to further improve participatory ergonomics programmes as a strategy for implementation. As a consequence of improved implementation, LBP and NP prevalence among workers may be reduced.

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6

Participatory ergonomics to reduce exposure to psychosocial and physical risk factors for low back pain and neck pain: results of a cluster randomised controlled trial

Driessen MT, Proper KI, Anema JR, Knol DL, Bongers PM, van der Beek AJ. Participatory ergonomics to reduce the exposure to psychosocial and physical risk factors for low back pain and neck pain: results of a cluster randomised controlled trial. Occup Environ Med 2010 doi:10.1136/oem.2010.056739.

Abstract

Objective: This study investigated the effectiveness of the Stay@Work participatory ergonomics programme to reduce workers' exposure to psychosocial and physical risk factors.

Methods: 37 departments (n = 3047 workers) from four Dutch companies participated in this cluster randomised controlled trial; 19 (n = 1472 workers) were randomised to an intervention group (participatory ergonomics) and 18 (n = 1575 workers) to a control group (no participatory ergonomics). During a 6-hour meeting guided by an ergonomist, working groups devised ergonomic measures to reduce psychosocial and physical workload and implemented them within three months in their departments. Data on psychosocial and physical risk factors for low back pain and neck pain were collected at baseline and after six months. Psychosocial risk factors were measured by means of the Job Content Questionnaire physical risk factors using the Dutch Musculoskeletal Questionnaire. Intervention effects were studied performing multilevel analysis.

Results: Intervention group workers significantly increased on decision latitude (0.29 points; 95% CI 0.07 to 0.52) and decision authority (0.16 points; 95% CI 0.04 to 0.28) compared to control workers. However, the exposure to awkward trunk working postures significantly increased in the intervention group (OR 1.86; 95% CI 1.15 to 3.01) compared to the control group. No significant differences between the intervention and control group were found for the remaining risk factors. After six months loss to follow-up was 35% in the intervention group and 29% in the control group.

Conclusions: Participatory ergonomics was not effective in reducing the exposure to psychosocial and physical risk factors for low back pain and neck pain among a large group of workers.

Introduction

Low back pain (LBP) and neck pain (NP) are important public health problems in industrialised nations.[1;2] In the Netherlands, the 1-year prevalence of LBP is estimated to be 44% and is 28% for NP.[3] These symptoms have serious consequences for the individual worker (i.e. pain and disability), and for society and companies (i.e. cost due to medical healthcare use, work absenteeism and loss of productivity).[4;5] Prevention is, therefore, very important.

LBP and NP have multifactorial origins[6], indicating that various risk factors are associated with the development of LBP and NP among workers. Risk factors for LBP and NP are classified into individual risk factors (i.e. gender, age, and history of LBP and NP)[6;7], psychosocial risk factors (i.e. poor social support, job dissatisfaction, high job demands and low job control)[8], and physical risk factors (i.e. heavy manual lifting, awkward working posture of the trunk, whole body vibration and neck flexion).[9-11] It has been postulated that exposures to psychosocial and physical risk factors for LBP and NP can be reduced in the workplace, for example by implementing ergonomic measures.[12]

Participatory ergonomics can be used to prioritise, devise and implement ergonomic measures in order to reduce workers' exposure to risk factors. In a systematic review of various study designs, participatory ergonomics proved to be a promising approach to reduce psychosocial and physical workload.[13] However, findings obtained from randomised controlled trials (RCT) are scarce. A recent cluster RCT on participatory ergonomics conducted among Finnish kitchen workers showed that participatory ergonomics did not result in significant reductions in either perceived physical workload or perceived psychosocial workload.[14;15] Due to the lack of high quality evidence in this area, more evidence from RCTs is required.

Using a cluster randomised controlled study design, The Stay@Work study investigated the effectiveness of a participatory ergonomics programme compared to no participatory ergonomics (control group) in reducing exposure to work-related psychosocial and physical risk factors for LBP and NP after 6 months.

Methods

Details on the study design, methods and intervention described in the current study have been published elsewhere.[16]

Study population

All 5798 workers within the 37 participating departments were allowed to take part in the study. Because the primary outcome of the Stay@Work study was to prevent LBP and NP, only workers who met the following criteria at baseline were included in the analyses: 1) aged between 18 and 65 years; 2) not pregnant; and 3) with no cumulative sick leave period longer than 4 weeks due to LBP or NP in the past 3 months.

Sample size

An annual incidence of LBP and NP in a general working population of 12-14% and 6%, respectively, were used. Due to the episodic nature of LBP and NP, repeated measurements were conducted every 3 months. Based on the study of IJmker et al (2006), an intra-class correlation coefficient (ICC) of 0.73 was estimated.[17] By using this ICC, the power analysis revealed that a sample size of 1662 workers (two groups of 831 workers) was needed to detect a 25% reduction of LBP and NP prevalence among the intervention group compared to the control group.[18] This difference can be detected with a power of 80% and a of 0.05. Taking into account a predicted dropout rate of 20% during the 12-month follow-up period, an initial study population of 2076 workers was needed.

Randomisation and blinding

An independent research assistant performed the randomisation by using a computer-generated randomisation programme. To avoid contamination of workers a in the control group by those allocated to the intervention, randomisation was done at the level of department.

Departments, each consisting of approximately 150 workers, from four Dutch companies (a railway transportation company, an airline company, a university including its university medical hospital, and a steel company) were pre-stratified according to their main workload: 1) mental, 2) mixed mental or physical, 3) light physical, or 4) heavy physical demanding.[19] Within each company, pairs of departments comparable workloads were randomly selected and one department was allocated to the participatory ergonomics intervention group and the other to the control group (no participatory ergonomics). Subsequently, department managers were informed about the randomisation outcome.

The participatory ergonomics intervention made it impossible to blind researchers, ergonomists, working group members, and department managers. However, workers of the departments were not aware of the study design, and were thereby blinded to the randomisation outcome.

Control

Before filling out the baseline questionnaire, all workers from the intervention and control departments were requested to watch three short (45 seconds) educational films showing LBP and NP risk factors (i.e. lifting too heavy loads, frequent twisting of the lower back, and holding the neck in an awkward position) as well as the (ergonomic) solutions on how to avoid these situations. The films were used as a sham intervention and are an ineffective strategy to prevent LBP and NP.[20]

Intervention

All details of the intervention have been described thoroughly elsewhere.[16] In short, directly after the randomisation outcome, each intervention department formed a working group consisting of eight workers and one department manager (or his/her representative). The intervention consisted of a 6-hour working group meeting which was held between December 2007 and December 2008. Under the guidance of a trained ergonomist, the working group followed the steps of the Stay@Work participatory ergonomics programme.

During the meeting working group members discussed a document which contained information on risk factors for LBP and NP in the department, which had been identified during a workplace visit by an (which was mandatory for each intervention department), pictures made by the working group members, and baseline questionnaire information (step 1). The working group could also add other risk factors for LBP and NP and evaluated the risk factors on their frequency and severity. Based on the perceptions of the working group, the most frequent and severe risk factors were prioritised, resulting in a top three of risk factors (step 2). Subsequently, the working group held a brainstorming session about different types of ergonomic measures targeting the prioritised risk factors and evaluated the ergonomic measures according to an implementation criteria list including: relative advantage, costs, compatibility, complexity, visibility and feasibility within a time frame of 3 months. Based on working group consensus, the three most appropriate ergonomic measures were prioritised (step 3). All prioritised risk factors and prioritised ergonomic measures were written down in an implementation plan (step 4). The implementation plan also described which working group member(s) was/were responsible for the implementation of the prioritised ergonomic measure(s); these persons were called implementers. Implementers were requested to apply the prioritised ergonomic measures within 3 months at their department (step 5), and reductions in workload were expected shortly after implementation. If necessary, a second (1-hour), optional meeting was arranged to evaluate or to adjust the implementation process (step 6).

To improve implementation, two or three implementers from each working group were asked to voluntary follow a special 4-hour implementation training programme to become a Stay@Work ergocoach. Forty implementers attended the training, during which they were educated in different implementation strategies to inform, motivate and instruct their co-workers about ergonomic measures. They also received a toolkit consisting of flyers and posters to inform their co-workers about both the prioritised risk factors and the ergonomic measures.[21]

In total, working groups prioritised: 32 individual ergonomic measures (i.e. improving awareness regarding ergonomics, worksite visits, and physical activity programmes), 27 physical ergonomic measures (i.e. ergonomic redesign or modification, new equipment and manual handling aids) and seven organisational ergonomic measures (i.e. pause software installation, job rotation and restructuring management style). After the implementation period, the implementers received a short questionnaire assessing whether the prioritised ergonomic measures for which the implementer was responsible had been implemented at the department. This method enabled the investigators to calculate the percentage of the perceived implementation. Approximately one third (34%) of the prioritised ergonomic measures were perceived as implemented in the intervention departments.[21]

Outcome measures and data collection

For practical reasons the baseline measurement took place after randomisation, and approximately 1 month before the start of the participatory ergonomics working group meetings. All workers within the randomised departments were invited to fill out the baseline questionnaire. Responders on the baseline questionnaire were sent the 6-month follow-up questionnaire.

Psychosocial risk factors

Data on the exposure to psychosocial risk factors were assessed at baseline and after 6-month follow-up by means of a Dutch version of the Job Content Questionnaire (JCQ)[22], which measures all dimensions of the demand-control-support model. Workers rated 25 items on a four-point scale (1= totally disagree, 2= disagree, 3= agree, 4= totally agree). By combining various items, the following dimensions were constructed: skill discretion, decision authority, psychosocial job demands, supervisor support, and co-worker support. These dimensions have shown moderate to good reliability.[23] The dimension decision latitude was constructed by combining the dimensions skill discretion and decision authority. The dimensions supervisor support and co-workers support were also combined into the dimension overall social support.

Physical risk factors

Data on exposure to physical risk factors were assessed at baseline and after 6-month follow-up by using the standardised Dutch Musculoskeletal Questionnaire (DMQ). By means of 63 items, the DMQ provides a brief overview of musculoskeletal workload and associated hazardous working conditions, which can be categorised into seven indices (forces, dynamic loads, static loads, repetitive loads, climatic factors, vibration, and ergonomic environmental factors) and four separate factors (standing, walking, sitting, uncomfortable postures).[24] Based on the literature[25-28], a total of 11 items (yes/no) that were considered to be associated with the onset of LBP or NP were selected from the DMQ (see table 1).

Confounders

At baseline, data on various potential confounders were assessed.[24] Gender, age, and level of education were considered as potential confounders for both psychosocial and physical workloads, whereas work hours per week in current function was considered a potential confounder for physical workload only.

Statistical analyses

All analyses were performed according to the intention to treat principle. Baseline characteristics of workers in the two groups were compared using the unpaired Student t test (continuous variables) and Pearson's chi-square test (categorical and dichotomous variables). Multilevel analysis was used to evaluate the intervention effects for all outcome variables.

Multilevel analysis enables adjustment for the clustering of observations within matched randomisation pairs and departments. In this study four levels were identified: time (pre/post), workers, department, and matched randomisation pairs.

Almost 30% of the baseline responders did not respond to the follow-up questionnaire after 6 months. Under the assumption that data were missing at random[29], the method of maximum likelihood (ML) yields unbiased estimates. A nice feature of the ML procedure is that all gathered data on the outcomes can be used.

For each outcome variable, two analyses were performed: 1) a crude analysis (i.e. the differences between the intervention and control group at 6-month follow-up adjusted for (minus) the corresponding baseline differences on the outcome variable), and 2) an adjusted analysis, encompassing an analysis as above but adjusted for potential confounders. For all analyses the intervention effect of interest was the interaction between group and measurement time.[30] Adding potential confounders to the model did not change the intervention effect with more than 10 %, and therefore, the results of the crude analysis are presented. All analyses were checked for effect modification by the main workload performed at the department. No significant interactions of $p< 0.05$ were found with workload, indicating that effect modification did not occur. For this reason no stratified analyses on workload were performed. Linear mixed models were used to evaluate the effects on psychosocial workload and logistic mixed models to evaluate the effects on physical workload. Logistic mixed models were not possible with all levels included, and the level 'randomisation pairs' was removed from the model. Intervention effects on four physical risk factors (lift and carry heavy loads, drive machines, and bend neck backwards) could not be determined. By deleting the level 'department' from the model, the analyses of these four risk factors were performed by including the 'workers level' only.

For all analyses a two-tailed significance level of $p <0.05$ was considered statistically significant. Linear mixed models were performed with SPSS version 15.0, and logistic mixed models were performed with Stata version10.0.

Results

Figure 1 shows that 19 randomisation pairs were formed and the randomisation procedure allocated 19 departments to the intervention group and 18 departments to the control group. Most departments were characterised by a mental workload (n =10 in each group). Due to a sudden reorganisation, the manager of an intervention department consisting of 128 workers decided that a section of the department (n =103 workers) was not allowed to participate in the study or to receive the baseline questionnaire. In total, the baseline questionnaire was sent to 5695 workers, of whom 3232 (57%) responded. Among the 3232 baseline responders, 185 did not meet the inclusion criteria and were excluded from the analyses. Therefore, 3047 workers (n = 1472 in the intervention group and n = 1575 in the control group) met the inclusion criteria at baseline and were approached for follow-up measurements. The loss to follow-up after 6 months was 35% in the intervention group and 29% in the control group. Reasons for loss to follow-up were not collected systematically and, therefore, were largely unknown.

Figure 1. Flow of departments and participants throughout the phases of the trial.

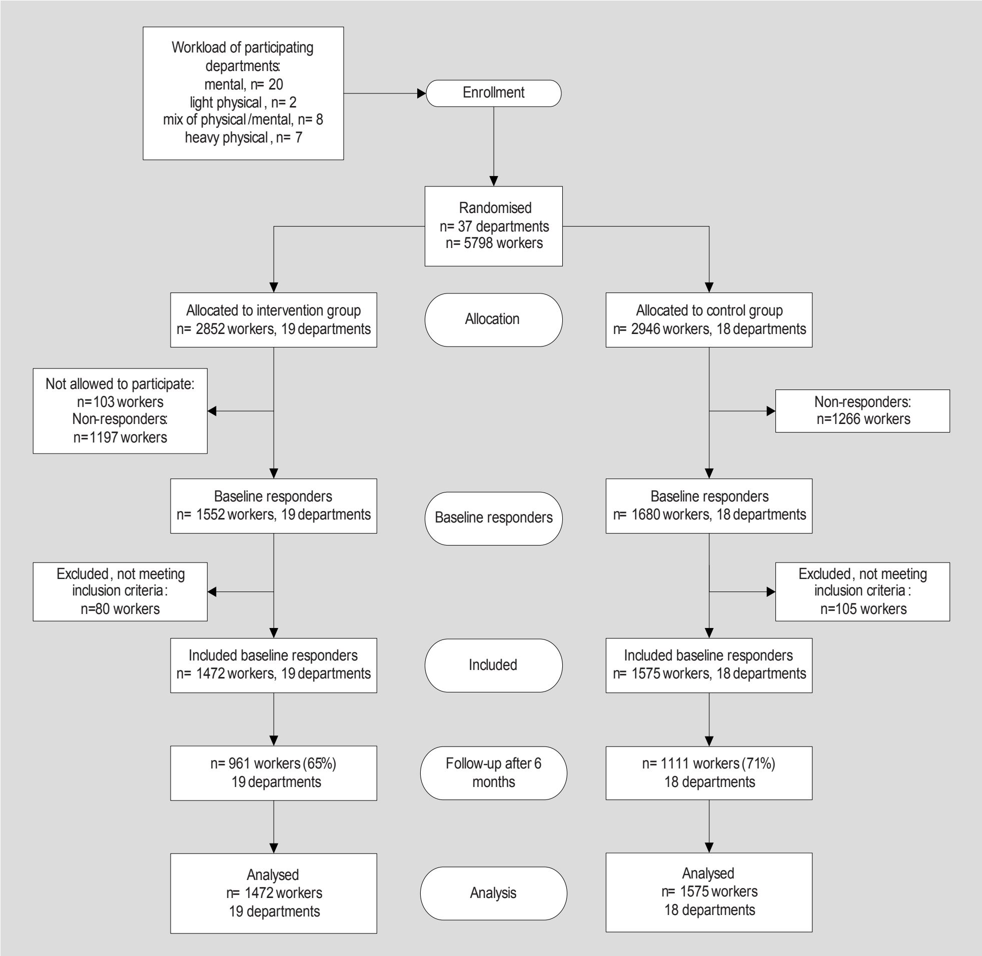

Table 1 presents the baseline characteristics of workers in the intervention and the control groups. Groups differed significantly on educational level and gender (57% men in the control group and 59% men in the intervention group). Regarding the outcome variables, various significant, but not clinically relevant differences were found between the intervention and the control group.

Table 1. Baseline characteristics.

Department characteristics	**Intervention group (n=19 departments)**	**Control group (n=18 departments)**
Workload departments [no.]		
Mental	10	10
Light physical	1	1
Mix mental/physical	4	4
Heavy physical	4	3
Worker characteristics	**Intervention group (n=1472)**	**Control group (n=1575)**
Age (yr) [mean (SD)]	41.9 (11.1)	42.1 (10.7)
Men [no. (%)]	861 (59.0)	891 (57.0)*
Education [no.(%)] *		
Lower education	202 (13.8)	126 (8.0)
Intermediate education	572 (39.1)	579 (36.8)
Higher education	690 (47.1)	868 (55.2)
Working hours per week in current function (including overwork) [mean (SD)]	34.8 (8.8)	34.5 (8.8)
Psychosocial risk factors [mean (SD)]		
Skill discretion (range 5-20 points)	15.9 (2.3)	16.2 (2.0) *
Decision authority (range 3-12 points)	9.0 (1.7)	9.1 (1.5) *
Decision latitude (range 8-32 points)	24.8 (3.6)	25.3 (3.1) *
Psychosocial job demands (range 5-20 points)	12.8 (2.3)	12.8 (2.2) *
Co-worker support (range 4-16 points)	12.1 (1.5)	12.2 (1.4) *
Supervisor support (range 4-16 points)	11.2 (2.1)	11.1 (2.1)
Overall social support (range 8-32 points)	23.3 (3.0)	23.3 (2.8)
Physical risk factors [no.(%)]		
Risk factors for low back pain		
Often manually lift loads >20kg	211 (14.3)	(17.6) *
Often manually carry load >20kg	105 (7.1)	149 (9.5) *
Often drive machines (lorry, crane, bulldozer)	248 (16.8)	124 (7.9) *
Work in heavily bent trunk forwards and backwards	373 (25.3)	412 (26.2)
Work in heavily awkward posture for a prolonged time	307 (20.9)	293 (18.6)
Work in heavily twisted posture for a prolonged time	227 (15.4)	237 (15.0)
Work in heavily awkward and twisted posture for a prolonged time	230 (15.6)	236 (15.0)
Work in same posture for a prolonged time	909 (61.8)	943 (59.9)
Risk factors for neck pain		
Often bends neck forwards or hold neck in a forward bent posture	508 (34.5)	531 (33.7)
Often holds neck in backwards posture for a prolonged time	169 (11.5)	169 (10.7)
Often holds neck in a twisted posture for a prolonged time	317 (21.5)	316 (20.1)

Abbreviations: no., number; SD, standard deviation .
* p<0.05.

Effects of the intervention on exposure to psychosocial risk factors

Table 2 shows the intervention effect on exposure to psychosocial risk factors after 6 months of follow-up. A statistically significant difference was found for the risk factors decision latitude (0.29 points; 95% CI 0.07 to 0.52) and decisions authority (0.16 points; 95% CI 0.04 to 0.28), indicating that decision latitude and decision authority among workers in the intervention group improved significantly compared to workers in the control group. On all other psychosocial risk factors except for supervisor support, the observed differences suggested that exposure to psychosocial risk factors among workers in the intervention group was slightly reduced. However, none of the differences were statistically significant.

Table 2. Intervention effect* on exposure to psychosocial risk factors between the intervention group and control group after 6 months of follow-up.

Psychosocial risk factors	Intervention effect (95% CI)
Decision latitude (range 8-32 points)	0.29 (0.07 to 0.52)
- Skill discretion (range 5-20 points)	0.12 (-0.04 to 0.28)
- Decision authority (range 3-12 points)	0.16 (0.04 to 0.28)
Psychosocial work demands (range 5-20 points)	-0.07 (-0.25 to 0.11)
Overall social support (range 8-32 points)	0.06 (-0.18 to 0.29)
- Co-workers support (range 4-16 points)	0.07 (-0.06 to 0.20)
- Supervisor support (range 4-16 points)	-0.01 (-0.18 to 0.15)

Results of the linear mixed models analyses.
Abbreviations: 95% CI, 95% confidence interval.
* Adjusted for baseline differences on the outcome variable.

Effects of the intervention on exposure to physical risk factors

Table 3 presents the intervention effect on exposure to physical risk factors after 6 months of follow-up. A statistically significant different OR was found for the LBP risk factor awkward posture (OR 1.86; 95% CI 1.15 to 3.01). This indicates that exposure to an awkward working posture of the trunk almost doubled among workers in the intervention group. With regard to the risk factor carry heavy loads, workers' exposure to this LBP risk factor was reduced among workers in the intervention group (OR 0.52; 95% CI 0.27 to 1.01). However, the difference was not significant ($p = 0.05$). Although not statistically significant, the remaining physical risk factors tended to increase somewhat among workers in the intervention group.

Table 3. Intervention effect* on exposure to physical risk factors between the intervention group and control group after 6 months of follow-up.

Physical risk factors for low back pain	OR (95% CI)
Lift heavy loads†	1.04 (0.49 - 2.21)
Carry heavy loads†	0.52 (0.27 - 1.01)
Drive machines†	1.00 (0.44 - 2.25)
Bend trunk forwards and backwards	1.08 (0.65 - 1.78)
Awkward posture	1.86 (1.15 - 3.01)
Twisted posture	1.35 (0.77 - 2.36)
Awkward and twisted posture	1.16 (0.69 - 2.01)
Same posture	0.93 (0.67 - 1.30)
Physical risk factors for neck pain	**OR (95% CI)**
Bend neck forwards or hold neck in a forward bent posture	1.00 (0.70 - 1.43)
Bend neck backwards†	1.38 (0.77 - 2.49)
Neck in twisted position	1.06 (0.67 - 1.65)

Results of the logistic mixed models analyses.
Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval.
* Adjusted for baseline differences on the outcome variable. † Only the worker level was taken into account.

Discussion

The results of this study showed that after 6 months the Stay@Work participatory ergonomics programme compared to no participatory ergonomics (the control group), resulted in statistically significant but small improvements in exposure to the psychosocial risk factors decision latitude and decision authority among workers in the intervention group. Because the dimension decision latitude was formed by combining the dimensions decision authority and skill discretion, it is possible that the increased decision latitude was the result of the improvement found on decision authority. A statistically significant result was found on the physical risk factor for LBP awkward working posture of the trunk almost doubled in the intervention group. Nevertheless, the sizes of the intervention effects were small and can be considered as not clinically relevant.[31] No statistically significant differences were found for the remaining psychosocial and physical risk factors.

There are several possible explanations why our trial generally failed to demonstrate that theparticipatory ergonomics programme was effective. The process evaluation of this study showed that 6 months after finishing the participatory ergonomics meeting, the implementers perceived approximately one third of the 66 prioritised ergonomic measures as implemented, while 26% of the workers in the intervention departments perceived the prioritised ergonomic measures as implemented.[21] The implementation rate was probably too low to successfully reduce exposure to risk factors among workers. We found that implementation of the prioritised ergonomic measures was hampered by factors such as a shortage of financial/personnel resources, lack of time to implement ergonomic changes and insufficient stakeholder involvement.[32] High implementation rates in participatory ergonomics programmes are, however, no guarantee of risk factor reduction. For example, the study by Haukka et al. (2008) reported that almost 80% of the prioritised ergonomic measures were implemented but found no significant reductions in workload.[14;15] In this context, the efficacy (can an ergonomic measure change the outcome?) of the prioritised ergonomic measures can be questioned. For example, in our study 32 out of the 66 prioritised ergonomic measures consisted of individual ergonomic measures (i.e. improving awareness regarding ergonomics using brochures, worksite visits and physical activity programmes)[21], whereas such measures may be not able to reduce workers' psychosocial and physical workload.[33]

Another explanation may be the general lack of exposure to psychosocial and physical risk factors between the two trial arms. At the very start of this study, the mean sum scores of the JCQ dimensions and the prevalence rates of physical risk factors in both groups were low, indicating that workers perceived low levels of psychosocial and physical workloads. Consequently, the effects of the participatory ergonomics programme on the reduction in risk factor exposure may be masked because little room was left for improvements. It is not thought that confounding played a role in this study because adding the most important potential confounders (age, gender, education and work hours per week) to the mixed models did not change the intervention effects of the crude models by more than 10%. It is therefore unlikely that variables such as lifestyle factors (e.g. smoking, alcohol consumption, and obesity/overweight) would have led to different results.

In this study workers' exposure to the risk factors was assessed using self-reports. Self-reports are commonly used for physical workload but may result in imprecise estimates of the workers' tasks and activities.[34] Direct measurements (i.e. EMG) on each individual worker may have been more precise and accurate tools for measuring exposure to posture, movement, and exerted forces in order to present valid estimates of physical workload.[35] However, practical aspects meant direct measurements on every individual worker were not feasible. Furthermore, this study focussed on a selection of 11 physical risk factors, whereas other possible physical risk factors (i.e. repetitive movements, maximal force extensions and lifting loads above chest height) or risk factors outside the workplace were not taken into account. Assessing the psychosocial workload was only possible by using self-reports and so the valid and reliable JCQ was used. Moreover, instead of using repeated measurements, this study used one follow-up moment, which may have not been sufficient to detect changes in workers' exposure.

In addition to the use of self-reports and lack of exposure, another limitation was the loss to follow-up after 6 months, which was considerable (>20%).[36] Non-responders were younger (mean 40.7 years SD11.3) compared to responders, and were predominantly men performing heavy physical work. However, we do not believe that this has influenced our study results, because the non-responders' characteristics did not significantly differ between the intervention and the control group.

Moreover, during all analyses the well-recognised ML procedure was applied to take into account the incompleteness in the data.[29] However, there are several distinctive features to our work. This cluster RCT is the first study to investigate the effectiveness of participatory ergonomics in reducing workers' exposure to psychosocial and physical workload in such a large working population with various task groups. Therefore, the generalisability of the results obtained from this study is high.

Furthermore, workers were kept blind to the study design and the randomisation outcome, and so the possibility that workers would undertake actions that could interfere with the experimental design was minimised. By performing the randomisation procedure at the department level, contamination between workers in the intervention and the control group was prevented. Co-interventions can be present in pragmatic trials, however, we do not believe that co-interventions have threatened the validity of our study results. During the follow-up period, the amount of ergonomic measures that were implemented at the intervention and control departments beyond the participatory ergonomics programme were equally distributed between the two groups (intervention group n = 442 and control group n = 483). Moreover, no departmental reorganisations occurred during follow-up.

Comparison with other studies

Our findings most often contradict with the conclusion drawn in the review of Rivilis et al. (2008). However, making comparisons with this review is hard. The authors concluded that participatory ergonomics was effective to reduce workers' exposure to both psychosocial and physical risk factors[13], but did not specifically mention the exact risk factors for which participatory ergonomics was effective. Comparing our results with some of the individual studies included in the Rivilis review was difficult, because the included studies differed largely from our study regarding the study design (controlled trial, before-after study), study populations (i.e. cleaners, hospital orderlies, industry workers), the content of the participatory ergonomics intervention (i.e. working group not allowed to make decisions), outcome assessments and follow-up duration.

The results of more recently conducted studies on participatory ergonomics (which were not included in the systematic review by Rivilis and colleagues) were more in line with our findings. For example, the studies of Laing et al. (2005 and 2007) showed that participatory ergonomics led to statistically significant reductions in mechanical exposures among automotive industry workers[37], but did not lead to statistically significant reductions in psychosocial workload.[38] Despite an implementation rate of 80% (n=402 ergonomic measures), the findings of a large cluster RCT among Finnish kitchen workers concluded that participatory ergonomics was not more effective in reducing physical and psychosocial workload than no participatory ergonomics in the control group.[14;15]

Next to the efficacy of prioritised ergonomic measures, compliance with the measures is also important in order to reduce workers' exposure to occupational risk factors. The use of implementation strategies to inform workers about the health risks and advantages of ergonomic measures, educate workers how to use the ergonomic measures and reduce workers' barriers to using the ergonomic measures can improve compliance, and thereby improve the effectiveness of ergonomic measures.[39] The current study made a first attempt by introducing the Stay@Work ergocoach as implementation strategy, and provided a special training to 40 implementers to become an ergocoach.[21] Probably because of the low implementation rate of the prioritised ergonomic measures, the ergocoaches played a less effective role than was expected. However, Jensen and Friche (2008) showed that a participatory ergonomics programme in combination with an implementation strategy (i.e. information about ergonomics and training in ergonomic skills) resulted in sustainable reductions in severe knee problems among Danish floor layers.[40] Based on the findings of our process evaluation in which participatory ergonomics appeared be a successful method to prioritise risk factors and develop and prioritise ergonomic measures[21], and the promising findings of Jensen and Friche we still believe that participatory ergonomics has the potential to reduce workers' exposure to occupational risk factors.

Therefore, researchers on future participatory ergonomics studies are not only encouraged to improve the implementation of ergonomic measures, but are also challenged to develop and incorporate adequate and intensive implementation strategies (i.e. use of informative materials, training in ergonomic skills, educate workers, and ergocoaches) into their participatory ergonomics programmes.

Conclusion

The results of this cluster RCT showed that after 6 months, exposure to the psychosocial risk factors decision latitude and decision authority significantly improved among workers in the intervention group. However, after 6 months workers in the intervention group were significantly more exposed to an awkward working posture of the trunk. Nevertheless, the effect sizes were small and were considered not clinically relevant. For the remaining psychosocial and physical risk factors for LBP and NP we could not detect a significant effect. The results should be interpreted with care as the implementation rate of the prioritised ergonomic measures was low. It is recommended that future participatory ergonomics research projects targeted at reducing workers' exposure to the psychosocial and physical risk factors for LBP and NP in combination with effective implementation strategies.

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7

The effectiveness of participatory ergonomics to prevent low back pain and neck pain: results of a cluster randomised controlled trial

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Abstract

Objective: To investigate the effectiveness of the Stay@Work participatory ergonomics programme to prevent low back pain and neck pain.

Methods: A total of 37 departments were randomly allocated to either the intervention (participatory ergonomics) or control group (no participatory ergonomics). During a 6-hour meeting, working groups followed the participatory ergonomicssteps, and composed and prioritised ergonomic measures aimed at preventing low back pain and neck pain. Subsequently, working groups were requested to implement the ergonomic measures in the departments. The primary outcomes were low back pain and neck pain prevalence and secondary outcomes were pain intensity and duration. Data were collected by questionnaires at baseline, and after three, six, nine, and 12-months follow-up. Additionally, the course of low back pain and neck pain (transitions from no symptoms to symptoms and from symptoms to no symptoms) was modelled.

Results: The randomisation procedure resulted in 19 intervention departments (n=1472 workers) and 18 control departments (n=1575 workers). After 12 months the intervention was neither more effective than the control in reducing the prevalence of low back pain and neck pain nor to reduce pain intensity and duration. Participatory ergonomics did not increase the probability of preventing low back pain (OR 1.23; 95% CI 0.97 – 1.57) or neck pain (OR 1.01; 95% CI 0.74 – 1.40). However, participatory ergonmics increased the probability of recovering from low back pain (OR 1.41; 95% CI 1.01 – 1.96), but not from neck pain (OR 0.95; 95% CI 0.72 – 1.26).

Conclusions: Participatory ergonomics did not reduce low back pain and neck pain prevalence, pain intensity and duration, and was neither effective in preventing low back pain and neck pain nor in recovering from neck pain. However, participatory ergonomics was more effective in recovering from low back pain.

Introduction

Low back pain (LBP) and neck pain (NP) are serious public health problems in Western-industrialised countries.[1;2] In the Netherlands, the 12-month prevalence of LBP is estimated at 44.4% and 28% for NP[3], and both are common among the working population as well. LBP and NP have unfavourable consequences for the individual worker in terms of pain and disability[1;4], but are also a burden for society and companies in terms of costs due to medical health care consumption, work absenteeism, and productivity loss at work.[5;6] In view of this impact, there is an obvious need for effective prevention strategies.

To prevent LBP and NP, various strategies (i.e. lumbar supports, advice or education on postures and working methods, physical exercise programs, lifting aids, new chairs, and pause software) have already been conducted at the workplace. Nevertheless, except for physical exercise programs, none of the strategies proved to be effective in preventing LBP or NP.[7-10] A promising strategy is participatory ergonomics. Supported by the management, participatory ergonomics involves workers to control their own work activities and empowers them to change their own workspace.[11] In both the Canadian and Dutch setting p resulted in a significantly earlier return to work among sick-listed workers with LBP compared to the control group that received usual care.[12-14]

A systematic review showed that participatory ergonomics was a successful strategy to reduce musculoskeletal disorders (MSD) such as LBP and NP.[15] However, many of the studies included in the review suffered from methodological shortcomings (i.e. lack of a proper randomisation procedure or a lack of a control group), making their findings at risk for bias. Several RCTs have been conducted to evaluate the effectiveness of participatory ergonomics as a strategy to prevent MSD and/or to reduce MSD-related pain.[16-19] However, no RCT on participatory ergonomics has been specifically focused on LBP and NP prevention. In order to draw more definite conclusions on the effectiveness of participatory ergonomics, it is required to conduct another RCT.

To this end, the current cluster RCT, called the ‘Stay@Work study’, investigated the effectiveness of a participatory ergonomics on the prevention of LBP and NP among a large and heterogeneous population of workers.

Methods

This cluster RCT was conducted at the departments of four Dutch companies: a railway transportation company, an airline company, a university including its university medical hospital, and a steel company. The study protocol was approved by the Medical Ethics Committee of the VU University Medical Center. More details on the study design and methods have been described elsewhere.[20]

Study population

All workers within the participating departments were allowed to participate in the study. Because the focus was on LBP and NP prevention, only workers meeting the following criteria at baseline were included in the analyses: 1) aged between 18-65 years; 2) not pregnant; and 3) no cumulative sick leave period longer than four weeks due to LBP or NP in the previous three months.

Control group

Before filling out the baseline questionnaire workers from both the intervention and control departments were requested to watch three short (45 seconds) educational movies about the prevention of LBP and NP. The movies were used as a sham intervention and can be considered as an ineffective strategy to prevent LBP and NP.[7]

Intervention

Intervention departments received the Stay@Work participatory ergonomics programme, which has been described in detail elsewhere.[20] Briefly, each intervention department formed a 'working group' in which eight workers and one department manager (or its representative) participated as working group members. Under the guidance of a trained ergonomist the working group followed the steps of the participatory ergonomics programme during a 6-hour working group meeting. All decisions during the working group meeting were made by the working group members and were consensus based. All working group meetings were focused on the prevention of LBP and NP in the department. By following the steps of the participatory ergonomics programme, the working group brainstormed about, evaluated, and prioritised the top three risk factors for LBP and NP. Subsequently, the working group brainstormed about, evaluated, and prioritised the top three of ergonomic measures. All information about the prioritised risk factors and ergonomic measures were written down in an implementation plan. The working group had to implement the prioritised ergonomic measures within three months in their department. To enhance implementation two or three working group members from each working group followed a 4-hour ergocoach (implementation) training. An optional second (1-hour) working group meeting was held to evaluate and/or modify the implementation process.

All together working groups prioritised 66 ergonomic measures: 32 individual ergonomic measures (i.e. improving awareness regarding ergonomics, worksite visits, and physical activity programs), 27 physical ergonomic measures (i.e. ergonomic redesign or modification, new equipment, and manual handling aids), and seven organizational ergonomic measures (i.e. pause software installation, job rotation, and restructuring management style). Approximately one third of the prioritised ergonomic measures were implemented in the intervention departments.[21]

Outcome measures and data collection

Baseline responders were sent follow-up questionnaires after three, six, nine, and 12 months. The primary outcome measure was the prevalence of LBP and NP and was assessed every three months using the Dutch Musculoskeletal Questionnaire (DMQ).[22] On a four-point scale the DMQ asked about the presence of LBP in the previous three months and the presence of NP in the previous three months: "no, never", "yes, sometimes", "yes, regularly", or "yes, always". Prevalence was determined by combining the categories "no, never" with "yes, sometimes" into "no LBP or NP", and the categories "yes, regularly" with "yes, always" into "LBP or NP". Secondary outcomes were also assessed every three months using the 11-point Von Korff scales and encompassed: 1) LBP and NP mean pain intensity in the previous three months, ranging from 0 'no symptoms' to 10 'worst imaginable', and 2) LBP and NP duration, defined as the total number of days with pain experienced in the past three months.[23]

Potential Confounders

At baseline, socio-demographic information was collected, including: age, gender, and level of education.[22] Moreover, the DMQ was also used to obtain information (yes/no) on physical risk factors (i.e. heavy manually lifting and carrying, awkward positions, driving machines, and neck flexion) of LBP and NP.[21] Psychosocial risk factors of LBP and NP were assessed using the Job Content Questionnaire (JCQ). Workers rated 25 items on a four-point scale (1 = totally disagree, 2 = disagree, 3 = agree, 4 = totally agree). By combining various items, the following dimensions were constructed: skill discretion, decision authority, psychosocial job demands, supervisor support, and co-worker support. The decision latitude dimension was constructed by combining skill discretion and decision authority, whereas the overall social support dimension was constructed by combining supervisor- and co-worker support.[24]

Ergonomic co-interventions

Ergonomic measures that were implemented in the department, but were not the result of the participatory ergonomics programme, were registered as 'ergonomic co-interventions'. Information on these co-interventions was obtained from the workers using a questionnaire. Furthermore, by means of a questionnaire also department managers were asked whether other co-interventions, such as LBP and NP prevention programs (e.g. chair massage, fitness programs, and lifestyle programs), had been conducted in their department during the period under study, and on the occurrence of reorganisations in their department.

Sample size

The sample size calculation showed that an initial study population of 2076 workers was needed to statistically find a 25% reduction of LBP and NP prevalence, with a power of 80% and a significance level of 0.05 (20).

Randomisation

Randomisation was performed at the level of the department. Based on their workload, the 37 participating departments were pre-stratified into various categories of demanding work: mentally, mixed mentally and physically, light physically, or heavy physically.[25] Within each company, a pair of departments with comparable workloads was randomly allocated to either the intervention group (participatory ergonomics) or the control group (no participatory ergonomics). The randomisation procedure was performed by an independent research assistant using a computer-generated randomisation programme. Department managers only were informed about the randomisation outcome.[20]

Blinding

The intervention made it impossible to blind workers, researchers, working group members and department managers. However, workers of the departments were kept blind to the study design, and were thereby blinded to the group assignment.

Statistical analysis

All analyses were performed according to the intention to treat principle. To assess the success of the randomisation descriptive statistics were used to compare the baseline measurement of the groups.

Multilevel analysis was used to evaluate the intervention effects for all outcome variables. Multilevel analysis enables adjustment for the clustering of observations within matched randomisation pairs, departments, and workers. In this study four levels were identified: 1. time (five occasions) 2. workers, 3. departments, and 4. matched randomisation pairs.

After 6 and 12 months, over 30% of the baseline responders were lost to follow-up. Under the assumption that data were missing at random[26], the method of maximum likelihood (ML) yields unbiased estimates. A nice feature of the ML procedure is that all collected data on the outcomes can be used.

For each outcome variable, two analyses were performed: 1) a crude analysis (i.e. the differences between intervention and control group at three, six, nine, and 12 months follow-up adjusted for the corresponding baseline differences on the outcome variable), and 2) an adjusted analysis, encompassing an analysis as above but adjusted for potential confounders (e.g. gender, age, level of education, or physical and psychosocial risk factors). For all analyses the intervention effect of interest was the interaction between group and measurement time.[27] Since potential confounders did not change the intervention effect by more than 10%, therefore the results of the crude analysis are presented. No significant interactions ($p< 0.05$) were found with main workload performed, indicating that effect modification did not occur. Therefore, the results of subgroup analyses on workload are not presented. In Stata version 10.0, logistic mixed models were used to study the intervention effects on LBP and NP prevalence (ORs). In SPSS version 15.0, linear mixed models were used to study the intervention effects on pain intensity and duration for three groups: 1) the whole study population including all workers with or without symptoms at baseline (primary and secondary prevention), 2) workers without symptoms at baseline (primary prevention), 3) workers with symptoms at baseline (secondary prevention). For all analyses a two-tailed significance level of $p < 0.05$ was considered statistically significant.

Transition models

LBP and NP are episodic, indicating that over time symptoms come and go. To study the intervention effects on the primary and secondary prevention of LBP and NP transitions models were used, in which the presence of LBP in the past three months and the presence of NP in the past three months were incorporated in the model. The transition models enabled to investigate the effectiveness of the participatory ergonomics intervention on the course of LBP and NP. In a so-called first order Markov transition model the probability of getting LBP given no LBP at the previous time interval and the reverse probability of getting no LBP given LBP at the previous time interval were modelled simultaneously by means of a logistic mixed model.[28;29] Simultaneously indicates that the transition model takes into account the previous state in order to determine whether an individual is at risk to develop symptoms. The course of NP was similarly modelled. Transition models were conducted using the gllamm procedure in Stata version 10.0, and were not adjusted for potential confounders.

Results

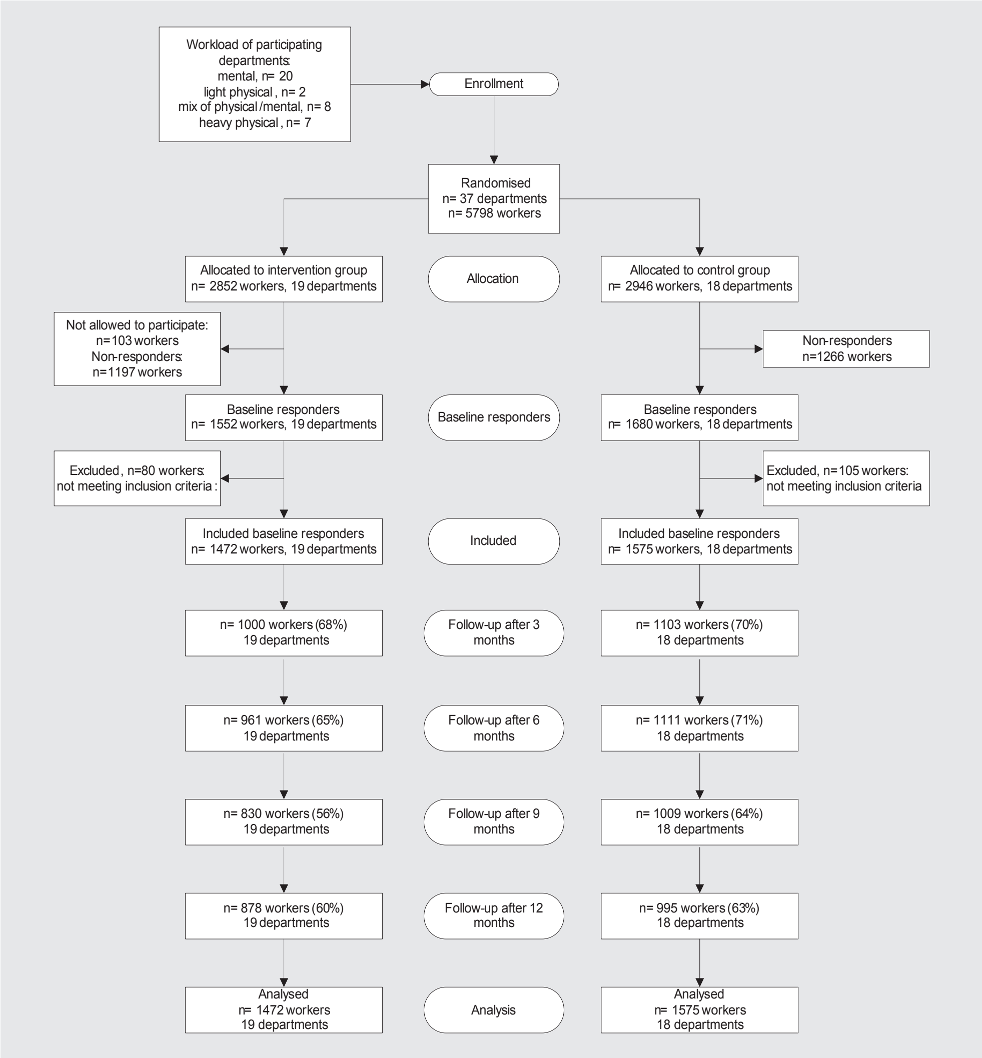
Participants flow

Figure 1 presents the flow of departments and participants in this trial. A total of 37 departments (n = 5798 workers) were randomised. 19 of which were allocated to the intervention group (n = 2852 workers) and 18 to the control group (n = 2946 workers). The baseline questionnaire was sent to 5695 workers, of whom 3232 (57%) responded. All together, 3047 workers met the inclusion criteria (n = 1472 intervention group, and n = 1575 control group, respectively) and were approached for the follow-up measurements.

Loss to follow-up

After 12 months, the loss to follow-up on the primary outcome measure was 40% in the intervention group and 37% in the control group. Complete follow-up data on the primary outcome measure (LBP and NP) was derived from 1280 workers.

Figure 1. Flow of departments and participants during the phases of the trial.



Baseline characteristics

Table 1 presents the baseline characteristics of the departments and the workers in the intervention group and the control group. At baseline, no meaningful differences between workers in the intervention and the control group were found either for the potential confounders or for the primary and secondary outcomes.

Effects on the prevalence of low back pain and neck pain

Table 2 shows that during the 12-month follow-up period participatory ergonomics was not more effective in comparison with the control group in reducing the prevalence of LBP and NP.

Table 1. Baseline characteristics.

Department characteristics	**Intervention group (n=19 departments)**	**Control group (n=18 departments)**
Workload departments [no.]		
Mental	10	10
Light physical	1	1
Mix mental/physical	4	4
Heavy physical	4	3
Worker characteristics	**Intervention group (n=1472)**	**Control group (n=1575)**
Age (years) [mean (SD)]	41.9 (11.1)	42.1 (10.7)
Men [no. (%)]	861 (59.0)	891 (57.0)*
Education [no.(%)]*		
Lower education	202 (13.8)	126 (8.0)
Intermediate education	572 (39.1)	579 (36.8)
Higher education	690 (47.1)	868 (55.2)
Work related psychosocial factors [mean (SD)]		
Decision latitude (range 8-32 points)	24.8 (3.6)	25.3 (3.1)*
Skill discretion (range 5-20 points)	15.9 (2.3)	16.2 (2.0)*
Decision authority (range 3-12 points)	9.0 (1.7)	9.1 (1.5)*
Social support (range 8-32 points)	23.3 (3.0)	23.3 (2.8)
Co-worker support (range 4-16 points)	12.1 (1.5)	12.2 (1.4)*
Supervisor support (range 4-16 points)	11.2 (2.1)	11.1 (2.1)
Psychosocial job demands (range 5-20 points)	12.8 (2.3)	12.8 (2.2)*
Work related physical factors [no.(%)]		
Often manually lift loads >20kg	211 (14.3)	277 (17.6)*
Often manually carry load >20kg	105 (7.1)	149 (9.5)*
Often drive machines (lorry, crane, bulldozer)	248 (16.8)	124 (7.9)*
Work in heavily awkward position for a prolonged time	307 (20.9)	293 (18.6)
Often bent neck forwards or hold neck in a forward bent posture	508 (34.5)	531 (33.7)
Low back pain, whole population		
Having had low back pain in the past 3 months [no.(%)]	404 (27.4)	415 (26.3)
Mean pain intensity in the past 3 months [mean (SD)]	2.2 (2.4)	2.1 (2.3)
Duration in the past 3 months [mean (SD)]	12.0 (21.7)	11.5 (21.0)
Population with low back pain at baseline		
Mean pain intensity in the past 3 months [mean (SD)]	4.9 (2.3)	4.6 (2.2)
Duration in the past 3 months [mean (SD)]	35.6 (29.7)	34.7 (29.0)
Population without low back pain at baseline		
Mean pain intensity in the past 3 months [mean (SD)]	1.1 (1.5)	1.1 (1.5)
Duration in the past 3 months [mean (SD)]	3.1 (5.0)	3.3 (6.0)
Neck pain, whole population		
Having had neck pain in the past 3 months [no.(%)]	319 (21.7)	325 (20.6)
Mean pain intensity in the past 3 months [mean (SD)]	1.7 (2.2)	1.7 (2.1)
Duration in the past 3 months [mean (SD)]	9.7 (19.8)	8.9 (18.6)
Population with neck pain at baseline		
Mean pain intensity in the past 3 months [mean (SD)]	4.6 (2.1)	4.4 (2.2)
Duration in the past 3 months [mean (SD)]	35.3 (29.3)	32.3 (28.4)
Population without neck pain at baseline		
Mean pain intensity in the past 3 months [mean (SD)]	0.9 (1.4)	0.9 (1.4)
Duration in the past 3 months [mean (SD)]	2.6 (5.5)	2.8 (6.9)

Abbreviations: no., number; SD, standard deviation.
* p<0.05.

Table 2. Intervention effects* on the prevalence of low back pain and neck pain during the 12-month follow-up period.

Low back pain	OR	95% CI	P-value
3 months	0.73	0.50 – 1.07	0.11
6 months	0.87	0.59 – 1.30	0.50
9 months	1.11	0.73 – 1.68	0.63
12 months	1.16	0.77 – 1.77	0.48
Neck pain	**OR**	**95% CI**	**P-value**
3 months	1.28	0.83 – 1.97	0.27
6 months	1.05	0.68 – 1.63	0.83
9 months	0.75	0.47 – 1.19	0.28
12 months	0.88	0.56 – 1.40	0.60

Results of the logistic mixed models analyses.
Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval.
* Adjusted for baseline differences on the outcome variable.

Effects on pain intensity and pain duration

Low back pain

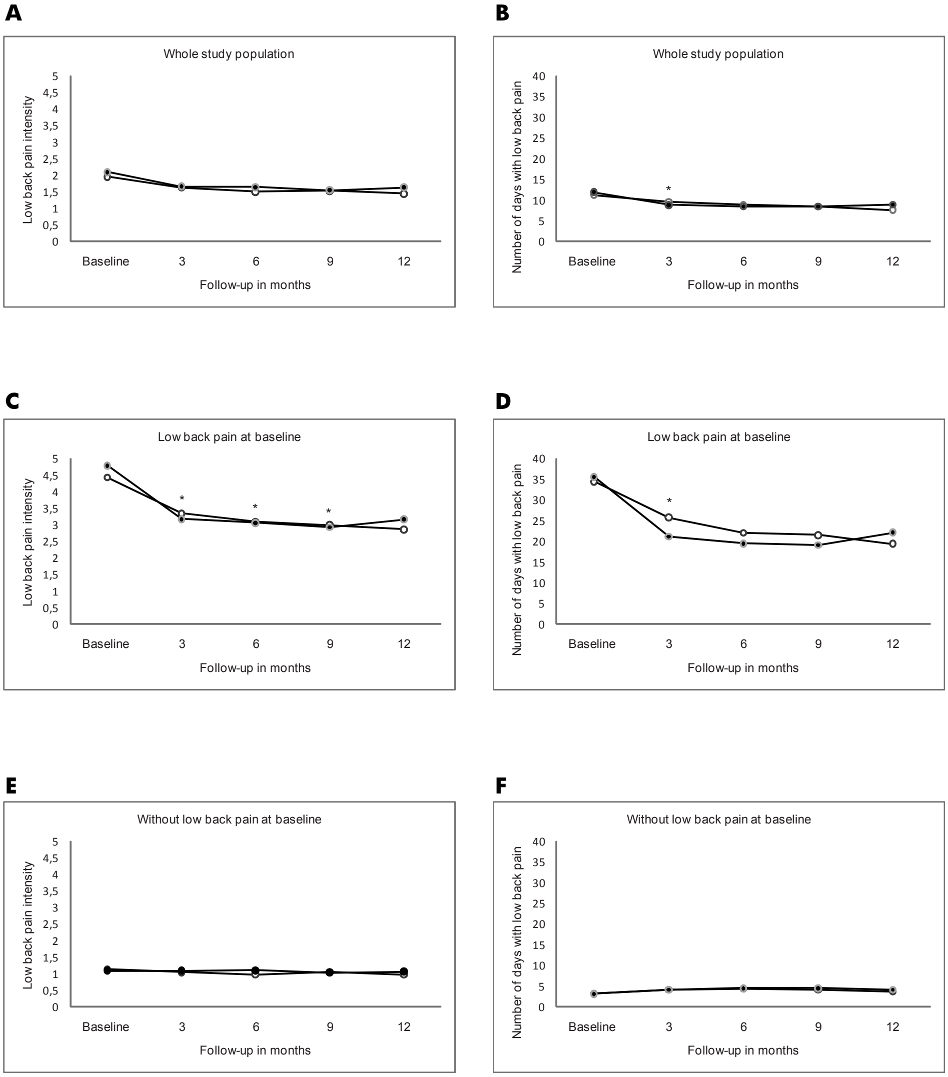
Figures 2 A-F show the mean low back pain intensity and mean pain duration at baseline and after three, six, nine, and 12 months of follow-up for three groups: 1) workers with or without LBP at baseline, 2) workers with LBP at baseline, and 3) workers without LBP at baseline. The figures show that during the 12-month follow-up period participatory ergonomics was not more effective than the control group on the reduction of pain intensity and pain duration. Among workers with LBP at baseline, participatory ergonomics statistically significantly reduced pain intensity in the first nine months. However, the effects were not sustained beyond 12 months. Regarding the other LBP outcomes, several statistically significant reductions were found but again reductions were small and disappeared after 12 months.

Neck pain

In figures 3 A-F the results on NP intensity and pain duration at baseline and after three, six, nine, and 12 months of follow-up are presented. Similar to the LBP results, the results on NP are presented separately for three groups. The results showed that participatory ergonomics compared to the control group did not result in statistically significant reductions in pain intensity and duration. Regarding NP intensity, workers in the intervention group perceived statistically significant higher levels of pain intensity. Nonetheless, differences were small and were not sustained.

Figure 2. Model-based mean low back pain intensity and duration at baseline and after three, six, nine, and 12-month follow-up.

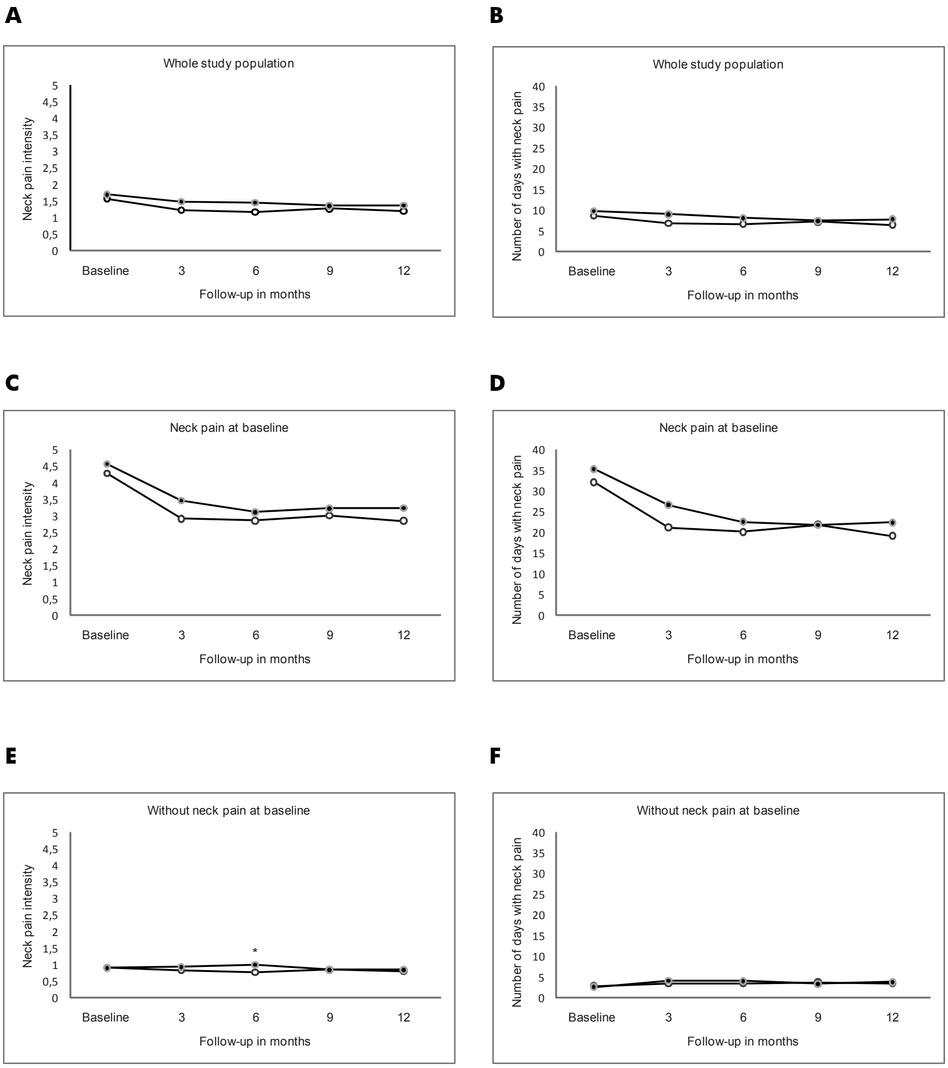
●Intervention group ○Control group



Note: The baseline values may slightly differ from the descriptive baseline values as presented in table 1, because figures (A-F) present the baseline values obtained from the (linear) mixed models.

Figure 3. Model-based mean neck pain intensity and duration at baseline and after three, six, nine, and 12-month follow-up.

● Intervention group ○ Control group



Note: The baseline values may slightly differ from the descriptive baseline values as presented in table 1, because figures (A-F) present the baseline values obtained from the (linear) mixed models.

Effects on the course of LBP and NP

Derived from the transition model Table 3 shows the intervention effects on the two transition probabilities: 1) getting LBP and NP (symptoms) given no LBP and NP (no symptoms) respectively, at the previous time interval; and 2) the reverse transition probability getting no LBP and NP (no symptoms) given LBP and NP (symptoms) respectively, at the previous time interval. The findings on LBP and NP indicated that participatory ergonomics did not statistically significantly increase the probability of preventing LBP and NP during the 12-month follow-up period. However, the probability of recovering from LBP was statistically significantly increased among workers who received participatory ergonomics (OR 1.41; 95% CI 1.01 - 1.96). Participatory ergonomics did not increase the probability of recovering from NP.

Table 3. Intervention effects during the 12-month follow-up period obtained from the transition model.

	From no symptoms to symptoms			*From symptoms to no symptoms*		
Outcome variable	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Low back pain	1.23	0.97 – 1.57	0.08	1.41	1.01 – 1.96	0.04
Neck pain	1.01	0.74 – 1.40	0.92	0.95	0.72 – 1.26	0.71

Abbreviations: OR; odds ratio, 95% CI; 95% confidence interval.

Ergonomic co-interventions

In the 12-month follow-up period, almost an equal amount of ergonomic co-interventions (ergonomic measures that were not the result of the participatory ergonomics programme) were implemented in the intervention departments (n = 883) and the control departments (n = 850). Most often the ergonomic co-interventions encompassed information about ergonomics, new desks/chairs, and job modifications. None of the departments implemented co-interventions, such as LBP and NP prevention programmes (i.e. health promotion programmes) during the 12-month follow-up period, and no departmental reorganisations occurred during this period.

Discussion

Principal findings

This study showed that the Stay@Work participatory ergonomics programme was not more effective than the control group in reducing LBP and NP prevalence during the 12-month follow-up period. Participatory ergonomics was not effective in preventing LBP, but was more successful in recovering from LBP (OR 1.41; 95% CI 1.01 – 1.96). Regarding NP, no differences between intervention and control group were found neither on prevention nor on recovery differences between intervention and control group were found. Participatory ergonomics was not effective to in reduceing pain intensity and duration, neither for LBP nor for NP.

Strengths and weaknesses of the study

Distinctive strengths of our work include: the cluster RCT study design, its statistical power, the use of a large study population as well as including workers from diverse task groups with various workloads. The generalisablity of our study findings towards the whole working population, therefore, is high. Furthermore, randomisation at the department level minimised possible contamination between workers from the intervention and control group. Repeated measurements were used as well as standardised questionnaires to measure study outcomes.[30]

A limitation of this study is the considerable loss to follow-up rates on the primary and secondary outcomes found after 12 months. Unfortunately, loss to follow-up is a common problem among prevention studies.[31] Checking our data for selective drop-out revealed that non-responders did not differ from responders on several important prognostic LBP and NP factors (i.e. age, gender, prevalence, pain intensity and duration). Nevertheless, loss to follow-up rates higher than 30% can introduce selection bias and thereby affect the ability to draw firm conclusions.[32] Another limitation is the follow-up period of 12 months, which may be too short to make preventive effects on LBP and NP visible.[33]

This pragmatic cluster RCT enabled us to study the effects of participatory ergonomics under realworld conditions, but it was unavoidable that a considerable number of ergonomic co-interventions were implemented – in almost equal quantities – in both the intervention and control departments. These ergonomic co-interventions may have reduced the contrast between the two trial arms.

In their framework, Haines et al. (2003) presented several important items that have to be incorporated in participatory ergonomic interventions.[11] According to this framework on participatory ergonomics, one of the main principles of participatory ergonomics is that workers themselves determine what they want to change in the workplace. In contrast to this principle, the current study decided in advance of the intervention that workers had to focus on LBP and NP. On the other hand, the high lifetime prevalence rates and 12-month prevalence rates of LBP and NP in the working population may justify our decision. Especially, when the aim is prevention it is necessary to make choices where to intervene on and to predefine the outcome measures of interests. The use of most of the other participatory ergonomics principles as described in the framework (i.e. mix of participants and guidance by the ergonomist) were covered by our intervention.

Comparison with other studies

A systematic review concluded that participatory ergonomics was effective on reducing MSD and MSD-related symptoms.[15] However, the results obtained from our study do not support this conclusion. Regarding LBP and NP the findings obtained from other RCTs are in accordance with our study findings. At 12 months follow-up Morken et al. (2002) found that participatory ergonomics among workers in the aluminium industry was neither more effective in preventing MSD (including LBP and NP) nor in reducing pain intensity.[19] Also, Haukka et al. (2008) found after 12 months of follow-up that participatory ergonomics was not more effective than a control group in preventing MSD (including LBP and NP) nor in reducing pain intensity among kitchen workers.[16] Among video display unit workers, it was found that after 10 months of follow-up participatory ergonomics was not more effective than a control group in reducing pain intensity.[18] On discomfort, the 12-month follow-up findings of Bohr et al. (2000) showed that participatory ergonomics was more effective than the control group in reducing upper body discomfort among hospital workers. However, no significant reductions were found on lower body discomfort.[34] The discrepancy between the findings obtained from RCTs and the conclusion of the systematic review, may be caused by the inclusion of study designs other than RCTs. It was found that non-randomised studies and studies that lacked a control group (i.e. pre-post studies) showed positive findings more often.[15]

When comparing our results with the findings obtained from other RCTs on participatory ergonomics, the existing heterogeneity regarding the content of intervention, study population, outcome measurements, and follow-up duration should be considered. Nonetheless, the direction of their results indicate that participatory ergonomics is neither effective in primary preventing LBP and NP nor in reducing pain intensity and pain duration.

Explanation of the findings

There are several possible explanations why our trial failed to demonstrate effectiveness of the Stay@Work participatory ergonomics programme. The first explanation is the modest implementation rate. After six months, the participatory ergonomics programme resulted in the implementation of approximately one third of the 66 prioritised ergonomic measures in the intervention departments[21], and did not increase after 12 months. On the other hand, the RCT by Haukka et al. (2008) showed that high implementation rates in participatory ergonomics did not guarantee the finding of statistically significant effects on the prevention of MSD. Despite an implementation rate of 80% (n = 402 ergonomic changes) participatory ergonomics was neither more effective than the control group in preventing MSD nor in reducing pain intensity.[16;35]

In line with the limited implementation, we found that participatory ergonomics was not able to reduce workload. Working groups most commonly prioritised the risk factors: unfavourable working posture, manually lifting and carrying of heavy loads, and problems with equipment/furniture. To resolve these risk factors, working groups prioritised mainly the more 'simple' and less expensive ergonomic measures (i.e. education on ergonomics or workplace visits by an expert or new desks, chairs or lifting devices). This is not surprising since the participatory ergonomics programme evaluated all ergonomic measures on several implementation criteria (costs, complexity, compatibility, and implementable within 3 months).

Possibly, the efficacy of the ergonomic measures derived from the current participatory ergonomics programme may be too limited to actually decrease risk factor exposure. In a previous analysis conducted on the data of this study showed that after six months participatory ergonomics generally failed to statistically significantly reduce workers' exposure to the perceived physical and psychosocial risk factors for LBP and NP. Improvements due to participatory ergonomics were only found on decision authority and decision latitude[36], however, were not sustained beyond the 12-months of follow-up (data not shown).

Another explanation is that at the very start of the current study the LBP and NP prevalence, intensity and duration in both groups were relatively low. Consequently, little room was left for participatory ergonomics to further improve on these outcomes. Moreover, the low prevalence rates make it plausible that departments did acknowledge LBP and NP as an important issue. Subsequently, the workers and the manager of the working group did not put personnel and financial efforts in implementing the prioritised ergonomic measures in the intervention departments.

Nonetheless, it is uncertain whether a reduction on the investigated risk factors would have actually led to LBP and NP prevention. This uncertainty is partly due to the lack of consensus in the literature about the most important risk factors for LBP and NP occurrence.[37;38] Moreover, LBP and NP are of multifactorial origin, meaning that various risk factors (or combinations thereof) are responsible for their occurrence.[39] In our study, most ergonomic measures were targeted on one single (prioritised) risk factor of LBP and NP. Subsequently, other risk factors for LBP and NP may have been targeted by the prioritised ergonomic measures. In addition, risk factors for LBP and NP that occur outside the workplace were not taken into account.

Participatory ergonomics was effective for recovery from LBP. Additional analyses showed that prioritised ergonomic measures were not implemented more often among workers with LBP, and risk factor reduction was not different for workers with LBP. The risk factors for the occurrence of LBP differ from those for developing chronic LBP. In the latter, psychological factors (i.e. stress and negative cognitive characteristics) as well as work environment factors (social support at work and job dissatisfaction) become increasingly important.[40] Therefore, a possible explanation for the increased recovery may be that participatory ergonomics resulted in more attention being given to the problem of LBP and NP. Possibly, workers with LBP might have interpreted this as positive, because they perceived that managers were taking (their) LBP problem seriously and were willing to undertake action.

Conclusion

After 12 months, results of this large cluster RCT showed that participatory ergonomics was not more effective than the control group in primary preventing LBP and NP, nor in reducing pain intensity and pain duration. There were no significant differences participatory ergonomics and the control group in recovering from NP. However, participatory ergonomics was more effective in recovering from LBP.

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9

General discussion

The primary objective of this thesis was to investigate the (cost-)effectiveness of the Stay@Work participatory ergonomics programme to prevent low back pain and neck pain among workers. Moreover, the effectiveness of participatory ergonomics on the secondary outcome measures was evaluated, including: exposure to work-related physical and psychosocial risk factors, pain intensity and pain duration, sick leave, and work performance. Also, the cost-effectiveness and cost-benefit of participatory ergonomics were investigated.

In this general discussion, the main findings obtained from this thesis are presented. Furthermore, we discuss our study findings, methodological issues, the overall evidence for the effectiveness of ergonomic interventions and participatory ergonomics, and possible explanations for our research findings. Finally, recommendations on future research as well as practical implications of the findings are provided.

Main findings of this thesis

1. Our systematic review showed that physical and organisational ergonomic measures were most often not more effective than the control group to prevent low back pain and neck pain and also not more effective to reduce the pain intensity of low back pain among non-sick listed workers. Some physical ergonomic interventions (i.e. a curved or flat seat pan chair or an arm board support) were effective to reduce the pain intensity of neck pain. (Based on chapter 2)
2. The participatory ergonomics intervention, as described in chapter 4, was delivered well. Moreover, participatory ergonomics showed to be an applicable method to develop and to prioritise ergonomic measures to prevent low back pain and neck pain. However, the intervention resulted in the implementation of only 34% of the prioritised ergonomic measures. (Based on chapter 4)
3. Factors that may have hampered the implementation of ergonomic measures were: lacking resources (personnel and financial), the working group composition, and insufficient stakeholder involvement. (Based on chapter 5)
4. After six months, participatory ergonomics was significantly more effective than the control group to improve workers' decision latitude (0.29 points; 95% CI 0.07 - 0.52) and decision authority (0.16 points; 95% CI 0.04 – 0.28). The observed effects were small and were considered as not relevant. No significant differences between the intervention and the control group were found for the remaining work-related psychosocial risk factors for low back pain and neck pain. (Based on chapter 6)
5. After six months, participatory ergonomics significantly increased the workers' exposure to working in an awkward working posture of the trunk (OR 1.86; 95% CI 1.15 - 3.01) compared to the workers in the control group. No significant differences between the intervention and the control group were found for the remaining work-related physical risk factors for low back pain and neck pain. (Based on chapter 6)
6. After 12 months, participatory ergonomics compared to the control group was not

more effective to reduce the prevalence of low back pain and neck pain. Participatory ergonomics was neither more effective to reduce pain intensity nor to reduce pain duration. Participatory ergonomics was neither more effective than the control group to prevent low back pain and neck pain nor to recover from neck pain. However, partici patory ergonomics proved to be more effective (OR 1.41; 95% CI 1.01 – 1.96) to recover from low back pain (transition from an episode of low back pain to no episode of low back pain) (Based on chapter 7)

7. Participatory ergonomics was neither more effective to reduce self-reported sick leave nor to improve self-reported work performance. (Based on chapter 8)
8. Participatory ergonomics was neither cost-effective nor cost-beneficial on any of the measures of effects. (Based on chapter 8)

Risk of bias of our cluster randomised controlled trial

To gain insight into the risk of bias of our cluster randomised controlled trial (RCT), we adopted the same quality assessment list that was used in our systematic review on the effectiveness of physical and organisational ergonomic measures (refer to chapter 2). The list and the operationalisation of the criteria have been described elsewhere.[1] A study was considered as 'low risk of bias' when at least 50% (six criteria) of the 12 criteria were met, otherwise the study was considered as 'high risk of bias'.[1]

Two reviewers (MTD and KIP) independently assessed the risk of bias of our cluster RCT.

Table 1 presents the risk of bias assessment score. The current cluster RCT would receive eight points, indicating a low risk of bias. Adding our low risk of bias cluster RCT to those RCTs included in the systematic review would increase the GRADE levels of evidence that physical and organisational ergonomic measures were neither more effective than a control group to prevent low back pain and neck pain nor to reduce pain intensity.

Table 1. Risk of bias assessment score of the cluster RCT by Driessen et al.

Criterion	A	B	C	D	E	F	G	H	I	J	K	L	
	Randomisation	Concealment	Patient blinded	Care provider blinded	Outcome blinded	Drop-out	Intention to treat	Selective report	Baseline	Co-interventions	Compliance	Timing	Total score
Score	1	1	0	0	0	0	1	1	1	1	1	1	**8**

0 = 'no'.
1 = 'yes'.

Methodological points to be considered

There are some distinctive strengths of our work. As a result of the high number of departments and workers that participated in the current cluster RCT, the statistical power of this study was quite sufficient. Instead of focussing on a homogeneous group of workers, this cluster RCT included both blue and white collar workers (i.e. industry workers, health care workers, and office workers). The pragmatic design of this cluster RCT made it possible to study the effects of participatory ergonomics under real life conditions.[2] The heterogeneous study population and the pragmatic study design increase the generalisablity of our study findings towards the entire working population. Furthermore, performing the randomisation at the department level minimised possible contamination between workers from the intervention and control group.[3] Finally, repeated measurements were used and study outcomes were assessed using standardised questionnaires.[4;5]

However, some methodological limitations need to be considered when interpreting the results of this thesis, including:

Blinding
Although we kept workers blind for the study design and the randomisation outcome, the participatory ergonomics intervention made it impossible to blind participants for the intervention (i.e. members of the working group and the workers at the participating departments). Moreover, ergonomists (the intervention providers) could not be blinded for the intervention, because they guided the working group meetings. Finally, as the study outcomes were obtained from the workers using questionnaires, the outcome assessors could neither be blinded to the intervention. As a consequence, the 'risk of bias assessment score' showed that three criteria referring to blinding were not met in the current cluster RCT. Not blinding participants or the intervention providers for the intervention could bias the results by affecting the actual outcomes of the participants in the trial. This type of bias is called information bias.[6] However, especially among studies conducted in the occupational setting, the practical and ethical aspects make it impossible to blind participants and intervention providers for the intervention.[7;8]

Loss to follow-up
The loss to follow-up on the primary outcome measure (the prevalence of low back pain and neck pain) was considerable.[6] After six months, 511 workers (35%) in the intervention group and 464 workers (29%) in the control group were lost to follow-up. After 12 months, the number of workers lost to follow-up was 594 workers (40%) in the intervention group and 580 workers (37%) in the control group. High loss to follow-up rates may introduce selection bias.[6] To investigate the presence of selection bias, we checked our data on selective drop-out. We found that non-responders did not differ significantly from responders on several important prognostic low back pain and neck pain factors (i.e. age, gender, work-related risk factor exposure, baseline prevalence of low back pain and neck pain, pain intensity, and pain duration). Therefore, we do not believe that the considerable loss to follow-up rate had a large influence on our findings.

Measurements

The use of direct (i.e. electromyography) and/or observational measurements (i.e. video recordings) may result in more precise measurements.[9;10] Due to practical reasons (costs and time), the exposure to work-related physical risk factors was assessed using self-reports (Dutch Musculoskeletal Questionnaire).[11] Exposure to work-related psychosocial risk factors was assessed using the well accepted Job Content Questionnaire.[12] Moreover, low back pain and neck pain prevalence, pain intensity, and pain duration were measured using internationally accepted questionnaires.[4;5]

The use of self-reports may lead to over- or under-estimations of the outcomes. However, since gold standards to measure these outcomes are lacking, the use of questionnaires seemed to be the best alternative.[4;9]

Follow-up duration

A follow-up duration of 12 months may have been too short to expect an effect on low back pain and neck pain prevention. To prevent low back pain and neck pain by ergonomic measures the workers have to be familiar with the measures and have to use them for a certain time.[13] The use of longer follow-up periods make it possible to measure intervention sustainability and enable identification of delayed intervention effects.

Regarding work-related risk factor exposure, the follow-up measurement after six months may have come too early for some working groups. At that time, some working groups were not finished yet with implementing all of the prioritised ergonomic measures. As a consequence, the prioritised ergonomic measures may not have had the chance to reduce workers' exposure to work-related risk factors. However, a quick inventory on our data showed no increased implementation rates after 12 months.

Risk factors exposure among the study population

At the very start of the study, the perceived exposure to most of the work-related physical and psychosocial risk factors among our study population was low. The relatively low exposure to risk factors among the study population made it difficult for participatory ergonomics to further reduce risk exposure (so-called floor effects). Additional analyses conducted among a subgroup of workers performing heavy physical work did not show any sign of better effectiveness.

Lack of contrast between the groups

During the 12 month follow-up period, it was found that a number of ergonomic co-interventions to prevent low back pain and neck pain were implemented at both intervention and control departments. These ergonomic co-interventions may have further reduced the contrast between the two trial arms. Hence, ergonomic co-interventions may have masked the effects of our participatory ergonomics programme on low back pain and neck pain prevention.

The participatory ergonomics programme

In the framework by Haines et al. (2003) several important items of a participatory ergonomic programme are described. According to this framework, one of the main principles of participatory ergonomics is that workers themselves determine what they want to change in the workplace. In contrast to this principle, the current study decided in advance of the intervention that workers had to focus on lwo back pain and neck pain. On the other hand, the high lifetime prevalence rates and 12-month prevalence rates of low back pain and neck pain in the working population may justify our decision. Especially, when the aim is prevention it is necessary to make choices where to intervene on and to predefine the outcome measures of interests. The use of most of the other participatory ergonomics principles as described in the framework (i.e. mix of participants and guidance by the ergonomist) were covered by our intervention.

Comparison with other studies on participatory ergonomics

Based on 12 studies that were published before July 2004, the systematic review by Rivilis et al. (2008) concluded that participatory ergonomics was an effective approach to prevent musculoskeletal disorders.[14] Next to three RCTs, the review also included nine studies that lacked a randomisation procedure or a control group (i.e. controlled trials and pre-post studies, respectively. Although these study designs can add to the knowledge on participatory ergonomics, these study designs are at risk for bias.[15] Therefore, the following section is focused on the findings obtained from RCTs only.

Next to the current cluster RCT, seven other RCTs on participatory ergonomics have been conducted.[16-22] Out of the seven studies, three RCTs were not aimed at low back pain and neck pain but were focused on: increasing the use of ergonomic measures[22], reducing work stress and improving work productivity[21], and reducing knee pain severity.[18] Hence, four RCTs[16;17;19;20] and our cluster RCT were aimed at the prevention of musculoskeletal disorders (including low back pain and neck pain) and/or on musculoskeletal disorder-related pain reduction (including low back pain and neck pain). In our discussion below we only consider the findings of RCTs on low back pain and neck pain.

Effectiveness on the reduction of low back pain and neck pain prevalence/incidence

In Norway, Morken et al. (2002) conducted a cluster RCT among workers in the aluminium industry. The authors found that after 12 months participatory ergonomics was not more effective than the control group to prevent low back pain and neck pain.[20]

In Finland, Haukka et al. (2008) conducted a cluster RCT among kitchen workers. Twelve months after finishing the intervention, no differences in low back pain and neck pain prevalence rates were found between the group that received participatory ergonomics compared to the control group (no participatory ergonomics).[17]

Our cluster RCT, as studied in this thesis, was conducted among industry, health care, and office workers. The intervention group received participatory ergonomics whereas the control group received no participatory ergonomics. After 12 months, our study showed that participatory ergonomics was not more effective to prevent both low back pain and neck pain. Participatory ergonomics was effective to recover from low back pain, but was not effective to recover from neck pain.

Effectiveness on low back pain and neck pain intensity reduction
In the USA, Bohr et al. (2002) the effects of participatory ergonomics were compared with the effects of a group that received traditional education on ergonomics. After 12 months of follow-up the authors found that participatory ergonomics was not more effective to reduce the intensity/discomfort of low back pain and neck pain in comparison with the traditional education group.[16]

In Finland, Ketola et al. (2002) conducted a RCT among Finnish video display unit workers. The intervention group received an intensive ergonomic intervention according to the principles of participatory ergonomics, while the control group only received a leaflet with information on musculoskeletal disorders prevention. Two months after the intervention, workers in the participatory ergonomics group perceived significantly less discomfort in the neck compared to the control group. However, observed differences were small. After 10 months of follow-up no differences on discomfort were found. Pain scores were only measured after 10 months, but did not differ between the two groups.[19]

Haukka et al. (2008) found that after 12 months participatory ergonomics was not more effective than the control group in reducing the pain intensity of low back pain and neck pain.[17] The findings obtained from our cluster RCT also showed that at the long term participatory ergonomics was not more effective than the control group to reduce the pain intensity of low back pain and neck pain.

Programme failure or theory failure?

Based on the results obtained from RCTs, it can be concluded that participatory ergonomics is not more effective than the control group to prevent low back pain and neck pain and not more effective to reduce pain intensity of these symptoms. An important question is 'how come that participatory ergonomics is not effective on these study outcomes?' Is the lack of an effect caused by a programme failure, which implicates that poorly implemented interventions result in no improvements on the study outcomes. Or is the lack of an effect the result of a theory failure, which implicates that an intervention has been perfectly implemented, but did not lead to improvements on the study outcomes.[23]

Programme failure

Several aspects may indicate the presence of a programme failure.

First, participatory ergonomics programmes may have failed because none or few of the prioritised ergonomic measures were implemented. In our study 34% of the prioritised ergonomic measures were implemented in the departments. The fact that only one third of the proposed ergonomic measures was implemented may be a possible explanation for the lack of an effect on low back pain and neck pain prevalence. Although this was less than intended, still in absolute sense quite a number of ergonomic measures were implemented. Regarding low back pain and neck pain prevention it can be suggested that every (extra) ergonomic measure implemented might be profitable. On the other hand, the study by Haukka et al. (2008) was more successful in implementing the prioritised ergonomic measures and obtained an implementation rate of 80% (n = 402 ergonomic measures).[24] Despite their high implementation rate, the authors also found no effect on the prevention of musculoskeletal disorders.[17]

Second, the efficacy (ability to change the outcome) of the ergonomic measures derived from participatory ergonomics may be limited. In our study ergonomic measures had to meet criteria such as: low initial costs, not complex, compatible with the current situation, visible, and implementable within three months.[25] Consequently, working groups perhaps prioritised the less expensive and more easy to implement individual ergonomic measures. In fact, the physical ergonomic measures were mainly the more 'simple' and less expensive workplace adjustments. Indeed, other studies on participatory ergonomics also implemented low intensity measures.[26-29] The efficacy of the ergonomic measures implemented in participatory ergonomics studies can be considered low. This may be an explanation why participatory ergonomics in the reviewed studies did not lead to workload reductions nor to the prevention of symptoms.[16;17;20;30]

To improve the success of a participatory ergonomics programme, the systematic review by van Eerd et al. (2010) pointed out that five key factors to implementation should be taken into account in advance of the programme.[28] The five key factors included:

1. Gain broad commitment for the participatory ergonomics programme (i.e. both management and worker level).
2. Provide sufficient resources for implementation (i.e. time, personnel, and money).
3. Create a sustainable working group with appropriate members (i.e. a participatory ergonomics champion, workers, managers, technicians, and entrepreneurs).
4. Provide ergonomic training (i.e. educate and train workers and supervisors on ergonomic skills).
5. Provide communication (i.e. inform all workers and stakeholders involved on the process outcomes).

Before the conduct of our study, all five key factors were covered by our participatory ergonomic programme. The findings obtained from our process evaluation showed that several factors negatively influenced implementation.

Theory failure

Next to a programme failure, a theory failure may have caused the lack of an effect.

The current study applied the assumption that the exposure to the prioritised risk factors was equal for all 150 workers of the department. In a similar way it was assumed that the prioritised ergonomic measures would be beneficial for all workers to reduce their exposure to work-related risk factors. However, in practice the participating departments had heterogeneous work tasks. For instance, in case a working group implemented new chairs, the ergonomic measure may have reduced the risk for a few workers, but probably not for all 150 workers.

A second point considers the multifactorial origin of low back pain and neck pain.[31] Our theoretical Stay@Work model, but also other models in ergonomics[32], considered the reduction of work-related physical and psychosocial risk factors as essential to prevent low back pain and neck pain. The literature shows only modest associations between work-related risk factors on the one hand and low back pain and neck pain occurrence on the other hand.[33;34] Particularly, these associations reported in the literature were found among workers performing heavy physical work.[35-37] Regarding our study and other participatory ergonomics studies, it is a theory failure to assume that ergonomic measures, which are most often aimed at one single work-related physical or psychosocial risk factor of modest intensity would be able to target the multifactorial and the largely unknown origin of low back pain and neck pain. This suggestion is supported by the results of two recent systematic reviews concluding that ergonomic measures, such as lifting devices, workplace adjustments, and computer rest breaks, are not able to prevent low back pain and neck pain.[38;39] Maybe interventions addressing other aspects than the risk factors at the workplace may prevent low back pain and neck pain. For example, according to the conceptual model of physical capacity and risk factor exposure, an imbalance between the two may lead to symptoms. Exercise can be used to increase a worker's physical capacity. A Danish RCT conducted among office workers, found that both a specific resistance training (SRT) and all-round physical exercises (APE) were more effective than no physical exercise intervention to reduce neck pain intensity and duration. SRT of the neck and shoulder muscles was more effective than no physical exercise intervention to prevent neck pain among workers without symptoms at baseline.[40;41] Moreover, among those workers with neck pain at baseline, SRT and all-round physical exercises were more effective to reduce the pain intensity of neck pain in comparison with no physical exercise.[40;41] Regarding low back pain, it was found that physical exercise was effective to prevent low back pain[42] as well as to reduce the pain intensity of low back pain among workers.[43] Despite these promising results, it should be emphasised that exercise programmes are only focussed on increasing capacity. Multidimensional intervention programmes, which are aimed at both increasing workers' capacity and work-related risk factor reduction, may be more effective to prevent low back pain and neck pain. In a multidimensional intervention programme, participatory ergonomics can for example be offered to the workers in combination with other interventions, such as life-style programmes, cognitive behavioural training, and physical exercise programmes. The effectiveness of such multidimensional intervention programme on musculoskeletal disorders prevention among construction workers, cleaners, nurses, and industrial workers is currently under study in the FINALE programme.[44]

A final point implying a theory failure is that our Stay@Work model considered the prevention of symptoms as an only option. However, our results showed that participatory ergonomics was significantly more effective to recover from low back pain (from an episode of low back pain to no episode of low back pain). Our findings on low back pain recovery show parallels with studies that investigated the effectiveness of participatory ergonomics as a return to work intervention for workers who were sick-listed due to low back pain. The return to work studies showed that in comparison with usual care, participatory ergonomics generally did not result in pain intensity reduction, but did result in a statistically significantly earlier return to work.[45-47] A qualitative paper showed that participatory ergonomics shifted the low back pain patients' goal from eliminating pain towards restoring return to work. Important aspects were that patients perceived improved abilities to cope with their low back pain but also perceived an increased supervisor support.[48] It should be emphasised that return to work and symptom recovery are quite different concepts. However, it might be that aspects such as improved coping or support may positively influence symptom recovery. To explain this mechanism we use the principles of the Vlaeyen model.[49] In this model, two options are provided in which the episodic nature of low back pain is better represented.[50] The first option illustrates a vicious circle in which a patient's beliefs and behaviours may result in low back pain maintenance. The second option shows an open end in which the patient's adequate beliefs and behaviours result in the recovery of low back pain. Many workers believe that their low back pain is caused for example by manually lifting of heavy loads during work time.[37] Since the workers perceive their low back pain as work-related, the workers experience that they have little control to solve the causes of their problem. In our opinion, participatory ergonomics may have positively influenced the believes of workers with low back pain, because participatory ergonomics enabled them to solve the work-related risk factors and empowered them to control the workplace design and their job tasks. Consequently, participatory ergonomics may have improved the workers' level of personal control to influence the problem. Hence, by changing the beliefs, participatory ergonomics may help workers with low back pain to cope with their work and thereby workers may recover from their low back pain. However, we found that participatory ergonomics was not more effective to recover from neck pain (from an episode of neck pain to no of neck pain). This may indicate that other mechanisms are responsible for the recovery of neck pain.

Follow-up on the case description

In the general introduction (chapter 1) of this thesis a case description was presented in which a company manager phoned an ergonomist to inquire about the possibilities to implement participatory ergonomics as a strategy to prevent low back pain among workers. However, the effects of Participatory ergonomics on the prevention of low back pain and neck pain were not established yet. Based on the research findings derived from this thesis we would provide them with the following advices:

To the company manager and his workers

There is sufficient evidence to support the use of participatory ergonomics as a return to work intervention for workers who are sick-listed due to their low back pain.[51] There is preliminary evidence that participatory ergonomics is effective to recover from low back pain (from an episode of low back pain to no episode of low back pain). However, future studies on participatory ergonomics should confirm the findings on recovery.

Our findings showed that participatory ergonomics was not cost-effective and was not cost-beneficial. Based on the evidence obtained from scientific research, implementing participatory ergonomics to primary prevent musculoskeletal disorders (including low back pain and neck pain) can not be recommended. Instead of focussing on single risk factors, strategies that consider the multifactorial origin of musculoskeletal disorders, such as a multidimensional intervention programme including strengthening physical capacity, may be more effective for the purpose of primary prevention. Moreover, by tailoring a multidimensional intervention programme to the needs of the company, department or the individual worker, the programme's effectiveness may be increased. For this purpose the company manager may use the information obtained from available instruments such as the risk inventory evaluations (containing information about the physical and psychosocial workload at the level of the department), and the periodical health screenings (containing information about worker's personal health status and exposure to risk factors at work). In doing so, the company manager gains insight into who are at risk or not at risk to develop low back pain and neck pain, which may enhance the decision for which department(s) a multidimensional intervention programme is most urgent. A study on the effectiveness of multidimensional intervention programmes to prevent musculoskeletal disorders is currently under conduct.[44]

To the ergonomist

Based on our cluster RCT findings, and from findings obtained from earlier RCTs, it was found that neither participatory ergonomics nor ergonomic measures were effective to prevent low back pain and neck pain. Also, participatory ergonomics was not effective to reduce the pain intensity or the pain duration of low back pain and neck pain. There is preliminary evidence that participatory ergonomics is effective to recover from low back pain (from an episode of low back pain to no episode of low back pain). Findings from systematic reviews showed that ergonomic interventions are not effective to prevent participatory ergonomics and not effective to reduce the pain intensity of low back pain. However, some physical ergonomic measures (i.e. a new chair seat or an arm board support) are effective to reduce the pain intensity of neck pain among office workers.

The lack of an effect to prevent symptoms does of course not imply that companies can not profit from ergonomics. As indicated earlier, we support the use of participatory ergonomics when the aim is to facilitate the return to work of sick-listed workers with low back pain.[51] In addition, ergonomics can still be used to optimise work processes, and may thereby improve aspects such as workers' productivity, product quality, and employee morale.[52] Moreover, implementing ergonomics may improve other important aspects such as work ability, work satisfaction, and comfort.[53;54] The changing demographics in the workforce may provide ergonomists with new opportunities. For example, the ageing workforce may urge companies to invest in ergonomic interventions to improve workers' sustainability, workplace safety, and workers' commitment.[55;56] On the other hand, the ageing workforce may also have large consequences for the group of young workers who might have to perform the work with less people. For this group, ergonomic interventions may be developed to enable this group of young workers to perform their work for a longer period.[57] However, the current evidence on the aforementioned items is premature, in the future, high quality studies should be conducted in order to deliver confirmative evidence on the effectiveness of ergonomics on these items.

This thesis adds to the current body of knowledge on how to prevent low back pain and neck pain among workers. Based on the findings of this thesis the following recommendations for future research and practical implications.

Implications for future research

1. The conduct of more RCTs on the effectiveness of participatory ergonomics to prevent low back pain and neck pain is discouraged. RCTs on the effectiveness of participatory ergonomics to recover from low back pain (from low back pain episode to no episode of low back pain) are needed to draw more definite conclusions on this preliminary finding.
2. The conclusion of our systematic review was that physical and organisational ergonomic interventions do not effectively prevent low back pain and neck pain. Most of the included studies were conducted among office workers. Therefore, future RCTs evaluating the effectiveness of ergonomic measures to prevent low back pain and neck pain should be aimed at workers with high physical loads (i.e. industrial workers, con struction workers, and shipyard workers).
3. Future RCTs have to investigate the effectiveness of multidimensional intervention programmes that combine physical exercises, participatory ergonomics, and cognitive

behavioural training may add to the current state of the art of the primary and the secondary prevention of low back pain and neck pain.

4. Longitudinal prospective cohort studies are needed to identify the prognostic factors responsible for the recovery of low back pain and neck pain among workers. The information can be used to optimise current ergonomic interventions aimed at recovery as well as to develop new ergonomic interventions.
5. Studies on ergonomic interventions and/or multidimensional intervention programmes should improve the reporting on the process, the implementation, and compliance.
6. Studies on the cost-effectiveness and cost-benefit are generally needed in order to gain insight into the costs and (financial) consequences of ergonomic interventions.

Practical implications

1. Based on the current evidence it can not be recommended to implement participatory ergonomics as a strategy to prevent low back pain and neck pain neither to reduce pain intensity and pain duration, nor to reduce the exposure to physical and psycho social work-related risk factors. Participatory ergonomics may be implemented in order to recover from low back pain (from an episode of low back pain to no episode of low back pain).
2. Based on the current evidence it can not be recommended to implement physical and organisational ergonomic interventions to prevent low back pain and neck pain among office workers. Physical ergonomic interventions (i.e. a curved or flat seat pan chair or an arm board support) may be implemented for the reduction of pain intensity among office workers with neck pain.
3. Participatory ergonomics proved to be an applicable and practical method to identify and prioritise risk factors as well as to list and prioritise ergonomic measures. Moreover, working groups were satisfied with the use of participatory ergonomics. Although this does not prevent low back pain and neck pain, the participatory ergonomics principles may be used as a supportive tool for the yearly risk inventory and evaluations.
4. Companies or departments that consider the use of participatory ergonomics should ensure the presence of several key factors, such as: having sufficient personnel and financial resources and broad commitment for participatory ergonomics at all management levels as well as at the worker level. Moreover, adequate stakeholders (including a facilitator, technician, occupational health workers, and entrepreneurs) should be involved in the working groups and these working groups have to sustain during the implementation period. These key factors should not only be ensured in advance of conducting the programme, but also during the conduct of the participatory ergonomics programme.

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Summary
Samenvatting

Preventie van lage rugpijn en nekpijn bij werknemers

Lage rug- en nekpijn komen vaak voor binnen de Nederlandse beroepsbevolking. In enkele gevallen leiden de klachten tot verzuim en arbeidsongeschiktheid, hetgeen enorme financiële gevolgen heeft voor de Nederlandse samenleving maar ook voor werkgevers. Het voorkomen van deze klachten bij werknemers is daarom van groot belang. Een mogelijke methodiek om lage rug- en nekpijn bij werknemers te voorkomen is participatieve ergonomie. Echter, de werkzaamheid (effectiviteit) van deze methodiek is tot op heden nog niet goed onderzocht. Om deze reden onderzocht het project 'Stay@Work' de effectiviteit van participatieve ergonomie op het voorkomen van lage rug- en nekpijn bij werknemers middels een cluster gerandomiseerde gecontroleerde studie. Naast de effectiviteit werden ook de kosteneffectiviteit en de kostenbaten van de methodiek onderzocht. Gezien de grote vraag vanuit de dagelijkse praktijk naar bewezen (kosten-)effectieve interventies, werden in hoofdstuk 1 van dit proefschrift vragen gesteld door diverse personen die baat kunnen hebben bij effectieve interventies. De antwoorden op deze vragen vatten de belangrijkste bevindingen van dit proefschrift samen.

De volgende vragen werden gesteld door:

De ergonomen en de werknemers: Wat is de effectiviteit van de huidige maatregelen om lage rug- en nekpijn te op de werkvloer te voorkomen?

In hoofdstuk 2 worden de resultaten beschreven van een systematisch literatuuronderzoek naar de effectiviteit van fysieke (zoals: nieuwe kantoormeubilair of aangepast gereedschap) en organisatorische ergonomische maatregelen (zoals: taakroulatie, inbouwen van pauzes en herverdelen van taken) ter preventie van lage rug- en nekpijn bij niet-verzuimende werknemers. In totaal voldeden tien gerandomiseerde gecontroleerde studies aan de insluitcriteria van het literatuuronderzoek.

Fysieke en organisatorische ergonomische interventies zijn op de korte en op de lange termijn niet effectiever om lage rug- en nekpijn te voorkomen dan een controlegroep (geen ergonomische interventies of alleen informatie over ergonomie). Ergonomische interventies bleken ook niet effectiever dan een controlegroep om op korte en lange termijn de pijnintensiteit van lage rugpijn te verminderen. De kwaliteit van het gevonden bewijs werd bepaald middels de GRADE methodiek en was laag tot middelmatig. Ondanks de lage kwaliteit van het gevonden bewijs, bleek een fysieke ergonomische interventie (aangepaste stoelzitting) significant effectiever om de pijnintensiteit van nekpijn op korte termijn te reduceren en bleek een andere fysieke ergonomische interventie (armondersteuning) op de lange termijn significant de pijnintensiteit van nekpijn te verminderen.

De onderzoekers: Wat zijn belangrijke aspecten in het ontwerp van participatieve ergonomie gericht op het voorkomen van lage rug- en nekpijn bij werknemers?

In hoofdstuk 3 van dit proefschrift wordt de opzet van onze cluster gerandomiseerde gecontroleerde studie beschreven. Diverse afdelingen van vier grote bedrijven namen deel aan dit onderzoek. Door middel van een loting werden afdelingen in de interventiegroep (participatieve ergonomie) of in de controlegroep (geen participatieve ergonomie) geloot. Afdelingen die werden toegewezen aan de interventiegroep vormden een werkgroep van tien personen bestaande uit werknemers en een afdelingsmanager. Onder leiding van een ergonoom volgde de werkgroep tijdens een zes uur durende bijeenkomst de stappen van de participatieve ergonomie. De werkgroep bedacht, beoordeelde en koos (op de afdeling aanwezige) knelpunten die tot lage rug- en nekpijn kunnen leiden. Achtereenvolgens bedacht, beoordeelde en koos de werkgroep adequate ergonomische maatregelen om de knelpunten aan te pakken. De oplossingen en de aan te pakken knelpunten werden beschreven in een implementatieplan. Daarna werd aan de werkgroep gevraagd om binnen drie maanden de gekozen maatregelen op hun eigen afdeling in te voeren. Voor een optimale implementatie, werd een implementatietraining aangeboden waarin twee tot drie leden van iedere werkgroep vrijwillig werden opgeleid tot Stay@Work ergocoach.

Aan het begin van het onderzoek (baseline) na drie, zes, negen en na twaalf maanden werden middels vragenlijsten gegevens over de primaire uitkomstmaten verzameld, zoals: de aanwezigheid van lage rug- en nekpijn in de afgelopen drie maanden en pijnintensiteit en pijnduur van rug- en nekpijn in de afgelopen drie maanden. Tevens werden elke drie maanden de zorgkosten, het ziekteverzuim en de werkprestatie in de afgelopen drie maanden gemeten. Secundaire uitkomstmaten zoals de blootstelling aan werkgerelateerde fysieke en psychosociale risicofactoren werden op baseline, na zes en na twaalf maanden gemeten.

De werkgevers: Wat vinden mijn werknemers van participatieve ergonomie?
De ergonomen: Wat is de toepasbaarheid van participatieve ergonomie en worden er daadwerkelijk ergonomische maatregelen ingevoerd op de afdelingen?

Hoofdstuk 4 beschrijft de resultaten van een procesevaluatie welke uitgevoerd is op de interventieafdeling. In de procesevaluatie wordt de kwaliteit van de participatieve ergonomie methode bestudeerd en wordt de ervaren implementatie van de geprioriteerde ergonomische maatregelen bepaald. Hoofdstuk 5 gaat een stap verder en probeert te achterhalen waarom bepaalde maatregelen juist wel of juist niet werden ingevoerd.

In totaal werden 19 afdelingen in de interventiegroep toegewezen en werden er 16 werkgroepen samengesteld. Van de 113 uitgenodigde werkgroepleden woonden 98 werkgroepleden (87%) de bijeenkomst bij. De werkgroepleden waren tevreden over de kwaliteit van de bijeenkomst en beoordeelden de stappen van de participatieve ergonomie op een

10-puntsschaal tussen gemiddeld een 7.3 en 7.6. Echter, de werknemers op de interventie-afdelingen bleken minder tevreden met participatieve ergonomie (gemiddeld een 5.6 op een 10-puntsschaal). De 40 werkgroepleden die werden opgeleid tot Stay@work ergo-coach waren tevreden over de kwaliteit van de implementatietraining (gemiddeld een 7.7 op een10-puntsschaal). In totaal kozen de werkgroepen 66 ergonomische maatregelen om op de afdelingen in te voeren. Volgens de werkgroepleden is 34% van de maatregelen ingevoerd, terwijl werknemers 26% van de maatregelen als ingevoerd beschouwden.

Bepaalde factoren bleken van invloed op de implementatie, zoals het ontbreken van een echte beslisser in de werkgroep of het ontbreken van een persoon die het initiatief nam tijdens het invoeren van de maatregelen. Andere belemmerende factoren waren: tijdgebrek om maatregelen in te voeren, een gebrek aan continuïteit van de werkgroep, financiële en personele tekorten. Maatregelen die vóór de werkgroepbijeenkomst al door het management waren goedgekeurd, hadden een grotere kans om ingevoerd te worden.

De ergonomen en de werknemers: Is participatieve ergonomie effectiever dan de controlegroep (geen participatieve ergonomie) om de blootstelling van werknemers aan werkgerelateerde risicofactoren voor lage rug- en nekpijn te verminderen?

De blootstelling aan werkgerelateerde fysieke en psychosociale risicofactoren voor lage rug- en nekpijn werden door middel van vragenlijsten op baseline en na zes maanden gemeten. Hoofdstuk 6 laat zien dat na zes maanden de werknemers in de interventiegroep statistisch significant vaker blootgesteld werden aan ‘werken in een voorovergebogen houding’ (OR 1.86; 95% BI 1.15 - 3.01). Er werden geen significante verschillen gevonden tussen interventie en controlegroep op de blootstelling aan de overige werkgerelateerde fysieke risicofactoren. Voor wat betreft de blootstelling aan werkgerelateerde psychosociale risicofactoren leidde participatieve ergonomie tot een significante verbetering van ‘controle op beslissingen’ (0.29 punten; 95% BI 0.07 - 0.52) en ‘beslissingsbevoegdheid’ (0.16 punten; 95% BI 0.04 – 0.28). Desalniettemin, waren deze verschillen zeer klein en kunnen als niet relevant worden beschouwd.

De onderzoekers: Is participatieve ergonomie effectiever dan de controle-groep (geen participatieve ergonomie) om de lage rug- en nekpijn te voorkomen?

Ondanks dat participatieve ergonomie niet effectief was om de fysieke en psychosociale werkdruk te verminderen, kan de methodiek nog wel effectief zijn om lage rug- en nekpijn te voorkomen. In hoofdstuk 7 wordt onderzocht of participatieve ergonomie effectiever is dan geen participatieve ergonomie (controlegroep) om deze klachten bij werknemers te voorkomen. Door middel van vragenlijsten zijn aan het begin van het onderzoek (baseline), na drie, zes, negen en twaalf maanden de aanwezigheid van lage rug- en nekpijn in de afgelopen drie maanden gemeten. De resultaten na twaalf maanden laten zien dat de

methodiek niet effectiever was geen participatieve ergonomie (controlegroep) om klachten te voorkomen, maar ook niet om de pijnintensiteit noch om de pijnduur te verminderen.

Lage rug- en nekpijn kennen een terugkerend (episodisch) beloop. Dit houdt in dat een werknemer op een moment klachten (een episode) kan hebben, maar op een volgend moment klachtenvrij kan zijn (geen episode). Participatieve ergonomie is effectief gebleken op het herstellen van lage rugpijn (OR 1.41; 95% BI 1.01 – 1.96). In deze context wordt herstel gedefinieerd als de verandering van het hebben van een episode van lage rugpijn (klachten) naar het hebben van geen episode van lage rugpijn (klachtenvrij). Voor het herstel van nekklachten was de methodiek niet effectiever dan de controlegroep.

De werkgevers: Wat zijn de effecten van participatieve ergonomie op ziekteverzuim en werkprestatie? Wat is de kosteneffectiviteit en de verhouding tussen de kosten en de baten van participatieve ergonomie?

Naast de effectiviteit van de interventie spelen ook de kosten van de interventie een rol als het gaat om het wel of niet invoeren in de praktijk. In hoofdstuk 8 wordt om deze reden de economische evaluatie van participatieve ergonomie beschreven. Uit de resultaten bleek dat participatieve ergonomie niet effectiever was in het verminderen van het ziekteverzuim en ook niet in het verbeteren van de werkprestatie van werknemers. Vervolgens werd bestudeerd of de interventie leidde tot een vermindering in de gemaakte zorgkosten en of de kosten als gevolg van productiviteitsverlies (ziekteverzuim) daalden. De gemiddelde kosten van de interventie bedroegen €29 per werknemer. Hoewel niet statistisch significant, waren de totale maatschappelijke kosten in de interventiegroep gemiddeld €127 (95% BI €-164 – €418) hoger in vergelijking met die van de controlegroep.

Vanuit het oogpunt van werkgevers bleek de interventie niet aantrekkelijk. Dit komt doordat het geld dat werkgevers in de interventie hebben geïnvesteerd uiteindelijk niet tot een kostenbesparing heeft geleid. Op basis van deze resultaten is er geen reden om participatieve ergonomie in te voeren in de dagelijkse praktijk ter voorkoming van lage rug- en nekpijn bij werknemers.

Algehele beschouwing

In hoofdstuk 9 worden de belangrijkste bevindingen van dit proefschrift samengevat. Vervolgens worden de bevindingen vergeleken met de bevindingen die door andere studies zijn gevonden Verder worden ook de sterke en minder sterke punten ten aanzien van de opzet en uitvoer van deze studie bediscussieerd. Ook worden er mogelijke verklaringen gegeven waarom ergonomische interventies en participatieve ergonomie niet effectief zijn ter voorkoming van klachten aan het bewegingsapparaat. Tot slot worden op basis van de resultaten aanbevelingen geformuleerd voor toekomstig onderzoek en toepassing in de praktijk.

Summary
Samenvatting

Participatory ergonomics to prevent low back pain and neck pain at the workplace

Low back pain and neck pain are prevalent among the Dutch working population. These symptoms may lead to unfavourable consequences (i.e. pain and disability) to the individual worker, but are also a financial burden for both society and companies. To prevent low back pain and neck pain various interventions have been conducted at the workplace, however, with mixed results. A potentially effective intervention is participatory ergonomics, an implementation strategy involving both workers and management in order to change the worksite. The Stay@Work study investigated the effectiveness of participatory ergonomics on the prevention on low back pain and neck pain. Moreover, Stay@Work evaluated the cost-effectiveness and the cost-benefits of participatory ergonomics aimed at the prevention of these symptoms. In chapter 1, several questions on participatory ergonomics were addressed by different stakeholders. Answers to these questions are presented in the following section.

Questions asked:

By the ergonomists and the workers: What is the effectiveness of the interventions we often use to prevent low back pain and neck pain?

Chapter 2 presents the results of a systematic review on the effectiveness of physical and organisational ergonomic intervention to prevent low back pain and neck pain among non-sick listed workers. A total of 10 randomised controlled trials (RCTs) met the criteria to be included in this systematic review. The risk of bias assessment resulted in seven low risk of bias RCTs and three high risk of bias RCTs. The quality of evidence was rated using the GRADE system.

The results showed low to moderate quality evidence that physical and organisational ergonomic interventions were not more effective than no ergonomic intervention on short and long term low back pain and neck pain incidence/prevalence and on short and long term low back pain intensity. There was low quality evidence that at the short term a physical ergonomic intervention (i.e. curved and flat seat pan chair) was significantly more effective on the reduction of neck pain intensity than no ergonomic intervention. There was low quality evidence that at the long term a physical ergonomic intervention (i.e. arm board support) was significantly more effective on the reduction of neck pain intensity than no ergonomic intervention.

By the researchers: What are important aspects in the design of a participatory ergonomics programme which is aimed at preventing low back pain and neck pain among workers?

Chapter 3 presents the design of a cluster randomised controlled trial to investigate the (cost-)effectiveness of participatory ergonomics compared to the control group (no participatory ergonomics) to prevent low back pain and neck pain among workers. The departments of four companies (a university including its university medical center, a railway transportation company, an airline company, and a steel company) participated in this study. The randomisation procedure was performed at the level of the department. At the intervention departments a working group of maximum of 10 persons was formed consisting of both workers and management. Guided by an ergonomist, the working group performed the steps of participatory ergonomics during a six-hour working group meeting. In the meeting, the working group brainstormed about, evaluated and prioritised risk factors for low back pain and neck pain at the department. In order to reduce the risk factors, the working group brainstormed about, evaluated, and prioritised ergonomics measures. Information about the prioritised risk factors and prioritised ergonomic measures were documented in an implementation plan. The working group was requested to implement the ergonomic measures at their department within three months. To improve implementation, two to three members of each working group were asked to voluntary participate in a special four-hour implementation training to become a Stay@Work ergocoach.

The main outcome measure of the Stay@Work study was the prevalence of low back pain in the past three months and the prevalence of neck pain in the past three months. Secondary outcome measures included: the exposure to work-related physical and psychosocial risk factors, pain intensity and pain duration, sick leave, and work performance. Also, the cost-effectiveness and cost-benefit of participatory ergonomics was investigated. Risk factors exposure was assessed using questionnaires at baseline and after six and 12 months. Data on low back pain and neck pain prevalence, as well as on pain intensity and pain duration, sick leave, work performance, and health care costs were collected at baseline, and after three-, six-, nine-, and 12-months follow-up.

By the employers: Are my workers satisfied with participatory ergonomics?
By the ergonomist: What is the applicability of participatory ergonomics and does participatory ergonomics lead to the implementation of ergonomic measures?

Chapters 4 and 5 present the results on the deliverance of the participatory ergonomics programme. A total of 19 departments were allocated, and 16 working groups were formed. In total, 113 working group (87%) members attended the meeting. The working group members rated the quality of the steps of the participatory ergonomics programme on a 10-pointscale on average between 7.3 and 7.6. Workers at the intervention departments were, however, less satisfied with the use of participatory ergonomics to develop and prioritise ergonomic measures (on average 5.6 on an 10-pointscale).
The additional Stay@Work ergocoach implementation training was attended by 40 working group members and the members reported to be satisfied with the quality of the implementation training (on average a 7.7 on a 10-pointscale).

Regarding the implementation of the prioritised ergonomic measures, it was found that after six months working groups implemented a total of 34% ergonomic measures at the intervention departments. According to the workers at the intervention departments, a total of 26% of the prioritised ergonomic measures were implemented. It was found that several factors played a role during implementation. Financial and personnel shortcomings as well as lacking stakeholder involvement (i.e. technicians, occupational health workers, and entrepreneurs) hampered the implementation. Also, the composition of the working group was important. Some working groups lacked the presence of a department manager who was entitled to make decisions, lacked a facilitating working group member for implementation, did not receive time to implement measures or the working group fell a part during the implementation period. Ergonomic measures that were already approved by the management before the working group meeting appeared to facilitate their implementation.

By the ergonomists and the workers: Is participatory ergonomics more effective than the control group (no participatory ergonomics) to reduce the exposure to work-related risk factors for low back pain and neck pain?

This question is answered in chapter 6. Data on both the work-related physical and psychosocial risk factors for low back pain and neck pain were collected at baseline and after six-month follow-up. After six months, the exposure to the work-related physical risk factors 'working in an awkward position' statistically significantly increased in the intervention group (OR 1.86; 95% CI 1.15 - 3.01) compared to the control group. Regarding the perceived exposure to work-related psychosocial risk factors, the workers in the intervention group slightly (but statistically significantly) improved on 'decision latitude' (0.29 points; 95% CI 0.07 - 0.52) and 'decision authority' (0.16 points; 95% CI 0.04 – 0.28). in comparison with the control group. No further significant differences between both groups were found for the remaining work-related psychosocial risk factors.

It was concluded that, after six months Participatory ergonomics was in general not effective to reduce workers' exposure to work-related physical and psychosocial risk factors among a large and heterogeneous group of workers.

By the researchers and by the ergonomist: Is participatory ergonomics more effective than the control group (no participatory ergonomics) to prevent low back pain and neck pain?

Although participatory ergonomics overall did not reduce the workers' exposure to work-related physical and psychosocial risk factors, the intervention may still be effective on low back pain and neck pain. Therefore, chapter 7 reports on the effectiveness of the participatory ergonomics on the prevention of low back pain and neck pain. The primary outcome measure was low back pain prevalence in the past three months and neck pain prevalence in the past three months. Additionally, the course of low back pain and neck pain (transitions from

no episode to episode and from episode to no episode) was modelled. Secondary outcomes were the level of pain intensity and pain duration in the past three months. Data were collected by questionnaires at baseline, and after three-, six-, nine-, and 12-months follow-up. After 12 months, participatory ergonomics was not more effective to reduce low back pain and neck pain prevalence, and was also not more effective to reduce pain intensity and pain duration. Participatory ergonomics was not effective to prevent low back pain and neck pain. Further, participatory ergonomics was not more effective in the recovery from neck pain. However, the intervention was statistically significantly more effective (OR 1.41; 95% CI 1.01 – 1.96) to recover from low back pain (from an episode of low back pain to no episode of low back pain).

Based on these findings it can be concluded that the current participatory ergonomics programme should not be used to prevent low back pain, but could be used as a method to recover from low back pain. However, more evidence on the findings on recovery obtained from high quality studies is needed.

By the employers and by the ergonomist: Does participatory ergonomics reduce sick leave and improve work performance? Is participatory ergonomics cost-effective and /or cost-beneficial?

In chapter 8 the results of the economic evaluation of the Stay@Work study are presented. Effect measures that were considered in the economic evaluation were low back pain prevalence in the past three months and neck pain prevalence in the past three months, self-reported sick leave, and self-reported work performance. In the economic evaluation, only costs that were directly related to low back pain and neck pain were taken into account. All data were collected by questionnaires at baseline, and after three-, six-, nine-, and 12-months follow-up.

Participatory ergonomics was not more effective than the control group to reduce self-reported sick leave or to improve self-reported work performance. The costs of participatory ergonomics were estimated to be €29 per intervention group worker. After 12 months, health care costs and costs of productivity losses were higher in the intervention group than in the control group (mean total cost difference €127; 95% CI €-164 – €418). These results indicate that from a societal perspective, participatory ergonomics was not cost-effective in comparison with the control group on low back pain and neck pain prevalence, self-reported sick leave, and self-reported work performance. The cost-benefit analysis from a company/employer perspective showed a negative monetary benefit of €78.

In conclusion, participatory ergonomics was neither cost-effective nor cost-beneficial on any of the effect measures in comparison with the control group. Based on these results, the implementation of this participatory ergonomics programme to prevent low back pain and neck pain is not supported.

General discussion

In chapter 9 of the thesis, we summarised the main findings obtained from this thesis. Furthermore, we discussed methodological considerations of our study and we compared our research findings with other studies on the effectiveness of participatory ergonomics and ergonomic interventions. Moreover, in our general discussion we expanded on the possibility that results obtained from participatory ergonomics intervention studies are due to a programme and theory failure. Finally, recommendations for research and practice were made. Main conclusions that can be derived from this thesis are:

1. Compared to the control group, participatory ergonomics is not more effective to reduce worker's exposure to work-related physical and psychosocial risk factors for low back pain and neck pain.
2 Compared to the control group, participatory ergonomics is not more effective: a) to prevent low back pain and neck pain among workers, b) to reduce the pain intensity and pain duration of low back pain and neck pain, and c) to recover from neck pain. It was found that participatory ergonomics is more effective to recover from low back pain (from an episode of low back pain to no episode of low back pain). However, more evidence to this findings is needed.
3. Participatory ergonomics is neither cost-effective nor cost-beneficial compared to the control group.

Implementation of participatory ergonomics to prevent low back pain and neck pain among workers is not recommended. More evidence obtained from high quality studies is needed to confirm the effectiveness of participatory ergonomics on low back pain recovery.