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

Driessen, M.T.

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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, participatory 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. 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’. 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.

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Score 1 = yes;
0 = no.

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.\textsuperscript{2} The heterogeneous study population and the pragmatic study design increase the generalisability 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.\textsuperscript{3} Finally, repeated measurements were used and study outcomes were assessed using standardised questionnaires.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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).\textsuperscript{11} Exposure to work-related psychosocial risk factors was assessed using the well accepted Job Content Questionnaire.\textsuperscript{12} Moreover, low back pain and neck pain prevalence, pain intensity, and pain duration were measured using internationally accepted questionnaires.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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 low 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. 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. 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. 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, reducing work stress and improving work productivity, and reducing knee pain severity. Hence, four RCTs 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.

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).

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). Despite their high implementation rate, the authors also found no effect on the prevention of musculoskeletal disorders.

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. 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. 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.

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. 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. Our theoretical Stay@Work model, but also other models in ergonomics, 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. Particularly, these associations reported in the literature were found among workers performing heavy physical work. 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. 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. 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. Regarding low back pain, it was found that physical exercise was effective to prevent low back pain as well as to reduce the pain intensity of low back pain among workers. Despite these promising results, it should be emphasised that exercise programmes are only focussed on increasing capacity.
mensional 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 lifestyle 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{49} In this model, two options are provided in which the episodic nature of low back pain is better represented.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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 focusing 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{52} Moreover, implementing ergonomics may improve other important aspects such as work ability, work satisfaction, and comfort.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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, construction workers, and shipyard workers).\textsuperscript{57}

3. Future RCTs have to investigate the effectiveness of multidimensional intervention programmes that combine physical exercises, participatory ergonomics, and cognitive
be 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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