Participatory Ergonomics for Return to Work

16

Dwayne Van Eerd, Donald C. Cole, and Ivan A. Steenstra

16.1 Introduction: The Burden of Musculoskeletal Disorders (MSDs)

Work-related musculoskeletal disorders (MSDs) are a constellation of painful soft-tissue disorders of muscles, tendons, joints and nerves which can affect all parts of the body, although the neck, upper limb and back are the most common areas (Schneider and Irastorza 2010; Silverstein and Evanoff 2011). Symptoms reported for MSDs include pain, burning, or numbness/tingling which can be mild or become quite severe, especially if not appropriately treated (Silverstein and Evanoff 2011).

MSDs continue to be problematic worldwide. In the USA, the Bureau of Labor Statistics (BLS) reported 333,760 MSDs in 2007, an annual incidence rate of 35 per 10,000 workers (Silverstein and Evanoff 2011). It is estimated that work MSDs account for 29 % of all injuries and illnesses. This is a drastic increase from the 5.1 per 10,000 workers reported in 1984 (Hales and Bernard 1996). Direct compensation costs for MSDs are estimated to be between $13 and $20 billion dollars annually in the USA where, on average, they result in a median of 9 days off work (Silverstein and Evanoff 2011).

In Europe, MSDs are considered to be an increasing and significant health problem, which make up approximately 39 % of the total occupational disease burden in Europe (Schneider and Irastorza 2010). The cost of work-related upper limb MSDs has been estimated at between 0.5 and 2 % of the Gross National Product (GNP) (Schneider and Irastorza 2010). MSDs are considered to result in a sizeable proportion of total absenteeism in Europe.

The MSD picture is similar in Canada, with upper extremity MSDs and low back pain the leading diagnoses of disabling work-related injuries. In Ontario, the Workplace Safety and Insurance Board (WSIB) reports soft tissue injuries as a consistent and sizeable problem, representing 40–50 % of lost-time claims since the year 2000 (WSIB 2009). In Nova Scotia, MSDs (sprains and strains) represented 53 % of all 2009 compensable time-loss claims (Workers' Compensation Board of Nova Scotia 2009), while in British Columbia (BC), 41 % of the total claims for 2009 were for MSDs (overexertion/bodily motion) (WorkSafeBC 2009). These data suggest MSDs are a leading cause of time-loss injury claims and lost productivity in Canadian workplaces.

D. Van Eerd (✉) • I.A. Steenstra
Institute for Work & Health, 481 University Ave, Suite 800, Toronto, ON, Canada, M5G 2E9
e-mail: dvaneerd@iwh.on.ca; isteenstra@iwh.on.ca

D.C. Cole
Dalla Lana School of Public Health, University of Toronto, Health Sciences Building, 155 College Street, Toronto, ON, Canada, M5T 3M7
e-mail: donald.cole@utoronto.ca

I.Z. Schultz, R.J. Gatchel (eds.), *Handbook of Return to Work*,
Handbooks in Health, Work, and Disability 1, DOI 10.1007/978-1-4899-7627-7_16

In all jurisdictions, difficulties exist in the classification (Van Eerd et al. 2003) and assignment of work-relatedness (Sluiter et al. 2001) of musculoskeletal disorders and, therefore, it is quite likely that the reported rates of MSDs are underestimates. Additionally, workers with MSD conditions such as pain are likely to underreport their condition (Sullivan and Cole 2002). Thus, the magnitude of the impact of MSDs on workers, employers, health care systems, and society is likely much larger than estimated by examining routinely collected administrative data.

Epidemiological investigations have identified a broad range of physical, psychological, psychosocial, and organizational risk factors for MSDs (Hagberg et al. 1995; National Research Council 2001; Silverstein and Evanoff 2011; Sluiter et al. 2001). There is relatively little debate among the scientific community regarding the work-relatedness of MSDs. The research focus has moved from establishing cause to studying effectiveness of prevention and treatment (Silverstein and Evanoff 2011).

Box 16.1 Definition of Ergonomics
Ergonomics, as defined by the International Ergonomics Association (IEA), is the "scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

Practitioners of ergonomics, ergonomists, contribute to the planning, design and evaluation of tasks, jobs, products, organizations, environments and systems in order to make them compatible with the needs, abilities and limitations of people." (www.iea.cc).

16.2 Ergonomics as an Intervention for MSDs

Broadly speaking ergonomics concerns the science and practice of improving work environments (see Box 16.1). When considering MSDs, ergonomists should have a solid understanding of the broad range of elements related to ergonomics. Research on the risk factors of MSDs has shown links to physical, psychosocial, and organizational factors (Evanoff et al. 1999; Laitinen et al. 1997a, b; Moore and Garg 1997). Depending on the circumstances and desired outcomes, workplaces may limit the scope of an ergonomic intervention, requiring a focus on certain factors. The literature describing ergonomics interventions for MSDs is dominated by a focus on the physical factors. The interventions often address force, repetition, and duration aspects of physical tasks and body postures in the working environment. However, there are examples from the literature where psychosocial (Evanoff et al. 1999) and organizational (Laitinen et al. 1997a, b) factors are considered within intervention programs to reduce risk factors for MSDs.

Ergonomists are trained to evaluate the working environment and human interaction, to identify risk factors, and to design and implement accommodations to reduce the risks for injury while maintaining productivity. Ergonomists will typically interact with the individuals involved in completing the tasks observed. This is a method of gaining useful, much needed information about the tasks, forces, and time pressures an individual worker faces in their job. However, in a consultant or practitioner model, the individual worker may not be involved in developing the solution or designing the changes to be implemented. Participatory ergonomics is a method of engaging the individuals who are involved in and/or responsible for completing the work tasks that may require change.

16.3 Participatory Ergonomics

16.3.1 The Origin and Nature of Participatory Ergonomics

Motamedzade et al. (2003) reported that the term "participatory ergonomics" (PE) was coined in 1983 by Kazutaka Kogi after discussions with

Kageyu Noro. The concept of a participatory approach was developed further by Noro in a workshop setting the following year (Noro and Imada 1991; Noro 2003). Participatory Ergonomic (PE) approaches grew out of quality circle experiences in Japan (Liker et al. 1989; Motamedzade et al. 2003) and participatory workplace design processes in Northern Europe (Elden 1986) and North America (Liker et al. 1989) during the 1980s.

PE interventions grew in popularity through the 1990s (Motamedzade et al. 2003), with increasing reports in the literature describing the interventions in different types of workplaces. Newspapers (Rosecrance and Cook 2000), meat packing plants (Moore and Garg 1997), automotive production (Liker et al. 1989), and hospitals (Evanoff et al. 1999; Bohr et al 1997), as well as unions (Simon and Leik 1999) and health and safety sector agencies (Wilson and Haines 1997) all actively promoted PE approaches.

A characteristic feature of most PE interventions has been the formation of some type of "team" or committee, typically made up of employees or their representatives, managers, ergonomists, health and safety personnel, and possibly research experts. Once formed, teams usually receive training from an expert, most often an ergonomist, to become familiar with ergonomic principles (Wells et al. 2000). Once this foundation is in place, the group uses its newly developed knowledge to make improvements in the workplace (Halpern and Dawson 1997; Haims and Carayon 1998; Reynolds et al. 1994). The process of making improvements typically involves the following steps: identifying areas of opportunity (where are the hazards), conducting hazard assessments, developing and proposing solutions, implementing solutions, and evaluating solutions. These steps are often iterative as new areas and hazards are identified.

Because team members work together in PE interventions to improve workplace conditions through participation, communication, and group problem-solving, they can have a positive impact on workers' exposures and health (de Jong and Vink 2000; Haims and Carayon 1998; Haines et al. 2002; Laitinen et al. 1997a, b; Nagamachi 1995; Simon and Leik 1999). Ideally, the PE approach encourages workers to be involved in controlling their own work activities, which consequently decreases work organization or psychosocial risk factors for MSDs (Wilson and Haines 1997; Westgaard 1999; Bongers et al. 2002).

In 1998, Haines and Wilson prepared a report for the Health and Safety Executive (HSE) of the UK describing the development of a framework for participatory ergonomics (Haines and Wilson 1998). The report was ambitious in its scope, including a review of literature on PE with a narrative synthesis of the practices regarding the implementation of PE. The report covered definitions of PE, showing that the concepts represented varied with the underlying approaches and the focus of the researchers-practitioners involved. Shaping the various definitions were concepts related to participative management, worker-centric views, and macro-ergonomics. Distinctions were also made about how participation is defined within PE.

The existing definitional idiosyncrasies were described by Haines and Wilson (1998) as the "fuzziness" associated with the concept of PE. As the authors recognized that there is no general agreement about the exact definition of PE, they went on to provide their own definition. They suggested that their new definition covers a broad range of PE interventions or programs in the full variety of settings that could implement PE. We use the Haines and Wilson definition in this chapter (see Box 16.2), agreeing that it is general enough to cover the variety of ways PE could be conceived in practice. We also include a shorter definition provided by Kuorinka (1997).

Box 16.2 Definitions of Participatory Ergonomics

1. "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" (Wilson and Haines 1997 p. 12).
2. "practical ergonomics with participation of the necessary actors in problem-solving" (Kuorinka 1997).

The main objective of Wilson and Haines' report was to describe a new framework for PE that could be used both for applied research and for the implementation of PE programs in workplaces. The framework built upon previous research and the work of others in the field to describe eight dimensions along which PE interventions or programs may vary. The authors provided an in-depth description of the PE process including key prerequisites necessary to initiate PE. The report's authors teamed up with other colleagues in an article describing their attempt at validating the framework (Haines et al. 2002). The updated participatory ergonomics framework (PEF) with nine dimensions (see Table 16.1) has been found useful by other researchers, demonstrating content validity and utility.

16.3.2 Evidence About the Effectiveness of Participatory Ergonomic Interventions

The effectiveness of PE interventions in improving health outcomes was examined in a systematic review (Rivilis et al. 2008). The review employed a comprehensive literature search and a rigorous and transparent review process to examine intervention effectiveness. Study relevance was determined by consensus in a screen of articles by two reviewers. The methodological quality of relevant articles was also determined by consensus achieved by two reviewers. Using a "best evidence" synthesis approach, 12 studies were identified and rated as medium or higher methodological quality. These studies provided some evidence that PE interventions could have a positive impact on musculoskeletal symptoms, on reducing injuries and workers' compensation claims, and on lost days from work or sickness absence. Despite the evidence, the authors recommended further high quality research was needed to gain a deeper understanding of PE interventions and their effectiveness in improving worker health.

More recent literature reviews of workplace interventions to prevent disability and/or improve return to work (RTW) have included studies about PE interventions (Aas et al. 2011; Caroll et al. 2010; Williams et al. 2007; van Oostrom et al. 2009). Findings from these reviews generally suggest positive impacts from PE interventions but heterogeneity of the interventions and the limited number of high quality studies posed challenges for determining the level of evidence regarding PE interventions.

Recent publications have been less positive than these reviews when examining the effectiveness of PE interventions. In a Finnish cluster-randomized trial (RCT), participatory ergonomic groups were formed across sets of three to five municipal kitchens, with support from an ergonomist (Pehkonen et al. 2009). Groups participated in workshops and workers' knowledge and awareness of ergonomics increased. Together, they implemented 402 ergonomic changes, which they perceived to decrease physical load and improve musculoskeletal health. However, among the 504 workers of 119 kitchens (intervention $n = 59$; control $n = 60$), no differences were observed in outcomes. These included the occurrence of and trouble caused by musculoskeletal pain in seven anatomical sites, local fatigue after work, and sick leave due to musculoskeletal disorders either during the 9–12 month intervention or over a 1-year follow-up period (Haukka et al. 2008). The authors across the two papers noted that hindering factors for implementation included lack of time and motivation, insufficient financial resources and limited support from the management and technical staff. They surmise, "that a more comprehensive redesign of work organization and processes is needed, taking more account of workers' physical and mental resources" (Haukka et al. 2008 p. 849).

Similar conclusions were reached in a multiple case study of four worksites in different companies using a quasi-experimental approach (Cole et al. 2009). It was concluded that, "Ergonomic change teams (ECTs) faced chal-

Table 16.1 Dimensions, categories, and criteria of PE according to the participatory ergonomics framework by Haines and Wilson (Van Eerd et al. 2010). Reprinted here with permission from Taylor & Francis Ltd, www.tandfonline.com

Dimensions	Categories	Criteria (based on Haines et al. 2002)
Permanence	Ongoing	Ongoing participatory mechanisms … more integrated into the structure of the organization
	Temporary	Participatory ergonomics mechanisms functioning on a temporary basis
Involvement	Full direct	Each employee participates directly in decisions about their work
	Direct representative	Employee representatives are selected to represent viewpoints of a large number of workers
	Delegated	Representatives not actively representing the views of others but represent a typical subset of a larger group
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)
	Entire organization	The PE process takes place at a single organization or workplace
	Department/work group	The PE process takes place in a department or workgroup within a single organization
Decision making	Group delegation	Management gives employees increased discretion and responsibility to organize … their jobs without reference back
	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
	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
Mix of participants	Operators	Workers involved in teams
	Line management	First level managers/supervisors involved in teams
	Senior management	Senior managers involved in teams
	Technical staff	Internal specialist or technical staff (such as engineers, or health a safety specialists) involved in team
	Union	Union members or representatives involved in team
	External advisor	External advisor (such as ergonomic consultant from outside of company) involved in team
	Supplier/purchaser	Supplier or purchaser of equipment involved in team
	Cross-industry organization	Cross industry or organization personnel (such as industry association representative) involved in team

(continued)

Table 16.1 (continued)

Dimensions	Categories	Criteria (based on Haines et al. 2002)
Requirement (for participation)	Compulsory	Participation required as part of job specifications
	Voluntary	Voluntary participation in PE process
Focus	Tools and equipment	Changes to "tools and equipment" involve physical changes to the workstation or tools/equipment used by workers.
	Work processes	"Work processes" may include, for example, changing the order or way of doing things, and may include job rotation and scheduling changes.
	Workplace organization	Examples of "workplace organization" include changes in management reporting, structure of departments or workgroups, or upper management changes (macro ergonomics).
Remit	Problems identification	Involved in identification of problems
	Solution development	Involved in generating solutions to problems identified
	Implementation	Involved in implementing change
	Set-up/structure	Involved in setting up or structuring the process
	Monitor/oversee	Involved in monitoring or overseeing the process of the initiative
Role of ergonomic specialist	Initiates and guides process	Ergonomist is key in initiating and guiding process as integral part of duties
	Acts as expert	Ergonomist is part of the team to provide expertise in ergonomic matters
	Trains members	Ergonomist primarily focuses on training
	Available for consultation	Ergonomist is available for consultation as needed (therefore may not be member of team)
	Not involved	Ergonomist is not involved in the PE process

lenges securing employees' time, varying management commitment and significant production pressures. Nevertheless, they actively introduced between 10 and 21 changes over 10–20 months of activity" (Cole et al. 2009 p. 161). However, these changes brought limited outcomes in the intensity of exposure reduction. Based on pre-post assessment, using questionnaire-based measures, no discernible effects in physical effort or pain were experienced by the employees. In parallel, the authors explored the intensities of changes in the same participatory ergonomics research program (Wells et al. 2009). Those changes affecting production system redesign and reconfiguration were judged to have medium to high intensity, while most other changes were judged to be of small intensity. This may be a particular concern for return to work related changes to a particular job or set of jobs for which a returning worker may be seeking accommodation, i.e., substantial efforts may need to be made in order to achieve sufficient intensity of changes to effectively reduce workloads.

In the Netherlands, a cluster RCT was conducted among 19 intervention departments and 18 control departments of "four Dutch companies: a railway transportation company, an airline company, a university including its university

medical hospital, and a steel company" (Driessen et al. 2011 p. 675). As part of a Stay@Work participatory ergonomics (PE) program, working groups in each intervention department followed a series of steps. They designed ergonomic changes for jobs causing low back and neck pain, prioritized them, and then implemented them. After 12 months, among the 3047 workers, no difference was observed between groups in the prevalence of low back and neck pain. PE interventions did, however, increase the probability of recovering from low back pain (OR 1.41, 95 % CI 1.01–1.96), something most relevant for RTW or stay at work situations.

In a secondary prevention trial, workers at three large Finnish companies with medically verified upper-extremity disorders not severe enough to require sick leave, were randomized to receive a new intervention (Martimo et al. 2010). The physician contacted the worker's supervisor to discuss accommodations. An occupational physiotherapist visited the workplace, assessed "the physical work environment, available tools or instruments, working postures, force requirements, work pace and breaks during work, as well as the employee's possibilities to continue working" (Martimo et al. 2010 p. 27). In a limited form of participation, she made some changes on site, and discussed her suggestions with the employee and the supervisor, the latter of whom then made the final decision on further technical and administrative changes. Among the 177 employees who were randomized, over 50 % self-reported productivity loss at baseline. At 12 weeks, statistically significant differences were observed in the proportion of workers self-reporting persistent productivity loss (25 % intervention, versus 51 % control). Further, intervention workers experienced a reduction in the magnitude of productivity loss (7 % versus 18 %, $P = 0.001$).

Hence, there remains a promise with respect to ergonomic changes in consultation with employees and their supervisors. However, PE interventions are heterogeneous and context dependent, with varying outcomes. Instituted changes must be substantial or intense enough, and focused on the particular needs of workers to which they are directed.

16.3.3 The Implementation of Participatory Ergonomics as an Intervention

Literature reviews provide details about the implementation and evaluation of PE interventions (Haims and Carayon 1998; Haslam 2002; Hignett et al. 2005; Nagamachi 1995), including elements of the process (Haines and Wilson 1998). Hignett's narrative review provides an excellent summary of the strengths of PE with examples from a range of industries (Hignett et al. 2005). The benefits of implementing successful PE programs are also described (Wilson and Haines 1997).

A recent systematic review of the literature on the implementation of PE interventions found some common elements across various studies from different jurisdictions and industries (Van Eerd et al. 2010). The review employed a comprehensive literature search of the peer-reviewed and grey literature. The grey literature (reports and documents that are not peer-reviewed and typically not controlled by commercial publishing) was considered an important source by the many stakeholders contacted as part of the review process. The review followed a rigorous and transparent process to reduce bias. However since the topic was not intervention effectiveness, the emphasis was not on methodological quality but on the description of the process and implementation of PE, adapting the Haines and Wilson framework to describe the nature of PE.

The review findings suggested that developing teams and involving the right people in the process were key aspects of the intervention. In addition, some of the most important facilitators to PE implementation were the following factors: support of management and coworkers, communication, training and resources (Van Eerd et al. 2010). The review findings were used to create an evidence-based guide to aid in the initiation of PE interventions in workplaces (see Fig. 16.1 below).

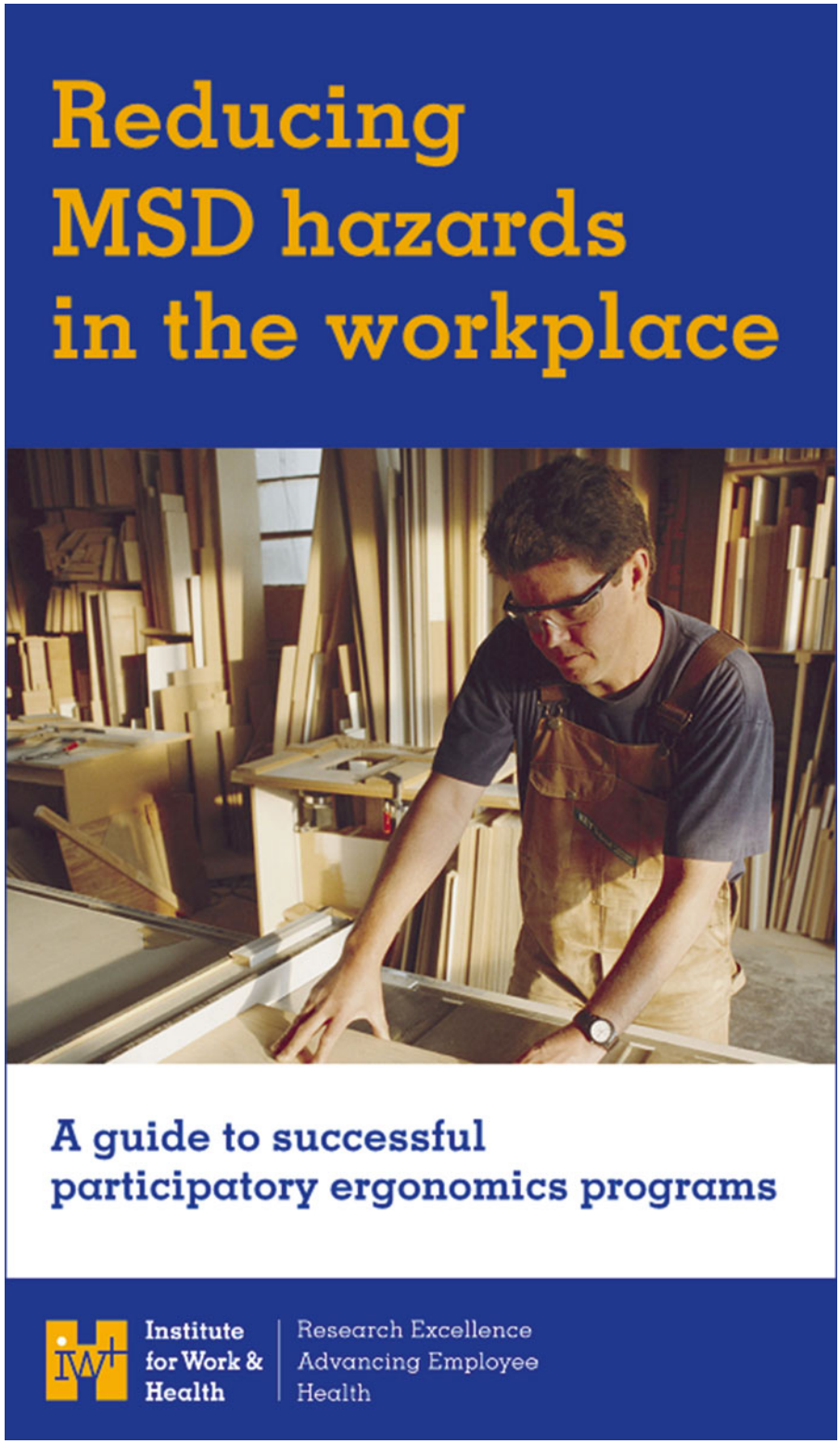

Fig. 16.1 Cover of the PE Guide, an evidence-based approach to initiating participatory ergonomics in workplaces (Institute for Work & Health 2009)

Recent studies have focused on the process evaluation of PE interventions (Cole et al. 2009; Driessen et al. 2010). Cole et al. (2009) presented a description of participatory interventions using a multiple case study approach. They examined four PE interventions across four workplaces and described the effects of the interventions using a path analysis. In addition, they conducted fieldwork and interviews to explore common themes about the process of the interventions across workplaces.

The findings from the process evaluation revealed issues and concerns with production pressures, securing employees' time, management commitment, and frustrations over delays. These issues were found across all workplaces to some degree. Prior to the PE intervention research, these workplaces did not exhibit participatory cultures and had little ergonomics knowledge. However, the early stages of the PE process showed advances in setting up the PE process by means of regular meetings and training in ergonomics. Cole et al. (2009) suggested that the process evaluation was most useful and that future research should report on the process to better understand how PE interventions can be effectively implemented. They suggested that process information, even without changes in health measures could be useful to future applications of PE.

Driessen et al. (2010) completed a process evaluation of a PE intervention which was part of a cluster randomized controlled trial. The focus of the PE intervention was to reduce low back pain and neck pain among workers. Driessen and colleagues (2010) selected and defined five key components from Linnan and Steckler (2002): recruitment, reach, fidelity, dose delivered, and dose received (the last two were combined and called implementation components). To these components, they added one called "satisfaction." The authors defined these components according to variables available in the PE intervention trial or self-report survey measures created to address the concept.

The results of the process evaluation suggested that the PE intervention was feasible and successful in prioritizing risk factors and in developing solutions to address these risk factors. The authors did not feel that the process evaluation was as useful in evaluating implementation of solutions, though study results suggested relatively limited implementation of the solutions developed by the workplace teams. Despite these findings, the authors point out that the process evaluation was useful in defining the successful and not so successful aspects of the PE intervention in a large intervention trial.

The focus on process evaluation can be important for successful intervention studies to better understand the mechanisms of beneficial effects and the transferability of the intervention to other contexts. This may be particularly important for complex interventions such as PE in which a better understanding of the contextual factors can assist in the implementation of PE interventions in other workplaces. It may take time for effective ergonomic interventions to result in a reduction of injuries and lost time claims (Rivilis et al. 2008). Therefore, process and implementation evaluation, together with consideration of additional indicators, are likely important in the evaluation of PE interventions.

16.4 Participatory Ergonomics as a Return to Work Intervention

16.4.1 The "Sherbrooke Model"

A number of intervention studies have aimed to examine the effectiveness of participatory ergonomics on return to work. One of the earliest attempts was published by Loisel et al. (1997). In this study, conducted in Quebec, Canada, participatory ergonomics was a part of the Sherbrooke model and a component of the first intervention step. It was followed by interventions based on back school principles and work hardening for workers on sick leave due to low back pain. In the first step, an injured worker was examined by an occupational physician and the jobsite was visited by an ergonomist to give appropriate recommendations for RTW to the worker's general practitioner. Each of the participating companies

had a PE team in place that was trained in the weeks after an injured worker came into the study. Both employees and management representatives were trained in the approach during a 2-day session and served as the back pain advisory group of that company. Although the study was ended prematurely because of changes in legislation that would have confounded the results, a statistically significant and relevant effect of PE on RTW was found, where those that received the intervention returned to work 1.9 times faster compared to those that did not (Hazard rate ratio and 95 % confidence interval, Hazard rate ratio = 1.91, [1.18–3.10]).

The first Dutch replication of the Sherbrooke model study also aimed to improve RTW in workers on sick leave due to low back pain (LBP). The PE intervention, however, was organized rather differently; PE teams were formed on an ad hoc basis. The injured worker, his/her direct supervisor, possible other stakeholders at the worksite (such as a coworker or facilities manager) met with a representative of the occupational health service for a half-day session where they were trained in the fundamentals of the PE approach. Despite a different approach, the Dutch trial yielded similar results as the Quebec trial (Hazard rate ratio = 1.7; 95 % confidence interval [1.2–2.3], for the PE intervention) (Anema et al. 2007).

In a commentary on the paper reporting the effectiveness of the model (Anema et al. 2007), Hadler (2007) stated that "only 50 %" of the solutions were implemented and therefore it must have been the process of worker involvement itself and not as much the ergonomic solutions that contributed to the outcomes. Although this is a plausible explanation, there is another side to this finding. When presenting the process of intervention (Anema et al. 2003) to ergonomists, the received feedback was more optimistic. A Dutch pilot study (Anema et al. 2003) found that 7.9 solutions per case (SD 3.9) were proposed and on average 50 % of these solutions were implemented. Loisel et al. (1994) had a similar result in their study. Experienced ergonomists explained that, in their practice, attempting to implement more than three solutions was considered non-feasible. They expressed their surprise over the large number of solutions that were implemented in the study. It should be noted that those implementing the intervention were advised to stay within a limit of three feasible solutions to be implemented by the stakeholders in the workplace.

Following the earlier Dutch trial (Anema et al. 2007), PE was also evaluated as part of an "integrated care approach" for chronic low back pain sufferers that were off work for a longer period of time (Lambeek et al. 2010). The overall approach was found to be highly effective, again, with workers receiving the intervention returning to work 1.9 times faster compared to those that did not (95 % confidence interval 1.2–2.8). The effects of the different intervention components (PE and graded activity) could not be disentangled due to the design of the study. However, unlike in the Anema et al. (2007) trial, the interventions were communicated to the patients as an integrated approach and all those in the intervention group received both intervention components. This intervention approach likely prevented miscommunication, increased treatment compliance, and decreased follow-up attrition in this study.

Further analysis of the earlier Dutch trial showed that the PE intervention was particularly effective in older (≥44 years) workers and those that reported sick leave in the year prior to inclusion in the study (Steenstra et al. 2009). This finding could be explained by the fact that these workers were more experienced in their job and likely more capable of providing appropriate solutions to remove barriers for sustainable RTW.

A participatory RTW intervention was also effective with respect to time reported for sustainable first RTW among temporary agency workers and unemployed workers sick-listed due to musculoskeletal disorders (Vermeulen et al. 2011). It should be noted that the reported Hazard rate ratio (HRR) was time dependent, which means that a positive effect occurred after 90 days post randomization. However, this finding seems inconsistent with an intention to treat analysis, whereby the intervention effect should be determined for all those included, starting right

after randomization. In a process evaluation, it was noted that offering of suitable temporary employment was delayed by 44.5 days (van Beurden et al. 2012). However, considering that these workers were finding a job in a time of economic recession, labeling this as a delay of the intervention might not be entirely justified.

Notably, PE did not seem to be effective in RTW for common mental disorders (HRR = 0.99 (95 % confidence interval 0.70–1.39) (van Oostrom et al. 2009). The development of the intervention was largely identical to the other versions of the PE approach of the studies that found a statistically significant effect. The authors state that stigma is more important in RTW scenarios involving common mental disorders. They also found that the intervention might be effective for those who reported at baseline that they had the intention to RTW compared to those who reported that they did not anticipate a possibility to RTW. However, this is an exploratory finding which was not hypothesized prior to data collection, and it should be confirmed in a future study (Sun et al. 2009). Overall, most PE interventions with solutions by all relevant stakeholders have been of relatively short duration.

16.4.2 Recent Studies: Going Beyond the "Sherbrooke Model"

Recent intervention studies have proposed participatory components to address RTW (Ammendolia et al. 2009; Bultmann et al. 2009). These studies included aspects of PE within the workplace interventions drawing upon the methods of the Sherbrooke studies and replications.

The intervention proposed by Ammendolia and colleagues (2009) was focused on the prevention of low back pain. It was developed through an intervention mapping process and synthesis of knowledge from a review of the literature. The evidence-informed approach led to a five-step RTW intervention that incorporated a participatory ergonomics approach built upon that of Loisel et al. (1997), Anema et al. (2007) and Steenstra et al. (2003). Unfortunately, the intervention developed by Ammendolia et al. (2009) was neither implemented nor evaluated for effectiveness because of changes in the case management approach at the workers compensation board (WSIB) in Ontario. These changes were deemed sufficient to compromise the internal validity of a possible randomized controlled trial.

Bultmann and colleagues (2009) conducted a study to compare the effectiveness of a coordinated, tailored work rehabilitation (CTWR) intervention with conventional case management (CCM) involving RTW of workers on sick leave due to MSDs. The intervention was a team-based approach, which drew upon PE, as described by Loisel et al. (1997), to identify the barriers to RTW. An interdisciplinary team, including an occupational physician, physiotherapist, psychologist and social worker, formulated and implemented a tailored work rehabilitation plan. The study found that the sickness absence hours were significantly lower in the CTWR group as compared to the CCM group for time intervals 0–6 months (average difference of 120 h, $p < 0.034$); 6–12 months (average difference of 221 h, $p < 0.009$); and the 0–12 months (average difference of 341 h, $p < 0.006$). The study also reported cost savings that were associated with the CTWR intervention.

These two studies are examples of how the PE approach could be applied in RTW interventions for workers with MSDs. These interventions appear to be more comprehensive in nature, with detailed consideration of workplace and system contexts.

16.5 Implementation of Participatory Ergonomics as a Return to Work Intervention

The research from the Netherlands, found that participatory ergonomics does not necessarily require major changes to get a worker back to work (Steenstra et al. 2003). The process leaders (ergonomists, occupational therapist, occupational physiotherapists and occupational nurses) involved in the Dutch study were trained to favor

solutions that are carried out by the stakeholders. Importantly, the worker is often the expert prepared to come up with solutions, which could also benefit coworkers. The worker-led solutions were employed even if they were not completely in line with the process leaders' professional beliefs about the most appropriate solution. Completely eliminating certain exposures, like lifting of loads over 25 kg, is highly unlikely in, for instance, the nursing profession. Nevertheless, the process of RTW provides a good opportunity to consider possible solutions to reduce the exposures, to retrain certain skills, and to reconsider the proper use of lifting aids. In the process of implementation, the research team found that it was important to have the intervention and the associated costs approved quickly by the workplace. Pre-authorization is preferred, which means that an employer agrees to implement the intervention as soon as an injured worker is off work for a certain amount of weeks.

The literature review by Shaw et al. (2008) showed that RTW coordination involves workplace assessment, planning for transitional duty, and facilitating communication and agreement among stakeholders. Successful RTW coordination may depend more on competencies in ergonomic job accommodation, communication and conflict resolution than on clinical training. Another consideration is that a process leader needs to be available when an injured worker is off work for a certain amount of time. Intervention might be needed at any time and process leaders cannot be scheduled in months in advance, unlike primary preventive interventions planning.

An important aspect of a RTW intervention is that responsibilities of the players need to be clearly defined and deadlines for implementation of solutions set and monitored. This is especially true in the early stages, when workers are potentially away from the worksite. Responsibility for implementing solutions might lie with the injured worker and/or direct supervisor, but a third party should be available to ensure that responsibilities are met in a timely manner.

A RTW intervention can only be successful when it takes place in the real-life workplace. Therefore, access to the workplace for the injured worker and a third party process leader is essential. In addition, within a given workplace, there should be a consistent approach to implementing modified duties or else resistance may occur when advising temporary modified duties. In some cases, modified duties do not seem to be temporary. Rather than modified, the assigned duties may be unrelated to the original job in question. Modified duties, if consistently implemented, can be a tool in the process of successful RTW.

16.6 Tools to Aid Participatory Ergonomics Implementation

A combination of factors tends to facilitate the implementation of PE in workplaces (Driessen et al. 2010; Van Eerd et al. 2010). Key among them are support for the PE program from the organization (management, coworkers and union), resource commitment (includes time and money), and open communication about the PE program. Therefore, PE implementation requires a clear outline of the main elements of a PE program along with an explanation of the barriers to overcome.

An evidence-based tool, the *PE Guide*, was designed by the Institute for Work & Health in Toronto, Canada (IWH) to address the challenges of initiating a PE program. The *PE Guide* was developed from the findings of the earlier cited systematic review of the literature about PE process and implementation (Van Eerd et al. 2010). Feedback from health and safety stakeholders from across Canada was received and helped to give the guide a practical focus. The PE guide provides evidence-based information to those who can initiate PE programs. The audience includes workplace managers, supervisors and workers who may have health and safety responsibilities. An additional audience is occupational health and safety practitioners, such as ergonomists or consultants who work with workplaces to implement programs to reduce risk and injuries. The guide, a 12 page brochure, was designed to be easy to understand and applicable to practice (see Fig. 16.1). It defines PE, describes how to initiate PE in a workplace and addresses the key facilitators for implementing a PE intervention.

The guide was designed to complement more process-oriented tools, such as the PE Blueprint (Wells et al. 2000) and the MSD Guidelines (from Ontario) (OSCHO 2007). Workplace parties can turn to such process tools to guide detailed PE processes.

16.7 Discussion and Summary

Participatory ergonomics has been used in a wide variety of workplaces to return injured workers to work. Most often, the workers' injuries are musculoskeletal disorders (Anema et al. 2007; Loisel et al. 1997), perhaps not surprising given the burden associated with these injuries. Nevertheless, a PE approach can be used for other types of disorders as well (van Oostrom et al. 2009).

Studies of effectiveness of PE interventions for prevention of injuries have yielded mixed findings. Some studies have shown that PE interventions can have a positive effect on MSD outcomes, such as musculoskeletal symptoms, injuries and workers' compensation claims, and on lost days from work or sickness absence (Rivilis et al. 2008). However, more recent studies with rigorous study designs have not found PE interventions to be effective in the prevention of MSDs (Haukka et al. 2008; Pehkonen et al. 2009). There appears to be a great deal of variability in the "intensity" of the PE interventions across studies. More research is necessary with attention to the process and implementation of the PE interventions. The recent focus on process evaluation (Anema et al. 2003; Cole et al. 2009; Driessen et al. 2010) seems to be a useful approach to better understand how PE interventions may achieve impacts.

Moreover, PE interventions have been employed in interventions to return injured workers to work. PE RTW interventions tend to be more tailored to the individual, involve more interdisciplinary teams, and incorporate interventions additional to PE interventions. Studies have fairly consistently shown PE RTW interventions to be effective. The increased focus on the individual, team diversity and specific rehabilitation intervention components may explain why PE RTW interventions are more commonly effective as compared to PE prevention interventions.

Participatory components within RTW interventions appear to show great promise, especially when combined with rehabilitation interventions. Participation involving an interdisciplinary team may go well beyond the redesign of job tasks and equipment in encouraging communication that is considered a key element of effective RTW (Franche et al. 2005). When the communication is related to PE, the focus is on solving concrete issues for RTW. Focusing on solutions may help reduce the potential negative effect of attention on barriers to RTW.

When implementing a PE RTW intervention, some key facilitators should be considered, including the following: reasonable access to the workplace; clearly defined responsibilities; prior (or early) approval for solutions; a process leader available when a worker and their supervisor are available; and adherence to timelines. Note that major changes are often not required to accommodate workers. However, modified duties may be required and can be productive if they are developed and applied consistently in the RTW process.

While participatory approaches are promising for RTW interventions, there is more research required to better design and understand RTW interventions. Durand and colleagues (2007) completed a review of the literature to identify various objectives of RTW interventions and describe the intervention activities. They found 21 published RTW intervention articles using a focused search, including two on interventions with a PE component (Anema et al. 2007; Loisel et al. 1997). The review revealed a great deal of variability among the objectives, content and activities of RTW interventions described. A key recommendation from the authors was that RTW interventions should be better and more completely described. This is increasingly important as interventions link clinical and workplace interventions and move towards including participatory and more tailored approaches. Two additional recommendations, which Durand and her colleagues made, include a concern about the inconsistent use of some RTW terminology and a need

for increased attention to process evaluations and outcomes.

The challenge of developing tailored RTW interventions was also raised by Marois and Durand (2009). They examined predictive factors and barriers to RTW in the context of participating in an interdisciplinary RTW program. The findings from this correlational study showed that there were clinical factors (e.g., diagnosis), psychosocial factors (e.g., perception of disability), and work-related factors (e.g., presence of awkward postures) that were related to RTW for both men and women. There were different additional factors for men (e.g., duration of work absence) and women (e.g., failed RTW due to pain levels), indicating the role of gender and other individual factors (Cole and Rivilis 2004). These results point to the importance of determining key factors to create an appropriate tailored intervention. Participatory approaches, with clinicians, workplace stakeholders, and workers involved, may be helpful in this type of tailored approach.

In addition to the need for better description of the intervention components, more quality research should be done to better understand the impacts of RTW interventions. Rigorous methodological designs of studies are needed, despite the challenges of conducting studies in workplaces (Kristensen 2005). Amick and colleagues (2008) describe the challenges of conducting workplace research despite both workplace stakeholders and researchers gaining from conducting research. The authors point out that developing and maintaining teams with workplace stakeholders and researchers is a key element to successful intervention research. With respect to study design challenges, Amick et al. (2008) point out that "one-size" does not fit all, suggesting that researchers use the most rigorous design possible but should keep in mind the context. They go on to point out the importance of meaningful outcomes for both workplace stakeholders and researchers and the need to continue a dialogue throughout to ensure maintenance of the appropriate level of commitment to see a project through to completion. To ensure that interventions achieve their intended impact, ongoing communication is also paramount to promote sustainability of outcomes (Durand et al. 2007).

In summary, participatory approaches can result in more tailored approaches and increased communication among interdisciplinary teams, with ongoing adaptation to interventions, and potentially targeted outcomes. These customized aspects of interventions are generally considered important by all stakeholders involved in the RTW process. Continued attention to and innovation in participatory processes can lead to better RTW interventions and ultimately diminish burden on workers, workplaces and systems.

References

Aas, R. W., Tuntland, H., Holte, K. A., Røe, C., Lund, T., Marklund, S., et al. (2011). Workplace interventions for neck pain in workers (review). *Cochrane Database of Systematic Reviews, 4*, CD008160.

Amick, B. C., III, Bigelow, P., & Cole, D. C. (2008). Workplace researcher relationships: Early research strategy and avoiding the data dearth! In E. Tompa, A. Culyer, & R. Dolinski (Eds.), *Economic evaluation of interventions for occupational health and safety. Developing good practice* (pp. 117–131). Oxford: Oxford University Press.

Ammendolia, C., Cassidy, D., Steenstra, I., Soklaridis, S., Boyle, E., Eng, S., et al. (2009). Designing a workplace return-to-work program for occupational low back pain: An intervention mapping approach. *BMC Musculoskeletal Disorders, 10*(1), 65.

Anema, J. R., Steenstra, I. A., Bongers, P. M., de Vet, H. C., Knol, D. L., Loisel, P., et al. (2007). Multidisciplinary rehabilitation for subacute low back pain: Graded activity or workplace intervention or both? A randomized controlled trial. *Spine, 32*(3), 291–298.

Anema, J. R., Steenstra, I. A., Urlings, I. J. M., Bongers, P. M., de Vroome, E. M., & van Mechelen, W. (2003). Participatory ergonomics as a return-to-work intervention: A future challenge? *American Journal of Industrial Medicine, 44*, 273–281.

Bohr, P., Evanoff, B., & Wolf, L. D. (1997). Implementing participatory ergonomics teams among health care workers. *American Journal of Industrial Medicine, 32*(3), 190–196.

Bongers, P. M., Kremer, A. M., & ter Laak, J. (2002). Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist? A review of the epidemiological literature. *American Journal of Industrial Medicine, 41*(5), 315–342.

Bultmann, U., Sherson, D., Olsen, J., Lysbeck Hansen, C., Lund, T., & Kilsgaard, J. (2009). Coordinated and tai-

lored work rehabilitation: A randomized controlled trial with economic evaluation undertaken with workers on sick leave due to musculoskeletal disorders. *Journal of Occupational Rehabilitation, 19*, 81–93.

Caroll, C., Rick, J., Pilgrim, H., Cameron, J., & Hillage, J. (2010). Workplace involvement improves return to work rates among employees with back pain on long-term sick leave: A systematic review of the effectiveness and cost-effectiveness of interventions. *Disability and Rehabilitation, 32*(8), 607–621.

Cole, D. C., & Rivilis, I. (2004). Individual factors and musculoskeletal disorders: A framework for their consideration. *Journal of Electromyography & Kinesiology, 14*, 121–127.

Cole, D. C., Theberge, N., Dixon, S. M., Rivilis, I., Neumann, W. P., & Wells, R. (2009). Reflecting on a program of participatory ergonomics interventions: A multiple case study. *Work, 34*, 161–178.

de Jong, A. M., & Vink, P. (2000). The adoption of technological innovations for glaziers: Evaluation of a participatory ergonomics approach. *International Journal of Industrial Ergonomics, 26*(1), 39–46.

Driessen, M. T., Proper, K. I., Anema, J. R., Bongers, P. M., & van der Beek, A. J. (2010). Process evaluation of a participatory ergonomics programme to prevent low back pain and neck pain among workers. *Implementation Science, 5*, 65.

Driessen, M. T., Proper, K. I., Anema, J. R., Knol, D. L., Bongers, P. M., & van der Beek, A. J. (2011). The effectiveness of participatory ergonomics to prevent low-back and neck pain–results of a cluster randomized controlled trial. *Scandinavian Journal of Work & Health, 37*(5), 383–393.

Durand, M. J., Vezina, N., Loisel, P., Baril, R., Richard, M. C., & Diallo, B. (2007). Workplace interventions for workers with musculoskeletal disabilities: A descriptive review of content. *Journal of Occupational Rehabilitation, 17*, 123–136.

Elden, M. (1986). Sociotechnical systems ideas as public policy in Norway. Empowering participation through worker-managed change. *Journal of Applied Behavioral Science, 22*, 239–255.

Evanoff, B. A., Bohr, P. C., & Wolf, L. D. (1999). Effects of a participatory ergonomics team among hospital orderlies. *American Journal of Industrial Medicine, 35*(4), 358–365.

Franche, R. L., Cullen, K., Clarke, J., Irvin, E., Sinclair, S., & Frank, J. (2005). Workplace-based return-to-work interventions: A systematic review of the quantitative literature. *Journal of Occupational Rehabilitation, 15*, 607–631.

Hadler, N. M. (2007). Point of view. *Spine, 32*(3), 299–300.

Hagberg, M., Silverstein, B., Wells, R., Smith, M. J., Hendrick, H. W., Carayon, P., et al. (1995). *Work related musculoskeletal disorders (WMSDs): A reference book for prevention*. London: Taylor & Francis.

Haims, M. C., & Carayon, P. (1998). Theory and practice for the implementation of 'in-house', continuous improvement participatory ergonomic programs. *Applied Ergonomics, 29*(6), 461–472.

Haines, H., & Wilson, J. (1998). *Development of a framework for participatory ergonomics, report 174/1998*. London: Health & Safety Executive.

Haines, H., Wilson, J. R., Vink, P., & Koningsveld, E. (2002). Validating a framework for participatory ergonomics (the PEF). *Ergonomics, 45*(4), 309–327.

Hales, T.R., & Bernard, B.P. (1996). Epidemiology of work-related musculoskeletal disorders. *Orthopedic Clinics of North America, 27*(4), 679–709.

Halpern, C. A., & Dawson, K. D. (1997). Design and implementation of a participatory ergonomics program for machine sewing tasks. *International Journal of Industrial Ergonomics, 20*(6), 429–440.

Haslam, R. A. (2002). Targeting ergonomics interventions—learning from health promotion. *Applied Ergonomics, 33*(3), 241–249.

Haukka, E., Leino-Arjas, P., Viikari-Juntura, E., Takala, E. P., Malmivaara, A., Hopsu, L., et al. (2008). A randomised controlled trial on whether a participatory ergonomics intervention could prevent musculoskeletal disorders. *Occupational and Environmental Medicine, 65*(12), 849–856.

Hignett, S., Wilson, J. R., & Morris, W. (2005). Finding ergonomic solutions—participatory approaches. *Occupational Medicine, 55*(3), 200–207.

Institute for Work and Health (IWH). (2009). *Reducing MSD hazards: A guide to successful participatory ergonomics programs*. Retrieved from http://www.iwh.on.ca/pe-guide.

Kristensen, T. S. (2005). Intervention studies in occupational epidemiology. *Occupational and Environmental Medicine, 62*, 205–210.

Kuorinka, I. (1997). Tools and means of implementing participatory ergonomics. *International Journal of Industrial Ergonomics, 19*(4), 267–270.

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

Laitinen, H., Saari, J., & Kuusela, J. (1997b). 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, 19*(4), 299–305.

Lambeek, L. C., van Mechelen, W., Knol, D. L., Loisel, P., & Anema, J. R. (2010). Randomised controlled trial of integrated care to reduce disability from chronic low back pain in working and private life. *BMJ.* 340:c1035.

Liker, J. K., Nagamachi, M., & Lifshitz, Y. R. (1989). A comparative analysis of participatory ergonomics programs in U.S. and Japan manufacturing plants. *International Journal of Industrial Ergonomics, 3*, 185–199.

Linnan, L., & Steckler, A. (2002). Process evaluation for public health interventions and research: An overview. In A. Steckler & L. Linnan (Eds.), *Process evaluation for public health interventions and research* (pp. 1–23). San Francisco, CA: Jossey-Bass.

Loisel, P., Abenhaim, L., Durand, P., Esdaile, J. M., Suissa, S., Gosselin, L., et al. (1997). A population based, randomized clinical trial on back pain management. *Spine, 22*, 2911–2918.

Loisel, P., Durand, P., Abenhaim, L., Gosselin, L., Simard, R., Turcotte, J., et al. (1994). Management of occupational back pain: The Sherbrooke model. Results of a pilot and feasibility study. *Occupational and Environmental Medicine, 51*, 597–602.

Loisel, P., Gosselin, L., Durand, P., Lemaire, J., Poitras, S., & Abenhaim, L. (2001). Implementation of a participatory ergonomics program in the rehabilitation of workers suffering from subacute back pain. *Applied Ergonomics, 32*(1), 53–60.

Marois, E., & Durand, M.-J. (2009). Does participation in interdisciplinary work rehabilitation programme influence return to work obstacles and predictive factors? *Disability and Rehabilitation, 31*(12), 994–1007.

Martimo, K.-P., Shiri, R., Miranda, H., Ketola, R., Varonen, H., & Viikari-Juntura, E. (2010). Effectiveness of an ergonomic intervention on the productivity of workers with upper-extremity disorders–a randomized controlled trial. *Scandinavian Journal of Work & Health, 36*(1), 25–33.

Moore, J. S., & Garg, A. (1997). The effectiveness of participatory ergonomics in the red meat packing industry evaluation of a corporation. *International Journal of Industrial Ergonomics, 21*(1), 47–58.

Motamedzade, M., Shahnavaz, H., Kazemnejad, A., Azar, A., & Karimi, H. (2003). The impact of participatory ergonomics on working conditions, quality, and productivity. *International Journal of Occupational Safety and Ergonomics, 9*(2), 135–147.

Nagamachi, M. (1995). Requisites and practices of participatory ergonomics. *International Journal of Industrial Ergonomics, 15*(5), 371–377.

National Research Council. (2001). *Musculoskeletal disorders in the workplace: Low back and upper extremities*. Washington, DC: National Academic Press.

Noro, K. (2003). Participatory ergonomics. In W. Karwowski & W. S. Marras (Eds.), *Occupational ergonomics: Design and management of work systems*. Boca Raton, FL: CRC Press.

Noro, K., & Imada, A. S. (1991). *Participatory ergonomics*. London: Taylor & Francis.

Occupational Health and Safety Council of Ontario (OSHCO). (2007). *MSD prevention guidelines for Ontario*. Retrieved from http://www.iwh.on.ca/msd-tool-kit.

Pehkonen, I., Takala, E. P., Ketola, R., Viikari-Juntura, E., Leino-Arjas, P., Hopsu, L., et al. (2009). Evaluation of a participatory ergonomic intervention process in kitchen work. *Applied Ergonomics, 40*(1), 115–123.

Reynolds, J. L., Drury, C. G., & Broderick, R. L. (1994). A field methodology for the control of musculoskeletal injuries. *Applied Ergonomics, 25*(1), 3–16.

Rivilis, I., Van Eerd, D., Cullen, K., Cole, D. C., Irvin, E., Tyson, J., et al. (2008). Effectiveness of participatory ergonomic interventions on health outcomes: A systematic review. *Applied Ergonomics, 39*(3), 342–358.

Rosecrance, J. C., & Cook, T. M. (2000). The use of participatory action research and ergonomics in the prevention of work-related musculoskeletal disorders in the newspaper industry. *Applied Occupational & Environmental Hygiene, 15*(3), 255–262.

Schneider, E., & Irastorza, X. (2010). *OSH in figures: Work-related musculoskeletal disorders in the EU—facts and figures* (European Agency for Safety and Health at Work (EU-OSHA)). Belgium: Luxembourg.

Shaw, W., Hong, Q. N., Pransky, G., & Loisel, P. (2008). A literature review describing the role of return-to-work coordinators in trial programs and interventions designed to prevent workplace disability. *Journal of Occupational Rehabilitation, 18*(1), 2–15.

Silverstein, B., & Evanoff, B. (2011). Musculoskeletal disorders. In B. S. Levy, D. H. Wegman, S. L. Baron, & R. K. Sokas (Eds.), *Occupational and environmental health: Recognizing and preventing disease and injury*. New York, NY: Oxford University Press.

Simon, S. I., & Leik, M. (1999). Breaking the safety barrier: Implementing culture change. *Professional Safety, 44*(3), 20–25.

Sluiter, J. K., Rest, K. M., & Frings-Dresen, M. H. W. (2001). Criteria document for evaluating the work-relatedness of upper extremity musculoskeletal disorders. *Scandinavian Journal of Work and Environmental Health, 27*, 1–102.

Steenstra, I. A., Anema, J. R., Bongers, P. M., de Vet, H. C., & van Mechelen, W. (2003). Cost effectiveness of a multi-stage return to work program for workers on sick leave due to low back pain, design of a population based controlled trial. *BMC Musculoskeletal Disorders, 4*(1), 26.

Steenstra, I. A., Knol, D. L., Bongers, P. M., Anema, J. R., van Mechelen, W., & de Vet, H. C. (2009). What works best for whom? An exploratory, subgroup analysis in a randomized, controlled trial on the effectiveness of a workplace intervention in low back pain patients on return to work. *Spine, 34*(12), 1243–1249.

Sullivan, T., & Cole, D. C. (2002). Work, health, safety and compensation. In B. S. Bolara & H. Dickenson (Eds.), *Health, illness and health care in Canada* (3rd ed.). Toronto: Nelson Thomas Learning.

Sun, X., Briel, M., Busse, J. W., Akl, E. A., You, J. J., Mejza, F., et al. (2009). Subgroup Analysis of Trials Is Rarely Easy (SATIRE): A study protocol for a systematic review to characterize the analysis, reporting, and claim of subgroup effects in randomized trials. *Trials, 10*, 101.

Van Beurden, K. M., Vermeulen, S. J., Anema, J. R., & van der Beek, A. J. (2012). A participatory return-to-

work program for temporary agency workers and unemployed workers sick-listed due to musculoskeletal disorders: A process evaluation alongside a randomized controlled trial. *Journal of Occupational Rehabilitation, 22*, 127–140.

Van Eerd, D., Beaton, D. E., Cole, D. C., Lucas, J., Hogg-Johnson, S., & Bombardier, C. (2003). Classification systems for upper-limb musculoskeletal disorders in workers: a review of the literature. *Journal of Clinical Epidemiology, 56*(10), 925–936.

Van Eerd, D., Cole, D. C., Irvin, E., Mahood, Q., Keown, K., Theberge, N., et al. (2010). Process and implementation of participatory ergonomic interventions: A systematic review. *Ergonomics, 53*(10), 1153–1166.

Van Oostrom, S. H., van Mechelen, W., Terluin, B., de Vet, H. C., & Anema, J. R. (2009). A participatory workplace intervention for employees with distress and lost time: A feasibility evaluation within a randomized controlled trial. *Journal of Occupational Rehabilitation, 19*(2), 212–222.

Vermeulen, S. J., Anema, J. R., Schellart, A. J. M., Knol, D. L., van Mechelen, W., & van der Beek, A. J. (2011). A participatory return-to-work intervention for temporary agency workers and unemployed workers sick-listed due to musculoskeletal disorders: Results of a randomized controlled trial. *Journal of Occupational Rehabilitation, 21*, 313–324.

Wells, R., Laing, A., & Cole, D. C. (2009). Characterizing the intensity of interventions for the prevention of musculoskeletal disorders by mechanical exposure reductions. *Work, 34*(2), 179–193.

Wells, R., Norman, R., Frazer, M., & Laing, A. (2000). *University of Waterloo ergonomics program implementation blueprint*. Retrieved from http://www.ergonomics.uwaterloo.ca/bprint.html.

Westgaard, R. H. (1999). Effects of physical and mental stressors on muscle pain. *Scandinavian Journal of Work, Environment and Health, 25*(S4), 19–24.

Williams, R. M., Westmorland, M. G., Lin, C. A., Schmuck, G., & Creen, M. (2007). Effectiveness of workplace rehabilitation interventions in the treatment of work-related low back pain: A systematic review. *Disability and Rehabilitation, 29*(8), 607–624.

Wilson, J. R., & Haines, H. M. (1997). Participatory ergonomics. In G. Salvendy (Ed.), *Handbook of human factors and ergonomics* (pp. 490–513). New York, NY: Wiley.

Workers' Compensation Board of Nova Scotia. (2009). *Annual report 2009*. Retrieved from http://www.wcb.ns.ca/app/DocRepository/5/About/Review/Reports/WCB_AR_2009_final2.pdf/.

Workplace Safety and Insurance Board (WSIB). (2009). *Statistical supplement to the 2009 annual report*. Retrieved from http://www.wsib.on.ca/wsib/wsibobj.nsf/LookupFiles/DownloadableFile2009Statistics/$File/StatSupp09.pdf/.

WorkSafeBC. (2009). *WorkSafeBC statistics 2009*. Retrieved from http://www.worksafebc.com/publications/reports/statistics_reports/assets/pdf/stats2009.pdf/.