Participatory ergonomics to prevent low back pain and neck pain at the workplace
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2011

document version
Publisher's PDF, also known as Version of record

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Download date: 11. May. 2022
The effectiveness of participatory ergonomics to prevent low back pain and neck pain: results of a cluster randomised controlled trial

Accepted as:
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 ergonomics steps, 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 ergonomics 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, this resulted in a significantly earlier return to work among sick-listed workers with LBP compared to the control group that received usual care.\(^12,13\)

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). 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.

Potential Confounders
At baseline, socio-demographic information was collected, including: age, gender, and level of education. 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. 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.

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.
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. 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.

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, 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. 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. 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 glamm 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.
**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.

<table>
<thead>
<tr>
<th>Department characteristics</th>
<th>Intervention group (n=19 departments)</th>
<th>Control group (n=18 departments)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workload departments [no.]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Light physical</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mix mental/physical</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Heavy physical</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Worker characteristics</th>
<th>Intervention group (n=1472)</th>
<th>Control group (n=1575)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years) [mean (SD)]</td>
<td>41.9 (11.1)</td>
<td>42.1 (10.7)</td>
</tr>
<tr>
<td>Men [no. (%)]</td>
<td>861 (59.0)</td>
<td>891 (57.0)*</td>
</tr>
<tr>
<td>Education [no. (%)]*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower education</td>
<td>202 (13.8)</td>
<td>126 (8.0)</td>
</tr>
<tr>
<td>Intermediate education</td>
<td>572 (39.1)</td>
<td>579 (36.8)</td>
</tr>
<tr>
<td>Higher education</td>
<td>690 (47.1)</td>
<td>868 (55.2)</td>
</tr>
<tr>
<td>Work related psychosocial factors [mean (SD)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision latitude (range 8-32 points)</td>
<td>24.8 (3.6)</td>
<td>25.3 (3.1)*</td>
</tr>
<tr>
<td>Skill discretion (range 5-20 points)</td>
<td>15.9 (2.3)</td>
<td>16.2 (2.0)*</td>
</tr>
<tr>
<td>Decision authority (range 3-12 points)</td>
<td>9.0 (1.7)</td>
<td>9.1 (1.5)*</td>
</tr>
<tr>
<td>Social support (range 8-32 points)</td>
<td>23.3 (3.0)</td>
<td>23.3 (2.8)</td>
</tr>
<tr>
<td>Co-worker support (range 4-16 points)</td>
<td>12.1 (1.5)</td>
<td>12.2 (1.4)*</td>
</tr>
<tr>
<td>Supervisor support (range 4-16 points)</td>
<td>11.2 (2.1)</td>
<td>11.1 (2.1)</td>
</tr>
<tr>
<td>Psychosocial job demands (range 5-20 points)</td>
<td>12.8 (2.3)</td>
<td>12.8 (2.2)*</td>
</tr>
<tr>
<td>Work related physical factors [no.(%)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Often manually lift loads &gt;20kg</td>
<td>211 (14.3)</td>
<td>277 (17.6)*</td>
</tr>
<tr>
<td>Often manually carry load &gt;20kg</td>
<td>105 (7.1)</td>
<td>149 (9.5)*</td>
</tr>
<tr>
<td>Often drive machines (lorry, crane, bulldozer)</td>
<td>248 (16.8)</td>
<td>124 (7.9)*</td>
</tr>
<tr>
<td>Work in heavily awkward position for a prolonged time</td>
<td>307 (20.9)</td>
<td>293 (18.6)</td>
</tr>
<tr>
<td>Often bent neck forwards or hold neck in a forward bent posture</td>
<td>508 (34.5)</td>
<td>531 (33.7)</td>
</tr>
<tr>
<td>Low back pain, whole population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Having had low back pain in the past 3 months [no.(%)]</td>
<td>404 (27.4)</td>
<td>415 (26.3)</td>
</tr>
<tr>
<td>Mean pain intensity in the past 3 months [mean (SD)]</td>
<td>2.2 (2.4)</td>
<td>2.1 (2.3)</td>
</tr>
<tr>
<td>Duration in the past 3 months [mean (SD)]</td>
<td>12.0 (21.7)</td>
<td>11.5 (21.0)</td>
</tr>
<tr>
<td>Population with low back pain at baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean pain intensity in the past 3 months [mean (SD)]</td>
<td>4.9 (2.3)</td>
<td>4.6 (2.2)</td>
</tr>
<tr>
<td>Duration in the past 3 months [mean (SD)]</td>
<td>35.6 (29.7)</td>
<td>34.7 (29.0)</td>
</tr>
<tr>
<td>Population without low back pain at baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean pain intensity in the past 3 months [mean (SD)]</td>
<td>1.1 (1.5)</td>
<td>1.1 (1.5)</td>
</tr>
<tr>
<td>Duration in the past 3 months [mean (SD)]</td>
<td>3.1 (5.0)</td>
<td>3.3 (6.0)</td>
</tr>
<tr>
<td>Neck pain, whole population</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Having had neck pain in the past 3 months [no.(%)]</td>
<td>319 (21.7)</td>
<td>325 (20.6)</td>
</tr>
<tr>
<td>Mean pain intensity in the past 3 months [mean (SD)]</td>
<td>1.7 (2.2)</td>
<td>1.7 (2.1)</td>
</tr>
<tr>
<td>Duration in the past 3 months [mean (SD)]</td>
<td>9.7 (19.8)</td>
<td>8.9 (18.6)</td>
</tr>
<tr>
<td>Population with neck pain at baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean pain intensity in the past 3 months [mean (SD)]</td>
<td>4.6 (2.1)</td>
<td>4.4 (2.2)</td>
</tr>
<tr>
<td>Duration in the past 3 months [mean (SD)]</td>
<td>36.3 (29.3)</td>
<td>32.3 (28.4)</td>
</tr>
<tr>
<td>Population without neck pain at baseline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean pain intensity in the past 3 months [mean (SD)]</td>
<td>0.9 (1.4)</td>
<td>0.9 (1.4)</td>
</tr>
<tr>
<td>Duration in the past 3 months [mean (SD)]</td>
<td>2.6 (5.5)</td>
<td>2.8 (6.9)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Outcome variable</th>
<th>From no symptoms to symptoms</th>
<th>From symptoms to no symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Low back pain</td>
<td>1.23</td>
<td>0.97 – 1.57</td>
</tr>
<tr>
<td>Neck pain</td>
<td>1.01</td>
<td>0.74 – 1.40</td>
</tr>
</tbody>
</table>

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 reducing 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 generalisability 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.

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. 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. Another limitation is the follow-up period of 12 months, which may be too short to make preventive effects on LBP and NP visible.

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. 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 predefined 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. 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. 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. 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. 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. 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.

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, 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.

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 parti-
cipatory 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\textsuperscript{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.\textsuperscript{37,38} Moreover, LBP and NP are of multifactorial origin, meaning that various risk factors (or combinations thereof) are responsible for their occurrence.\textsuperscript{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.\textsuperscript{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.
Reference list


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