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# Effectiveness of Participatory Ergonomic Interventions

## A systematic review

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## Introduction

Work related musculoskeletal disorders (MSD) are responsible for considerable financial costs in the form of worker compensation claims, medical assistance, and lost productivity (76). As well, the health and financial burden of MSD extends beyond that demonstrated in administrative databases, as it affects workers, their families, the medical system, and society in general (4; 66).

It has been recognized that poor ergonomics, particularly inappropriate design of equipment, workplaces and work processes, can result in important risk factors for MSD and the disability that ensues (5; 28; 52). Consequently, workplace ergonomic interventions have garnered interest as a means of improving working conditions, occupational health, and productivity. For example, a recent Occupational Health and Safety Council of Ontario (OHSCO) initiative is exploring the claims costs associated with MSD and the implementation of ergonomic strategies to reduce the number of MSD claims submitted by Ontario workers (56).

Participatory Ergonomic (PE) approaches grew out of quality circle experiences in Japan (50) and participatory workplace design processes in Northern Europe (22) and North America (43) during the 1980s. Unions (13), health and safety sectoral agencies (3), and health and safety associations (53) have actively promoted PE approaches. Wells et al. (70) and researchers from the Centre for Research Expertise on the Prevention of Musculoskeletal Disorders and Disability (cre-PREMUS) have advocated the use of a PE blueprint specifically developed to guide PE interventions. Interventions using this blueprint have been implemented in several manufacturing workplaces in Southern Ontario and are being adapted by Ontario health and safety associations (34).

### I 1 Scientific literature on Participatory Ergonomics

The number of studies examining PE approaches reported in the scientific literature grew substantially during the 1990s, as can be seen in the bibliometric analysis by year of publication for the articles identified in this review (Figure I.1).

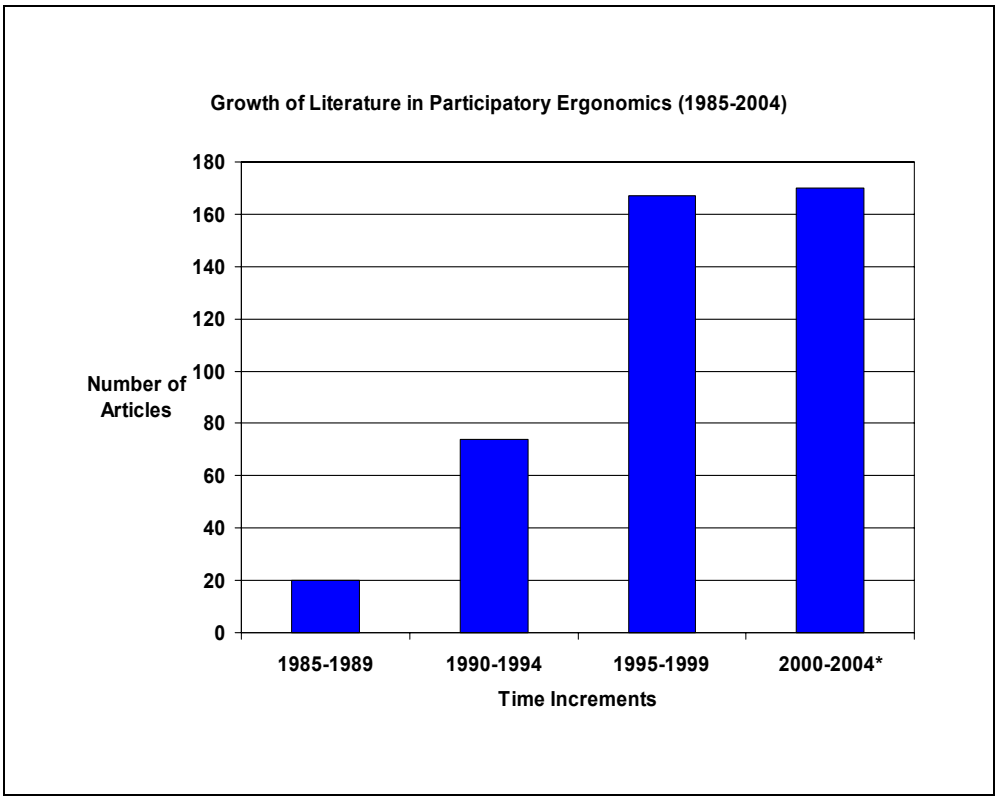


**Figure I.1** Bibliometric data on articles on PE by year of publication (*to July 2004)

Building on this growth in literature, important narrative reviews on experiences with ergonomic interventions (29; 61; 30; 32) have reflected upon how to better frame or implement PE interventions. In policy circles, substantial judgments have been made about the effectiveness of ergonomic interventions in general (26) yet the evidence supporting the effectiveness of PE interventions in decreasing MSD per se has not been summarized. A systematic evaluation of the quality, quantity and consistency of evidence of effectiveness of PE has not been reported in the scientific literature. Hence, a systematic review of the scientific literature on the effectiveness of PE was thought to be valuable for practitioners, policy makers and researchers interested in PE interventions.

## I 2 Concept of Participatory Ergonomics

Examining the effectiveness of PE requires some understanding of the constituent characteristics of PE. PE has been defined as "the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals" (75), and more recently by Kourinka (38) as "practical ergonomics with participation of the necessary

actors in problem solving". These definitions are often accompanied by a description of the various elements or dimensions of PE (30).

A characteristic feature of PE is the formation of an ergonomics 'team' which guides the intervention process. The team is typically made up of employees or their representatives, managers, ergonomists, health and safety personnel, and research experts. This can be considered as a means of using an organization's experience together with expert input to devise the best possible interventions (51). Newly formed teams typically undergo training by an expert (usually an ergonomist) to become familiar with ergonomic principles. With a foundation of ergonomic concepts and methods in place, the group uses their newly developed knowledge in making improvements in their workplace (29; 57).

Work organization and psychosocial factors are risk factors for MSD (71; 7; 44). Therefore it is important for PE interventions to have both employee and management participation in identifying and implementing changes (50; 30). By working together to improve workplace conditions through participation, communication, and group problem solving, a PE intervention can positively impact on the organization's culture as well as worker's health (40; 62). Ideally, the PE approach encourages workers to be involved in controlling their own work activities. This may decrease work organization risk factors (38). Moreover, PE aims to develop the problem solving capabilities needed to improve working conditions, facilitate communication among workplace parties, and promote acceptance of change by the workforce (70; 31; 29; 75).

**I 3 Scope of the review**

The prerequisites and benefits of implementing successful PE programs have been described (50; 75). However evaluations often focus on particular aspects of PE, with only a subset of evaluations focusing on employee health. We can conceive of a number of steps along a pathway by which PE might improve both employee health and productivity as per Figure I.2.

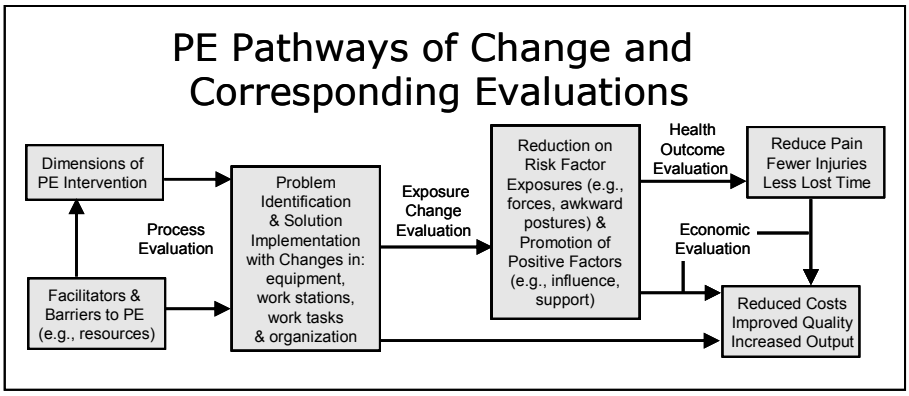


**Figure I.2** PE Pathways of change and corresponding Evaluations

*Process evaluation* of PE implementation is important for understanding how changes are brought about. Qualitative and quantitative literature on PE processes is available (39; 58), relevant to those with a primary interest in how to improve ways of implementing PE. Although this is of interest to practitioners, a systematic review would pose the research question differently to address the success of the process in making effective changes.

Similarly a literature exists on the effectiveness of PE in reducing exposures or risk factors for MSD i.e., *exposure change evaluations*. For example, a randomized controlled trial by Straker and colleagues (65) demonstrated reductions in a variety of important indicators of biomechanical exposure. Such changes in exposure are important to overall judgments of the effectiveness of PE (16) and as such are included in our quality criteria (see section M3). However, given our primary interest in *health outcome evaluations*, we decided against expanding the review to answer sub-questions addressing exposure reductions.

Finally, a nascent formal *economic evaluation* literature on the efficiency of workplace interventions in achieving changes in both employee health and production outcomes is developing (21). Questions in a review of economic evaluations address the relative cost-benefit of implementing PE in different kinds of workplaces. The relative paucity of available studies on PE alone and the additional disciplinary skills required precluded our inclusion of studies focusing solely on economic outcomes. However, studies which included both economic analyses based on reported health outcomes were included though our focus remained on methodological strengths for PE effectiveness in improving health outcomes.

In summary, we recognize the importance of assessing process and exposure reduction for improving health outcomes within a broader evaluation theory perspective and we understand the importance of economic outcomes for workplace parties and policy makers. Nevertheless, based upon resource and time constraints, we limited the scope of this systematic review to *health outcome evaluation*.

## I 4 Objectives of the Systematic Review

The *first* objective of this review was to synthesize evidence on the effectiveness of workplace-based participatory ergonomic (PE) interventions in improving health outcomes. Effectiveness was determined by examining quantitative evidence regarding achievement of the desirable consequences, such as reduced levels of musculoskeletal (MSK) pain or discomfort, injuries or claims and time loss.

The *second* objective was to provide an assessment of the methodological strengths and weaknesses which characterize the quantitative health outcome evaluation studies conducted on PE interventions in order to provide guidance for future research and evaluation.

## I 5 Organization of the report

We follow this introduction with a detailed description of the methods used to conduct the selection, quality appraisal, data extraction and best evidence synthesis of the quantitative studies. Our findings include sections on: the number of studies found, the quality and methodological strengths observed; the characteristics of PE interventions, changes identified or implemented, barriers and facilitators of implementation, risk factors identified, health outcomes observed, other outcomes extracted from the studies reviewed and the synthesis of evidence regarding PE for different health outcomes. We conclude the document with recommendations for future PE research and evaluation.

## Methods

### M 1 Literature Search

The following electronic databases were searched from their inception until July 2004: MEDLINE (from 1966), EMBASE (from 1980), Cumulative Index to Nursing & Allied Health Literature (CINAHL, from 1982), Canadian Centre for Occupational Health and Safety (CCINFO web), Safety Science and Risk (from 1981), and Ergonomic Abstracts (from 1969). Since the search terms and languages of the databases differed significantly, the terms used in the search were customized for each database. The search was limited to English language sources since we did not have a minimum of two reviewers competent in any other language. A copy of our general search strategy can be found in Appendix Table M.1.

Databases were searched for articles satisfying four general criteria for inclusion: the presence of an intervention, the use of ergonomics, the use of participatory techniques, and the presence of health outcomes. The search strategy combined these four sets of keywords using an "AND" strategy (Appendix Figure M.1), the terms within each group were OR'd. For the most part, the titles, abstracts, case registry or subject headings were all searched for keywords. However, due to the different algorithms employed by the different databases this was not always the case. In addition, the reference lists of all papers selected for review were manually searched. Conference proceedings were excluded because most are not peer reviewed, and because of insufficient information that is usually provided in proceedings to adequately assess quality and extract data for review compared to journal articles.

The search strategy was designed to be inclusive and identify as many relevant studies as possible. We were aware that the search strategy may capture non-relevant studies; therefore subsequent steps in the review process were designed to identify and omit non-relevant studies from further review.

### M 2 Selection for Relevance

Titles and abstracts of each article were screened by at least two reviewers. Full text articles were retrieved for those studies that appeared to meet the inclusion and exclusion criteria (Table M.2.), and for those in which insufficient information was presented in the title, abstract, and key words to determine eligibility. Disagreements between the two reviewers were discussed until agreement could be reached. When agreement could not be reached between the initial two reviewers, a third reviewer was consulted to come to a resolution about relevance.

Judgements about the participatory approach were often difficult to make. The inclusion and exclusion statements represent the two extremes of a range of participation. We considered all studies that did not meet the

exclusion criteria. This enabled us to review studies employing a range of participation approaches.

**Table M.2** Criteria for inclusion and exclusion of studies

| | Inclusion | Exclusion |
|---|---|---|
| **Publication Type** | • Journal articles that are peer reviewed | • Magazine articles (including all works that are published in a format aimed at an educated lay audience, in contrast with those reporting on research aimed at an academic audience)<br>• Book chapters<br>• Conference proceedings<br>• Dissertations<br>• Non peer reviewed publications |
| **Population of interest** | • Any working population | • Any populations that are not of working age (adolescents, retired, etc.) or are not actively participating in the workforce |
| **Presence of Intervention** | • An intervention/change process had to occur | • No changes were carried out<br>• Papers describing best practices, or methods were to be excluded |
| **Ergonomics** | • Intervention must be of ergonomic nature or have something to do with work design.<br>• Ergonomics was defined as contributing to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people | • Other types of interventions that do not utilize ergonomics. Examples of exclusions include health promotion interventions such as smoking cessation programs, workplace exercise programs, cognitive ergonomics, occupational health services or disability management interventions that do not use ergonomics |
| **Participatory Approach** | • Interventions must be participatory or utilize participatory principles.<br>• Participatory approach defined as the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goals.<br>• Training/knowledge are important elements of the intervention process | • No direct or indirect involvement of the end users of the intervention in the intervention process. For example, an intervention carried out solely by consultants external to the workplace and does not use worker/management input, is to be excluded as it is not considered to be participatory |
| **Outcomes** | • At least one health outcome had to be measured for evaluation purposes. One of the following outcomes must be included in the study to be considered relevant: pain/discomfort, musculoskeletal symptoms, injury rates, accident/first aid rates, absenteeism, sick leave, or work function/limitation | • No health outcomes of interest are reported |
| **Languages** | • English only | |

**M 3 Quality Appraisal**

We developed our quality criteria to apply to a broad range of research designs (27). We sought strong experimental designs such as randomized controlled trials (RCTs) but encountered very few. However RCTs tend to be challenging, complex interventions which may not be feasible in workplaces given their requirement for investigator control and generally high cost. Therefore we also included quasi-experimental designs with non-random control groups or longitudinal data collection (18; 27; 37) because often workplace parties must be involved in decisions on participation and the timing of interventions. Hence, our quality criteria were based on both design-specific quality appraisal systems typically found in systematic reviews (8; 20; 55) and newly emerging systems from the literature focusing on interventions (77).

Our quality appraisal (QA) form (see Appendix M.3 materials) drew on previous work by Franche et al. (25), Côté et al. (19; 20), Oxman & Guyatt (55), Smith et al. (64), and Zaza et al. (77). Included was information pertinent to 27 QA criteria in the following categories: study design, study population, level of recruitment, study objectives, exposure to intervention, intensity of intervention process, risk factors/exposures, health outcomes, potential confounders, and statistical analyses. Criteria were developed to be applicable to all studies regardless of design. Two final questions asked about confidence in the reported effects of the study and whether the study should go on to data extraction, with reasons for each. Each relevant study was quality assessed independently by rotating pairs of reviewers, followed by a meeting of the pair to discuss any disagreements. If agreement could not be reached about relevance, a third reviewer was brought in to achieve consensus on criteria and whether a study was suitable for data extraction (DE).

Study ratings on the QA criteria were compared between those studies that were judged appropriate for DE and those that were not (non-DE). Each criterion was rated on a three-point scale, regarding its importance in the decision to proceed to DE, ranging from ‘not important’ to ‘very important’. The QA criteria rated as ‘important’ (n=5) or ‘very important’ (n=11) are listed below in Table M 3.2. The majority assess aspects of internal validity applicable across all study designs. Many are also important for replication and application in other settings (i.e., they are relevant to external validity). The latter is particularly important for complex workplace preventive or health promoting interventions as discussed by Bull and colleagues (11).

**Table M.3.2** Quality appraisal (QA) criteria importance for suggested data extraction (DE) and decision on methodological strength (MS) criteria

| QA criteria | Importance for DE Suggestion | MS Criteria # |
|---|---|---|
| Clearly stated research question/objective | Important | - |
| Multiple levels of recruitment | Important | - |
| Description of baseline characteristics at each level | Very Important | (1) |
| Concurrent comparison groups used | Very Important | (2) |
| Intervention allocation described | Important | - |
| Randomized allocation used | Very Important | (3) |
| Participation in intervention documented | Very Important | (4) |
| Multiple levels involved in decisions around changes | Important | - |
| Changes resulting from the intervention documented | Very Important | (5) |
| Co-interventions and/or contamination described | Very Important | (6) |
| Risk factors for musculoskeletal disorders measured | Very Important | (7) |
| Risk factors measured at baseline and follow-up | Very Important | - |
| Health outcomes measured at baseline and follow-up | Important | (8) |
| Potential confounders measured | Very Important | (9) |
| Appropriate statistical analyses conducted | Very Important | (10) |
| Adjustment for relevant baseline differences | Very Important | (11) |

Of the 16 criteria in Table M.3.2, eleven were deemed to be critical for adequate internal validity. These were designated 'methodological strength (MS) criteria' (last column of table M.3.2). Based on these MS criteria, four quality categories were developed:

- Very High – 100% of MS criteria met
- High -75 – 99% of MS criteria met,
- Medium – 45 – 74% of MS criteria met
- Low – 0 – 44% of MS criteria met.

Each study was assigned a rating from this scale. Only studies which were rated 'medium' or higher i.e., met 45% or more of the MS criteria, went on to data extraction (DE).

**M 4 Data extraction**

Standardized data extraction forms were developed by the review team, based on existing forms and data extraction procedures (25; 64; 77) (see Appendix M4 for the DE guide to reviewers on completing the forms). The pairs of reviewers extracted data on: year of study, jurisdiction, industry sector, study design (according to Zaza et al. (77)), study participant characteristics, follow-up time, risk factors considered, health outcome measures, statistical analyses, health outcome findings, co-interventions,

facilitators/barriers, confounders, non-health measures, and non-health outcome findings. In addition the reviewers extracted detailed information about the interventions employed.

**M 5 Evidence synthesis**

A number of frameworks are available for synthesis of evidence. We had to consider synthesis approaches which were applicable to a diversity of disciplinary backgrounds in those evaluating PE interventions and a potentially broad range of epidemiological rigour in the studies of PE. We also needed to use synthesis approaches which were applicable to health but were not discipline-specific e.g., Rychetnik et al. (61), Task Force on Community Preventive Services (10), Ontario Effective Public Health Practice Project (54), and the American Journal of Preventive Medicine (1) special issue on injury prevention interventions.

Further, we needed to be able to accommodate substantial heterogeneity in the studies proceeding to data extraction. They came from different countries, carried out different kinds of PE interventions, focused on different risk factors, used different levels of health outcome measurement (workplace and individual) and conducted substantially different kinds of statistical analyses. Such a high level of heterogeneity required use of a synthesis approach most commonly associated with Slavin known as "Best evidence synthesis" (63).

Our best evidence synthesis was based on three aspects of the evidence on PE interventions affecting health outcomes: Quality, Quantity, and Consistency. Quality refers to the methodological strength of the studies as discussed above. Quantity refers to the number of studies that provide evidence on the same health outcome. Consistency refers to the similarity of results observed across the studies on the same health outcome.
Synthesis of the reviewed evidence on a particular PE intervention-health outcome relationship was ranked on a scale from strong evidence, through moderate, limited (partial) and mixed, down to insufficient evidence. Our guidelines were adapted from the best evidence guidelines used in the systematic review of workplace-based return to work interventions (25), themselves based on the review of prevention incentives of insurance and regulatory mechanisms for occupational health and safety (67). The specifics of our best evidence guidelines are found in Table M.5.
Application of these guidelines for each of the health outcome groupings was by consensus among the review team.

**Table M.5** Participatory Ergonomics systematic review evidence synthesis guidelines

| |
|---|
| **Strong evidence** |
| Minimum quality: Very high |
| Minimum number of studies: 3 very high quality studies |
| Consistency: Very high quality studies all agree, and > 50% of high quality studies are consistent with very high quality studies. |
| **Moderate evidence** |
| Minimum quality: High |
| Minimum number of studies: 3 high quality studies |
| Consistency: 100% of high quality agree **OR** 66% of very high quality studies agree and > 50% of high studies are consistent with very high quality studies. |
| **Limited (partial) evidence** |
| Minimum quality: Medium |
| Minimum number of studies: 2 |
| Consistency: Two studies converge on the same findings. |
| **Mixed evidence** |
| Minimum quality: Medium |
| Minimum number of studies: 2 |
| Consistency: If there are two studies, they do not converge on the same findings. If more than two, relatively equal numbers of studies support and do not support effectiveness. |
| **Inadequate evidence** |
| No more than 1 at least moderate quality study (May be many more low quality studies) |

## M 6 Summary

After merging citations identified from the electronic search of the seven databases, removing duplicate citations, and including applicable studies from references lists the studies were reviewed for relevance. Following the review of titles and abstracts (and initial screening of full papers where necessary) those that met the relevance inclusion criteria and were appraised further for quality. Studies that were rated as medium quality or better using methodological strength criteria proceeded to data extraction. These studies formed the basis for our synthesis of evidence, though we were cognizant of all relevant studies when making our recommendations.

The steps of our review process, from the initial search strategy to evidence synthesis, are found in Figure M.6 below. The different reasons for exclusion in the steps outlined in Figure M.6 were documented and

recorded. A copy of the papers which were selected for quality appraisal and/or for data extraction can be found in Appendix M.6.

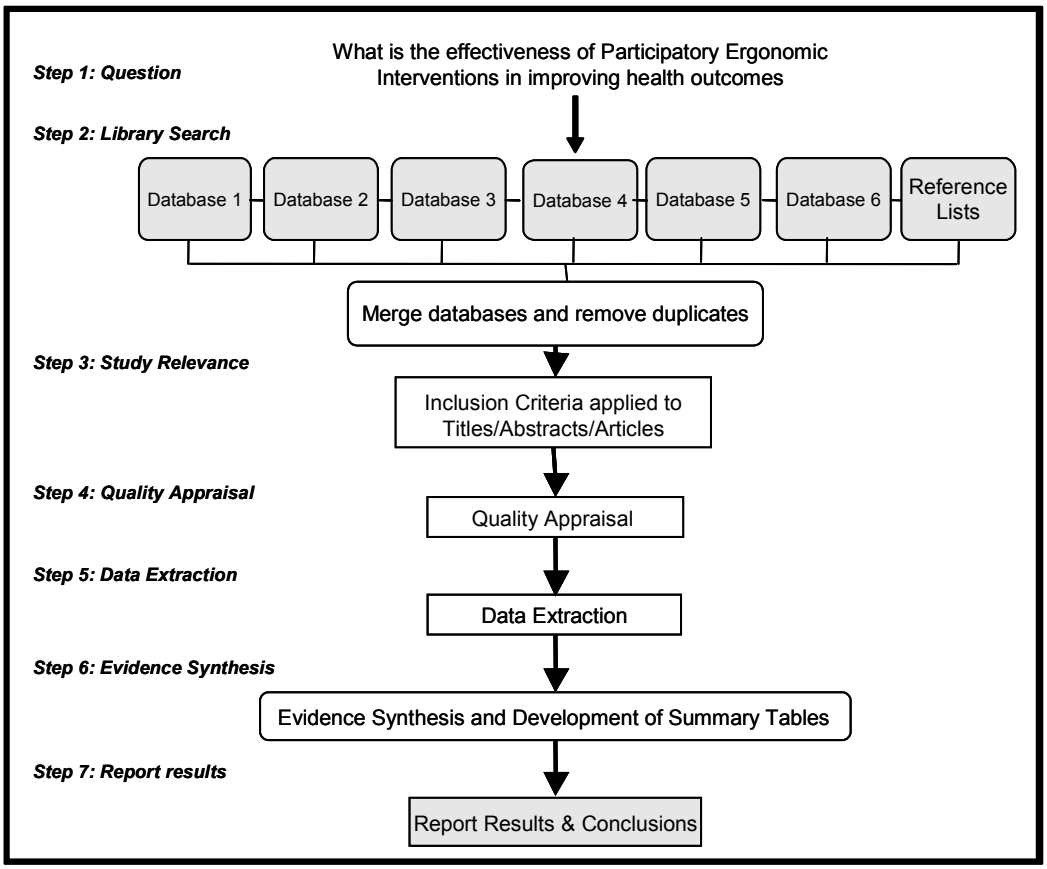


**Figure M.6 Review process flowchart**

## Findings

### F 1 Literature search results

Of the 442 non-duplicate retrieved citations, 23 studies met our relevance inclusion criteria and were assessed for methodological quality. Ten studies were rated as medium quality or better using methodological strength criteria and proceeded to data extraction. These ten studies formed the basis for our synthesis of evidence. A detailed breakdown of the flow of studies, including when studies were excluded, from the initial search strategy to evidence synthesis is found in Figure F.1 below.

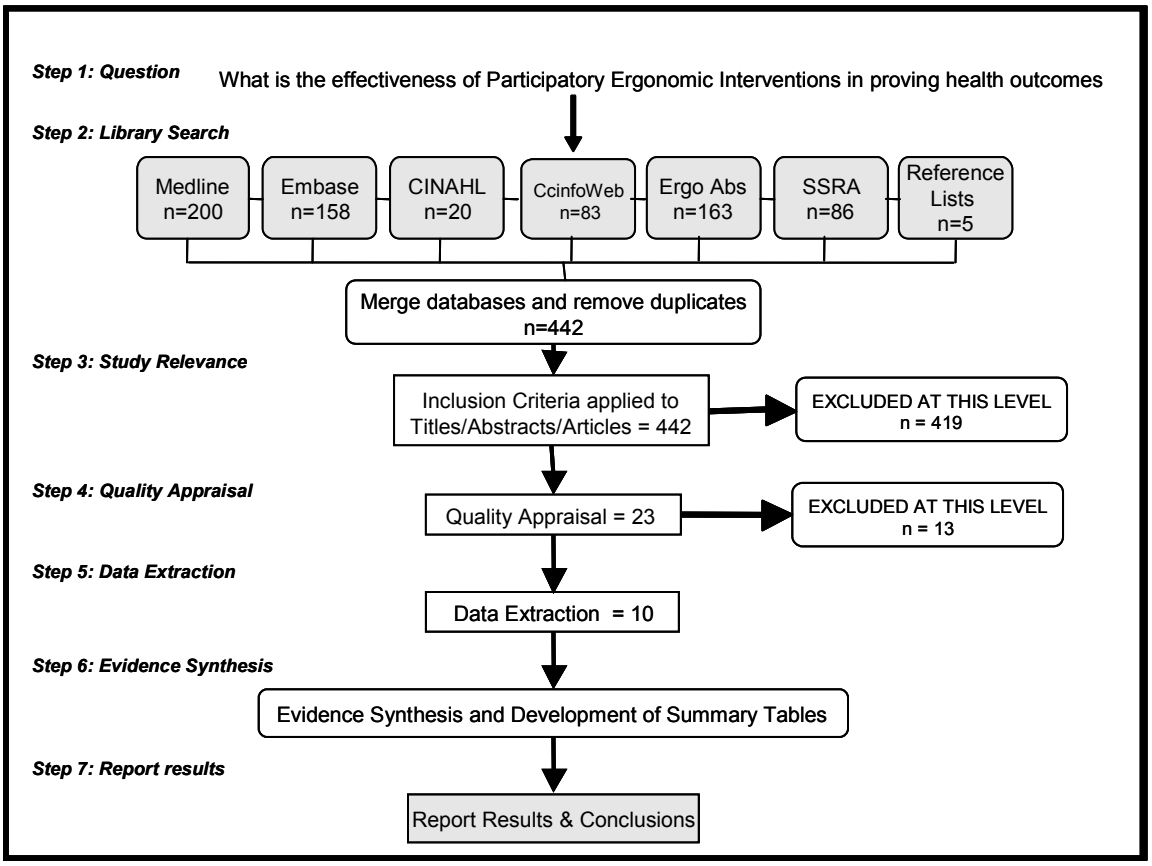


**Figure F.1 Review process flowchart of studies at each step**

## F 2 Reasons for study exclusion

**F 2.1 Study relevance** There were different reasons for exclusion in the steps outlined in Figure F.1. Many (419 of 442 non duplicate studies) were not relevant to our research question. Although these studies often reported on interesting frameworks, experiences or aspects of ergonomics, they could not help us answer our *health evaluation* question of interest.

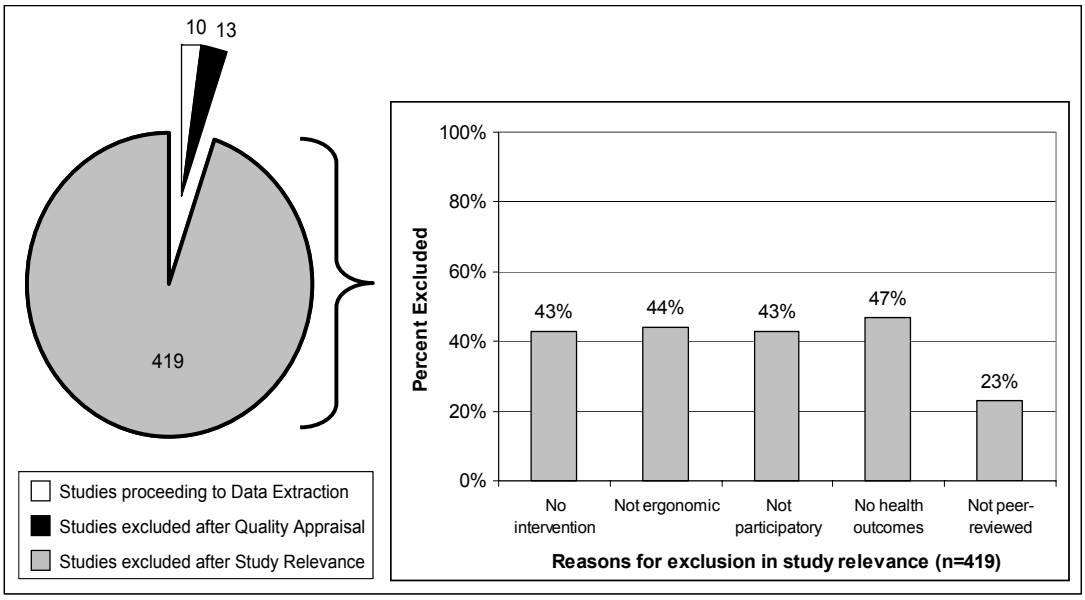


**Figure F.2 Number of studies considered in literature review**

**F 2.2 Quality** Similarly at the quality appraisal stage, many studies did not report on information important for assessing quality of *health evaluations.* These studies often provided important information about the process of participatory ergonomics. However our primary interest in *health evaluation*, with the concomitant criteria for methodological strength, was the primary reason for exclusion in the step from quality appraisal to data extraction. Hence the exclusion of studies in our review process does not necessarily suggest poor quality but rather reflects the number of studies addressing our specific research question.

## F 3 Quality Appraisal

The 23 studies which met the study relevance criteria were assessed for methodological quality using our 27-item standardized quality appraisal form. As described in section M.3. *Quality Appraisal,* eleven of these questions were identified as being important to assess the internal validity of each study. These criteria were selected as the 'methodological strength'

(MS) criteria, and were used to determine which studies were of sufficient quality to proceed to data extraction.

Using these eleven criteria, studies were rated into four quality categories: very high (100% of MS criteria), high (75 – 99% of MS criteria), medium (45 – 74% of MS criteria) and low (≤ 44% of MS criteria). Studies rated as medium or higher were considered for data extraction. Of the 23 studies, 13 were rated as low and were not considered further in this review.

Ten studies were of sufficient quality to proceed to data extraction. Overall, one study was judged to be of very high quality, one of high quality, and eight of medium quality (see Table F.3). Profiles for these 10 studies can be found in Appendix F 3 (materials). For a listing of those studies that proceeded to quality appraisal and data extraction please refer to Appendix M.6.

**Table F.3** Fulfillment of methodological strength (MS) criteria by DE studies in order of MS rating

| First Author | # MS Criteria met by study | MS Rating |
|---|---|---|
| Ketola | 11 | Very High |
| Morken | 10 | High |
| Evanoff | 8 | Medium |
| Carrivick | 7 | Medium |
| Halpern | 6 | Medium |
| Lanoie | 6 | Medium |
| Reynolds | 6 | Medium |
| Wickström | 6 | Medium |
| Laitinen | 5 | Medium |
| Moore | 5 | Medium |

In examining the methodological strengths and weaknesses of the state of evidence in PE interventions relevant to *health outcomes*, comparisons were made between DE studies (n=10), and Non-DE studies (n=13) on MS criteria. Not surprisingly, DE studies more commonly provided information relevant for our methodological strength criteria. However, there were some criteria in which all studies faired well and others in which both DE and Non-DE studies could improve. A summary of these comparisons appears below. More detailed comparisons on these quality criteria can be found in Appendix F.3 (F3 Figures and Table F 3).

The following MS criteria were **met frequently** by both DE and Non-DE studies:

- *Description of baseline characteristics at each level* – 100% of DE studies and 62% of Non-DE provided adequate information on baseline characteristics at the organization, department and worker level.

- *Changes resulting from the intervention documented* – 90% of DE studies and 70% of Non-DE studies reported on specific ergonomic changes that were either identified or implemented as a result of the PE intervention (see section F.4.2 for fuller description).

- *Health outcomes measured at baseline and follow-up* – 100% of DE studies measured health outcomes at both baseline and follow up. In regards to the Non-DE studies, 93% included baseline measures and 85 % had follow up measures.

- *Risk factors for musculoskeletal disorders measured* – 80% of DE studies vs. 63% of Non-DE studies measured risk factors for MSK disorders. However, this is an important difference, as intermediate outcomes or risk factors along the causal path are essential in understanding the effectiveness of PE in leading to changed health outcomes.

The following MS criteria were **met less frequently** by both DE and Non-DE studies:

- *Randomized allocation used* – Only 20% of DE studies and 0% of the Non-DE studies randomly allocated the intervention across equivalent groups. For the DE studies, allocation was at a group level for one study (Morken (49)), and at an individual level for one study (Ketola (36)).

- *Participation in intervention documented* – 30% of DE studies and 23% of Non-DE studies included documentation of participation. For DE studies, this criterion is elaborated on in section F4.1. Nevertheless, in many cases reviewers had difficulty ascertaining what proportion of those who might have participated actually did so.

    - *Co-interventions described* – 40% of DE studies vs. 23% of Non-DE studies addressed the issue of co-interventions in their report. Co-interventions considered in this literature included: workplace wide changes in production volumes or employee turnover, as well as specific additional components like clinical

rehabilitation, e.g. physiotherapy, occupational therapy, or return to work activities.

- *Potential confounders measured* – 40% of DE studies vs. 0% of Non-DE studies measured confounders. Most confounders were considered at the individual level (i.e., seniority, age workload), as most workplace-level confounders were not tested for associations with the PE intervention and the health outcome. Lanoie (41) were the only investigators that included both levels.

- *Adjustment for relevant baseline differences* – 40% of DE studies vs. 0% of Non-DE studies adjusted for baseline differences, crucial in non-randomized designs.

The following MS criteria were **met frequently** by DE studies and **less frequently** by Non-DE studies.

- *Concurrent comparison groups used* – 70% of DE studies used comparison groups, while only 31 % of Non-DE studies used concurrent comparison groups. In this literature, comparison groups included: other similar workplaces, the rest of the workforce, similar groups of workers, and individually selected and randomized groups.

- *Appropriate statistical analyses conducted* – 90% of DE studies had appropriate statistical analyses, compared with only 15% of Non-DE studies. Among the DE studies, many made simple pre-post comparisons. Only 1 DE study (Laitinen (40)) completed descriptive analyses only for their health outcomes (although ANOVAs were done for intermediate variables). However, 62% Non-DE studies did not perform any statistical analyses.

Overall, the quality of PE intervention studies that assess health outcomes is quite low. Of the 23 relevant studies examining this question, 2 studies rated at high or very high on methodological quality. An additional eight studies were rated at 'medium', while 13 studies rated low in terms of their methodological quality.

There are several areas that studies of PE interventions could improve, including the documentation of participation level within the intervention, description of co-interventions and confounders, and adjustment for relevant baseline differences between groups. Random allocation procedures were also generally not used in these interventions. We recognize the challenge of doing so in complex interventions of existing groups (e.g., workplaces, departments). However, as noted above, techniques to minimize bias due to non-random sampling (e.g., adjustment for co-interventions, confounders, and baseline group differences) are also not well employed in these studies.

These weaknesses are particularly critical to workplace intervention research.

Despite the general weaknesses in methodological quality in this literature, there are several internal validity issues that studies seem to be addressing adequately, including: describing sample baseline characteristics, documenting ergonomic changes resulting from PE intervention, measuring health outcomes at baseline and follow-up, and measuring important MSD risk factors.

**F 4 Data Extraction**

There were ten studies that proceeded to the data extraction step. These ten DE studies came from a wide range of European and North American jurisdictions and occurred in a range of sectors. In this section, we describe our substantive findings on PE interventions in steps that parallel our conceptual framework set out in the Introduction (Figure I.2). We start with characterization of PE interventions and how they were structured (sub-section F.4.1), the kinds of changes that were identified and implemented (sub-section F.4.2.) and the information available (in these studies) on facilitators and barriers to the interventions (sub-section F.4.3). We then turn to documentation of risk factors and any changes in risk factors during the PE interventions (sub-section F.4.4), the health outcomes of interest (sub-section F.4.5), and the other outcomes that were included in the studies (sub-section F.4.6). See Appendix F.4, Tables F.4 a,b,c for detailed data extracted.

**F 4.1 Characteristics of participatory ergonomics interventions**

As indicated in the methods, the concept of participatory ergonomics (PE) was variously interpreted in the studies we reviewed. We chose to classify the characteristics of the PE interventions according to the participatory ergonomics framework (PEF) proposed and validated by Haines and colleagues (30). The PEF has nine dimensions with several nested categories and criteria to describe process and supporting characteristics of PE programs (see Table F.4.1 and below).

**Table F.4.1** Number of DE studies described by each dimension and categories of the participatory ergonomic framework (PEF) (Haines et al., (30).

| Dimensions | Categories | Criteria (taken from text and Table 6 of Haines et al, 2002)* | Number of studies† |
|---|---|---|---|
| **Permanence** | Ongoing | Ongoing participatory mechanisms … more integrated into the structure of the organization | 5 |
| | Temporary | Participatory ergonomics mechanisms functioning on a temporary basis | 5 |
| **Involvement** | Full Direct | Each employee participates directly in decisions about their work | 2 |
| | Direct Representative | Employee representatives are selected to represent viewpoints of a large number of workers | 8 |
| | Delegated | Representatives not actively representing the views of others but represent a typical subset of a larger group | 2 |
| **Level of Influence** | Group of Organizations | The PE process takes place across a number of organizations working or belonging to a group (such as a professional association) | 1 |
| | Entire Organization | The PE process takes place at a single organization or workplace | 5 |
| | Department/ Work Group | The PE process takes place in a department or workgroup within a single organization | 10 |
| **Decision Making** | Group Delegation | Management gives employees increased discretion and responsibility to organize … their jobs without reference back | 2 |
| | Group Consultation | The PE team is encouraged to make their views known on work-related matters but management retains the right to take action or not | 7 |
| | Individual Consultation | An individual worker is encouraged to make their views known on work-related matters but management retains the right to take action or not | 2 |
| **Mix of** | Operators | Workers involved in teams | 10 |

| Dimensions | Categories | Criteria (taken from text and Table 6 of Haines et al, 2002)* | Number of studies† |
|---|---|---|---|
| **Participants** | Line Management (Supervisors) | Managers/supervisors involved in teams | 9 |
| | Senior Management | Senior managers involved in teams | 3 |
| | Internal specialist/ Technical Staff | Internal specialist or technical staff (such as engineers, or health a safety specialists) involved in team | 8 |
| | Union | Union members or representatives involved in team | 3 |
| | External Advisor | External advisor (such as ergonomic consultant from outside of company) involved in team | 7 |
| | Supplier/Purchaser | Supplier or purchaser of equipment involved in team | 0 |
| | Cross-Industry Organization | Cross industry or organization personnel (such as industry association representative) involved in team | 1 |
| **Requirement (for participation)** | Compulsory | Participation required as part of job specifications | 5 |
| | Voluntary | Voluntary participation in PE process | 5 |
| **Focus** | Physical design/ Specification of Equipment/ Workstation/ Work tasks | Physical aspects of Equipment/ Workstation/ Work tasks were the focus of the intervention | 10 |
| | Design of Job Teams or Work Organization | Design of Job Teams or Work Organization were the focus of the intervention | 6 |
| | Formulation of Policies or Strategies | Formulation of Policies or Strategies was the focus of the intervention | 1 |
| **Remit** | Problems Identification | Involved in identification of problems | 10 |
| | Solution Development | Involved in generating solutions to problems identified | 10 |
| | Implementation of change | Involved in implementing change | 10 |
| | Set-up/ Structure Process | Involved in setting up or structuring the process | 2 |

| Dimensions | Categories | Criteria (taken from text and Table 6 of Haines et al, 2002)* | Number of studies† |
|---|---|---|---|
| | Monitor/ Oversee Process | Involved in monitoring or overseeing the process of the initiative | 4 |
| **Role of Ergonomic Specialist** | Initiates and Guides Process | Ergonomist is key in initiating and guiding process as integral part of duties | 6 |
| | Acts as Expert | Ergonomist is part of the team to provide expertise in ergonomic matters | 8 |
| | Trains Members | Ergonomist primarily focuses on training | 7 |
| | Available for Consultation | Ergonomist is available for consultation as needed (therefore may not be member of team) | 8 |
| | Not Involved | Ergonomist is not involved in the PE process | 0 |

* There was some interpretation involved in determining the exact criteria for some of the categories because they were not explicitly defined in Haines et al. (30)
† Multiple responses to several categories are possible for some dimensions

Observations from applying the PEF framework to describe the PE interventions follow:

Permanence: half (5) of the studies reviewed had ongoing participatory ergonomics (PE) programs or processes, and half had temporary PE programs. However the permanence of the PE intervention was not always clearly indicated in the studies and those with ongoing programs reported permanence more clearly than those with temporary programs.

Involvement: eight studies had 'direct representative' involvement. This was likely the most common approach as 'delegated' (two studies) may not be perceived as participatory and 'full direct' (two studies) could be more difficult to implement, especially in larger workplaces.

Level of influence: all 10 studies reported that there was influence at the department level. Five studies reported having influence also at the level of the organization, while one study reported influence among a group of organizations. Departmental influence is likely more common as work at this level poses fewer implementation challenges than work with entire organizations or groups of organizations.

Decision making: seven studies had decision making power at a group consultative level, while two studies had decision making at a group delegation level. Two studies were also considered to have decision making

at an individual consultation level i.e., a minority with individual workers having authority to make changes to their workstation or worktasks.

Mix of participants: all 10 studies reported some employee involvement in the PE process, a requirement for studies to not be excluded at the relevance stage. Nine reported supervisor involvement, eight had specialist/technical staff involved, and seven PE processes had an external advisor. Three studies reported union involvement and three studies reported senior management involvement. This mix of workplace and other actors with different interests, perspectives, skills and roles likely assists in mobilizing resources from within and outside an organization (see facilitators and barriers in Section F.4.3 below).

Requirement: It was often unclear whether participation in the PE process was completely voluntary for all participants at all times. Different team members may have been needed at different stages of the process e.g., ergonomic training may have been compulsory but involvement in a 'change' team more voluntary. Given the different disciplinary backgrounds of the researchers and practical, workplace nature of many of the interventions, informed written consent was not a usual procedure. Nonetheless, the review team thought that five studies had voluntary participation and five, compulsory participation.

Focus: in all 10 studies, workplace parties dealt with physical design or specification of equipment/workplace/work tasks (see section F.2 below for more on changes). Six also included design of job teams or work organization, while one formalized policies relevant to ergonomics. We recognize that the different levels of intervention focus may only represent part of what was actually carried out in the workplace or organization.

Remit: in all 10 studies, participants were involved in problem identification, solution development and implementation of change, consistent with a more ample notion of PE. In two studies PE teams were also responsible for setting up the PE structure or process, while in four team responsibility extended to monitoring/overseeing the PE process. Interestingly, the latter were more likely in 'ongoing' PE programs (versus temporary ones).

Role of ergonomist: in six studies an ergonomist (or individual with ergonomic responsibilities) was involved in initiating the PE process. Ergonomists also acted as experts (8 studies), consultants (10 studies) and team members (7 studies) i.e., they most commonly assumed multiple roles and likely multiple kinds of involvement.

There was substantial heterogeneity across studies particularly in the permanence of the PE process, requirement for participation and the role of the ergonomist. Some of this heterogeneity could have been due to

differential reporting, as study authors did not set out to describe their PE interventions using the PEF. In fact, we extended our description of PE processes to include reports of ergonomic training and the duration of the PE intervention. Nine studies indicated that some ergonomic training was provided as part of the intervention (PE process). Seven indicated who provided training, in all cases the ergonomist (or person responsible for ergonomics). Eight clearly indicated who received the training: most often workers (8 of 9), supervisors in five, and only foremen and safety representatives in one (Wicktroem (73)).

As to content of the training, broad principles of ergonomics were conveyed in nine. Some also included assessment/identification of problems, problem solving approaches and solution implementation. The length of time spent in training varied greatly, from a single one hour session to 20 hours. In one case ongoing education was provided via notice boards (Wickström (73)).

The duration of the intervention was sometimes difficult to assess because of confusion with follow-up times post intervention or, in the case of ongoing programs, no fixed ending date. Nevertheless we found that durations varied from a matter of weeks (Reynolds (57), Ketola (36)) to 84 months or more (Moore (48)). Overall, six studies reported intervention durations of two years or more, perhaps reflecting the time required to implement sufficient changes with a PE process.

**F 4.2 Changes Identified or Implemented**

Turning to the types of changes reported, we found that the majority of studies identified (without implementation) or implemented (after identification) changes to the physical design of equipment and workplaces (see Table F.4.2). Fewer studies included changes in work tasks, job teams or work organization, the formulation of policies, or specific training. The focus on physical changes may be due to the traditional emphasis of ergonomics and workplace parties on the physical aspects of the work/worker interaction when concerned about MSD, despite the growing literature that indicates a role for psychosocial or work organization factors.

**Table F.4.2** Types of changes identified and implemented *.

| First Author | Physical design or Specification of: | | | Design of job teams and work organization | Creating Policies / Strategies | Training regarding specific techniques/ tasks† | Other |
|---|---|---|---|---|---|---|---|
| | Equip-ment | Work-places | Work tasks | | | | |
| Carrivick | im | im | im | | im | im | |
| Evanoff | id, im | | | | | im | id |
| Halpern | im | im | | im | | | im |
| Ketola | id, im | im | | | | | |
| Laitinen | im | im | | | | | im |
| Lanoie | im | im | | im | | | im |
| Moore | im | im | im | im | | | |
| Morken | im | im | | im | | | |
| Reynolds | id, im | im | | | | | |
| Wickström | | | | | | im | im |

* id= identified im = implemented

†Not including general ergonomic training.

Many studies (6 of 10) reported changes that did not match the specific categories of Table F.4.2. These changes included:

- Creating a stretching and exercising program (Halpern (31)) or improving physical conditioning of workers (Wickström (73))
- Identifying improved maintenance procedures for existing equipment (Evanoff (22))
- Designing and implementing new rooms for rest-breaks (Laitinen (40))
- Working with a supplier to change the glue on existing packaging (Lanoie (41))

PE interventions can be expected to include a variety of changes that are not easily classifiable according to a set of generic categories. Such variety can be considered a strength of the PE approach, as the changes are directed to particular situations in particular workplaces with particular needs.

**F 4.3 Facilitators and Barriers**

Most studies made at least some reference to factors that either facilitated or hindered the PE process and implementation of identified changes. One of the most consistent findings was the importance of *active participation* and *acceptance* of the team members, particularly by the following actors: workers, senior and middle management, and union representatives (where applicable). This was an important hurdle that workplaces with an underlying "trust gap" or "scepticism" between management and labour had to deal with at the outset of the PE process.

The availability of an ergonomic expert, as either an active team member or an external advisor, was consistently reported as a benefit. These technical experts provided ergonomic training/education, assisted in identifying risk factors, and facilitated the team in problem identification and solution development strategies. Teams without such guidance and support noted that they were limited in their ability to adequately identify and remedy problems within the workplace. Nevertheless, one must be mindful that the interveners commonly co-authored the study reports, with only a few studies clearly separating the roles of intervener and evaluator. Therefore, a basis for potential bias exists towards finding a benefit in expert involvement and, further, reporting on positive experiences (but not the negative or null ones). On the one hand, we admire those interveners who subjected their work to formal evaluation and encourage such openness to scrutiny. On the other hand we worry that interveners may overplay benefits, primarily because of their belief in intervention efficacy and desire to promote beneficial interventions, though financial interests have also been found important for health care interventions).

Access to adequate resources was also a commonly identified factor. Provision of 'protected' time for members to participate in team meetings, financial investment in the process, and availability of workplace structures for accessing information regarding risk factors, equipment specifications, and personnel were key facilitators of the PE process. Conversely, constraints on resources were significant barriers to adequate implementation in some studies.

Instability within the workplace e.g., employee turnover, downsizing, or more globally at the industry level e.g., economic recession, at the time of the PE intervention was found to hinder the PE process – affecting both workers' confidence in and the everyday implementation of the participatory ergonomic process.

## F 4.4 Risk Factors Considered

Identification and assessment of risk factors were suggested as integral parts of the PE process in most of the DE studies, in keeping with our conceptual framework for PE (see Figure I.2 in Introduction). Table F.4.4 shows the variety of risk factors and, when reported, the changes observed during the course of the study.

**Table F.4.4** Summary of risk factors considered and changes recorded for those risk factors (if reported).

| First Author | Risk Factors / Intermediate Variables Considered | Change in Risk Factors* |
|---|---|---|
| **Carrivick** | Risk factors checklist used to assess:<br>- actions and movements<br>- workplace and workstation layout<br>- working posture and position<br>- duration and frequency of manual handling<br>- location and distance of loads moved<br>- weight and forces<br>- characteristics of loads and equipment<br>- work organization<br>- work environment<br>- skills and experience<br>- age and clothing | Not reported |
| **Evanoff** | 1) Job satisfaction<br>2) Psychosocial stressors<br>3) Social support among co-workers (work APGAR) | Improvements in<br>1) job satisfaction ($p<0.01$),<br>2 ) perceived psychosocial stressors ($p<0.01$), and<br>3) social support among co-workers ($p<0.05$)<br>associated with decreases in proportion of workers reporting symptoms. |
| **Halpern** | Hazard intervention and abatement strategies identified:<br>- Posture,<br>- Forces,<br>- Repetitions,<br>such as: excessive reaching, twisting and bending, forceful pinching and gripping, awkward hand postures when cutting | Although changes to workstations, tools, process flow and employee exercise/stretching were described which indicated that posture and force were improved, specific changes to the risk factors identified were not reported in this study. |

| First Author | Risk Factors / Intermediate Variables Considered | Change in Risk Factors* |
|---|---|---|
| **Ketola** | 1) Workstation settings<br>2) Ergonomic rating (video analysis - scale 4-10, 10 is better) | 1) Changes in screen height, keyboard height and acquisition of accessories occurred more often in the intensive group. Adjustments to chair or mouse location occurred in all groups.<br>2) Mean ergonomic ratings significantly higher in the intensive group than in the education or reference group at 2 and 10 months follow ups, but not at baseline. |
| **Laitinen** | 1) housekeeping standards<br>2) perceived physical changes<br>3) perceived psychosocial changes | 1) Housekeeping index increased from 57% to 89% ( $p<0.001$);<br>2 & 3) physical working conditions and psychosocial work environment both significantly improved when considered for all responses ($p < 0.001$ and $p < 0.02$ respectively). All other aggregated Time 1 (Q1) findings not significant;<br><br>2) Perception of physical working conditions improved in all departments: order and tidiness ($p<0.001$), pleasantness of work environment ($p<0.05$), layout of work stations ($p<0.05$), safety of working methods ($p<0.05$).<br><br>3) Psychosocial environment improved in three departments ($p<0.05$); For Time 2 (Q2) two of 11 groups of questions showed statistical improvements: communication and cooperation (p level not given) - other 9 groups showed no significant difference; For specific Q2 questions - total responses: Company goals are known ($p<0.01$), Practical places for tools ($p<0.01$), workstation is clean and in good order ($p<0.05$). In Dept. H: positive prospects in work, practical tools are available ($p<0.05$); practical places for tools, workstation is clean and in good order, regular feedback of outcome, visual appearance of work station is pleasant ($p<0.01$); Company goals are known ($p<0.001$); In Dept. J: daylight in workstation, company goals are known ($p<0.05$); workstation is clean and in good order ($p<0.01$); |

| First Author | Risk Factors / Intermediate Variables Considered | Change in Risk Factors* |
|---|---|---|
| **Lanoie** | 1) Muscular use<br>2) asymmetric postures<br>3) lumbar strain in biomechanical laboratory<br>4) physiologic demand measures | 1) muscular use decreased in manual handling of boxes from 80% of maximal capacity to 40% of maximal capacity<br>3) biomechanical analysis in laboratory found a decrease in low back muscle use by 15.7% with new glue used<br>4) significant reduction in physiologic demand with new handling equipment |
| **Moore** | 1) worker safety survey<br>2) CTD risk factor checklist<br>3) worker feedback<br>4) strain index | 2) significant reduction in percentage of MSK risk factors found (no statistical significance)<br><br>One of the articles that represent this study indicated detailed changes in risk factors for individual job changes based on the risk factor checklists and strain index tool. These changes were not statistically analyzed but were mostly positive. |
| **Morken** | 1)Coping strategies<br>2) Job demands, Job control and Social support | 1) coping strategies: intervention groups used more strategies then control groups (p=0.043, ANOVA). Intervention group 2 increased most (mean change=0.041, 95% CI 0.005, 0.077). Control group B declined by 0.010, 95% CI -0.02, 0.001). Intervention group 2 and control group B differed (p=0.017) and Intervention group 2 and control group A differed at borderline significance (p=0.068). The largest increase in intervention group2 was for following: "work on other tasks that are less strenuous", “use equipment to reduce physical strain" & "ask colleagues for help with strenuous work tasks".<br><br>2) job demands, control and social support: social support in intervention group 2 improved slightly from pre to post. All other groups tended to decline (p=0.10, ANOVA). Job demands and control did not differ significantly. |

| First Author | Risk Factors / Intermediate Variables Considered | Change in Risk Factors* |
|---|---|---|
| **Reynolds** | 1) CTD task analysis using manual methods<br>2) acquiring biomechanical data on posture, force, repetition,<br>3) calculating daily exposure scores for wrists (DWE), neck/back, shoulders, and legs (DE).<br>DWE = (grip force + postural deviations) x frequency<br>DE = postural deviations x frequency | Case study presented results on:<br>3) DWE which showed a reduction in daily wrist exposures comparing 'before' to 'after' (before R wrist: 30,927 to after R wrist: ~10,500; before L wrist: 16,653 to after L wrist: ~14,000) ~14,000)<br>and DE which also showed a reduction comparing 'before' to 'after' (shoulders before: 47,580 to shoulders after: ~23,000; and Neck/back before: 41,236 to neck/back after: ~19,500)<br>Other risk factor measures were not presented. |
| **Wickström** | 1) biomechanical load (reported as occurrence of low back pain, which is a health outcome measure)<br>2) ergonomic ways of working<br>3) physical exam (fitness of back tissues) | 2) ergonomic ways of working: - adhering to ergo principles at work (white collar: chisq(2)=2.17, p=0.34; blue collar: chisq(2)=9.64, p=0.008)<br>- use of mech equip to avoid excessive postures blue collar: chisq(2)= 17.28, p=0.001); no white collar exposure<br>- physical exercise no changes (white collar: chisq(2)=4.83, p=0.089; blue collar: chisq(2)=1.054, p=0.59)<br><br>3) fitness of back tissues: - performance of abdominal muscles better among white collar than blue collar (no stats provided)<br>- no changes observed in mobility of spine of performance of abdominal muscles in either group<br>- blue collar endurance time of back muscles increased (F(2,128)=3.99, p=0.021) |

* refer to Appendix Tables F.4a, b, c for fuller version of the data extracted.

The rigor used to measure risk factors and explicitness in reporting these factors varied considerably across the studies. Several studies only conducted risk factor assessment as part of the initial hazard identification step in the PE process. Those reported reflected the particular nature of the work operation or job. In other studies, the risk factors were measured using explicit standardized tools, considered intermediate variables, and analyzed statistically for change over the course of the intervention. The latter approach considerably aids interpretation of changes or lack of changes in health outcomes.

**F 4.5 Health Outcomes**

We grouped the wide variety of health outcome measures in the DE studies (refer to Appendix Table F 4b) into three main groupings:
1) symptoms of musculoskeletal pain and/or discomfort, most often from questionnaire; 2) injury records in-plant or lost time claims for workers' compensation; and 3) sick leave in general or lost workdays specifically due to MSD (see Table F 4.5 below). Symptoms (5 studies) and injuries (6 studies) were more common, likely in keeping with their greater frequency (prevalence for symptoms and incidence for injuries) and greater sensitivity to change during the course of a PE intervention. Three studies had more than one health outcome: Evanoff (24) and Reynolds (57) measured both symptoms and injury data and Wickström (73) included measures of both symptoms and sick leave.

**Table F.4.5** Summary of Health Outcomes Measured and Results Obtained

| First Author | MSK Symptoms (1) | Injury Records/ Claims (2) | Sick Leave/ Lost Workdays (3) | Results (for health outcomes only) |
|---|---|---|---|---|
| Carrivick | | • | | Positive |
| Evanoff | • | • | | Positive |
| Halpern | | • | | Positive |
| Ketola | • | | | Positive |
| Laitinen | | | • | Positive |
| Lanoie | | • | | Positive |
| Moore | | • | | Positive |
| Morken | • | | | No Change |
| Reynolds | • | • | | Positive |
| Wickström | • | | • | Positive |
| **Total # of Studies** | **5** | **6** | **2** | |

We also attempted to estimate effect sizes for 1) odds ratios and rate ratios according to guidelines devised for this review (see Appendix Table F.4.5). and 2) means, proportions, chi-square and regression estimates using Cohen's approach (14).

*Outcome 1: MSK symptoms:* Among the five DE studies that measured musculoskeletal symptoms (Evanoff (24), Ketola (36), Morken (49), Reynolds (57), Wickström (67)), various questionnaire instruments were used that captured different attributes of MSK symptoms. These attributes included the frequency or severity of symptoms overall, the intensity of pain, and the location of symptoms by body region e.g., low back pain

occurrence in the past year. Four of the five DE studies found a reduction in MSK symptoms with the PE intervention. Morken (49), however, found that change in MSK symptoms did not differ significantly between intervention and control groups. Effect size could only be estimated in the Ketola (36), study, and it was small.

*Outcome 2: Injury Records or Claims.* Six DE studies sought to determine the effect of a PE intervention on the number of injuries, as measured by plant injury records (i.e. OSHA 200 logs in the US based studies), claims, , or equivalent measures as obtained from administrative database sources. All studies reported reductions in injury rates to varying extents. For example, one of the biggest improvements was shown in the study by Halpern (31), where the intervention group had an 85% reduction in the total number of claims, compared to the reference group which experienced an increase in the number of claims. The PE intervention reported by Carrivick (12) also showed a large effect, with an odds ratio for lost time injury frequency post intervention of 0.353 compared to the referent group (significantly different from zero). In general, the large effect sizes occurred with cruder analyses as in Halpern above. The small effect sizes were found in more sophisticated analyses which took into account population characteristics and co-interventions i.e. Lanoie (41).

*Outcome 3: Sick leave/lost workdays*. Both studies using this type of health outcome extracted from administrative data bases reported improvements. Specifically, Laitinen (40) demonstrated that following a PE intervention absenteeism went from 12.8% to 9.9% in the affected workforce. In the study by Wickström (73), sick leave decreased from an average of 3.1 days lost due to low back disorders before the PE intervention to 1.9 days lost after the PE intervention. Formal effect size estimates could not be estimated for either of these, however.

**F 4.6 Other Outcomes** Some studies included findings on outcomes that were not of primary interest for this review. They were included in the data extraction tables to capture any other potential changes resulting from the PE interventions (see Appendix Table F.4c). A number of studies that reported on workers' compensation claim data, also included the monetary valuation of these health outcomes as compensation costs or the like, which most often were towards reduced costs to the workplace e.g., Evanoff (24), Halpern (31), Moore (48). In addition, using a simple productivity measure Reynolds (57) was able to demonstrate improvements with the PE intervention.

**F 5 Evidence Synthesis**

Among DE studies, the PE intervention always included multiple activities at several levels of the organization (Section F 5.1). Across the studies, the

mix of ergonomic changes made by the PE teams varied substantially (Section F 5.2) as did the risk factor changes found (Section F 5.4). All but one of the DE studies showed positive health outcomes (Section F 5.5) but effect sizes could only be estimated for a small number of the outcomes. The large variety in PE characteristics, ergonomic changes and changes in risk factors and the small number in which we could estimate health outcome effect sizes meant that we could not analyse the role of the former in determining variation in the latter, as hoped for in our initial conceptual framework for PE intervention evaluation (Fig I.2).

We could, however, synthesize the evidence for each health outcome.

### F 5.1 What is the impact of workplace PE interventions on musculoskeletal pain & discomfort?

One very high quality study (Ketola (36)) was positive and showed small effects; one high quality study (Morken (49)) found little change; and three medium studies (Evanoff (24); Reynolds (57); Wickström (70)) found improvements in MSK symptoms, though the effect sizes could not be estimated.

Taken together, using a best evidence synthesis approach, the current studies provide **limited (partial) evidence** that PE interventions can have a small, positive impact on MSK symptoms.

### F 5.2 What is the impact of workplace PE interventions on injuries and workers' compensation claims?

Six medium quality studies (Carrivick (12); Evanoff (24); Halpern (31); Lanoie (41); Moore (48); Reynolds (57)) all showed reductions in lost time injuries or claims, particularly for MSK conditions e.g., low back pain. Effect sizes ranged from large in the cruder analyses to small in the more sophisticated analyses that took into account employee population changes and co-interventions.

Taken together, using a best evidence synthesis approach, the current studies provide **limited (partial) evidence** that PE interventions can have a positive impact in reducing injuries and workers' compensation claims. The size of this impact may range from small to large and requires clearer characterization in future research.

### F 5.3 What is the impact of workplace PE interventions on lost workdays and sickness absence?

Two medium quality studies showing positive results were found (Laintinen (40); Wickström (73)) but effect sizes could not be estimated from either.

Taken together, using a best evidence synthesis approach, the current studies provide **limited (partial) evidence** that PE interventions have a positive impact on lost days from work or sickness absence, but the magnitude of the effect requires more precise definition.

**F 6 Conclusions**

Nine out of ten studies of medium quality or better reported a positive effect on health outcomes associated with PE. However, the heterogeneity in research methods and reporting across the studies led the review team to assign an appraisal of 'limited (partial) evidence' that PE interventions are effective in improving health outcomes. Specifically, our findings can be summarized as follows:

- There is **limited (partial) evidence** that PE interventions have a positive impact on **MSK symptoms.**
- There is **limited (partial) evidence** that PE interventions have a positive impact on **injuries and workers' compensation claims**.
- There is **limited (partial) evidence** that PE interventions have a positive impact on **sickness absence or lost days from work.**

**F 6.1 Strengths of conducting a systematic review**

The volume of studies published is more than most practitioners or researchers can easily keep track of or synthesize. This is confirmed for participatory ergonomics by the number of studies shown in Figure I.1 in the Introduction. Systematic reviews are useful tools for researchers, practitioners, workplaces, and policy makers to remain current with the evidence.

A systematic review differs from a narrative review written by a content expert in a relevant field because it is designed to be transparent and reproducible in the judgements made. In following an explicit process of scrutinizing, tabulating, and integrating all relevant studies that address a specific research question, a systematic review aims to eliminate bias in the selection and synthesis of evidence. It strives to produce an objective appraisal that can enable practitioners and researchers to resolve uncertainty when original studies and editorials disagree on the conclusions to be drawn from the evidence for a particular research question. In many cases, a systematic review can demonstrate gaps in the quality of evidence for a question and thereby identify areas for further research and evaluation.

**F 6.2 Limitations of this systematic review** The evidence considered was from peer-reviewed literature which could be identified through the search of the seven electronic databases and scanning of reference lists from

selected studies. It is possible that a broader search of the grey literature, conference proceedings, and dissertations might have yielded further relevant evidence on the effectiveness of PE interventions on health outcomes.

Time and resource availability limited the range of research questions on PE interventions considered in this review, leaving other pertinent questions such as determining the most effective process for conducting PE interventions, measuring risk factors/exposures, ensuring adequate participation, or maintaining interest to ensure sustainability to other reviews.

**F 6.3 Strengths of this systematic review** Our search for evidence confirmed that this is the first systematic review to focus on the effectiveness of PE interventions in improving health outcomes **(see Figure I.2**). Our review has advanced the methodology for appraising study quality within this body of literature to include a wider spectrum of study designs than is typically considered in most systematic reviews. We actively engaged the participation of stakeholders in the genesis and conduct of this review. Such early involvement was important to ensure our research question responded to our stakeholders' needs and interests. Further, including a stakeholder in conducting the review was a means to build capacity in utilization of research findings.

## Recommendations

After the critical scrutiny that is involved in conducting a systematic review, it is tempting to only recommend that more and better research is needed. Nevertheless, the generally positive findings that we uncovered provide us enough assurance to recommend continued implementation of PE interventions (R.1.), in parallel with improved evaluation research on the impacts of PE interventions on health outcomes (R.2), and consideration of systematic reviews on other kinds of evaluations of PE (R.3).

**R 1 Implementing PE interventions to reduce MSD burden**
Given the evidence linking workplace exposures to the burden of MSD in working populations (52) we should continue to practice methods proven to reduce the burden. Some might suggest that our review did not uncover sufficiently strong evidence to endorse PE interventions. However, others have argued for different standards of evidence for *preventive* interventions like PE which reduce exposure to hazards (26). The review team agrees with this perspective and recognizes the struggles faced by workplace parties and policy makers in finding effective interventions to reduce the unacceptable burden of MSD among working Canadians. Hence our first recommendation that:

*PE interventions continue to be implemented in workplaces as one means of reducing MSD burden among Canadian workers* (R.1)

**R 2 Evaluating PE interventions for improved MSK health**
Our systematic review points to the need for researcher/evaluators to accompany workplace parties in their efforts to evaluate the impact of PE interventions along with ergonomists and other technical experts. In doing so, we have a set of recommendations that are directed both at researcher/evaluators and workplace/ergonomist interveners. Note that we suggest a separation of these roles, in keeping with the need to reduce the perception of bias as much as any possibility of actual bias in the results of an evaluation of a PE intervention.

Drawing particularly on the findings pertaining to methodological criteria, we propose the following recommendations to improve the quality of research and evaluation of PE intervention impacts on MSK health:

**R 2.1 Evaluation study designs.** Many PE interventions are initiated by enthusiastic workplace parties or skilled ergonomists who are fundamentally engaged volunteers. Hence the notion of randomization of interventions appears foreign to the very principle of participation. While recognizing this tension, when opportunities arise at the multiple organization or multiple site level to sequentially initiate PE processes, randomization of initiation should be considered e.g., as Straker and colleagues did in conjunction with labour

inspectors. Organizations may find this appealing because they can sequentially apply limited resources to making changes, leaving some sites to act as time-based referents (often called controls). Robson and colleagues (59) have argued strongly for the greater study validity that can be achieved by such designs. Others have argued at a minimum for the use of concurrent comparison groups (16), as was creatively achieved by a number of the studies included in this systematic review. Hence our first evaluation research recommendation is that:

*Concurrent comparison or referent groups be used in PE evaluations whenever possible, including consideration of randomization of interventions when many sites or organizations are involved* ***(R 2.1).***

**R 2.2 Source population and sampling frame.** Many of the studies that we assessed for quality lacked sufficient information regarding the source population and sampling frame. In some instances, this reflects an oversight on the part of the researchers or a lack of appreciation of its importance (15). As well, part of the explanation lies in the fact that many studies used administrative data as their primary source of outcome measures. Consequently their unit of analysis was the department or workplace, but there remained inadequate descriptions of the other work groups or departments that made up the larger whole used for comparison purposes. Different units of analyses such as workers, workplaces, wards, and supervisors, reflect the fact that interventions can be aimed at different levels of action (16). Hence our second evaluation research recommendations is that:

*Greater efforts should be made to document and describe the source population(s). (****R 2.2)***

**R 2.3 Level and Intensity of Participation**. Participation in PE was interpreted and applied differently in different studies, which we documented with the help of the extensive PE framework (PEF) devised by Haines et al. (30). Yet a considerable lack of consistency was noted in reporting on the various dimensions of the framework, partly because of the use of different frameworks, or partly because no overarching theory of change was used for many interventions. As in most interventions, intensity and coverage are important. For PE this must be partly measured by the kind and extent of participation in PE implementation. Although the research methods to achieve such documentation should partly be qualitative (see R.3. below) quantitative measures are also important. Hence, we recommend that:

*Those utilizing PE approaches should formally document the level of participation within the organization, the extent of involvement, and the coverage or proportion of those involved in order to provide much needed measures of PE intensity* ***(R 2.3****).*

**R 2.4 Specific Ergonomic Changes**. In our review, we included an extensive summary table of the types of ergonomic changes that were identified and/or implemented in each of the studies. Such documentation is key to permit adequate explanation for the reasons for changes in risk factors and eventually health outcomes (as per Figure I.2). Hence we recommend that:

*Ergonomic changes be documented in as much detail as possible, to help describe intervention intensity and type, and to aid the applicability of the research or evaluation findings to other workplace settings* ***(R 2.4)***. .

**R 2.5 Changes in Risk Factors/Exposures.** Given the growing understanding of the contribution of physical and organizational risk factors in the causation of MSK disorders, intervention studies need to document changes in these risk factors to bolster explanation of a PE interventions' effectiveness. As per Figure I.2, changes in exposures are important intermediate variables on the path to changes in health outcomes. We therefore strongly recommend that:

*PE evaluations should delineate the various risk factors measured and their links to health outcomes should be explicitly analyzed* ***(R 2.5)***. .

**R 2.6 Co-interventions.** If major changes in the workplace, reorganizations, or other interventions, aside from the intended PE intervention under investigation, have taken place during the study period, changes in health outcomes may be hard to attribute to the PE intervention alone. As co-interventions were particularly poorly addressed in the studies in this review, except for Lanoie and colleagues evaluation in Quebec (41), we recommend that:

*Future evaluation research pay particular attention to ways of explicitly describing co-interventions and dealing with their impacts in the analyses.* ***(R 2.6)***.

**R 2.7 Confounders**. Individual confounders such as demographic factors and co-morbidities can differ greatly between groups in a study and departmental confounders such as grievance rates may also vary across groups. By definition, confounders are related to both the PE intervention and to the health outcome, making attribution of changes in health outcomes to the PE intervention along difficult. Few of the studies that the review team appraised for quality adequately dealt with confounders. Hence, we recommend that:

*Potential confounders at different workplace levels be clearly described and adjustment for their effects carried out if required.* ***(R 2.7)***

**R 3 Conducting complementary systematic reviews**

When considering the process of PE, workplace context is of considerable importance in potentially facilitating or hindering the success of a PE intervention. Previous studies have identified such factors as the organization's commitment to change, the existing organizational climate, and resources as especially significant (12; 40). Despite their utility for practitioners, not all studies consistently reported on such issues. Moreover, a mention of facilitators and/or barriers of the intervention was usually very brief in the DE studies. Although we might argue for greater information on these aspects in the studies reviewed, we are aware that we did not include a number of studies that do in fact examine context and the facilitators and barriers to PE interventions. Such a focus is more in keeping with the *process evaluation* literature and could be extremely useful to PE practitioners, workplace parties and policy makers. Hence, we recommend that:

*A systematic review of PE process evaluations be undertaken by a team including qualitative researchers* ***(R 3.1***).

We understand the need for greater information relevant to the "business case" for ergonomics and the parallel inclusion of both productivity outcomes and health outcomes in research on PE interventions (21). On the other hand, we know that the number of economic evaluations and their quality is likely limited at the present time. Hence, we recommend that:

*PE interventions be included in systematic reviews of economic evaluations of workplace interventions to reduce the burden of MSD* **(R 3.2).**

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# Appendices for:

# Effectiveness of Participatory Ergonomic Interventions: A Systematic Review

**January 2005**

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## List of Appendices

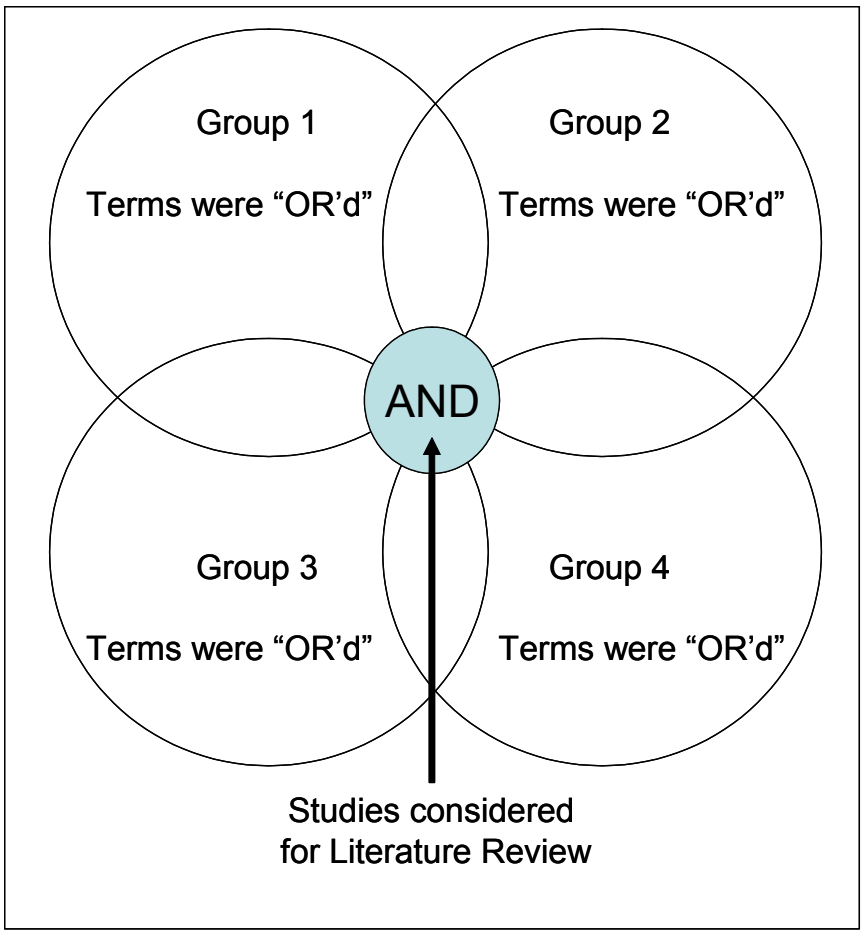
# Appendix M.1: Literature Search

**Appendix Table M.1 Search Terms***

| Group 1: Intervention/Change Terms | Group 2: Ergonomic Terms |
|---|---|
| • intervention(s/studies)<br>• program(s)<br>• change(s)<br>• modif(ication/iers)<br>• implement(s/ations)<br>• process<br>• method(s)<br>• approach(es)<br>• safety management<br>• program evaluation<br>• prevention | • ergonomic(s)<br>• human engineering<br>• work design<br>• human factors<br>• occupational (health/diseases)<br>• musculoskeletal diseases |
| **Group 3: Participatory Terms** | **Group 4: Health Outcome Terms** |
| • participat(ion/ory/ive)<br>• ergonomics group<br>• ergonomics team<br>• labor-management/labour-management<br>• consultative<br>• action research | • musculoskeletal<br>• injur(y/ies/ed)<br>• accidents<br>• disorder(s)<br>• pain<br>• shoulder<br>• low back pain<br>• back<br>• extremity<br>• sick leave<br>• absenteeism<br>• reemployment<br>• work disability<br>• injured worker<br>• functional limitation<br>• physical capacity<br>• work limitation<br>• compensation (cost/claims)<br>• workers compensation<br>• time on benefit<br>• benefit duration<br>• sick listed<br>• sickness absence<br>• lost time<br>• time los(s/t)<br>• wage replacement<br>• outcome assessment |

*Some physical terms used in the search are not represented in this table.

**Appendix Figure M.1** Boolean Logic of the Search



## Appendix M.3: Quality Appraisal Process

The Quality Appraisal (QA) form was developed for critically appraising the quality of the papers that have been deemed relevant for this review. Once an article has been reviewed for relevance based on it title and abstract, or if the reviewers were unsure of its relevancy, then the full article was obtained. At the quality appraisal level of the review, the relevancy of the article must be confirmed as either relevant or not relevant, before proceeding QA.

### Quality Appraisal Form

| | |
|---|---|
| **Were concurrent comparison group(s) used?** | • Yes; single referent<br>• Yes; multiple referents<br>• Unclear<br>• No |
| **Were time-based comparisons used?** | • Yes; pre-post<br>• Yes; pre-during-post<br>• Unclear<br>• No |
| **Was an intervention allocation described? (Check all that apply):** | • Yes; self-selection<br>• Yes; matched<br>• Yes; random<br>• Unclear<br>• No |
| **Is the research question/objective clearly stated?** | • Yes<br>• Unclear<br>• No |
| **Please indicate which levels of recruitment were described (check all that apply):** | • Organizations/ Workplaces<br>• Department/ Supervisors/ Work Groups<br>• Employees/ Workers<br>• Unclear |
| **Was recruitment rate reported and & greater than 40% for (If yes then check all that apply):** | • Organizations/ Workplaces<br>• Department/ Supervisors/ Work Groups<br>• Employees/ Workers<br>• Unclear |
| **Were characteristics at baseline described for (If yes then check all that apply):** | • Organizations/ Workplaces<br>• Department/ Supervisors/ Work Groups<br>• Employees/ Workers<br>• Unclear |

| | |
|---|---|
| **Were there any differences across groups at baseline for (If yes then check all that apply):** | • Organizations/ Workplaces<br>• Department/ Supervisors/ Work Groups<br>• Employees/ Workers<br>• Unclear<br>• No |
| **Was the loss to follow up less than 50% for (If yes then check all that apply):** | • Organizations/ Workplaces<br>• Department/ Supervisors/ Work Groups<br>• Employees/ Workers<br>• Unclear |
| **Were there any important differences between remaining and drop out participants for (check all that apply):** | • Organizations/ Workplaces<br>• Department/ Supervisors/ Work Groups<br>• Employees/ Workers<br>• Unclear<br>• No |
| **Was the intervention process described?** | • Yes<br>• Unclear<br>• No |
| **Was training/education in ergonomics provided?** | • Yes<br>• Unclear<br>• No |
| **Which workplace parties were involved in decisions around changes? (Check all that apply)** | • Management<br>• Supervisors<br>• Workers<br>• Unclear<br>• None |
| **Was the participation in the intervention documented?** | • Yes<br>• Unclear<br>• No |
| **Were changes resulting from the intervention documented?** | • Yes<br>• Unclear<br>• No |
| **Was the calendar duration of the intervention documented?** | • Yes<br>• Unclear<br>• No |

| | |
|---|---|
| **Were co-interventions described or documented in this study?** | • Yes<br>• Unclear<br>• No |
| **Was contamination between groups described or documented?** | • Yes<br>• Unclear<br>• No<br>• Not Measured<br>• Not Applicable |
| **Were sources of any risk factors/exposures for musculoskeletal disorders measured?** | • Yes<br>• Unclear<br>• Not Measured |
| **When were risk factors measured? (Check all that apply.)** | • Baseline<br>• Follow up<br>• Unsure<br>• Not measured |
| **Were health outcomes measured?** | • Yes<br>• Unclear<br>• Not Measured |
| **When were health outcomes measured? (Check all that apply.)** | • Baseline<br>• Follow up<br>• Unsure<br>• Not measured |
| **Were potential confounders/effect modifiers measured?** | • Yes<br>• Unsure<br>• No<br>• Not Applicable |
| **When were potential confounders/effect modifiers measured? (Check all that apply.)** | • Baseline<br>• Follow up<br>• Unsure<br>• Not measured |
| **Were the statistical analyses appropriate to the study design?** | • Yes<br>• Unclear<br>• No<br>• Not measured |
| **Was there adjustment for relevant baseline differences?** | • Yes<br>• Unclear<br>• No<br>• Not Applicable |

| | |
|---|---|
| **Was there adjustment for other potential confounders?** | • Yes<br>• Unclear<br>• No |
| **How confident are you (as a reviewer) that the reported effects are attributable to the intervention?** | • Very confident<br>• Relatively confident<br>• Relatively not confident<br>• Not at all confident |

## Quality Appraisal Guide for Reviewers

Questions 1 and 2 of this guide refer to study relevance and are not included here.

*Design and Objectives*

**Q3. Were concurrent comparison groups(s) used? (choose only one answer)**
Inadequate comparison groups, or not utilizing referents at all is an important problem, which may undermine the conclusions drawn from a study. Therefore, it is important for a study to provide adequate description of the types of comparison groups used, if any. Considering the importance of having a comparison group to document and account for the potential effects of unexpected secular changes, having a closely analogous referent group, with similar exposure to causal risk factors as the intervention subjects, is a major strength of a workplace intervention study.

**a) Yes; single referents**
One comparison group was used against which intervention's effect were evaluated.

OR

**b) Yes; multiple referents**
More than one comparison group was used to evaluate intervention's effects. Referents can be within the same plant (such as different departments), or outside the intervention plant (such as a similar company in the same industry, etc.) and may have received no interventions, or some interventions that differ from those of the study group.

OR

**c) Unclear**

OR

**d) No**
No concurrent comparison groups were used in this study.

**Q4. Were time-based comparisons used? (choose only one answer)**

**a) Yes; pre-post**

Evaluations of the intervention took place at two times points only – before (or at the beginning stages of the intervention) and after (or towards the end) the intervention**.**

OR

**b) Yes; pre-during-post**

Evaluations of the intervention were taken more than twice throughout the study – for example: before, during, and after the intervention. Also check this answer if there were multiple measurements taken during the intervention (such as monthly injury rates used).

OR

**c) Unclear**

OR

**d) No**

Evaluation took place at only one time point during the study, i.e. the study is cross-sectional.

**Q5. Was an intervention allocation described? (Check all that apply)**

Inadequate description of the exposure/intervention allocation strategy makes it impossible to reproduce the intervention in another population. This should be clearly stated in the study to allow for interventions to be reproducible by others. Effects of confounding may be reduced when participants are matched. However, random allocation of treatment/intervention conditions is the preferred scientific method as it is most likely to control for confounding.

**a) Yes; self-selection**

The study provides information on how the intervention was given to the participants. In this specific allocation strategy, the researchers normally do not have much control over who receives the intervention in the study, the allocation of the intervention is not random (not due to chance), therefore participants are self-selected. For example, in the case where all workplaces within a certain industry are targeted for interventions, all the eligible workplace are self selected to participate. This selection can occur at different levels, such as the plant, department, group, worker level, etc.

OR

**b) Yes; matched**

Intervention recipients were described as being matched based on certain criteria, such as based on belonging to a particular department within the plant or based on their work role function.

OR

**c) Yes; random**

Study participants are described as randomly receiving the intervention. Randomization of intervention conditions is typically preferred because it avoids systematic confounding by known and unknown factors.

d) **Unclear**
e) **No**

**Q6. Is the research question clearly stated?**
If the aim of the study is not clearly stated then results are likely of limited value. A clear, explicit statement of objectives should be included in the study.

a) **Yes**
b) **Unclear**
c) **No**

**Q7. Please indicate which levels of recruitment were described (check all that apply)**
Workplace intervention can typically occur at different levels. It is important to distinguish between the various levels so that results can be interpreted in relation to the level at which interventions were applied. Also, differences in recruitment strategies for individuals/groups/workplaces could led to differences in characteristics of the participants.

a) **Organizations/workplace**
b) **Department/supervisors**
c) **Employees/workers**
d) **Unclear**

*Level of Recruitment*

**Q8. Was recruitment rate reported and >40% (if yes then check all that apply)**
In relation to each of the levels of recruitment identified above, please indicate whether the number of eligible participants from the study population that refused to participate in the study are identified. Greater rate of participation (or recruitment) reduces non-response bias.

**Q9. Were characteristics at baseline described for (if yes, then check all that apply)**
a) **Organizations/workplace**
b) **Department/supervisors**
c) **Employees/workers**
d) **Unclear**

In relation to each of the levels of recruitment identified above, please indicate if baseline characteristics are described, these may include job related factors, individual characteristics, and factors related to exposures and outcomes (for example baseline pain levels across groups).

**Q10. Were there any differences across groups at baseline for (if yes then check all that apply)**

e) **Organizations/workplace**
f) **Department/supervisors**
g) **Employees/workers**
h) **Unclear**

If there are no major significant differences between the groups on baseline characteristics or other demographic variables, one can be confident that selection bias to participate in the study was minimal and that the results obtained are not likely affected by these differences.

**Q11. Was the loss to follow up <50% for (if yes then check all that apply)**

a) **Organizations/workplace**
b) **Department/supervisors**
c) **Employees/workers**
d) **Unclear**

There should be adequate follow up rate for each of the levels of recruitment identified above. If the lost to follow up is substantial, it introduces the potential for exclusion bias, reduces the available sample size, and reduces the confidence in the results obtained.

**Q12. Were there any important differences between remaining and drop out participants for (check all that apply)**

a) **Organizations/workplace**
b) **Department/supervisors**
c) **Employees/workers**
d) **Unclear**
e) **No**

Differential attrition of subjects poses a major threat to internal validity. Exclusion bias can result if certain subjects are systematically more likely to be lost to follow-up than others. Comparisons should be made for drop-outs and remaining participants on baseline characteristics or other demographic variables, as available. When there are no statistical differences between these groups, one can be more confident that attrition bias did not occur.

*Intervention*

**Q13. Was the intervention process described?**
Inadequate description of the intervention strategy makes it impossible to reproduce the intervention in another population. The setting of the intervention, i.e. where it was carried out, and specifically what was changed and how, are important aspects to document.

**a) Yes**
All or most aspects of the intervention are clearly described.

OR

**b) Unclear**
There is not enough information provided, the intervention process is not clearly described.

OR

**c) No**
The intervention process is not described.

**Q14. Was training/education in ergonomics provided?**
Providing knowledge in ergonomics through training is a key part of the participatory approach. This training allows the intervention group to effectively identify and deal with ergonomic hazards in the workplace.

**a) Yes**
**b) Unclear**
**c) No**

**Q15. Which workplace parties were involved in decisions around changes? (check all that apply)**
The level of workplace involvement is a very important aspect determining how truly participatory the intervention process is. Involvement can be through representatives, and not necessarily direct.

**a) Management**
**b) Supervisors**
**c) Workers**
**d) Unclear**
**e) No**

*Intensity of the Intervention*

**Q16. Was the participation in the intervention documented?**
Examining the intensity with which the intervention is implemented within the organization is an important part of an evaluation, which has not been extensively documented in the literature. In the case of a participatory ergonomics program, one way the intensity of an intervention can be assessed is by looking at the extent to which the workplace parties actually participate in the intervention process. An intervention that supposedly uses participatory techniques but fails to achieve significant participation of the relevant stakeholders, may undermine the results and conclusion drawn from a study.

a) **Yes**
b) **Unclear**
c) **No**

**Q17. Were changes resulting from the intervention documented?**
Another way the intensity of an intervention can be assessed is by looking at the extent to which ergonomic changes were actually implemented as a result of the intervention process. For this reason documenting the changes is of key importance, particularly if one wishes to understand the pathway leading from the intervention to changes in health outcomes.

a) **Yes**
b) **Unclear**
c) **No**

**Q18. Was the calendar duration of the intervention documented?**
The calendar duration refers to the number of months or years over which the intervention took place. The duration of the intervention is an important aspect to document. Interventions of short duration (i.e. a couple of months) could have insufficient time between evaluations to allow for the changes to exert their effects particularly with respect to musculoskeletal health outcomes that take a long time to develop. Conversely, interventions that take too long (i.e. 5 yrs) may also hinder the evaluation. As workplaces are dynamic environments and many other changes may have taken place during that period of time, other than the intervention itself, which can confound the results.

a) **Yes**
b) **Unclear**
c) **No**

**Q19. Were the issues of co-intervention addressed in this study?**
Co-interventions are any other changes either deliberately or inadvertently applied to study participants, such as an introduction of a lifting device that was not documented as part of an intervention. Effects that are in fact due to co-interventions may be falsely attributed to the intervention. If co-interventions were disproportionately taken by one group but not the other, then the observed effect cannot be easily ascribed to the tested intervention.

a) **Yes**
b) **Unclear**
c) **No**

**Q20. Was contamination between groups described or documented (please select not applicable if there were no referent workplaces or groups in this study).**
Contamination can occur when the interventions assigned to participants in one group are also used by some or all members of the other groups. This can introduce bias in the results if comparison groups, for example, have been exposed to some of the interventions intended for the study group, unbeknownst to the researchers. This is an issue particularly when a study uses controls from the same workplace as the intervention group.

a) **Yes**
b) **Unclear**
c) **No**
d) **Not applicable**

*Risk Factors*

**Q21. Were sources of risk factors/exposures for musculoskeletal disorders measured? (if described but not measured then please answer no).**
Documentation of risk factors for musculoskeletal disorders can include the following physical factors: time spent in awkward postures, number of lifts performed, magnitude of force applied, time spent doing repetitive tasks, etc. Psychosocial and organizational risk factors can include: social support, job satisfaction, control over one's job, etc. As changes in exposures are believed to be on the pathway leading to changes in health outcomes, if no changes in risk factors occur, this can provide important information regarding why health outcomes have or have not changed.

a) **Yes**
b) **Unclear**
c) **No**

**Q22. When were risk factors measured?**

**a) Baseline**
Risk factors were assessed before the intervention took place (or at the beginning stages of the intervention).
**b) Follow up**
Risk factors were measured after (or towards the end) the intervention.
**c) Unsure**
**d) Not measured**

*Health Outcomes*

**Q23. Were health outcomes measured?**
Refer to the list of health outcomes in the inclusions and exclusions table in the relevance for review section above.

**a) Yes**
**b) Unclear**
**c) No**

**Q24. When were health outcomes measured? (check all that apply)**

**e) Baseline**
Outcomes were assessed before the intervention took place (or at the beginning stages of the intervention).
**f) Follow up**
Outcomes were measured after (or towards the end) the intervention**.**
**g) Unsure**
**h) Not measured**

*Potential Confounders*

**Q25. Were potential confounders/effect modifiers measured?**
A confounder is a variable which is independently related to the exposure (the intervention) and the health outcome (e.g. injury rates ). Effect modifiers are variables that modify the association between exposures and outcomes. Potential confounders/effect modifiers relevant to this study could be: age, sex, years employed, work load, work role function, prior history of injury, psychosocial factors, etc. It is extremely important to measure potential confounders as they could mask any true associations that may be present in a given study.

**a) Yes**
**b) Unsure**
**c) No**
**d) Not applicable**

**Q26. When were potential confounders/effect modifiers measured?**

**a) Baseline**
confounders/effect modifiers were assessed before the intervention took place (or at the beginning stages of the intervention).
**b) Follow up**
confounders/effect modifiers were measured after (or towards the end) the intervention.
**c) Unsure**
**d) Not measured**

*Analysis*

**Q27. Were the statistical analyses appropriate to the study design?**

**a) Yes**
Statistical methods are described sufficiently, and the methods used were appropriate and properly applied.
**b) Unclear**
**c) No**

**Q28. Was there adjustment for relevant baseline differences?**
Statistical adjustment allows the researchers to control for factors that may potentially confound the relationship between the exposure and outcome. Possible adjustment methods include stratifying based on the difference (for example if sex is different one can do separate analyses for males and females). Another method is including the variable in the statistical model, this does not allow for the variable to vary, which eliminates its effect on the association of interest.

**a) Yes**
Baseline differences were observed and adjusted for
**b) Unclear**
**c) No**
Baseline differences were observed but not adjusted for
**d) Not applicable**
There were no baseline differences observed so adjustment was not needed

**Q29. Was there adjustment for other potential confounders?**
Similar principles apply as in the previous question.

**a) Yes**
**b) Unclear**
**c) No**

**Q30. Are there other primary studies listed in this reference list which should be retrieved for consideration? (if yes, please include reference ID or author/year/publication etc.)**
It is important to look in the reference section of relevant studies because usually other studies that may be of potential use for this review are cited, which could have been missed in our search strategy.

a) **Yes**
b) **No**

**Q31. Are there other review studies listed in this reference list which should be retrieved for consideration? (if yes, please include reference ID or author/year/publication etc.)**
Same as above.

a) **Yes**
b) **No**

**Q32. How confident are you (as a reviewer) that the reported effects are attributable to the intervention? (If unconfident, summarize the issues or concerns with the scientific credibility of the paper)**
Using all the information you have gathered on the article and after critically appraising its quality, please assess how confident you are that the results are valid, reliable, and that bias in the results was minimal. If certain issues pertaining to the study quality have reduced your confidence in the results, please summarize these in the space provided.

a) **Very confident**
b) **Relatively confident**
c) **Relatively not confident**
d) **Not at all confident**

**Q33. Should this reference proceed to data extraction? Why?**

a) **Yes**
b) **No**

## Appendix M.4: Instructions for Data Extraction

**Study characteristics**

**Refid/Author –** List all the authors for the article. If multiple publications were used for data extraction (DE), list only the authors for the primary study, or if no primary study was identified, then the study that appeared first chronologically. Similar to what was done in quality appraisal.

**Year/ Jurisdiction –** Write the year of publication, followed by whatever information is available regarding the country, region, province, city, etc. where the study was carried out.

**Industry/Sector –** Describe the industry and classify the study into one of the following sectors: Manufacturing, Auto, Steel, Service, Education, Municipal, Health Care, Transportation, Chemical, Electrical, Food, Construction, Agriculture, Forestry, Mining, Pulp & Paper, Unknown or Missing, Other (please specify).

**Study Design –** Refer to Zaza study design classification tool (74).

**Participants (Intervention / Referent) –** For each of the groups involved i.e. intervention and referent (if available), list participants' characteristics including the sample size (n), demographics (mean, standard deviation), names of departments, type of work done, etc. Classify the information into three levels as follows:
Organization –
Department –
Employee –

**Follow Up –** Indicate the duration of the intervention (the number of months over which the intervention took place) and the follow up i.e. when measurements were taken. Use months to indicate the length of follow up. For example: "The intervention period lasted for 2 yrs. Questionnaires were administered at 6, 12, and 18 months".

**Co-intervention(s) -** Co-interventions are any other changes either deliberately or inadvertently applied to study participants or referents. Examples would be major renovations, changes in production processes, lifting assists, additional training, major turnover/drop out, etc. that are not planned as part of the participatory ergonomic process but could nonetheless have an effect, either positive or negative, on intervention's effectiveness.

**Facilitators/barriers –** Briefly describe what factors were mentioned, if any, that either facilitated or hindered the intervention process. Avoid making judgements, or statements that are not explicitly expressed in the article itself. Classify the information into two categories as follows:

Facilitators –
Barriers –

**Reviewers –** Write down the names of both reviewers that are responsible for doing DE for the particular article.

**Intervention components from PEF framework and other components relevant for the review.**

*Text in the following text boxes are explanations of intervention's dimensions directly from Haines et al. (2002) p. 310-313*

| **Dimension 1: Permanence of initiative** |
| --- |
| The first dimension considers the permanence of participatory ergonomics within an organization. Participatory ergonomics mechanisms may function on a temporary basis and may take place outside the normal organizational structures. Alternatively, ongoing participatory mechanisms may be developed which may well be much more integrated into the structure of the organization.<br><br>Categories for permanence: **Temporary – Ongoing** |
| **Dimension 2: Involvement** |
| The second dimension of participatory ergonomics considers whether people participate directly or indirectly (via representatives). Cotton (1993) refers to work by Dachler and Wilpert (1978) in which direct involvement is seen as `immediate personal involvement of organizational members' (p. 12) Cotton goes on to describe this as `typically face-to-face involvement where workers can have an immediate and personal impact' and contrasts this with indirect involvement which `incorporates some type of employee representation in which, rather than the employee interacting, his or her representative is involved' (p. 28). Liker et al. (1989) used the distinction between direct and representative participation coined by Coch and French (1948) `Direct participation means each employee participates directly in decisions about their own work. Representative participation means that employee representatives are selected to represent the viewpoints of a large number of workers' (Liker et al. 1989: 187). Examples of both direct and representative participation may be found in the participatory ergonomics literature. In developing this framework, it was important to look more closely at how the term representative may be interpreted. There seems to be two possible meanings. On the one hand, representatives may allow a wider group to participate by proxy (as in the case of elected representatives). Alternatively, representatives may not set out to actively represent the views of others, but instead participate because they represent a typical subset of a larger group. To recognize this latter form of representation a category has been introduced into this dimension, termed `partial direct participation'.<br><br>Categories for involvement: **Full Direct - Direct Representative – Delegated** |

**Dimension 3: Level of influence**

A further dimension considers the organizational level at which participatory ergonomics takes place. There are mechanisms that operate at the level of a particular department or work group, and there are cross-organization mechanisms.

Categories for level of influence: **Group of Organizations - Entire Organization - Department/Work Group**

**Dimension 4: Decision-making power**

The fourth dimension of participatory ergonomics considers the question: who has the power to make decisions? This is an important consideration as, although employees are frequently asked to express their views, in many participatory ergonomics initiatives the authority to make decisions still remains with someone other than the participants. To clarify this, the framework makes the distinction between consultative participation and delegative participation which has been used by (amongst others) the European Foundation for the Improvement of Living and Working Conditions, as follows: consultative participation - management encourages employees to make their views known on work-related matters, but retains the right to take action or not. Delegative participation - management gives employees increased discretion and responsibility to organize their jobs without reference back.

Categories for decision-making power: **Group Delegation - Group Consultation /- Individual Consultation**

**Dimension 5: Composition**

The fifth dimension considers the occupational groups involved in the participatory process, and is self-explanatory.

Categories for composition: **Operators - Line Management (Supervisors) - Senior Management - Internal specialist/ Technical Staff - Union - External Advisor - Supplier/Purchaser - Cross-Industry Organization**

**Dimension 6: Requirement**

The sixth dimension of participatory ergonomics concerns the requirement for participation: is it voluntary or compulsory? Although, in some cases, participation will be entirely voluntary, some participatory ergonomics mechanisms such as quality circles or production groups require involvement in troubleshooting and continuous improvement as a part of the job specifications.

Categories for requirement: **Compulsory / Voluntary**

**Dimension 7: Focus**

The next dimension identifies the topics addressed by participants, and is self explanatory.

Categories for focus: **Physical design/ Specification of Equipment/ Workplaces/ Work tasks - Design of Job Teams or Work Organization - Formulation of Policies or Strategies**

| Dimension 8: Remit |
| --- |
| The eighth dimension of participatory ergonomics describes the broad activities that fall within participants' remit, and by extension how extensive is their involvement in the change process. Process development refers to being involved in setting up or structuring the participatory process. Process maintenance refers to any involvement in monitoring or overseeing the progress of the initiative. Involvement in problem identification, solution generation and evaluation, if this is on-going, means being part of a continuous improvement process.<br><br>Categories for remit: **Problems Identification - Solution Development - Implementation of change - Set-up/ Structure Process - Monitor/ Oversee Process** |
| **Dimension 9: Role of 'ergonomics specialist'** |
| The final dimension describes the nature of ergonomists' involvement in a participatory process. Many participatory ergonomics initiatives will involve an 'ergonomics specialist', although the roles they play in the process may differ and can evolve over time.<br><br>Categories for role of specialist: **Initiates and Guides Process - Acts as Expert - Trains Members - Available for Consultation - Not Involved** |

## Other components of the intervention

**Training in Ergonomics –** Describe the characteristics of the training that was provided to the intervention participants, if any. This refers to the general ergonomic training that is provided to workers, as per the requirements for participatory ergonomics. That is the participants must have knowledge (i.e. general ergonomic principles, hazard identification and control, etc.) to make informed decisions regarding what changes to implement in the workplace. The following questions are to be answered with regards to training in ergonomics:

**Who Provided the Training?** – self explanatory
**Who Received the Training?** – i.e. who attended the training sessions
**What was the Nature of the Training?** – i.e. describe what was taught to the participants
**How Long did the Training Last for?** – i.e. how many sessions, how long did each session last (hrs), over how many days, etc.

**Intervention Duration –**
**What was the Calendar Duration of the Intervention?** – in months
**How Often did the Change Team Meet?** – if a change team was present (i.e. the group of people responsible for identifying and implementing changes), describe how many sessions the team had, over what period of time, etc.
**How Long did Each Meeting Last?** – refers to the duration of the change team meetings

**Ergonomic Changes**

Mark all the ergonomic changes that were identified (but not implemented) and those that were actually implemented in the study. If desired provide brief explanations for specific changes (optional).

**Additional Study summary details**

**Risk Factors Considered** – list all the risk factors considered in the study this may include physical factors like forces and movements, body postures, work load, and psychosocial factors, such as job satisfaction, and job influence. Risk factors, in epidemiological terms would be mediating variables, i.e. those factors that are conceptualized to be on the pathway between the exposure (the intervention) and outcome.

**Confounding Variables Considered** - list all the risk factors considered in the study (even if the authors do not control for these confounders, but have considered them, then include them here as well). A confounder is a variable which is independently related to the exposure (the intervention) and the health outcome (e.g. injury rates). Confounders are different from risk factors because they must not be on the causal pathway between exposure and outcome. This may include age, sex, duration employed, and previous history of injury.

**Health Outcomes** – List all the outcomes documented in the study. Number each of the outcomes i.e. 1), 2), etc. For example outcomes may include:

1) Injury rates
2) Accident or first aid rates
3) MSK pain or MSK symptoms
4) Absenteeism
5) Sick leave
6) Work function (Amick, DASH, Roland, etc.)

**Other Outcomes** – Other outcomes may include productivity measures, or any other outcomes that are not intermediate and not health outcomes.

**Statistical Analyses** – Describe what statistical analyses were used.

**Findings** – Referring back to the outcomes in the previous column, describe for each what were the results obtained. Use the same numbers to refer to each outcome as in the preceding column. Be brief and concise.

**Other Finding** – List the findings for the other outcomes
**Reviewers** – Write down the names of both reviewers that are responsible for doing DE for the particular article.

## Appendix M.6: Studies that Proceeded to Quality Appraisal and Data Extraction

**List of studies proceeding to Data Extraction (n=10)**

Carrivick PJ, Lee AH, Yau KK. Consultative team to assess manual handling and reduce the risk of occupational injury. Occupational and Environmental Medicine. 2001;58(5):339-44.

> **Related Articles**
> Carrivick PJW, Lee AH, Yau KKW. Effectiveness of a participatory workplace risk assessment team in reducing the risk and severity of musculoskeletal injury. Journal of Occupational Health. 2002;44(4):221-225.
>
> Carrivick PJW, Lee, AH, Yau KKW. Effectiveness of a workplace risk assessment team in reducing the rate, cost, and duration of occupational injury. Journal of Occupational & Environmental Medicine. 2002;44(2):155-159.
>
> Carrivick, PJW, Lee AH, Yau KKW. Zero-inflated Poisson modeling to evaluate occupational safety interventions. Safety Science. 2003;41(1):53-63.

Evanoff BA, Bohr PC, Wolf LD. Effects of a participatory ergonomics team among hospital orderlies. Americal Journal of Industrial Medicine. 1999;35(4):358-65.

> **Related Article**
> Bohr PC, Evanoff BA, Wolf LD. Implementing participatory ergonomics teams among health care workers, American Journal of Industrial Medicine. 1997;32(3):190 – 196.

Halpern CA, Dawson KD. Design and implementation of a participatory ergonomics program for machine sewing tasks. International Journal of Industrial Ergonomics. 1997;20:429-40.

Ketola R, Toivonen R, Hakkanen M, Luukkonen R, Takala EP, Viikari-Juntura E, Expert Group in Ergonomics. Effects of ergonomic intervention in work with video display units. Scandinavian Journal of Work, Environment and Health. 2002;28(1):18-24.

Laitinen H, Saari J, Kuusela J. Initiating an innovative change process for improved working conditions and ergonomics with participation and performance feedback: A case study in an engineering workshop. International Journal of Industrial Ergonomics. 1997;19:299-305.

> **Related Article**

Laitinen H, Saari J, Kivisto M, Rasa PL. Improving physical and psychosocial working conditions through a participatory ergonomic process: A before-after study at an engineering workshop. International Journal of Industrial Ergonomics. 1997;21(1):35-45.

Lanoie P, Tavenas, S. Costs and benefits of preventing workplace accidents: The case of participatory ergonomics. Safety Science. 1996;24(3):181-96.

Moore JS, Garg A. The effectiveness of participatory ergonomics in the red meat packing industry. Evaluation of a corporation. International Journal of Industrial Ergonomics. 1998;21:47-58.

**Related Articles**

Moore JS, Garg A. Participatory ergonomics in a red meat packing plant, Part I: evidence of long-term effectiveness. American Industrial Hygiene Association Journal. 1997;58(2):127-131.

Moore JS, Garg A. Participatory ergonomics in a red meat packing plant part II: case studies. American Industrial Hygiene Association Journal. 1997;58(7):498-508.

Moore JS, Garg A. Participatory ergonomics in the red meat packing industry: a case study of a corporation and a plant. Cincinnati: National Institute for Occupational Safety and Health, 1994.

Morken T, Moen B, Riise T, Hauge SHV, Holien S, Langedrag A, et al. Effects of a training program to improve musculoskeletal health among industrial workers – effects of supervisors role in the intervention. International Journal of Industrial Ergonomics. 2002;20:115-27.

Reynolds JL, Drury CG, Broderick RL. A field methodology for the control of musculoskeletal injuries. Applied Ergonomics. 1994;25(1):3-16.

Wickström G, Hyytiainen H, Laine M, Pentti J, Selonen R. A five-year intervention study to reduce low back disorders in the metal industry. International Journal of Industrial Ergonomics. 1993;12:25-33.

**List of studies not proceeding to Data Extraction (n=13)**

Bohr PC. Efficacy of office ergonomics education. Journal of Occupatioanl Rehabilitation. 2000;10(4):243-55.

Brenner S, Ostberg O. Working conditions and environment after a participative office automation project. International Journal of Industrial Ergonomics. 1995;15:379-87.

Collins M. A comprehensive approach to preventing occupational back pain among nurses. Journal of Occupational Health and Safety. 1990;6(5):361-8.

Haims MC, Carayon P. Theory and practice for the implementation of 'in-house', continuous improvement participatory ergonomic programs. Applied Ergonomics. 1998;29(6):461-72.

Herbert R, Dropkin J, Warren N, Sivin D, Doucette J, Kellogg L, et al. Impact of a joint labor-management ergonomics program on upper extremity musculoskeletal symptoms among garment workers. Applied Ergonomics. 2001;32(5):453-60.

Joseph BS. Corporate ergonomics programme at Ford Motor Company. Applied Ergonomics. 2003;34(1):23-8.

Maciel R. Participatory ergonomics and organizational change. International Journal of Industrial Ergonomics. 1998;22:319-25.

Marcal MA, Mazzoni CF. A participatory ergonomic training program for preventing low back pain. In: Das B, Karwowski W, editors. Advances in occupational ergonomics and safety II. Washington D.C.: IOS Press and Ohmsha; 1997. p. 443-6.

Moore SJ. Flywheel truing – A case study of an ergonomic intervention. American Journal of Industrial Hygiene Association Journal. 1994;55(3):236

Simon SI, Leik M. Breaking the safety barrier: Implementing culture change. Professional Safety. 1999;44(3):20-5.

Udo H. Yoshinaga F. The role of the industrial medical doctor in planning and implementing ergonomic measures at workplaces. International Journal of Industrial Ergonomics. 2001;28:237-46.

Vink P, Peeters M, Grundemann RMW, Smulders PGW, Kompier MAJ, Dul J. A participatory ergonomics approach to reduce mental and physical workload. International Journal of Industrial Ergonomics. 1995;15:389-96.

Vink P, Urlings IJM, van der Molen HF. A participatory ergonomics approach to redesign work of scaffolders. Safety Science. 1997;26(1/2):75-85.

# Appendix F 3: Quality Appraisal of Studies

## Study Profiles for the 10 DE studies

**Study:** Carrivick, P. J. W., Lee, A. H., and Yau, K. K. W., Consultative team to assess manual handling and reduce the risk of occupational injury, Occupational and Environmental Medicine. 2001; 58(5): 39-344.

**Supplemental studies:**
Carrivick, P. J. W., Lee, A. H., and Yau, K. K. W., Effectiveness of a workplace risk assessment team in reducing the rate, cost, and duration of occupational injury. J Occup Environ Med. 2002; 44(2): 155-159.
Carrivick, P. J. W., Lee, A. H., and Yau, K. K. W., Effectiveness of a participatory workplace risk assessment team in reducing the risk and severity of musculoskeletal . J Occup Health. 2002; 44(2): 221-225.
Carrivick, P. J. W., Lee, A. H., and Yau, K. K. W., Zero-inflated poisson modeling to evaluate occupational safety interventions. Safety Science. 2003; 41: 53-63.

| **Research Question:** | |
|---|---|
| To describe the formation of a consultative team to assess the risk of manual handling in the workplace … and to evaluate the effectiveness of its recommendations in reducing the rate a severity of workers' compensation injury. | |
| **Study Characteristics:** | |
| Study Design: | Pre-post with 3 comparison groups |
| Jurisdiction | Victoria, Australia |
| Industry / sector | Healthcare – hospital workers |
| Length of Follow-up | 36 months<br>Intervention commenced in 1992, both cleaners (intervention group) and orderlies (control group) were observed for 36 months prospectively. In addition, data were retrieved back 52 months to 1988. |
| **Participant Characteristics:** | |
| Intervention: | For primary study: Study hospital: 1) Cleaners, mean n=145 (507 total), 65% female.<br><br>Mean age in both cleaner and orderly groups = 37 years |
| Referent: | 1) Orderlies from same hospital, mean n=140 (279 total), 5% female, mean age 37years.<br>2) Cleaners from another hospital within the same city (n=not reported, no demographics)<br>3) State level data on all hospital cleaners (n=not reported, no demographics) |

| | |
|---|---|
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | Risk factors checklist used to assess:<br>- actions and movements<br>- workplace and workstation layout<br>- working posture and position<br>- duration and frequency of manual handling<br>- location and distance of loads moved<br>- weight and forces<br>- characteristics of loads and equipment<br>- work organization<br>- work environment<br>- skills and experience<br>- age and clothing |
| Co-interventions | None reported |
| Confounders | Age, gender, hours worked, days of work experience |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☐ Ongoing |
| | ☒ Temporary |
| Involvement | ☐ Full Direct |
| | ☒ Direct Representative |
| | ☐ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☐ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☐ Group Delegation |
| | ☒ Group Consultation |
| | ☐ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☒ Line Management (Supervisors) |
| | ☐ Senior Management |
| | ☒ Internal specialist/ Technical Staff |
| | ☐ Union |
| | ☐ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☒ Compulsory |
| | ☐ Voluntary |

| | | |
|---|---|---|
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks | |
| | ☒ Design of Job Teams or Work Organization | |
| | ☒ Formulation of Policies or Strategies | |
| Remit | ☒ Problems Identification | |
| | ☒ Solution Development | |
| | ☒ Implementation of change | |
| | ☐ Set-up/ Structure Process | |
| | ☐ Monitor/ Oversee Process | |
| Role of Ergonomic Specialist | ☐ Initiates and Guides Process | |
| | ☒ Acts as Expert | |
| | ☒ Trains Members | |
| | ☒ Available for Consultation | |
| | ☐ Not Involved | |
| **2. Ergonomic Training.** | | |
| Trainer | Hospital ergonomist | |
| Trainee(s) | Cleaners selected by management based on their commitment to safety, familiarity with duties, physical environments, equipment, and policies/procedures related to the work of cleaners (Eight people were on the team not including ergonomist) | |
| Description | Training covered principles of safe manual handling, and identification, assessment and control of hazards | |
| Length | Three 2hr sessions | |
| **3. Intervention Duration.** | | |
| Calendar duration | 36 months (Nov 1992 to Oct 1995) | |
| Meeting frequency | Bi-monthly for 3 years | |
| Meeting length | Approximately 1 hour each | |
| **Ergonomic changes (identified or implemented):** | | |
| ☒ Physical design or specification of: | ☒ Equipment | ☒ Redesign existing work tools/equipment |
| | | ☐ Purchase new work tools/equipment (other than PPE) |
| | | ☐ Introduce person protective equipment (PPE) |
| | | ☐ Introduce mechanical assists |
| | ☒ Workplaces | ☐ Ergonomic redesign of workstation |
| | | ☐ Improve housekeeping |
| | | ☒ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☒ Work tasks | ☒ Altering work duties / job sharing |

| | |
|---|---|
| ☐ Design of job teams and work organization | ☐ Altering production processes |
| | ☐ Job rotation / scheduling changes / job breaks |
| ☒ Formulation of policies or strategies | ☒ Purchasing criteria were changed |
| ☒ Training for specific techniques/ tasks | ☒ Safe manual handling training (also training on floor buffing) |
| ☐ Other | ☐ |
| **Outcomes:** | |
| ☐ MSK Symptoms/ Pain | |
| ☒ Injury/ Claims Records | 2) Lost time injury & Frequency (lost time injury per hours worked)<br>3) Lost time duration & Duration rate |
| ☐ Sick Leave/ Lost Workdays | |
| ☐ Other(s) | |
| **Statistical Analyses:** | |
| Descriptive statistics, relation of time between implementation of recommendations and number of injuries. Univariate analyses and Generalized Linear Models (controlling for confounders) | |
| **Results:** | |
| ☐ MSK Symptoms/ Pain | |
| ☒ Injury/ Claims Records | 1) The intervention group experienced 59 LTI (46 MSK, 13 NMSK) in the 4.25 yrs pre-intervention period and 15 LTI (11 MSK, 4 NMSK) in the 3 yr post intervention period. OR for frequency rate of LTI = 0.353 (significantly different from 0) for cleaners and OR=1.536 (significantly different from 0) for orderlies.<br>2) Duration rate of LTI OR=0.573 (not significantly different from 0) for cleaners and OR=2.361 (significantly different from 0) for orderlies. |
| ☐ Sick Leave/ Lost Workdays | |
| ☒ Other(s) | Claims cost rate for cleaners decreased significantly OR=0.275, however for orderlies costs increased significantly OR=2.68 (significantly different from 0). |
| **Facilitators/ Barriers:** | |
| Facilitators | Large reduction in number of injuries was contributed to by a fall in risks of both manual handling and other injuries. Despite focus on manual handling, many other hazards were considered concurrently by the team. |
| Barriers | Intervention group membership was dynamic (i.e. high turnover) |
| **IWH Reviewers' Comments: (design issues, stats, power etc?)** | |
| Well done quasi-experimental study and generally well reported. Better reporting of the sample size and descriptives for the control groups along with some discussion of possible co-interventions would have strengthened this medium quality study. | |

**Study:** Evanoff BA, Bohr PC, Wolf LD. Effects of a participatory ergonomics team among hospital orderlies, American Journal of Industrial Medicine. 1999; 35(4):358-365.

**Supplemental Study:**
Bohr PC, Evanoff BA, Wolf LD. Implementing participatory ergonomics teams among health care workers, American Journal of Industrial Medicine. 1997;32(3):190 – 196.

| **Research Question:** | |
|---|---|
| To determine if the implementation of a PE team among hospital orderlies would result in lower rates of injury, lost time, and musculoskeletal symptoms. | |
| **Study Characteristics:** | |
| Study Design: | Before-During-Post<br>referred to as "prospective intervention trial"<br>Does not fit into Zaza nicely |
| Jurisdiction | 1999/St. Louis, Missouri, USA |
| Industry / sector | Health Care |
| Length of Follow-up | 24 months for OSHA 200 log and WC injuries and costs during the intervention.<br>Repeat questionnaires 1, 7 & 15 months following intervention. |
| **Participant Characteristics:** | |
| Intervention: | Department:<br>Central Dispatch Office, 100-111 orderlies<br>Employee:<br>67 pre, 88 post, 27 of these in both |
| Referent: | Same hospital ICU nurses, n=50 and Lab workers, n=450<br>Other hospital n=? |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | 1) Job satisfaction<br>2) Psychosocial stressors<br>3) Social support among co-workers (work apgar) |
| Co-interventions | Orderly turnover with 65 of original group of 99 leaving before 15 month survey. Parallel formation of Employee-Management Advisory Teams in two other departments (ICU & Laboratory) but less complete and later implementation and sharing of lifting training manual with nursing supervisors could affect |
| Confounders | None |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☒ Ongoing |
| | ☐ Temporary |
| Involvement | ☐ Full Direct |
| | ☒ Direct Representative |
| | ☐ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☐ Entire Organization |

| | |
|---|---|
| | ☒ Department/Work Group |
| Decision Making | ☐ Group Delegation |
| | ☒ Group Consultation |
| | ☐ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☒ Line Management (Supervisors) |
| | ☐ Senior Management |
| | ☐ Internal specialist/ Technical Staff |
| | ☐ Union |
| | ☒ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☐ Compulsory |
| | ☒ Voluntary |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☒ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☐ Set-up/ Structure Process |
| | ☐ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☐ Initiates and Guides Process |
| | ☐ Acts as Expert |
| | ☒ Trains Members |
| | ☒ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | The occupational therapist/co-investigator provided the training |
| Trainee(s) | Employees and supervisors making up the Employee-Management Advisory Team |
| Description | Included:<br>team-building, basic technical info on hazard identification and control, exercises in observation and measurement, procedural and logistic implementation information. |
| Length | one 8 hr session |

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| **3. Intervention Duration.** | | |
| Calendar duration | 2 years | |
| Meeting frequency | EMAT team met weekly for a period and then less frequently | |
| Meeting length | Approximately one hour? | |
| **Ergonomic changes (identified or implemented):** | | |
| ☒ Physical design or specification of: | ☒ Equipment | ☐ Redesign existing work tools/equipment |
| | | ☒ Purchase new work tools/equipment (other than PPE) |
| | | ☐ Introduce person protective equipment (PPE) |
| | | ☒ Introduce mechanical assists |
| | ☐ Workplaces | ☐ Ergonomic redesign of workstation |
| | | ☐ Improve housekeeping |
| | | ☐ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☐ Work tasks | ☐ Altering work duties / job sharing |
| ☐ Design of job teams and work organization | ☐ Altering production processes | |
| | ☐ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ | |
| ☒ Training for specific techniques/ tasks | ☒ training in use of standardized lifting techniques | |
| ☒ Other | ☒ Improved maintenance procedures for existing equipment | |
| **Outcomes:** | | |
| ☒ MSK Symptoms/ Pain | Symptom survey (orderlies) (1=uncomfortable to 5=comfortable) | |
| ☒ Injury/ Claims Records | OSHA 200 log. (Orderlies vs. all hospital staff) | |
| ☒ Sick Leave/ Lost Workdays | Worker Comp records (Orderlies vs. all hospital staff) | |
| ☒ Other(s) | Workers' Compensation costs | |
| **Statistical Analyses:** | | |
| McNemar & Chi Square test for paired and unpaired dichotomous data and Wilcoxon paired sign rank test and Wilcoxon rank sum for paired and unpaired ordinal data.<br>Rate ratios with confidence intervals for injury and lost day rates<br>Unpaired t-test for workers comp costs | | |
| **Results:** | | |
| ☒ MSK Symptoms/ Pain | 1) Proportion of workers reporting symptoms decreased with improvements in A) job satisfaction ($p<0.01$), B) perceived psychosocial stressors ($p<0.01$), and C) social support among co-workers ($p<0.05$). | |
| ☒ Injury/ Claims Records | Decreased risks of work injury (RR=0.50, 95% CI 0.35-0.72), | |

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| ☒ Sick Leave/ Lost Workdays | Decreased lost time injury (RR=0.26, 95% CI 0.14-0.48), and injury with 3 or more days of time loss (RR=0.19, 95% CI 0.07-0.53). Total lost days declined from 136.2 to 23.0 annually per 100 FTE. |
| ☒ Other(s) | Decreased WC costs/employee by 41%. Estimated WC savings at US$22,758 versus intervention costs of $5000. |
| **Facilitators/ Barriers:** | |
| Facilitators | Orderlies' active role in developing standardized lifting procedures and mandatory training materials, coalescing as team, protected time and efficient management of time. |
| Barriers | Time pressures on personnel, hospital structure for accessing equipment and needed personnel |
| **IWH Reviewers' Comments:** | |
| Good single workplace study with multiple health outcome measures used. Less on risk reduction than some other studies. Adjustments for baseline differences between groups and consideration of potential confounders would have strengthened this medium quality study. | |

**Study:** Halpern CA & Dawson KD. Design and implementation of a partcipatory ergonomics program for machine sewing tasks. International Jouranl of Industrial Ergonomics. 1997;20:429-440.

| **Research Question:** | |
|---|---|
| To evaluate the effect of a participatory ergonomics intervention on the long-term musculoskeletal and financial outcomes within an automobile manufacturing machine sewing department. | |
| **Study Characteristics:** | |
| Study Design: | Before-after |
| Jurisdiction | Colorado, USA |
| Industry / sector | Auto accessories/ Manufacturing |
| Length of Follow-up | 36 months (WC claims) |
| **Participant Characteristics:** | |
| Intervention: | Organization: Automotive accessory manufacturing company.<br>Department: Sewing department targeted for intervention based on high WC rates. Work involves specific, repetitive tasks in assembly line - attaching zippers and support binding and other sub-assemblies (such as poly-carbonate glass and structural steel) to canvas pieces.<br>Employee: Sewers, n=250 |
| Referent: | All departments workers (including sewers, glass, manufacturing and 'other' departments), n=~700 |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | Hazard intervention and abatement strategies identified:<br>- Posture,<br>- Forces,<br>- Repetitions, such as: excessive reaching, twisting and bending, forceful pinching and gripping, awkward hand postures when cutting |
| Co-interventions | Medical and claims management program initiated at same time (involved stretching to provide breaks in repetitive tasks, and modified RTW program) |
| Confounders | None. |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☒ Ongoing |
| | ☐ Temporary |
| Involvement | ☐ Full Direct |
| | ☒ Direct Representative |
| | ☐ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☐ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☐ Group Delegation |
| | ☒ Group Consultation |

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|---|---|
| | ☐ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☒ Line Management (Supervisors) |
| | ☒ Senior Management |
| | ☒ Internal specialist/ Technical Staff |
| | ☐ Union |
| | ☒ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☒ Compulsory |
| | ☐ Voluntary |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☒ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☒ Set-up/ Structure Process |
| | ☒ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☐ Initiates and Guides Process |
| | ☒ Acts as Expert |
| | ☒ Trains Members |
| | ☐ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | Insurance Management Associates (IMA) consulting ergonomist |
| Trainee(s) | 1) Ergonomics education to the Participatory Ergonomics sub-committee which was called the 'Analysis and Design committee' (2 day),<br>2) Awareness education was provided to all assembly employees |
| Description | 1) The 2-day ergonomic education seminar given to the analysis and design committee involved training in ergonomic principles, risk analysis techniques, and workstation desgin guidelines.<br>2) The awareness education involved making employees aware of their responsibility to use equipment properly, and the importance of proper posture & technique to prevent injuries. |
| Length | 1) Ergonomic training was a 2-day seminar<br>2) Awareness training - not specified. |
| **3. Intervention Duration.** | |

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| Calendar duration | Intervention lasted for 3 years (1993 - 1996). The hazard identification took 6 months at which time analysis and design team was formed. | |
| Meeting frequency | Not reported<br>Very little detail provided on process. | |
| Meeting length | Not reported | |
| **Ergonomic changes (identified or implemented):** | | |
| ☒ Physical design or specification of: | ☒ Equipment | ☒ Redesign existing work tools/equipment |
| | | ☒ Purchase new work tools/equipment (other than PPE) |
| | | ☐ Introduce person protective equipment (PPE) |
| | | ☐ Introduce mechanical assists |
| | ☒ Workplaces | ☒ Ergonomic redesign of workstation |
| | | ☐ Improve housekeeping |
| | | ☐ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☐ Work tasks | ☐ Altering work duties / job sharing |
| ☒ Design of job teams and work organization | ☒ Altering production processes | |
| | ☐ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ | |
| ☐ Training for specific techniques/ tasks | ☐ | |
| ☒ Other | ☒ Created an exercise/stretching program | |
| **Outcomes:** | | |
| ☐ MSK Symptoms/ Pain | | |
| ☒ Injury/ Claims Records | 1) Total number of claims | |
| ☐ Sick Leave/ Lost Workdays | | |
| ☒ Other(s) | 1) Cost per claim<br>2) Total incurred losses ($) | |
| **Statistical Analyses:** | | |
| % Change from pre (1992) to post (1996) intervention | | |
| **Results:** | | |
| ☐ MSK Symptoms/ Pain | | |
| ☒ Injury/ Claims Records | 1) Sewing department reduced total number of claims by 85% (from 13 to 2) compared with a 21% increase in all other operations (from 106 to 128). | |
| ☐ Sick Leave/ Lost Workdays | | |

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| ☒ Other(s) | 1) Sewers demonstrated an 83% reduction in costs per claim (from $31,846 to $5,500) compared with a 52% reduction in all other departments (from $6,821 to $3,281).<br>2) This translated into an overall 97% decrease in total incurred losses (from $414,000 to $11,000) in the Sewing department compared to a 42% decrease in all others (from $723,000 to $420,000) pre to post intervention. |
| **Facilitators/ Barriers:** | |
| Facilitators | None reported |
| Barriers | None reported |
| **IWH Reviewers' Comments: (design issues, stats, power etc?)** | |
| This study provided a good description of study population, and methods. Authors described relevant co-interventions ongoing during study period, however, no discussion was presented regarding the impact of this on the targeted participatory ergonomics intervention. More sophisticated statistical analyses, and random allocation to groups and/or controlling for baseline differences between groups would have strengthened this medium quality study. | |

**Study:** Ketola R, Toivonen R, Hakkanen M, Luukkonen R, Takala EP, ViikariJuntura E. Effects of ergonomic intervention in work with video display units. Scandinavian Journal of Work, Environment & Health. 2002; 28(1):18-24)

| **Research Question:** | |
|---|---|
| To evaluate the effect of an intensive ergonomic approach and education on workstation changes and musculoskeletal disorders among workers who used a video display unit (VDU). | |
| **Study Characteristics:** | |
| Study Design: | Individual randomized trial |
| Jurisdiction | 2002, Espoo, Finland |
| Industry / sector | Municipal/administrative office work on VDUs |
| Length of Follow-up | Interventions took place likely within weeks. Diary of discomfort, workload and workplace layout measurements, and video recordings done at baseline, 2, and 10 months follow up. Questionnaires administered at 10 months follow up as well. |
| **Participant Characteristics:** | |
| Intervention: | Employees with MSK symptoms were selected to participate. 2 groups received interventions: Intensive Group: n=39, 40% male, mean age=46 yrs, mean work experience 17 yrs, VDU work 44% of time, mouse use 41% of time. Education Group=n=35, 40% male, mean age=49 yrs, mean work experience 19 yrs, VDU work 46% of time, mouse use 45% of time. |
| Referent: | Employees with MSK symptoms were selected to participate. Referent Group=n=35, 46% male, mean age=49 yrs, mean work experience 19 yrs, VDU work 44% of time, mouse use 41% of time. |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | 1) Workstation settings<br>2) Ergonomic rating (video analysis - scale 4-10, 10 is better) |
| Co-interventions | Occupational physiotherapy consultations available over the entire study period: intensive n=10, education n=7, reference n=8 |
| Confounders | Work experience (yrs), Age (yrs), workload (mouse & key events) & gender |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☐ Ongoing |
| | ☒ Temporary |
| Involvement | ☒ Full Direct |
| | ☐ Direct Representative |
| | ☐ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☐ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☐ Group Delegation |
| | ☐ Group Consultation |

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|---|---|
| | ☒ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☐ Line Management (Supervisors) |
| | ☐ Senior Management |
| | ☒ Internal specialist/ Technical Staff |
| | ☐ Union |
| | ☒ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☐ Compulsory |
| | ☒ Voluntary |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☐ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☐ Set-up/ Structure Process |
| | ☐ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☒ Initiates and Guides Process |
| | ☒ Acts as Expert |
| | ☒ Trains Members |
| | ☒ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | Physiotherapists expert in ergonomics |
| Trainee(s) | Formally workers in education group, informally workers in intensive group |
| Description | Principles of ergonomics, use of workstation & posture checklist, role of pauses and relaxed postures |
| Length | 1 hour for Education group, some part of the 1.5-2 hr consultation in intensive group |
| **3. Intervention Duration.** | |
| Calendar duration | Likely weeks (to fit between baseline assessment and 2 month follow-up) during 1998-9 |
| Meeting frequency | NA |
| Meeting length | NA |

| **Ergonomic changes (identified or implemented):** | | |
|---|---|---|
| ☒ Physical design or specification of: | ☒ Equipment | ☒ Redesign existing work tools/equipment |
| | | ☒ Purchase new work tools/equipment (other than PPE) |
| | | ☐ Introduce person protective equipment (PPE) |
| | | ☐ Introduce mechanical assists |
| | ☒ Workplaces | ☒ Ergonomic redesign of workstation |
| | | ☐ Improve housekeeping |
| | | ☐ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☐ Work tasks | ☐ Altering work duties / job sharing |
| ☐ Design of job teams and work organization | ☐ Altering production processes | |
| | ☐ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ | |
| ☐ Training for specific techniques/ tasks | ☐ | |
| ☐ Other | ☐ | |
| **Outcomes:** | | |
| ☒ MSK Symptoms/ Pain | Mean daily musculoskeletal discomfort rates (1 feel good to 5 feel very uncomfortable) Also pain/strain in the last 30 days (yes, no) | |
| ☐ Injury/ Claims Records | | |
| ☐ Sick Leave/ Lost Workdays | | |
| ☐ Other(s) | | |
| **Statistical Analyses:** | | |
| One way ANOVA across ergonomic ratings at each time, ANCOVA for MSK discomfort using baseline discomfort, ergonomic rating and workload as covariates. Intervention groups vs. reference group. Logistic regression for pain, intervention dummies, baseline value of pain. | | |
| **Results:** | | |
| ☒ MSK Symptoms/ Pain | 1) Most changes in workstations occurred in all groups. 2) Mean ergonomic ratings significantly higher in the intensive group than in the education or reference group at 2 and 10 months follow ups, but not at baseline. 3) At 2 months follow up, in the intensive group, significant reduction in MSK discomfort in the neck, area between neck and shoulder (right side), shoulders, right forearm, left fingers, and upper back. In the education group, similar changes except shoulders. At 10 month follow up, no significant changes were shown in both groups compared to referent. 4) Intensive group had a non significant reduction in strain/pain compared to education, and referent groups. | |
| ☐ Injury/ Claims Records | | |

| | |
|---|---|
| ☐ Sick Leave/ Lost Workdays | |
| ☐ Other(s) | |
| **Facilitators/ Barriers:** | |
| Facilitators | Inferred: - active involvement of workers and one-on-one guidance. |
| Barriers | Inadequate guidance for education group |
| **IWH Reviewers' Comments: (design issues, stats, power etc?)** | |
| This study, which rated very high in methodological quality, employed a strong design including random allocation of individuals to groups. This study documented participation in the intervention and the nature of ergonomic changes well. Rigorous statistical analyses used, including consideration of co-interventions and potential confounders and adequate measurement of potential risk factors for MSK symptoms. | |

**Study:** Laitinen H, Saari J, Kuusela J. Initiating an innovative change process for improved working conditions and ergonomics with participation and performance feedback: A case study in an engineering workshop. International Journal of Industrial Ergonomics 1997; 19; 299-305

**Supplemental studies:**
Laitinen H, Saari J, Kivisto M, Rasa PL. Improving physical and psychosocial working conditions through a participatory ergonomics process: a before-after study at an engineering workshop. International Journal of Industrial Ergonomics 1998; 21(1):35-45.

| **Research Question:** | |
|---|---|
| To determine the effects of management involvement, workers' participation and performance feedback, through the introduction of the TUTTAVA programme, on the implementation of a project aiming to change behaviour and technical improvements in working methods. | |
| **Study Characteristics:** | |
| Study Design: | Before-after |
| Jurisdiction | Finland (1997) |
| Industry / sector | Transportation / Steel<br>(State Railway / metal working shop) |
| Length of Follow-up | 24 months. Sick leave is measured yearly; Psychosocial questionnaire 1 (Q1) administered at start and after 4-5 months in 6 departments; Psychosocial questionnaire 2 (Q2) administered at start and after 9 months in 4 departments. |
| **Participant Characteristics:** | |
| Intervention: | 300 workers total with 60 white collar; 11 departments; 5-7 employees per departmental team;<br>Avg. age of workforce: 42;<br>Q1 administered to 93 pre / n=96 post (75% of employees in 6 departments);<br>O2 administered to 64 pre / n=63 post (96% of employees in 4 departments) |
| Referent: | Statistics from the Finnish industry (database) |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | 1) housekeeping standards<br>2) perceived psychosocial changes<br>3) perceived physical changes |
| Co-interventions | New wage system based on demands on jobs and skills of workers was implemented. Pay was still based on piece work but workers were guaranteed the same or greater wage. |
| Confounders | None |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☒ Ongoing |
| | ☐ Temporary |
| Involvement | ☐ Full Direct |
| | ☒ Direct Representative |

| | |
|---|---|
| | ☐ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☒ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☒ Group Delegation |
| | ☐ Group Consultation |
| | ☐ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☒ Line Management (Supervisors) |
| | ☒ Senior Management |
| | ☒ Internal specialist/ Technical Staff |
| | ☒ Union |
| | ☒ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☒ Compulsory |
| | ☐ Voluntary |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☐ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☐ Set-up/ Structure Process |
| | ☐ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☒ Initiates and Guides Process |
| | ☒ Acts as Expert |
| | ☒ Trains Members |
| | ☒ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | Training provided by it is not clear who provided / conducted it – it is assumed the researchers lead the training |
| Trainee(s) | n=20 (supervisors, designers & workers, no indication of how many of each or where they came from) |
| Description | Lectures and practical exercises - solving concrete problems |

| | | |
|---|---|---|
| Length | 5 day course | |
| **3. Intervention Duration.** | | |
| Calendar duration | 24 months | |
| Meeting frequency | Weekly meetings held along with an initial 2 hr seminar | |
| Meeting length | Initial seminar was 2hrs long. Length of weekly meetings is not given. | |
| **Ergonomic changes (identified or implemented):** | | |
| ☒ Physical design or specification of: | ☒ Equipment | ☐ Redesign existing work tools/equipment |
| | | ☒ Purchase new work tools/equipment (other than PPE) |
| | | ☒ Introduce person protective equipment (PPE) |
| | | ☒ Introduce mechanical assists |
| | ☒ Workplaces | ☒ Ergonomic redesign of workstation |
| | | ☒ Improve housekeeping |
| | | ☒ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☐ Work tasks | ☐ Altering work duties / job sharing |
| ☐ Design of job teams and work organization | ☐ Altering production processes | |
| | ☐ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ None Reported | |
| ☐ Training for specific techniques/ tasks | ☐ None Reported | |
| ☒ Other | ☒ "New rooms for rest breaks" | |
| **Outcomes:** | | |
| ☐ MSK Symptoms/ Pain | | |
| ☐ Injury/ Claims Records | | |
| ☒ Sick Leave/ Lost Workdays | 1) Sick leaves (as % of working hours) for workshop and Finnish industry | |
| ☒ Other(s) | 1) Housekeeping index<br>2) Perceived psychosocial changes<br>3) Perceived physical changes | |
| **Statistical Analyses:** | | |
| None for sick leave. Two-way ANOVA applied to perceived psychosocial and physical changes. | | |
| **Results:** | | |
| ☐ MSK Symptoms/ Pain | | |
| ☐ Injury/ Claims Records | | |

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|---|---|
| ☒ Sick Leave/ Lost Workdays | Absenteeism went from 12.8% in 1991 to 9.9% in 1994; |
| ☒ Other(s) | 1) Housekeeping index increased from 57% to 89% ($p<0.001$);<br><br>2) Physical working conditions and psychosocial work environment both significantly improved when considered for all responses ($p < 0.001$ and $p < 0.02$ respectively).<br><br>All other aggregated Q1 findings not significant; Perception of physical working conditions improved in all departments: order and tidiness improved ($p<0.001$), pleasantness of work environment ($p<0.05$), layout of work stations ($p<0.05$), safety of working methods ($p<0.05$); psychosocial environment improved in three departments ($p<0.05$);<br><br>For Q2, two of 11 groups of questions showed statistical improvements: communication and cooperation (p level not given) - other 9 groups showed no significant difference; For specific Q2 questions - total responses: Company goals are known ($p<0.01$), Practical places for tools ($p<0.01$), workstation is clean and in good order ($p<0.05$). In Dept. H: positive prospects in work, practical tools are available ($p<0.05$); practical places for tools, workstation is clean and in good order, regular feedback of outcome, visual appearance of work station is pleasant ($p<0.01$); Company goals are known ($p<0.001$); In Dept. J: daylight in workstation, company goals are known ($p<0.05$); workstation is clean and in good order ($p<0.01$) |
| **Facilitators/ Barriers:** | |
| Facilitators | Union Representatives |
| Barriers | Management and employee skepticism |
| **IWH Reviewers' Comments: (design issues, stats, power etc?)** | |
| Medium quality descriptive study on PE and effect on sick leaves. More control and description of co-interventions and possible confounders would have strengthened this study. | |

**Study:** Lanoie, P. and Tavenas, S., Costs and benefits of preventing workplace accidents: The case of participatory ergonomics. Safety Science. 1996; 24( 3):181 – 196.

| **Research Question:** | |
|---|---|
| To evaluate the impact of a participatory ergonomics program upon on work accidents, particularly low back injuries, and to conduct a cost-benefit analysis of the PE program | |
| **Study Characteristics:** | |
| Study Design: | Pre-During-Post |
| Jurisdiction | 1996, Montreal & Quebec City |
| Industry / sector | Food (alcohol distribution) |
| Length of Follow-up | 1989 to 1993 |
| **Participant Characteristics:** | |
| Intervention: | About 90 warehouse workers |
| Referent: | none |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | 1) Muscular use<br>2) asymmetric postures<br>3) lumbar strain in biomechanical laboratory<br>4) physiologic demand measures |
| Co-interventions | Strike |
| Confounders | Organizational level: grievances, strike dummy, absenteeism, overtime hours. Individual level: Age, seniority, work status |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☒ Ongoing |
| | ☐ Temporary |
| Involvement | ☐ Full Direct |
| | ☒ Direct Representative |
| | ☒ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☒ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☐ Group Delegation |
| | ☒ Group Consultation |
| | ☐ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☒ Line Management (Supervisors) |
| | ☒ Senior Management |

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|---|---|
| | ☐ Internal specialist/ Technical Staff |
| | ☒ Union |
| | ☒ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☐ Compulsory |
| | ☒ Voluntary |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☒ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☐ Set-up/ Structure Process |
| | ☒ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☒ Initiates and Guides Process |
| | ☒ Acts as Expert |
| | ☒ Trains Members |
| | ☒ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | Ergonomist Researchers |
| Trainee(s) | Working groups |
| Description | Ergonomics, participation & group dynamics, accident & video analysis, design methods |
| Length | 20 hours or 5 days |
| **3. Intervention Duration.** | |
| Calendar duration | October 1989..ongoing but data to 1993 |
| Meeting frequency | Working groups- planned weekly, biweekly implementation |
| Meeting length | Not reported |

| | | |
|---|---|---|
| **Ergonomic changes (identified or implemented):** | | |
| ☒ Physical design or specification of: | ☒ Equipment | ☒ Redesign existing work tools/equipment |
| | | ☒ Purchase new work tools/equipment (other than PPE) |
| | | ☒ Introduce person protective equipment (PPE) |
| | | ☒ Introduce mechanical assists |
| | ☐ Workplaces | ☐ Ergonomic redesign of workstation |
| | | ☐ Improve housekeeping |
| | | ☐ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☐ Work tasks | ☐ Altering work duties / job sharing |
| ☒ Design of job teams and work organization | ☒ Altering production processes | |
| | ☐ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ | |
| ☐ Training for specific techniques/ tasks | ☐ | |
| ☒ Other | ☒ Worked with glue supplier to change type of glue or type of cardboard in boxes. | |
| **Outcomes:** | | |
| ☐ MSK Symptoms/ Pain | | |
| ☒ Injury/ Claims Records | All injuries & back injuries/100 workers | |
| ☒ Sick Leave/ Lost Workdays | Workdays lost due to back-related injuries and other accidents | |
| ☒ Other(s) | Cost-Benefit analyses | |
| **Statistical Analyses:** | | |
| econometric analysis using regression models | | |
| **Results:** | | |
| ☐ MSK Symptoms/ Pain | | |
| ☒ Injury/ Claims Records | Decreasing number of back injuries across years, both unadjusted (table 4) and adjusted for multiple organizational co-interventions and individual level confounders | |
| ☐ Sick Leave/ Lost Workdays | | |
| ☒ Other(s) | For most scenarios and discount rates, benefits greater than the costs of the PE intervention (table 6) | |

| **Facilitators/ Barriers:** | |
|---|---|
| Facilitators | Steering committee support, training sessions, use of video |
| Barriers | Antagonisms between labour & mgt at beginning, lack of experience in participatory processes |
| **IWH Reviewers' Comments:** | |
| Medium quality single workplace study. This study provided one of the more rigorous analyses in terms of control for both workplace level and individual level confounders and co-interventions. Major weaknesses of this study were: no comparison group, limited documentation of participation in the intervention, and inadequate measurement of risk factors for MSK symptoms. | |

**Study:** Moore JS, Garg A. The effectiveness of participatory ergonomics in the red meat packing industry evaluation of a corporation, International Journal of Industrial Ergonomics. 1997; 21(1): 47-58.

**Supplemental studies:**

Moore JS, Garg A. Participatory ergonomics in the red meat packing plant, Part I: Evidence of long-term effectiveness. American Industrial Hygiene Association Journal. 1997; 58: 127-131.

Moore JS, Garg A. Participatory ergonomics in the red meat packing plant, Part II: Case studies. American Industrial Hygiene Association Journal. 1997; 58: 498-508.

Moore JS, Garg A. Use of participatory ergonomics teams to address musculoskeletal hazards in the red meat packing industry. American Journal of Industrial Medicine. 1996; 29: 402-408.

| **Research Question:** | |
|---|---|
| To evaluate the effectiveness of a corporate ergonomics program that used a participatory approach to solving problems related to musculoskeletal hazards. | |
| **Study Characteristics:** | |
| Study Design: | Before-after (not all measures taken before), Case study |
| Jurisdiction | Mid-west United States of America |
| Industry / sector | Food (red meat packing) |
| Length of Follow-up | 1987-1993 (6yrs)<br>(Demonstration project 1992/1993, plant injury and time loss data to 1993, post data on further interventions to 1996 (renovations from Table 3 in Moore JS, Garg A. Participatory ergonomics in the red meat packing plant, Part I: Evidence of long-term effectiveness. American Industrial Hygiene Association Journal. 1997; 58: 127-131) |
| **Participant Characteristics:** | |
| Intervention: | Entire plant n approximately 930, 830 were production workers.<br>Kill department n=not reported<br>Cut department n=not reported |
| Referent: | none |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | 1) worker safety survey<br>2) CTD risk factor checklist<br>3) worker feedback<br>4) strain index |
| Co-interventions | 1) major renovations starting (and ending at different times in different departments)<br>2) Line Speed increases<br>possibly: 3) medical management was a component of the ergonomics program |
| Confounders | |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☒ Ongoing |
| | ☐ Temporary |
| Involvement | ☐ Full Direct |

| | |
|---|---|
| | ☒ Direct Representative |
| | ☐ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☒ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☐ Group Delegation |
| | ☒ Group Consultation |
| | ☒ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☒ Line Management (Supervisors) |
| | ☐ Senior Management |
| | ☒ Internal specialist/ Technical Staff |
| | ☐ Union |
| | ☐ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☒ Compulsory |
| | ☒ Voluntary |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☒ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☐ Set-up/ Structure Process |
| | ☒ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☒ Initiates and Guides Process |
| | ☒ Acts as Expert |
| | ☐ Trains Members |
| | ☒ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | Primarily corporate ergonomist. In demonstration project, university based investigators. |

| | | |
|---|---|---|
| Trainee(s) | General training to all hourly employees (plant and office), engineering and maintenance personnel, supervision, management, and health care providers. Training more specific to problem solving offered to ergonomic team. | |
| Description | General training: proper and safe work methods, the physiology and symptoms of CTD, means of prevention, coping or treatment.<br>Ergonomic team training: basic epidemiology of injuries, etiology and development of LBP & UE disorders plus problem-solving of ergonomic problems | |
| Length | General training: unspecified duration.<br>Ergonomic team training in demonstration project: 8 hours | |
| **3. Intervention Duration.** | | |
| Calendar duration | Two years for demonstration project, 7 years of interventions | |
| Meeting frequency | Twice a month.<br>During demonstration project 5 times with investigators plus occasionally on their own. | |
| Meeting length | Not Reported | |
| **Ergonomic changes (identified or implemented):** | | |
| ☒ Physical design or specification of: | ☒ Equipment | ☒ Redesign existing work tools/equipment |
| | | ☒ Purchase new work tools/equipment (other than PPE) |
| | | ☐ Introduce person protective equipment (PPE) |
| | | ☒ Introduce mechanical assists |
| | ☒ Workplaces | ☒ Ergonomic redesign of workstation |
| | | ☒ Improve housekeeping |
| | | ☐ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☒ Work tasks | ☒ Altering work duties / job sharing |
| ☒ Design of job teams and work organization | ☒ Altering production processes | |
| | ☒ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ | |
| ☐ Training for specific techniques/ tasks | ☐ | |
| ☐ Other | ☐ | |
| **Outcomes:** | | |
| ☐ MSK Symptoms/ Pain | | |
| ☒ Injury/ Claims Records | Crude annual incidence rates 1987 – 1993.<br>Percentage of recordable incidents related to MSK risk factors 1987 - 1993 and MSK morbidity from Moore JS, Garg A. Participatory ergonomics in the red meat packing plant, Part II: Case studies. American Industrial Hygiene Association Journal. 1997; 58: 498-508. | |
| ☒ Sick Leave/ Lost Workdays | Lost-time incidence rates 1984 - 1993 | |

| | |
|---|---|
| ☒ Other(s) | Valuing through WC costs.<br>Impressions on effectiveness of intervention implementation and process to identify problem and develop solution |
| **Statistical Analyses:** | |
| 1) Cox-Stuart test for trend (only used on lost-time incidence as this test requires at least 10 observations to determine significance at 0.05 level)<br>2) Descriptive | |
| **Results:** | |
| ☐ MSK Symptoms/ Pain | |
| ☒ Injury/ Claims Records | crude annual incidence rates increased 1987 (100%) to 1991 (133%) to 1993 (107%), |
| ☒ Sick Leave/ Lost Workdays | marked decrease in the lost-time incidence rate from recording 1984 at 100%, through ergonomics program initiation in 1986 (50%), to 1993 (end of PE demonstration project) 11% ($p<0.05$) |
| ☒ Other(s) | Marked reduction in total and per capita annual worker's compensation costs.<br>Favourable impressions by workers on intervention process. |
| **Facilitators/ Barriers:** | |
| Facilitators | Management commitment, effective PE team leadership, substantial resource investments, structured problem-solving methods. |
| Barriers | Time constraints to meetings |
| **IWH Reviewers' Comments: (design issues, stats, power etc?)** | |
| Important study in high risk industry. Descriptive study detailing the implementation and process of PE well. A more complete description of the sample and a more rigorous statistical approach would have strengthened this medium quality study. | |

**Study:** Morken T, Moen B, Riise T, Hauge SHV, Holien S, Langedrag A, Olson HO, Pedersen S, Saue ILL, Seljebo GM, Thoppil V. Effects of a training program to improve musculoskeletal health among industrial workers - Effects of supervisors role in the intervention, International Journal of Industrial Ergonomics. 2002; 30(2):115-127.

| **Research Question:** | |
|---|---|
| The aim of this randomized, controlled intervention study among operators in the aluminum industry in Norway was to examine the effects of a 1-year training program on musculoskeletal symptoms, psychosocial factors and coping by comparing three types of intervention groups: (1) workers and supervisors; (2) workers without supervisor; and (3) managers only. | |
| **Study Characteristics:** | |
| Study Design: | Group randomized trial |
| Jurisdiction | 2002; Norway (country wide) |
| Industry / sector | Aluminium Industry |
| Length of Follow-up | 16 months (Questionnaires pre and post intervention administered 16 months apart) |
| **Participant Characteristics:** | |
| Intervention: | All employees from 8 plants completed questionnaire (baseline n=5654, follow-up n= 5143) ages 18-69yrs, 14% female.<br>Employees from the production line (potroom and cast house) randomized into 3 Intervention Groups (fig) 2:<br>1) Group1: 20 groups of operators & supervisors, 132 operators<br>2) Group2: 18 groups of operators only, 135 operators<br>3) Group3: 2 groups of supervisors and managers and 10 groups of operators, 147 operators |
| Referent: | 1) Control group A (also from the production line): 55 groups, 423 operators<br>2) Control group B (from other parts of the same plant): 1344 operators<br>Control group B had higher age mean=40 yrs, and greater mean yrs employed=16 |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | 1)Coping strategies<br>2) Job demands, Job control and Social support |
| Co-interventions | Organizational restructuring may have affected some departments |
| Confounders | Confounding variables were considered through the randomization process which resulted in similar demographics and risk factors in groups |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☐ Ongoing |
| | ☒ Temporary |
| Involvement | ☒ Full Direct |
| | ☒ Direct Representative |
| | ☐ Delegated |
| Level of Influence | ☒ Group of Organizations |

| | |
|---|---|
| | ☒ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☐ Group Delegation |
| | ☒ Group Consultation |
| | ☐ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☒ Line Management (Supervisors) |
| | ☐ Senior Management |
| | ☒ Internal specialist/ Technical Staff |
| | ☒ Union |
| | ☒ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☒ Cross-industry Organization |
| Requirement (for participation) | ☐ Compulsory – Unclear to us |
| | ☐ Voluntary – Unclear to us |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☒ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☒ Set-up/ Structure Process |
| | ☒ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☒ Initiates and Guides Process |
| | ☒ Acts as Expert |
| | ☒ Trains Members |
| | ☒ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | Physiotherapists from occupational health association for industry |
| Trainee(s) | 40 groups were to participate in the entire training program (assume all did) |
| Description | 10 different topics covered including: didactic sessions on knowledge of MSK probs, physical, psychosocial , work-organizational and individual risk factors, basic ergo principles and coping with MSK symptoms. Discussion session focussed on: individual solutions and obtaining optimal work environment both organizationally and technically. |

| | | |
|---|---|---|
| Length | Each of the 10 sessions lasted for 2 hrs. 1 hrs and 15 min of each session devoted to training. | |
| **3. Intervention Duration.** | | |
| Calendar duration | 1 year, sometime from 1998-2000 | |
| Meeting frequency | 10 times over the course of a year | |
| Meeting length | 2 hours each meeting: 45 min of each session devoted to discussion re changes, change team meetings were combined with the training sessions. | |
| **Ergonomic changes (identified or implemented):** | | |
| ☒ Physical design or specification of: | ☒ Equipment | ☒ Redesign existing work tools/equipment |
| | | ☐ Purchase new work tools/equipment (other than PPE) |
| | | ☐ Introduce person protective equipment (PPE) |
| | | ☐ Introduce mechanical assists |
| | ☒ Workplaces | ☒ Ergonomic redesign of workstation |
| | | ☐ Improve housekeeping |
| | | ☐ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☐ Work tasks | ☐ Altering work duties / job sharing |
| ☒ Design of job teams and work organization | ☐ Altering production processes | |
| | ☒ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ | |
| ☐ Training for specific techniques/ tasks | ☐ | |
| ☐ Other | ☐ | |
| **Outcomes:** | | |
| ☒ MSK Symptoms/ Pain | 1) MSK symptoms | |
| ☐ Injury/ Claims Records | | |
| ☐ Sick Leave/ Lost Workdays | | |
| ☒ Other(s) | 1) Impressions on Effectiveness of intervention implementation and process to identify problem and develop solution | |
| **Statistical Analyses:** | | |
| Descriptive stats, paired t-tests to examine change from pre to post in each group.<br>ANOVA comparing groups for differences at baseline and change. Post hoc Dunnette test if significant ANOVA differences. Participants matched, significance set at p=0.05 | | |
| **Results:** | | |

| | |
|---|---|
| ☒ MSK Symptoms/ Pain | 1) MSK symptoms: increased from pre to post in control group B (shoulders p=0.014; hands p<0.0001; elbows p<0.0001). No significant changes in other groups. The change did not differ significantly between intervention and control. Noted loss of respondents but suggest that there was no bias as a result of this loss. |
| ☐ Injury/ Claims Records | |
| ☐ Sick Leave/ Lost Workdays | |
| ☒ Other(s) | Favourable impressions by workers on intervention process. |
| **Facilitators/ Barriers:** | |
| Facilitators | Workers' active involvement in making changes was seen as facilitating the intervention process |
| Barriers | Personal interaction between the groups was possible (contamination) |
| **IWH Reviewers' Comments: (design issues, stats, power etc?)** | |
| High quality study with strong methodology. Good description of risk factors and intervention. One of the few studies to use randomization in their design. | |

**Study:** Reynolds JL, Drury CG, Broderick RL. A Field Methodology for the Control of Musculoskeletal Injuries, Applied Ergonomics 1994; 25(1):3–16.

| **Research Question:** | |
|---|---|
| To investigate the effect of a participatory ergonomic intervention on worker well-being and injury costs in a large apparel manufacturer. | |
| **Study Characteristics:** | |
| Study Design: | Before-after |
| Jurisdiction | 1994, Pennsylvania, USA |
| Industry / sector | Apparel/ Manufacturing |
| Length of Follow-up | 5 months (January 1992 - May 1992) |
| **Participant Characteristics:** | |
| Intervention: | Organization: Large Apparel Manufacturer (VF Corporation)<br>Department: Half-felled inseam job<br>Employee: Sewing machine operators n=18 |
| Referent: | None. |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | 1) Cumulative trauma disorder task analysis using manual methods.<br>2) Biomechanical data on posture, force, repetition,<br>3) Daily exposure scores for wrists (DWE), neck/back, shoulders, and legs (DE).<br>DWE = (grip force + postural deviations) x frequency<br>DE = postural deviations x frequency |
| Co-interventions | None identified. |
| Confounders | None were considered. |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☐ Ongoing |
| | ☒ Temporary |
| Involvement | ☐ Full Direct |
| | ☐ Direct Representative |
| | ☒ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☐ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☒ Group Delegation |
| | ☐ Group Consultation |
| | ☐ Individual Consultation |
| Mix of Participants | ☒ Operators |

| | |
|---|---|
| | ☒ Line Management (Supervisors) |
| | ☐ Senior Management |
| | ☒ Internal specialist/ Technical Staff |
| | ☐ Union |
| | ☒ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☐ Compulsory |
| | ☐ Voluntary |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☐ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☐ Set-up/ Structure Process |
| | ☐ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☒ Initiates and Guides Process |
| | ☒ Acts as Expert |
| | ☐ Trains Members |
| | ☒ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | No training was provided. |
| Trainee(s) | Not applicable. |
| Description | Not applicable. |
| Length | Not applicable. |
| **3. Intervention Duration.** | |
| Calendar duration | Late 1991 to early 1992 |
| Meeting frequency | Not reported |
| Meeting length | Not reported. |

| **Ergonomic changes (identified or implemented):** | | |
|---|---|---|
| ☒ Physical design or specification of: | ☒ Equipment | ☒ Redesign existing work tools/equipment |
| | | ☒ Purchase new work tools/equipment (other than PPE) |
| | | ☐ Introduce person protective equipment (PPE) |
| | | ☐ Introduce mechanical assists |
| | ☒ Workplaces | ☒ Ergonomic redesign of workstation |
| | | ☐ Improve housekeeping |
| | | ☐ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☐ Work tasks | ☐ Altering work duties / job sharing |
| ☐ Design of job teams and work organization | ☐ Altering production processes | |
| | ☐ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ None Reported | |
| ☐ Training for specific techniques/ tasks | ☐ None Reported | |
| ☐ Other | ☐ None Reported | |
| **Outcomes:** | | |
| ☒ MSK Symptoms/ Pain | Body part discomfort (BPD) by area (collected 3 times per day for 8 days). | |
| ☒ Injury/ Claims Records | Injuries with associated lost time | |
| ☐ Sick Leave/ Lost Workdays | | |
| ☒ Other(s) | Productivity (as measured by average hourly earnings) | |
| **Statistical Analyses:** | | |
| Wilcoxon signed-rank test for BPD | | |
| **Results:** | | |
| ☒ MSK Symptoms/ Pain | Significant decreases in BPD DE scores for wrists-hands (n=4, T*=0, p=0.125), shoulders-arms (n=4, T*=0, p=0.125), and non-significant decreases in neck/back discomfort among 4 operators. Increased leg discomfort (n=4, T*=0, p=0.125). | |
| ☒ Injury/ Claims Records | Decrease in lost time injuries from 14 incidents/yr prior to intervention to 0/yr in first 5 months post-intervention. | |
| ☐ Sick Leave/ Lost Workdays | | |
| ☒ Other(s) | Significant productivity increase from 6 months pre- to 2 months post-intervention (from $7.34 to $8.56; n=8, T*=35, p=0.01) | |

| Facilitators/ Barriers: | |
|---|---|
| Facilitators | Enthusiasm & active participation of workers in making changes was seen as facilitating the intervention process |
| Barriers | Personal interaction between the groups was possible (contamination) |
| **IWH Reviewers' Comments: (design issues, stats, power etc?)** | |
| This study is a good example of a real-world implementation, providing significant details on the process of implementing PE interventions. The study population was well-described; however there was no comparison group. Risk factors for MSK symptoms were adequately assessed. Symptom data was particularly measured and analyzed well. Consideration of confounders and co-interventions would have strengthened this medium quality study. | |

**Study:** Wickström G, Hyytiäinen K, Laine M, Pentti J, Selonen R. A five-year intervention study to reduce low back disorders in the metal industry. International Journal of Industrial Ergonomics, 1993; 12: 25-33.

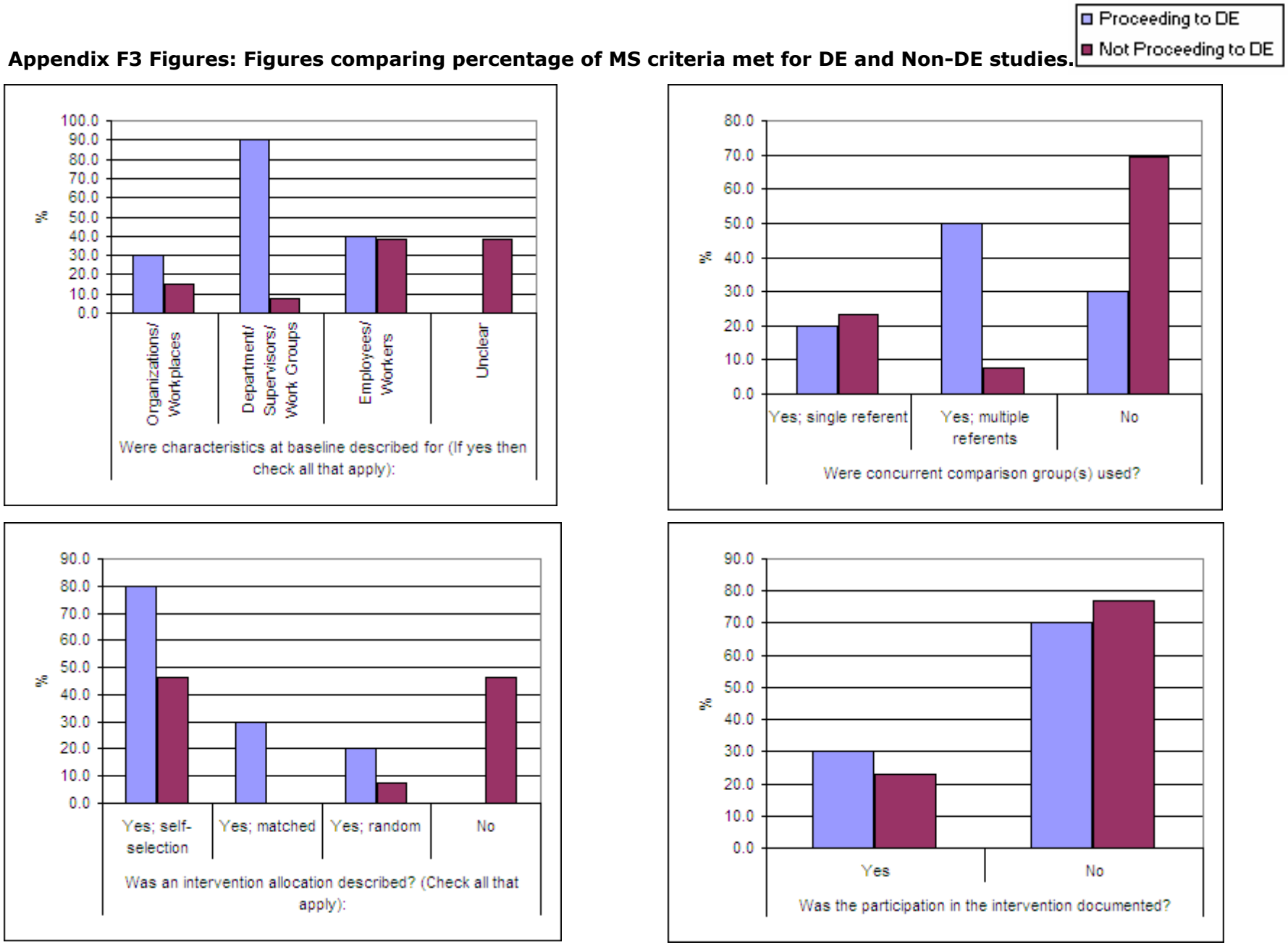
| **Research Question:** | |
|---|---|
| An intervention study aimed at reducing the occurrence of low back disorders was carried out among … metal workers in a ventilation equipment producing plant. | |
| **Study Characteristics:** | |
| Study Design: | Non-randomized Time Series with referent group |
| Jurisdiction | Finland |
| Industry / sector | Metal Industry |
| Length of Follow-up | From 1986-1991 three phases: determination of base-line (1986-1987), intervention (1988-1989), follow up (1990 onwards) |
| **Participant Characteristics:** | |
| Intervention: | White-collar group of planners n=88, all males, average age 39.9 yrs age range 24-55. Blue-collar group of metal workers n=125, all males, average age =39.7 yrs range 19-56 |
| Referent: | All white and blue collar employees in another metal company, situated 100 km away, n not reported |
| **Risk Factors, Confounders, Co-interventions:** | |
| Risk Factors | 1) biomechanical load<br>2) ergonomic ways of working<br>3) physical exam (fitness of back tissues) |
| Co-interventions | Plant closure due to downsizing during 4th follow-up year (1998). |
| Confounders | Plant closure announcement and final accident / injury data |
| **Characteristics of PE Intervention:** | |
| **1. Dimensions of PE Framework (from Haines et al., 2002).** | |
| Permanence | ☐ Ongoing |
| | ☒ Temporary |
| Involvement | ☐ Full Direct |
| | ☒ Direct Representative |
| | ☐ Delegated |
| Level of Influence | ☐ Group of Organizations |
| | ☒ Entire Organization |
| | ☒ Department/Work Group |
| Decision Making | ☐ Group Delegation |
| | ☒ Group Consultation |
| | ☐ Individual Consultation |
| Mix of Participants | ☒ Operators |
| | ☒ Line Management (Supervisors) |

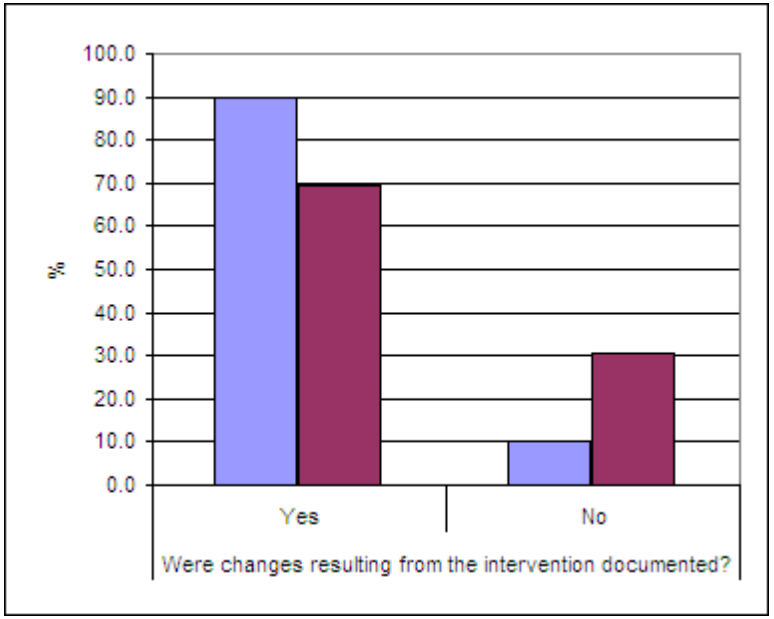
| | |
|---|---|
| | ☐ Senior Management |
| | ☒ Internal specialist/ Technical Staff |
| | ☐ Union |
| | ☐ External Advisor |
| | ☐ Supplier/ Purchaser |
| | ☐ Cross-industry Organization |
| Requirement (for participation) | ☒ Compulsory |
| | ☒ Voluntary |
| Focus | ☒ Physical design/ Specification of Equipment/ Workstation/ Work tasks |
| | ☐ Design of Job Teams or Work Organization |
| | ☐ Formulation of Policies or Strategies |
| Remit | ☒ Problems Identification |
| | ☒ Solution Development |
| | ☒ Implementation of change |
| | ☐ Set-up/ Structure Process |
| | ☐ Monitor/ Oversee Process |
| Role of Ergonomic Specialist | ☐ Initiates and Guides Process |
| | ☐ Acts as Expert |
| | ☐ Trains Members |
| | ☐ Available for Consultation |
| | ☐ Not Involved |
| **2. Ergonomic Training.** | |
| Trainer | Unclear |
| Trainee(s) | Foremen and safety reps of employees |
| Description | Unclear for work group.<br>Use of the back at work, fitness of back tissues, biomechanics basic principles provided to all workers (36% attended) |
| Length | Notice boards were ongoing, physical exercise sessions occurred twice in the beginning. Basic principles of biomechanics presentation occurred once in the beginning. |
| **3. Intervention Duration.** | |
| Calendar duration | Approximately 24 months from 1988-1989 |
| Meeting frequency | once a month during one year |
| Meeting length | 1-2 hours |

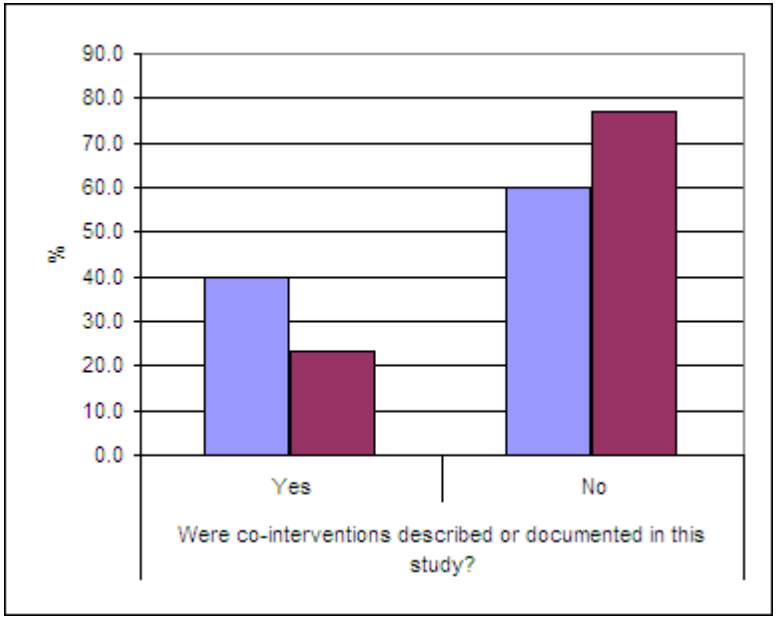
| | | |
|---|---|---|
| **Ergonomic changes (identified or implemented):** | | |
| ☐ Physical design or specification of: | ☐ Equipment | ☐ Redesign existing work tools/equipment |
| | | ☐ Purchase new work tools/equipment (other than PPE) |
| | | ☐ Introduce person protective equipment (PPE) |
| | | ☐ Introduce mechanical assists |
| | ☐ Workplaces | ☐ Ergonomic redesign of workstation |
| | | ☐ Improve housekeeping |
| | | ☐ Reduce environmental exposure (noise, heat, chemicals, etc.) |
| | ☐ Work tasks | ☐ Altering work duties / job sharing |
| ☐ Design of job teams and work organization | ☐ Altering production processes | |
| | ☐ Job rotation / scheduling changes / job breaks | |
| ☐ Formulation of policies or strategies | ☐ | |
| ☒ Training for specific techniques/ tasks | ☒ training on preventing lumbar fatigue, reducing sudden peak loads, keeping lumbar tissues fit | |
| ☒ Other | ☒ physical work conditions, fitness of the employees were targeted | |
| **Outcomes:** | | |
| ☒ MSK Symptoms/ Pain | 1) Occurrence of low back disorders/pain in past 12 months (questionnaire) | |
| ☐ Injury/ Claims Records | | |
| ☒ Sick Leave/ Lost Workdays | 2) Sick leave due to low-back disorders | |
| ☐ Other(s) | | |
| **Statistical Analyses:** | | |
| a) Proportions by Chi-square<br>b) Means by 1-way ANOVA<br>c) Sick leaves by t-test | | |
| **Results:** | | |
| ☒ MSK Symptoms/ Pain | 1) Occurrence of low back pain: declining trend seen in low back pain for both white and blue collar workers | |
| ☐ Injury/ Claims Records | | |
| ☒ Sick Leave/ Lost Workdays | 2) Sick leave: decrease in sick leaves due to low back disorders from average of 3.1 days lost in 1985-1989 to average of 1.9 days lost in 1990-91 among blue collar ($t(5)=2.57$, $p=0.05$) but not among white collar ($t(5)=0.87$, $p=0.43$). Similar comparison in referent company did not show significant changes in sick leaves due to low back disorders. | |
| ☐ Other(s) | | |

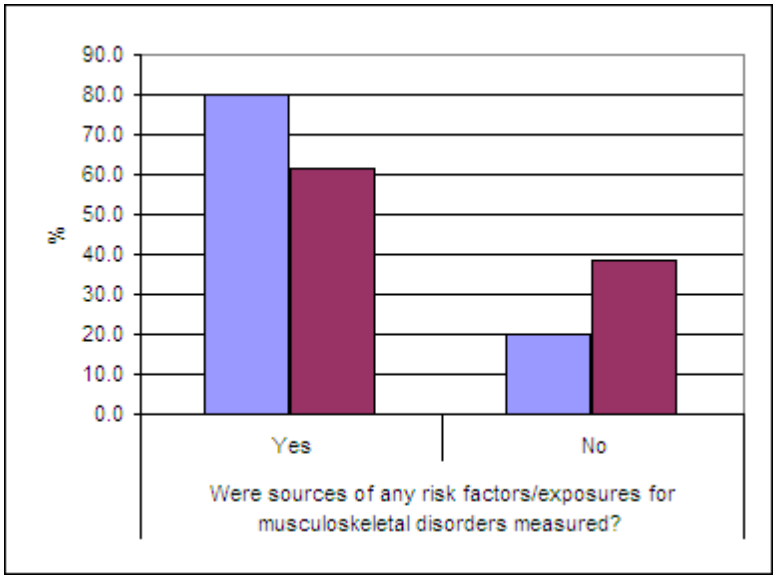
| **Facilitators/ Barriers:** | |
|---|---|
| Facilitators | EHS officer hired by management at start of intervention; Specific allocation of resources (both time and financial - $50,000 specified in first year, other years not reported); commitment from both top management and union. |
| Barriers | History of unsuccessful attempts to improve H&S in plant; high overall OSHA recordable incidents; Large trust gap between management and labour. |
| **IWH Reviewers' Comments: (design issues, stats, power etc?)** | |
| Medium quality study that describes PE process to decrease low-back pain in metal workers. Study would be stronger with a clearer description of the process, controlling for confounders and description of possible co-interventions. | |

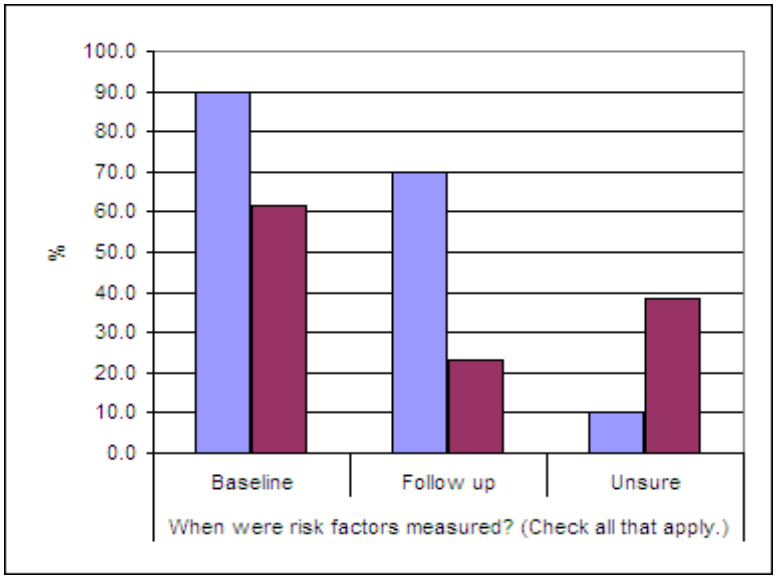
**Appendix F3 Figures: Figures comparing percentage of MS criteria met for DE and Non-DE studies.**

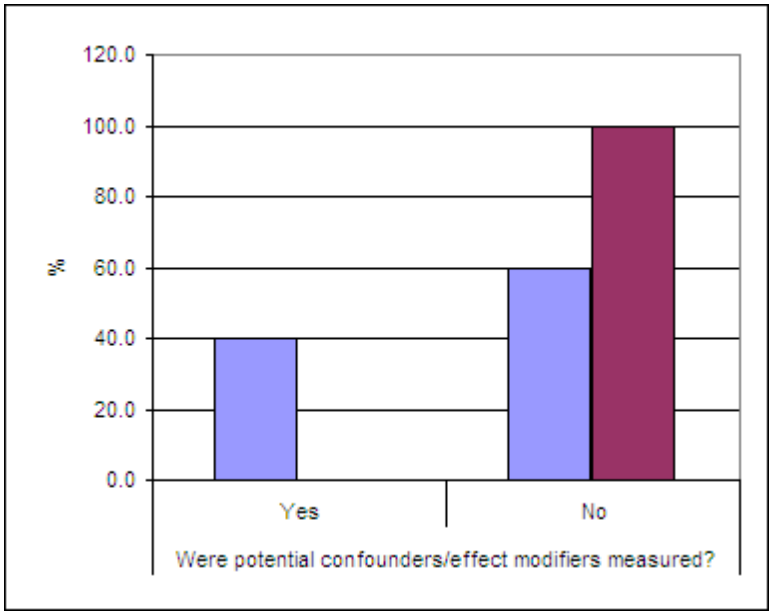


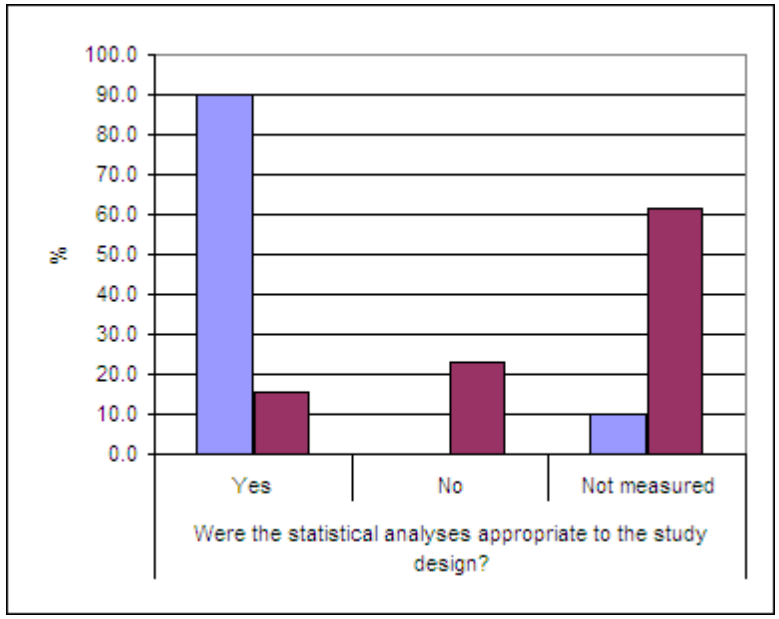

100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
%
Yes
No
Were changes resulting from the intervention documented?

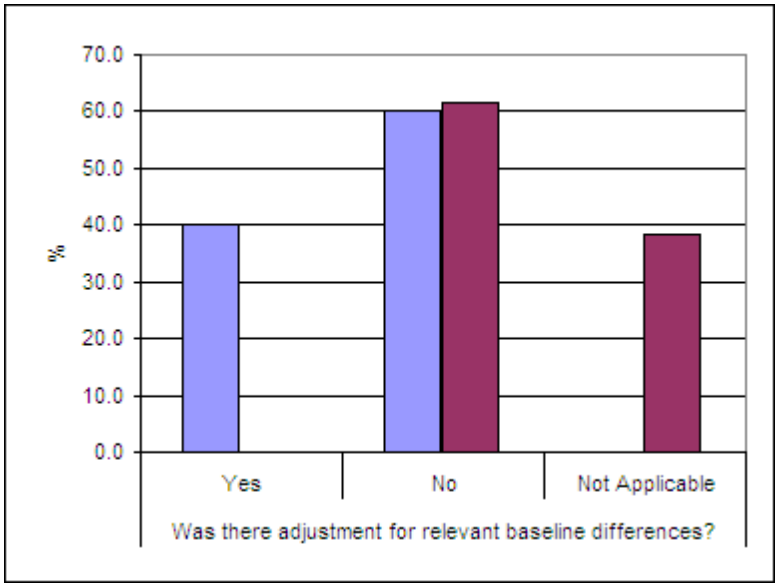

90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
%
Yes
No
Were co-interventions described or documented in this study?


90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
%
Yes
No
Were sources of any risk factors/exposures for musculoskeletal disorders measured?


100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
%
Baseline
Follow up
Unsure
When were risk factors measured? (Check all that apply.)


120.0
100.0
80.0
60.0
40.0
20.0
0.0
%
Yes
No
Were potential confounders/effect modifiers measured?


100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
%
Yes
No
Not measured
Were the statistical analyses appropriate to the study design?


70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
%
Yes
No
Not Applicable
Was there adjustment for relevant baseline differences?

## Appendix Table F.3 Methodological strength criteria by study

| | Methodological Strength (MS) Criteria | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | |
| **First Author** | **Baseline Characteristics** | **Concurrent Comparison Groups** | **Randomized Allocation** | **Participation Documented** | **Changes Documented** | **Co-interventions Described** | **Risk Factors Documented** | **Risk Factors Baseline & Follow-up** | **Potential Confounders Measured** | **Appropriate Statistical Analyses** | **Adjustment for Baseline Differences** | **Total** | **Quality Rating** |
| **DE Studies** | | | | | | | | | | | | | |
| Carrivick | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | **7** | Medium |
| Evanoff | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | **8** | Medium |
| Halpern | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | **6** | Medium |
| Ketola | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **11** | Very High |
| Laitinen | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | **5** | Medium |
| Lanoie | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | **6** | Medium |
| Moore | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | **5** | Medium |
| Morken | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | **10** | High |
| Reynolds | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | **6** | Medium |
| Wickström | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | **6** | Medium |
| **Non-DE studies** | | | | | | | | | | | | | |
| Bohr | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **4** | Low |
| Brenner | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | **4** | Low |
| Collins | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | **3** | Low |
| Haims | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **1** | Low |
| Herbert | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | **4** | Low |
| Joseph | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** | Low |
| Maciel | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | **3** | Low |
| Marcal | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **2** | Low |
| Moore | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **4** | Low |
| Simon | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **3** | Low |
| Udo | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **2** | Low |
| Vink | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | **4** | Low |
| Vink | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | **4** | Low |

## Appendix F.4: Data Extraction

### Appendix Table F.4a. Study Characteristics

| Author | Year/ Jurisdiction | Industry / Sector | Study Design | Participants | | Follow Up |
|---|---|---|---|---|---|---|
| | | | | Intervention | Referent | |
| **Carrivick** | 2001; Victoria, Australia | Healthcare - hospital | Pre-post with 3 comparison groups | Changes based on which paper you look at.<br>For refid 63 study hospital: 1)cleaners, mean n=145 (507 total), 65% female.<br><br>Mean age in both cleaner and orderly groups = 37 | 1) Orderlies from same hospital, mean n=140 (279 total), 5% female, mean age 37?.<br>2) Cleaners from another hospital within the same city (n=?, no demographics)<br>3) State level data on all hospital cleaners (n=?, no demographics) | 36 months (Intervention commenced in 1992, both cleaners and orderlies were observed for 36 months prospectively. Also, data were retrieved back 52 months to 1988.) |
| **Evanoff** | 1999/St. Louis, Missouri, USA | Health Care | Before-During-Post<br>referred to as "prospective intervention trial"<br>Does not fit into Zaza nicely | Department: Central Dispatch Office, 100-111 orderlies Employee: 67 pre, 88 post, 27 of these in both | Same hospital ICU nurses, n=50 and Lab workers, n=450<br>Other hospital n=? | 24 months for OSHA 200 log and WC injuries and costs during the intervention.<br>Repeat questionnaires 1, 7 & 15 months following intervention. |

| Author | Year/ Jurisdiction | Industry / Sector | Study Design | Participants | | Follow Up |
|---|---|---|---|---|---|---|
| | | | | Intervention | Referent | |
| **Halpern** | 1997, Colorado, USA | Auto accessories/ Manufacturing | Before-after | Department: Sewing department targeted for intervention based on high WC rates. Work involves specific, repetitive tasks in assembly line - attaching zippers and support binding and other sub-assemblies (such as poly-carbonate glass and structural steel) to canvas pieces. Employees: Sewers, n=250 | All departments workers (including **sewers**, glass, manufacturing and 'other' departments), n=~700 | 36 months (WC claims) |
| **Ketola** | 2002, Espoo, Finland | Municipal/administrative office work on VDUs | Individual randomized trial | Employees with MSK symptoms were selected to participate. 2 groups received interventions: Intensive Group: n=39, 40% male, mean age=46 yrs, mean work experience 17 yrs, VDU work 44% of time, mouse use 41% of time. Education Group=n=35, 40% male, mean age=49 yrs, mean work experience 19 yrs, VDU work 46% of time, mouse use 45% of time. | Employees with MSK symptoms were selected to participate. Referent Group=n=35, 46% male, mean age=49 yrs, mean work experience 19 yrs, VDU work 44% of time, mouse use 41% of time. | Interventions took place likely within weeks. Diary of discomfort, workload and workplace layout measurements, and video recordings done at baseline, 2, and 10 months follow up. Questionnaires administered at 10 months follow up as well. |

| Author | Year/ Jurisdiction | Industry / Sector | Study Design | Participants | | Follow Up |
|---|---|---|---|---|---|---|
| | | | | Intervention | Referent | |
| **Laitinen** | 1997 - Finland | Transportation / Steel (State Railway / metal working shop) | Before-after | 300 workers total; 11 departments; 5-7 per departmental team; n=60 white collar Avg. age: 42; n=93 pre / n=96 post for Q1 (75% of employees in 6 departments); n=64 pre / n=63 post for Q2 (96% of employees in 4 departments) | Finnish industry stats (database) | 24 months (Sick leave measured yearly; Q1 at start and @ 4-5 months; Q2 at start and @ 9 months) |
| **Lanoie** | 1996, Montreal & Quebec City | Food (alcohol distribution) | Pre-During-Post | About 90 warehouse workers | NA | 1989 to 1993 |
| **Moore** | 1998; Mid-west United States of America | Food (red meat packing) | Before-after (not all measures taken pre), Case study | Entire plant n~930, n=830 were production workers. Kill dept n=? Cut dept n=? | none | 1987-1993 (6yrs) (Demonstration project 1992/1993, plant injury and time loss data to 1993, post data on further interventions to 1996 (renovations from Table 3 ref 114)) |

| Author | Year/ Jurisdiction | Industry / Sector | Study Design | Participants | | Follow Up |
|---|---|---|---|---|---|---|
| | | | | Intervention | Referent | |
| **Morken** | 2002; Norway (country wide) | Aluminium Industry | Group randomised trial | All employees from 8 plants completed questionnaire (baseline n=5654, follow-up n= 5143) ages 18-69yrs, 14% female.<br>Employees from the production line (potroom and cast house) randomized into 3 Intervention Groups (fig) 2:<br>1) Group1: 20 groups of operators & supervisors, 132 operators<br>2) Group2: 18 groups of operators only, 135 operators<br>3) Group3: 2 groups of supervisors and managers and 10 groups of operators, 147 operators | 1) Control group A (also from the production line): 55 groups, 423 operators<br>2) Control group B (from other parts of the same plant): 1344 operators<br>Control group B had higher age mean=40 yrs, and greater mean yrs employed=16. | 16 months (Questionnaires pre and post intervention administered 16 months apart) |
| **Reynolds** | 1994, Pennsylvania, USA | Apparel/ Manufacturing | Before-after | Department: Half-felled inseam job Employees: Sewing machine operators n=18 | NA | 5 months (January 1992 - May 1992) |
| **Wickström** | 1993, Finland | Metal Industry | Non-randomized Time Series with referent group (does not fit Zaza) | White-collar group of planners n=88, all males, average age 39.9 yrs age range 24-55. Blue-collar group of metal workers n=125, all males, average age =39.7 yrs range 19-56 | All white and blue collar employees in another metal company, situated 100 km away | From 1986-1991 three phases: determination of base-line (1986-1987), intervention (1988-1989), follow up (1990 onwards) |

## Appendix Table F.4b. Risk Factors & Health Outcomes

| Author | Risk Factors / Intermediate Variables Considered | Health Outcome Measures | Statistical Analyses | Health Findings |
|---|---|---|---|---|
| **Carrivick** | Risk factors checklist used to assess:<br>- actions and movements<br>- workplace and workstation layout<br>- working posture and position<br>- duration and frequency of manual handling<br>- location and distance of loads moved<br>- weight and forces<br>- characteristics of loads and equipment<br>- work organization<br>- work environment<br>- skills and experience<br>- age and clothing | 2) Lost time injury & Frequency (lost time injury per hours worked)<br>3) Lost time duration & Duration rate | Descriptive stats, relation of time between implementation of recommendations and number of injuries. Univariate analyses and Generalized Linear Models (controlling for confounders) | The intervention group experienced 59 LTI (46 MSK, 13 NMSK) in the 4.25 yrs pre-intervention period and 15 LTI (11 MSK, 4 NMSK) in the 3 yr post intervention period. OR for frequency rate of LTI = 0.353 (significantly different from 0) for cleaners and OR=1.536 (sig different from 0) for orderlies. Duration rate of LTI OR=0.573 (not sig different from 0) for cleaners and OR=2.361 (sig diff from 0) for orderlies. |

| Author | Risk Factors / Intermediate Variables Considered | Health Outcome Measures | Statistical Analyses | Health Findings |
|---|---|---|---|---|
| **Evanoff** | A) Job satisfaction<br>B) Psychosocial stressors<br>C) Social support among co-workers (work apgar) | 1) Symptom survey (orderlies) (1=uncomfortable to 5=comfortable)<br>2) OSHA 200 log. (Orderlies vs. all hospital staff)<br>3) Worker Comp records (Orderlies vs. all hospital staff) | 1) McNemar & Chi Square test for paired and unpaired dichotomous data and Wilcoxon paired sign rank test and Wilcoxon rank sum for paired and unpaired ordinal data.<br>2) Rate ratios with confidence intervals for injury and lost day rates<br>3) Unpaired t-test for workers comp costs | 1) Proportion of workers reporting symptoms decreased with improvements in A) job satisfaction ($p<0.01$), B) perceived psychosocial stressors ($p<0.01$), and C) social support among co-workers ($p<0.05$).<br><br>2&3.Decreased risks of work injury (RR=0.50, 95% CI 0.35-0.72), lost time injury (RR=0.26, 95% CI 0.14-0.48), and injury with 3 or more days of time loss (RR=0.19, 95% CI 0.07-0.53). Total lost days declined from 136.2 to 23.0 annually per 100 FTE. |
| **Halpern** | Hazard intervention and abatement strategies identified:<br>- Posture,<br>- Forces,<br>- Repetitions,<br>such as: excessive reaching, twisting and bending, forceful pinching and gripping, awkward hand postures when cutting | 2) Total number of claims | % Change from pre (1992) to post (1996) intervention | 2) Sewing department reduced total number of claims by 85% (from 13 to 2) compared with a 21% increase in all other operations (from 106 to 128). |

| Author | Risk Factors / Intermediate Variables Considered | Health Outcome Measures | Statistical Analyses | Health Findings |
|---|---|---|---|---|
| **Ketola** | A) Workstation settings<br>B) Ergonomic rating (video analysis - scale 4-10, 10 is better) | 1) Mean daily musculoskeletal discomfort rates (1 feel good to 5 feel very uncomfortable) Also pain/strain in the last 30 days (yes, no) | 1 way ANOVA across ergonomic ratings at each time, ANCOVA for MSK discomfort using baseline discomfort, ergonomic rating and workload as covariates. Intervention groups vs. reference group. Logistic regression for pain, intervention dummies, baseline value of pain. | 1) At 2 months follow up, in the intensive group, significant reduction in MSK discomfort in the neck, area between neck and shoulder (right side), shoulders, right forearm, left fingers, and upper back. In the education group, similar changes except shoulders. At 10 month follow up, no significant changes were shown in both groups compared to referent. 4) Intensive group had a non significant reduction in strain/pain compared to education, and referent groups |
| **Laitinen** | A) Housekeeping standards<br>B) Perceived psychosocial changes<br>C) Perceived physical changes | 3) Sick leaves (as % of working hours) for workshop and Finnish industry | None for sick leaves<br>(2 way ANOVA for perceived psychosocial and physical changes) | Absenteeism went from 12.8% in 1991 to 9.9% in 1994; |
| **Lanoie** | A) Muscular use<br>B) asymmetric postures<br>C) lumbar strain in biomechanical laboratory<br>D) physiologic demand measures | 2) All injuries, back injuries/100 workers<br>3) lost-time injuries | econometric analysis using regression models | 2) Decreasing number of back injuries across years, both unadjusted (table 4) and adjusted for multiple organizational co-interventions and individual level confounders |

| Author | Risk Factors / Intermediate Variables Considered | Health Outcome Measures | Statistical Analyses | Health Findings |
|---|---|---|---|---|
| **Moore** | A) worker safety survey<br>B) CTD risk factor checklist<br>C) worker feedback<br>D) strain index | 2) Crude annual incidence rates 1987 – 1993, Percentage of recordable incidents related to MSK risk factors 1987 - 1993 & MSK morbidity from refid104<br>3) Lost-time incidence rates 1984 - 1993 | 2) Cox-Stuart test for trend (only used on lost-time incidence as this test requires at least 10 observations to determine significance at 0.05 level)<br>3) Descriptive | 2) Crude annual incidence rates: increased, but beginning to decline in last year<br>Marked decrease in the lost-time incidence rate |
| **Morken** | A)Coping strategies<br>B) Job demands, Job control and Social support | 1) MSK symptoms | Descriptive stats, paired t-tests to examine change from pre to post in each group.<br>ANOVA comparing groups for differences at baseline and change. Post hoc Dunnette test if significant ANOVA differences. Participants matched, significance set at p=0.05) | 1) MSK symptoms: increased from pre to post in control group B (shoulders p=0.014; hands p<0.0001; elbows p<0.0001). No significant changes in other groups. The change did not differ significantly between intervention and control. Noted loss of respondents but suggest that there was no bias as a result of this loss. |

| Author | Risk Factors / Intermediate Variables Considered | Health Outcome Measures | Statistical Analyses | Health Findings |
|---|---|---|---|---|
| **Reynolds** | A) CTD task analysis using manual methods<br>B) acquiring biomechanical data on posture, force, repetition,<br>C) calculating daily exposure scores for wrists (DWE), neck/back, shoulders, and legs (DE).<br>DWE = (grip force + postural deviations) x frequency<br>DE = postural deviations x frequency | 1) Body part discomfort (BPD) by area (collected 3 times per day for 8 days) (DE score changes<br>2) Injuries with associated lost time | Wilcoxon signed-rank test for BPD | 1) Significant decreases in BPD DE scores for wrists-hands (n=4, T*=0, p=0.125), shoulders-arms (n=4, T*=0, p=0.125), and non-significant decreases in neck/back discomfort among 4 operators. Increased leg discomfort (n=4, T*=0, p=0.125).<br>2) Decrease in lost time injuries from 14 incidents/yr prior to intervention to 0/yr in first 5 months post-intervention. |
| **Wickström** | A) biomechanical load<br>B) ergonomic ways of working<br>C) physical exam (fitness of back tissues) | 1) Occurrence of low back disorders/pain in past 12 months (questionnaire)<br>2) Sick leave due to low-back disorders | a) Proportions by Chi-square<br>b) Means by 1-way ANOVA<br>c) Sick leaves by t-test | 1) Occurrence of low back pain: declining trend seen in low back pain for both white and blue collar workers<br>2) Sick leave: decrease in sick leaves due to low back disorders from average of 3.1 days lost in 1985-1989 to average of 1.9 days lost in 1990-91 among blue collar ($t(5)=2.57$, $p=0.05$) but not among white collar ($t(5)=0.87$, $p=0.43$). Similar comparison in referent company did not show significant changes in sick leaves due to low back disorders. |

## Appendix Table F.4c. Other Outcomes

| Author | Co-intervention(s) | Facilitators / barriers | Confounding Variables Considered | Other Outcomes | Other Findings |
|---|---|---|---|---|---|
| **Carrivick** | None | Facilitators: large reduction in number of injuries was contributed to by a fall in risks of both manual handling and other injuries. Despite focus on manual handling, many other hazards were considered concurrently by the team. Barriers: intervention group membership was dynamic (i.e. high turnover) | 1) age<br>2) gender<br>3) hours worked<br>4) days of work experience (refid 55) | | Claims cost rate for cleaners decreased significantly OR=0.275, however for orderlies costs increased significantly OR=2.68 (significantly different from 0). |
| **Evanoff** | Orderly turnover with 65 of original group of 99 leaving before 15 month survey. Parallel formation of Employee-Management Advisory Teams in two other departments (ICU & Laboratory) but less complete and later implementation and sharing of lifting training manual with nursing supervisors could affect hospital referent group. | Facilitators - orderlies' active role in developing standardized lifting procedures and mandatory training materials, coalescing as team, protected time and efficient management of time. Barriers - time pressures on personnel, hospital structure for accessing equipment and needed personnel | None | | Annual workers comp costs decreased from $237/FTE to $139/FTE. ) |

| Author | Co-intervention(s) | Facilitators / barriers | Confounding Variables Considered | Other Outcomes | Other Findings |
|---|---|---|---|---|---|
| **Halpern** | Medical and claims management program initiated at same time (involved stretching to provide breaks in repetitive tasks, and modified RTW program) | | None | Claim costs | Sewers demonstrated an 83% reduction in costs per claim (from $31,846 to $5,500) compared with a 52% reduction in all other departments (from $6,821 to $3,281). This translated into an overall 97% decrease in total incurred losses (from $414,000 to $11,000) in the Sewing department compared to a 42% decrease in all others (from $723,000 to $420,000) pre to post intervention. |
| **Ketola** | Occupational physiotherapy consultations over the entire study period: intensive n=10, education n=7, reference n=8 | Facilitators (inferred) - active involvement of workers and one-on-one guidance. Barriers - inadequate guidance for education group | Work experience (yrs), Age (yrs), workload (mouse & key events) & gender | None | None |
| **Laitinen** | New wage system based on demands on jobs and skills of workers (still a piece work system, same wage or more guaranteed for all workers) | Facilitators - Union Reps<br><br>Barriers - Management and employee scepticism | None | 1) Housekeeping index<br>2) Perceived psychosocial changes<br>3) Perceived physical changes | 1) Housekeeping index increased from 57% to 89% ($p<0.001$);<br><br>2 & 3) psychosocial assessments: physical working conditions and psychosocial work environment both significantly improved when considered for all responses ($p < 0.001$ and $p < 0.02$ respectively). All other aggregated Q1 findings not |

| Author | Co-intervention(s) | Facilitators / barriers | Confounding Variables Considered | Other Outcomes | Other Findings |
|---|---|---|---|---|---|
| | | | | | significant; Perception of physical working conditions improved in all departments: order and tidiness improved ($p<0.001$), pleasantness of work environment ($p<0.05$), layout of work stations ($p<0.05$), safety of working methods ($p<0.05$); psychosocial environment improved in three departments ($p<0.05$); For Q2 two of 11 groups of questions showed statistical improvements: communication and cooperation (p level not given) - other 9 groups showed no significant difference; For specific Q2 questions - total responses: Company goals are known ($p<0.01$), Practical places for tools ($p<0.01$), workstation is clean and in good order ($p<0.05$). In Dept. H: positive prospects in work, practical tools are available ($p<0.05$); practical places for tools, workstation is clean and in good order, regular feedback of outcome, visual appearance of work station is pleasant ($p<0.01$); Company goals are known ($p<0.001$); In Dept. J: daylight in workstation, company goals are known ($p<0.05$); workstation is clean and in good order ($p<0.01$); |

| Author | Co-intervention(s) | Facilitators / barriers | Confounding Variables Considered | Other Outcomes | Other Findings |
|---|---|---|---|---|---|
| **Lanoie** | Strike | Facilitators - Steering committee support, training sessions, use of video<br>Barriers - antagonisms between labour & mgt at beginning, lack of experience in participatory processes | Organizational level: grievances, strike dummy, absenteeism, overtime hours.<br><br>Individual level: Age, seniority, work status, | Recorded and estimated costs of intervention. Valued benefits accrued .Both with varying discount rates. | Net present value positive in all cases for 5% discount rate and for one of the scenarios with higher discount rates. Judgement of the researchers was that the PE intervention was cost-beneficial to the firm. |
| **Moore** | 1) major renovations starting (and ending at different times in different depts) refid104.<br>2) Line Speed increases refid114<br>3) medical management was a component of the ergonomics program? | Facilitators - Management commitment, effective PE team leadership, substantial resource investments, structured problem-solving methods.<br>Barrier - Time constraints to meetings | Organizational level: grievances, strike dummy, absenteeism, overtime hours.<br>Individual level: Age, seniority, work status, | Valuing through WC costs<br><br>Impressions on effectiveness of intervention implementation and process to identify problem and develop solution | Marked reduction in total and per capita annual worker's compensation costs.<br><br>Favourable impressions by workers on intervention process. |
| **Morken** | Organizational restructuring may have affected some departments | Facilitators: workers' active involvement in making changes was seen as facilitating the intervention process<br><br>Barriers: Personal interaction between the groups was possible (contamination) | Many variables listed but seem not to be considered (check p 117 design).<br>It seems that confounding variables were considered through randomization process which resulted in similar demographics and risk factors in groups | Coping strategies | 2) Coping strategies: intervention groups used more strategies then control groups (p=0.043, ANOVA). Intervention group 2 increased most (mean change=0.041, 95% CI 0.005, 0.077). Control group B declined by 0.010, 95% CI -0.02, 0.001). Intervention group 2 and control group B differed (p=0.017) and Intervention group 2 and control group A differed at borderline significance (p=0.068). The largest increase in intervention group2 was for following: "work on other tasks |

| Author | Co-intervention(s) | Facilitators / barriers | Confounding Variables Considered | Other Outcomes | Other Findings |
|---|---|---|---|---|---|
| | | | | | that are less strenuous", use equipment to reduce physical strain" & "ask colleagues for help with strenuous work tasks".<br>3) Job demands, control and social support: social support in intervention group 2 improved slightly from pre to post. All other groups tended to decline (p=0.10, ANOVA). Job demands and control did not differ significantly. |
| **Reynolds** | | Facilitators: enthusiasm & active participation of workers in making changes was seen as facilitating the intervention process<br><br>Barriers: Personal interaction between the groups was possible (contamination) | | Productivity (as measured by average hourly earnings) | Significant productivity increase from 6 months pre- to 2 months post-intervention (from $7.34 to $8.56; n=8, T*=35, p=0.01) |

| Author | Co-intervention(s) | Facilitators / barriers | Confounding Variables Considered | Other Outcomes | Other Findings |
|---|---|---|---|---|---|
| **Wickström** | Plant closure due to downsizing during 4th follow-up year (1998). | Facilitators - EHS officer hired by management at start of intervention; Specific allocation of resources (both time and financial - $50,000 specified in first year, other years not reported); commitment from both top management and union. Barriers - History of unsuccessful attempts to improve H&S in plant; high overall OSHA recordable incidents; Large trust gap between management and labour. | Plant closure announcement and final accident / injury data | | |

## Appendix Table F.4.5. Details of Health Outcome Findings that Assist with Estimation of Effect Size

| First Author | Health Outcome Measures | Statistical Analyses | Health Findings | Effect Size Descriptor* |
|---|---|---|---|---|
| **Carrivick** | 2) lost time injury (LTI), frequency (lost time injury per hours worked) & duration (days lost per hours worked) | Univariate analyses and Generalized Linear Models (controlling for confounders) | 2)The intervention group (cleaners) experienced 59 LTI (46 MSK, 13 NMSK) in the 4.25 yrs pre-intervention period and 15 LTI (11 MSK, 4 NMSK) in the 3 yr post intervention period. OR for frequency rate of LTI = 0.353 (significantly different from 0) for cleaners (intervention) and OR=1.536 (sig. different from 0) for orderlies (referent).<br>3) Duration rate of LTI OR=0.573 (not sig. different from 0) for cleaners and OR=2.361 (sig. diff from 0) for orderlies. | LTI rate - large<br><br>LTI duration - medium |
| **Evanoff** | 1) Symptom survey (orderlies) (1=uncomfortable to 5=comfortable)<br><br>2) OSHA 200 log. (Orderlies vs all hospital staff)<br>Worker Comp records (Orderlies vs all hospital staff) | 1) McNemar & Chi Square test for paired and unpaired dichotomous data and Wilcoxon paired sign rank test and Wilcoxon rank sum for paired anf unpaired ordinal data.<br>2) rate ratios with confidence intervals for injury and<br>3) lost day rates | 1) Significant mean discomfort rating changes from: 3.5 to 3.9, neck; 3.0 to 3.4, lower back, 3.7 to 4.0, forearm; 3.3 to 3.8, knee.<br><br>2) decreased risks of work injury (RR=0.50, 95% CI 0.35-0.72), lost time injury (RR=0.26, 95% CI 0.14-0.48), and injury with 3 or more days of time loss (RR=0.19, 95% CI 0.07-0.53).<br><br>3) Total lost days declined from 136.2 to 23.0 annually per 100 FTE. | 1) could not estimate<br><br>2)<br>work injury – medium,<br>lost-time injury - large |
| **Halpern** | 2) total number of claims & cost per claim | % change from pre (1992) to post (1996) intervention | 2) Sewing department reduced total number of claims by 85% (from 13 to 2) compared with a 21% increase in all other operations (from 106 to 128).<br><br>3) Sewers demonstrated an 83% reduction in costs per claim (from $31,846 to $5,500) compared with a 52% reduction in all other departments (from $6,821 to $3,281). | 2) # of claims – large |

| First Author | Health Outcome Measures | Statistical Analyses | Health Findings | Effect Size Descriptor* |
|---|---|---|---|---|
| **Ketola** | Mean daily musculoskeletal discomfort rates (1 feel good to 5 feel very uncomfortable) Also pain/strain in the last 30 days (yes, no) | ANCOVA for MSK discomfort using baseline discomfort, ergonomic rating and workload as covariates. Intervention groups vs. reference group. Logistic regression for pain, intervention dummies, baseline value of pain. | 1) at 2 months follow up, in the intensive group versus referent group, significant reduction in MSK discomfort in the neck (2.7 vs. 3.3), area between neck and shoulder (right side) (2.5 vs. 3.1), shoulders (2.2 vs. 2.8 right, 1.9 vs. 2.4 left), right forearm (2.1 vs. 2.5), left fingers (1.8 vs. 2.3), and upper back (2.2 vs. 2.9) (Mean differences from 0.4 to 0.7, most SE 0.1 or 0.2, n's of 26 and 28, implies SD approximately 4). In the education group, similar changes except shoulders. At 10 month follow up, no significant changes were shown in both groups compared to referent.<br>Intensive group had a non signficant reduction in strain/pain compared to education, and referent groups | 1) Pain - small |
| **Laitinen** | 1) sick leaves (as % of working hours) for workshop and Finnish industry | none for sick leaves | absenteeism went from 12.8% in 1991 to 9.9% in 1994; | Could not estimate |
| **Lanoie** | 2) crude annual incidence rates 1987 – 1993<br>Lost-time incidence rates 1984 - 1993<br>percentage of recordable incidents related to MSK risk factors 1987 - 1993 | Regression models with yearly incidence of accidents function of ergonomics, control variables & error. | 2) Decreasing number of back injuries across years, unadjusted frequency from 0.31 to 0.13 for ergonomics intensity of 0 to 3 respectively.<br>Adjusted for multiple organizational co-interventions and individual level confounders:<br>Accidents ergo not significant, back-related injuries ergo 3 (most effect) coefficient -0.45 (-1.67), $p<0.1$ | LTI - Small |
| **Moore** | 2) OSHA 200 logs of injury/illness statistics, for all MSK and for CTD,<br># of disorders according to anatomical distribution | 2) Cox-Stuart test for trend (only used on lost-time incidence as this test requires at least 10 observations to determine significance at 0.05 level) | 2) crude annual incidence rates increased 1987 (100%) to 1991 (133%) to 1993 (107%),<br>marked decrease in the lost-time incidence rate from recording 1984 at 100%, through ergonomics program initiation in 1986 (50%), to 1993 (end of PE demonstration project) 11% ($p<0.05$) | Could not estimate. |

| First Author | Health Outcome Measures | Statistical Analyses | Health Findings | Effect Size Descriptor* |
|---|---|---|---|---|
| | | | | |
| **Morken** | 1) MSK symptoms | descriptive stats, paired t-tests to examine change from pre to post in each group. ANOVA comparing groups for differences at baseline and change. Post hoc Dunnette test if significant ANOVA differences. Participants matched, significance set at p=0.05 | 1) MSK symptoms: increased from pre to post in control group B (shoulders p=0.014; hands p<0.0001; elbows p<0.0001). No significant changes in other groups. The change did not differ significantly between intervention and control. Noted loss of respondents but suggest that there was no bias as a result of this loss. | Could not estimate. |
| **Reynolds** | 1) body part discomfort (BPD) by area (collected 3 times per day for 8 days) (DE score changes<br>2) injuries with associated lost time | Wilcoxon signed-rank test for BPD | 1) Significant decreases in BPD DE scores for wrists-hands (n=4, mean from 0.25 to 0.03, T*=0, p=0.125), shoulders-arms (n=4, mean from 0.29 to 0.03, T*=0, p=0.125), and non-significant decreases in neck/back discomfort among 4 operators. Increased leg discomfort (n=4, T*=0, p=0.125).<br>2) Decrease in lost time injuries from 14 incidents/yr prior to intervention to 0/yr in first 5 months post-intervention. | 1) Likely large for pain but could not estimate.<br><br>2) could not estimate |

| First Author | Health Outcome Measures | Statistical Analyses | Health Findings | Effect Size Descriptor* |
|---|---|---|---|---|
| **Wickström** | 1) occurrence of low back disorders/pain in past 12 months (questionnaire)<br>3) sick leave due to low-back disorders | 1) proportions by Chi-square means by 1-way ANOVA<br><br>3) sick leaves by t-test | 1) proportion reporting low back pain, non-significant decline in target company over 4 years (1986, 88, 90) among sheet metal workers (74%, 76%, 58%) and planners (52%, 37%, 41%) compared to reference (79%, 84%, 78%; 63%, 59%, 53% respectively).<br>3) sick leave: decrease in sick leaves due to low back disorders from average of 3.1 days lost in 1985-1989 to average of 1.9 days lost in 1990-91 among blue collar ($t(5)=2.57$, $p=0.05$) but not among white collar ($t(5)=0.87$, $p=0.43$). Similar comparison in referent company did not show significant changes in sick leaves due to low back disorders. | 1) could not estimate<br><br>3) could not estimate |

* For odds ratios and relative risks, our guideline was: small, 1-1.3 or .77 to 1; medium, >1.3 but <2.5, <0.77 and >0.4; large, 2.5 or more, 0.4 or less. For differences in means, proportions, Chi-square, ANOVA and regression relied on Cohen J (1988).