Pergamon

Ann. occup. Hyg., Vol. 45, No. 4, pp. 283–289, 2001
Published by Elsevier Science Ltd on behalf of British Occupational Hygiene Society
Printed in Great Britain.
PII: S0003-4878(01)00005-9
0003-4878/01/$20.00

Grassroots Ergonomics: Initiating an Ergonomics Program Utilizing Participatory Techniques

D. M. ZALK*

University of California, Hazards Control Department, Lawrence Livermore National Laboratory, Livermore, CA, USA

The introduction of ergonomics programs throughout the world requires an easy to understand and inexpensive process. Participatory ergonomic intervention techniques have proven to be beneficial in the prevention of musculoskeletal disorders. The participatory approach to ergonomics has also been found to be a useful application within industrialized (developed) countries and industrially developing countries (IDCs). Grassroots Ergonomics principles utilize expertise within a workforce that focuses on participatory ergonomics interpretations of quantitative and qualitative risk and exposure assessment information that in turn results in a peer-developed ergonomics training. Regardless of the intricacy of the exposure assessment tools, workers should fully assist in gathering and analyzing data, then in identifying and implementing solutions. A coordinated and multidisciplinary application of this approach within IDCs would succeed in the creation and sharing of job-specific ergonomics training information for high physical exposure professions, such as agriculture, fishing, forestry, mining, and small-scale enterprises, to initiate ergonomics programs regionally. Published by Elsevier Science Ltd on behalf of British Occupational Hygiene Society

Keywords: participatory ergonomics; developing countries; exposure assessment; risk factors; psychological; training; ergonomics; program; musculoskeletal disorders

INTRODUCTION

Reduction in the occurrence of musculoskeletal disorders (MSDs) is essential to the improvement of occupational health in both industrialized (developed) countries (DCs) and industrially developing countries (IDCs) (Jafry and O'Neill, 2000; Buckle and Devereux, 1999; Partanen *et al*., 1999; Bernard, 1997; GAO, 1997). Currently 40% of the world's occupational and work-related health costs are attributed to musculoskeletal diseases, so the concern can be considered to be distributed throughout both DCs and IDCs (Takala, 1999). Efforts to introduce ergonomics programs within IDCs have focused primarily on large-scale industries and since the majority of the working population of IDCs are involved in the agricultural trades, ergonomic interventions need to have the adaptability to go beyond the factory environment and into rural villages (Jafry and O'Neill, 2000). This requires a programmatic process that is low cost, easy to understand, and sensitive to the social, cultural, and political considerations of a given population (Shahnavaz, 2000; Kawakami *et al*., 1999; Rubio, 1995).

An ergonomics program should utilize intervention techniques that focus on a method of achieving prevention. Ergonomic interventions have been successful in reducing the number of MSDs by over 50%, especially in professions that expose employees to a high level of work risk factors (Rosskam, 1997; Hagberg and Wegman, 1987; Fine *et al*., 1987). Acknowledged hazardous work in IDCs, with a high level of physical demand, include agriculture, mining, construction, fishing, and logging (Takala, 1999). Participatory ergonomics, utilizing worker involvement as part of an intervention, has been a successful technique for the prevention of MSDs in many of these professions (Jafry and O'Neill, 2000; Kawakami *et al*., 1999; Koda *et al*., 1997; Moir and Buchholz, 1996; Rainbird and O'Neill, 1995).

Effective interventions must actively involve the worker, must reduce exposure to the stressor, and must affect the organizational culture (Westgaard and Winkel, 1997). When the worker is involved in ergonomic interventions it offers a greater likelihood

Received 4 September 2000; in final form 27 November 2000.
*Tel.: +1-925-422-8904; fax: +1-925-422-9974; e-mail: zalk1@llnl.gov

of reducing musculoskeletal problems (Buckle and Devereux, 1999). Recent recommendations from the National Institute of Occupational Safety and Health (NIOSH), European Agency for Safety and Health at Work (EASHW), and the General Accounting Office (GAO) include participatory ergonomics as an important method for controlling MSDs and initiating an ergonomics program.

The GAO report highlights the components of effective ergonomics programs. Five companies were reviewed and the synopsis emphasizes a core set of six elements necessary to ensure the identification and control of ergonomic hazards to protect workers: (1) management commitment, (2) employee involvement, (3) identification of problem jobs, (4) development of solutions (controls) for problem jobs, (5) training and education for employees, and (6) appropriate medical management. The application of these elements has resulted in the reduction of injuries and illnesses as well as reduced worker compensation costs. There were also reports of improved worker morale, productivity, and product quality. The GAO goes further to recommend that federal and state-operated Occupational Safety and Health Administration (OSHA) programs utilize a similar approach in developing a framework for worksite ergonomic programs that emphasizes the need to develop and implement flexible site-specific efforts that effectively address hazards (GAO, 1997).

The NIOSH publication recommends a focus on controlling work-related MSDs. This publication provides information to identify, correct, and prevent MSDs by following seven steps: (1) determining if musculoskeletal problems exist in a workplace, (2) developing roles for managers and workers in an ergonomic program, (3) recognizing and filling the training needs, (4) gathering and analyzing the data to define the scope and characteristics of ergonomics concerns, (5) developing control solutions, (6) establishing health care management, and (7) creating a proactive ergonomics program. NIOSH adds two very important criteria to the GAO recommendations, the gathering and analysis of data and the emphasis on the creation of a proactive program (Bernard, 1997).

The EASHW report defines a scope for the prevention of work-related upper limb disorders that includes risk assessment, health surveillance, employee information, training, ergonomic work systems, and the prevention of fatigue. Exposure and risk assessment methods are put forward while giving acknowledgement that these methods are often in competition with the realities of field applications. The report also emphasizes the use of an ergonomic intervention that focuses on the whole workplace and work system as an integrated approach. Participatory ergonomics has the potential to assist in the development of this integrated approach (Buckle and Devereux, 1999).

PRINCIPLES AND PROCESSES

The Grassroots Ergonomics (GE) approach to initiating an ergonomics program utilizes participatory ergonomics (PE) principles as a part of its integrated process. As a necessary part of the GE process, PE principles are combined with the gathering and analysis of exposure assessment (EA) data as well as the creation of training (CT) in the following manner:

$$GE = PE + EA + CT$$

This combination of the elements essential to creating a successful ergonomics program also assist in the maximization of benefits obtained from a given intervention.

Participatory ergonomics (PE)

Participation at work is a general technique of giving employees an opportunity to control the design of their workplace and plan their work activities. The premise is that workers know their workplace better than anyone else does, and that this knowledge allows them to develop a more comprehensive approach to their work. This is the fundamental benefit of PE. The participatory process, when applied to the study of the musculoskeletal system and its disorders, creates a more thorough understanding of ergonomic problems and a more diagnostic approach to their solutions (Noro and Imada, 1991).

The amount of control which workers are given over their workplace is an important element, as well as a potential limitation, for the effectiveness of the participatory process. By definition, managers have a level of control over their workplace that is not available to the workers. Without an appropriate incentive, management is not usually willing to truly empower workers to determine their own solutions. Additionally, a situation in which workers do not have a climate of trust between themselves and upper management can, in and of itself, add to their ergonomic and psychosocial risk factors (Israel *et al*., 1989). This problem exists as much in developed as in developing countries. Unfortunately, lack of worker empowerment is not consistent with the fact that workers are usually the ones who know their job and their peers well enough to identify and create solutions that will persist (Noro and Imada, 1991). However, management can be in a position to give a certain level of control to the workers when their production costs increase due to MSDs. These increased costs can often be related to decreased working efficiency, absenteeism, medical care, and worker's compensation (Buckle and Devereux, 1999; Bernard, 1997; GAO, 1997). In these instances, the need to reduce MSDs can be seen as directly linked to the need to increase production. Therefore, both management and workers have a vested interest in achieving these objectives. It is important to all the

parties that the involvement and support of top management is often related to the reduction in workers' exposure to ergonomic and psychosocial risks (Israel *et al*., 1996).

PE is one intervention strategy that can simultaneously address both ergonomics and the psychosocial risk factors in the work environment (Haims and Carayon, 1998; May and Schwoerer, 1994). Psychosocial factors, and their relationship to MSDs, are characterized as being associated with work organization factors, the external work environment, and the characteristics of the individual worker (Buchanan *et al*., 1998; Bernard, 1997). Cumulative research has indicated that MSDs may act through a variety of physical or biological mechanisms, with psychosocial factors also playing an important role in the onset and development of MSDs (NRC, 1999). The very complex nature of psychosocial implications, and its relationship with ergonomics, underlies the benefits of the participatory approach in both DCs and IDCs. There are often cultural differences in how work is performed between companies as well as between countries. PE can assist in developing an approach that takes cultural work method differences into account (Buchanan *et al*., 1998).

Addressing the social, psychological, and cultural needs of a given working population has been an important aspect of PE. Within both DCs and IDCs, the PE approach has been successfully applied by maximizing the role of the employee within the company. PE principles have been applied to reduce MSDs in an extensive variety of occupational fields within DCs. Examples include: carpentry, components-parts manufacturing, construction, custodians (janitors), health care industry, meat packing, newspaper industry, and waste container handling (Rosecrance and Cook, 2000; Zalk *et al*., 2000; Evanoff *et al*., 1999; Albers *et al*., 1997; Bohr *et al*., 1997; Moore and Garg, 1997; Zalk *et al*., 1997; Moir and Buchholz, 1996; Moore and Garg, 1996; Israel *et al*., 1989). This approach has also been applied within IDCs in Asia for assessing the needs of small enterprises and agriculture by building on local practices within the limitations of locally available resources (Kawakami *et al*., 1999). Small-scale enterprises within Thailand have also emphasized participation to improve working conditions, materials handling methods, and productivity with a special focus on the locally invented improvements (Tandhanskul *et al*., 1995). Collaborative participatory ergonomic efforts have also emphasized the skills of the local population to create practical, inexpensive solutions that have resulted in development and implementation of training packages (Kogi, 1998).

Exposure assessment (EA)

During a participatory ergonomic intervention, employees become aware of their ergonomic problems and can identify work procedures that may have ergonomic risk factors associated with them. There is an important need to quantify the level of exposure in these procedures (Buckle and Devereux, 1999; Bernard, 1997). This quantification, or ergonomics EA, is crucial to GE and is essential to determine the scope and characteristics of ergonomics concerns for everyone involved (Zalk *et al*., 1997). This is one point that is emphasized in the NIOSH and EASHW publications, but not addressed by the GAO report. Ergonomic analysis tools are used to gather and analyze data on identified procedures to form an EA. Tools for an EA can be as inexpensive as checklists and video for posture analysis and targeting or as intricate as three-dimensional motion evaluation systems and surface electromyography (Zalk *et al*., 2000; Li and Buckle, 1999).

Identifying the ergonomic risk factors, including posture, force, and repetition, within a work procedure is useful for EA of MSDs (Burdorf, 1992). If the EA data will be utilized for in-depth research on a given profession's exposure, then more intricate measures should be considered. However, limitations of funds and the lack of availability of measuring equipment within DCs and IDCs require an emphasis on the inexpensive approaches. This reality presents a difficult dilemma facing ergonomics research in the field. The feasibility of a measurement device, level of detail required, and variation of exposures needs to be weighed against practicality and ease of use of obtaining this information from the field (Burdorf and van der Beek, 1999; Buckle and Devereux, 1999). This may necessitate compromise, especially if monetary funding is as scarce as EA tool availability everywhere, but especially in IDCs.

If the goal is to collect less detailed data for practical work situations, an EA tool should be chosen with consideration given to its use and practicality in the field. Li and Buckle (Li and Buckle, 1999) have performed a review of the current techniques available for assessment. The strengths and limitations of pen and paper observational methods, videotaping, computer-aided analysis, and self-report assessment are considered. Most of the existing tools are found to be research-oriented rather than field-oriented. They are designed to maximize the information obtained for a job and its procedures. The field practitioner's need during an intervention may not require a researcher's level of information. Most important, according to Li and Buckle, is the information that helps decide whether an intervention is necessary and a measurement to determine whether the intervention was effective. The GE process takes this into account with an additional consideration that the workers fully assist in gathering and analyzing data, utilizing the data to address training needs, then identifying and implementing solutions (Zalk *et al*., 2000).

An ergonomics EA should be aimed at collecting information that accurately reflects the exposures and

behaviors of the employees in the field. This approach is recommended in the NIOSH publication within the step of gathering and analyzing data to define the scope and characteristics of ergonomics concerns (Bernard, 1997). GE takes this recommendation two steps further in that it emphasizes that the gathering of data should be performed in the field under actual working conditions and that the data be quantifiable to afford replication after the ergonomic intervention (Zalk *et al*., 1997). This extra effort allows the opportunity to quantify the ergonomic exposures before and after the intervention has been completed and controls have been implemented. This concept is similar to traditional occupational hygiene sampling theories and is a more appropriate measure of the intervention's success rather than the use of often transient injury statistics.

Checklists have frequently been the ergonomic tool of choice within participatory ergonomic interventions (Kawakami *et al*., 1999; Moir and Buchholz, 1996; Tandhanskul *et al*., 1995). Regardless of the intricacy of the EA tools, workers should fully assist in gathering and analyzing data, then in identifying and implementing solutions. A team of custodial (janitorial) employees designed and implemented a GE intervention that included video-based posture analysis and posture targeting applied in the field (Zalk *et al*., 1997). Using the same PE approach, waste container handling employees used the above video-based analyses and added surface electromyography and lumbar motion monitor direct measuring instruments to ensure that the field analysis optimized the EA information pertaining to their profession (Zalk *et al*., 2000). Each employee's interpretations of musculoskeletal quantitative and qualitative data are an essential part of the GE process. These interpretations can be developed into a training program that focuses on the prevention of MSDs within the professions analyzed (Zalk *et al*., 2000; Kawakami *et al*., 1999; Tandhanskul *et al*., 1995).

Creation of training (CT)

Emphasis on ergonomics training has been an historical focus for assisting in the creation of ergonomics programs. Over thirty years ago the World Health Organization made this an important element in a plan to develop an inter-regional course on ergonomics for developing countries (Singleton and Whitfield, 1968). The creation of a training program, resulting from the application of PE principles, is a relatively new concept. When participatory techniques are utilized in the CT, the resultant training proves most useful for the promotion of intervention successes that have come from the local workplace population (Kogi, 1998).

CT is the culmination of the GE process, which often begins with employees and occupational health and hygiene staff working together to discuss ergonomics-related problems within a given company, or profession, and its population. Schemes to address these problems, by developing a framework for the research and intervention, have the potential to enhance the relevance and utilization of results when employees are involved as researchers to address the causes and the symptoms of the problems identified (Baker *et al*., 1994; Israel *et al*., 1989). Occupational health and hygiene staff are useful in the collection of background and ergonomics exposure data to be used at the discussion sessions, which can serve for the foundation for the CT (Zalk *et al*., 2000). Interventions for particular musculoskeletal issues raised during these discussions are most effectively initiated with consensus from the entire group (Moore and Garg, 1997).

Once these musculoskeletal issues are identified, a participatory ergonomic intervention team should be created that consists of a small, representative group of affected workers, a health and safety professional (ergonomist), and a management representative (GAO, 1997; Bernard, 1997; Zalk *et al*., 1997; Israel *et al*., 1996). In the GE process, the workers are in control of the intervention team, so one of these members serves as the team's leader. The workers' initial role is to teach the ergonomist about their work and its procedures. The ergonomist's role is teaching basic principles of ergonomics, how these principles may apply to the work's procedures or cycles, and consulting on behalf of the workers.

The consulting role of the ergonomist is extremely important to the CT because this person not only serves as a conduit of introductory, as well as technical, ergonomics information, but they may also have to serve as a mediator between workers and their management. Management should have a representative on the team to understand the inner workings of the PE approach and provide guidance on management issues (Bernard, 1997; GAO, 1997; Koda *et al*., 1997; Israel *et al*., 1996; Tandhanskul *et al*., 1995). Management representatives need to know the right people to go to when obtaining funding, making changes in the workplace, and implementing the training. They also need to become an advocate for the needs of the workers, as determined by the intervention team, to assist in the implementation of the overall ergonomics program. This begins a process for sustaining an ergonomics program after the initial participatory ergonomic intervention (Zalk *et al*., 2000; Kawakami *et al*., 1999; Tandhanskul *et al*., 1995).

For an effective ergonomic program to be initiated, training needs to be developed in hand with ergonomic research that is both flexible and dynamic (Kawakami *et al*., 1999; Baker *et al*., 1994). An appropriate goal of an ergonomic intervention team is to create and implement training for the affected workforce that includes discussion of the ergonomic EA study and its results (Zalk *et al*., 2000; Kawakami *et al*., 1999; Kogi, 1998). Since workers are in control

of the GE process, they assist in selecting the EA techniques that best address their job task and most likely reduce their exposure to musculoskeletal hazards during their work. It is necessary for an ergonomist to take the process into the field, working with the employees to obtain and analyze the data. This includes full worker participation in the measurement, processing, and interpretation of ergonomics EA information. This process is known as in-the-job training (IJT). The IJT obtained by the team's workers while going through the GE process is far more intricate and involved than typical classroom and hands-on training.

IJT intrinsically educates the workers in ergonomics because they are fully involved in applying solutions that they helped develop. Thus, they are trained within the parameters of their own job. The information obtained from the EA study within the GE process will assist the intervention team in developing their own training, their own training manual, and applying appropriate controls for their own co-workers. This training also becomes an IJT for workers who are not part of the intervention team because their peers' interpretations of the GE process are presented in work-related language they can understand. Additionally, when training comes from within the trainees' own ranks there is a much greater participation, acceptance, retention, and application of the goals from the training. Workers from the team can also become qualified to assist in presenting the IJT, creating their own periodic training, and reinforcing ergonomic lessons learned (Zalk *et al*., 2000; Kawakami *et al*., 1999).

RESULTS

Office and production workers in a newspaper company teamed with ergonomists to reduce MSD risk factors by developing and implementing solutions for very low intervention costs (Rosecrance and Cook, 2000). PE principles in the meat packing industry were implemented with ergonomic intervention teams, utilizing workers as researchers, with a problem solving method that began with obtaining background, exposure, and effects data. The teams then approached solutions to the problems with brainstorming sessions and selected interventions by consensus that effectively addressed and reduced MSDs (Moore and Garg 1997, 1996). A similar approach with health care workers proved, for some, to be highly effective in identifying problems and implementing solutions (Bohr *et al*., 1997). By including management on the team and focusing efforts on designing and implementing changes in training, hospital orderlies showed a decline in MSD symptoms and improvements in job satisfaction and psychosocial stressors (Evanoff *et al*., 1999).

Participatory training, using hands-on exercises and 'learner-centered' instruction, was found to be extremely useful in acquiring and retaining ergonomic knowledge among apprentice carpenters, when compared to a control group (Albers *et al*., 1997). Applications in the construction industry have utilized participatory ergonomic interventions for not just the practical needs associated with training, but for political reasons as well (Moir and Buchholz, 1996). These construction advisory groups served to evaluate intervention ideas and compare safety systems within the company. A ten-year follow-up study in a waste management bureau that found significant reductions in compensation claims for low back pain demonstrates the endurance of the participatory process (Koda *et al*., 1997). This participatory ergonomic intervention began with a revision of the safety procedure manual and an emphasis on continual participatory training classes.

A custodial (janitorial) workforce of 150 employees, 25 of whom are developmentally disabled, used the GE process and its principles, including EA, to address their consistent rise in MSDs (Zalk *et al*., 1997). The custodians on the intervention team revised their training manual and created an ergonomics training based on their EA results. This resulted in a training video and manual package that has been shared in over 20 countries. Substantial reduction of MSDs and a measured decrease in EA results were found three years after the initial training (Tolley *et al*., 1998). Use of more intricate EA techniques, such as surface electromyography and lumbar motion monitor, did not deter waste container handling employees from also interpreting the results into their own training that they assisted in presenting to their peers (Zalk *et al*., 2000). The training methods developed by both of these GE interventions have not only resulted in a decrease in ergonomics-related injuries, more importantly they have reduced employee exposure to the ergonomic stressors identified through the PE process.

Participatory ergonomic interventions have also been a successful approach for the reduction of MSDs in IDCs (Jafry and O'Neill, 2000; Buckle and Devereux, 1999). Successful applications of this intervention method within IDCs have come from utilizing local talent, skills, and available resources (Jafry and O'Neill, 2000; Kawakami *et al*., 1999; Koda *et al*., 1997; Rainbird and O'Neill, 1995; Tandhanskul *et al*., 1995). Participatory ergonomic interventions within IDCs have done extremely well in keeping costs to a minimum, adapting to the customs, traditions and politics of a given region, and achieving the management buy-in which is essential for the in-house development of a PE program (Rubio, 1995).

Ergonomic programs in Asia have grown out of successful participatory interventions. Assessment of the local needs in small-scale enterprises and agriculture have resulted in the development and implementation of widely-applicable ergonomic improvements

and the sharing of training methods (Kawakami *et al*., 1999). These improvements include materials handling, design of workstations, and work organization — all achieved by utilizing local resources. It is the participatory process that assisted in the creation of the improvements and training methods that meet the diversity of a given local population. Locally invented ergonomic improvements were utilized to initiate ergonomic programs within small-scale enterprises in Thailand (Tandhanskul *et al*., 1995). The improvements from this intervention included workstation redesign and material handling changes that were derived from the results of a checklist for ergonomic risk assessment. Field study interventions, use of practical assessment methods, and voluntary efforts within a participatory framework are all part of the collaborative research and training approach that has been successful within Asian IDCs (Kogi, 1998).

DISCUSSION

When a training program is derived from the workers, both the process of learning and the process of teaching will assist in the reinforcement of ergonomics as an essential element in work procedures. Program initiation occurs when the training is presented to the employees' peers, and the feedback incorporated into future ergonomic training sessions. By utilizing the GE principles, the nature of the program incorporates the psychosocial and cultural issues that are virtually inseparable within working populations. Further, understanding of ergonomic concepts is best described from the perspective of local interpretation and application (Jafry and O'Neill, 2000; Kogi, 1998; Wisner, 1989). Therefore, resulting training packages and workplace redesign applications are well situated to be introduced to other workers within similar professions both regionally and worldwide (Kawakami *et al*., 1999; Kogi, 1998; Tandhanskul *et al*., 1995). This is especially important for the rural, or informal, working populations throughout the world where the application of GE is most difficult or impossible due to the limited size of the workforce, minimal finances, and the lack of professional ergonomics expertise. Workers whose employment is not connected with companies or factories, such as small-scale enterprises, independent farmers, or artisans, have the most to gain from the sharing of GE training packages.

Most of the ergonomics research performed in IDCs, especially when supported or implemented at the management level, has been in the industrial sector and has focused primarily on maximizing work efficiency and increased productivity (Jafry and O'Neill, 2000; LaDou, 1996). Technological advancement has brought new sources of musculoskeletal stresses and requirements for rapid production schedules as well as an increase in chemical exposures and related occupational diseases (Shahnavaz, 2000; Cory, 1999; Takala, 1999). Perhaps utilizing the GE process and its principles can assist in achieving maximum benefits for the working population that can balance out the continually increasing demands for production. Participatory principles, like those within the GE process, are an essential part of the collaborative, multidisciplinary approach necessary to reduce occupational health diseases (Stubbs, 2000). To lower the occupational health cost of musculoskeletal diseases internationally over time, this approach must assist in standardizing criteria so international organizations can add to the global database on accurate statistical musculoskeletal information and share job-specific ergonomic training information to initiate ergonomic programs within and between DCs and IDCs.

Acknowledgements—Work performed under the auspices of U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract W-7404-Eng-48.

REFERENCES

Albers JT, Li Y, Lemasters G, Sprague S, Stinson R, Bhattacharya A. An ergonomic education and evaluation program for apprentice carpenters. Am J Ind Med 1997;32(6):641–6.

Baker EA, Israel BA, Schurman SJ. A participatory approach to worksite health promotion. J Ambul Care Manage 1994;17(2):68–81.

Bernard BP. Elements of ergonomics programs: a primer based on workplace evaluations of musculoskeletal disorders. US Department of Health and Human Services publication number 97-117. Cincinnati: National Institute of Occupational Safety and Health, 1997.

Bohr PC, Evanoff BA, Wolf LD. Implementing participatory ergonomics teams among health care workers. Am J Ind Med 1997;32(3):190–6.

Buchanan D, Cressey P, Hiba JC, Scmid F, Wilson J. Work organization and ergonomics. Geneva: International Labour Office, 1998.

Buckle P, Devereux J. Work-related neck and upper limb musculoskeletal disorders. Bibao: European Agency for Safety and Health at Work, 1999.

Burdorf A. Exposure assessment of risk factors for disorders of the back in occupational epidemiology. Scand J Work Environ Hlth 1992;18(4):1–9.

Burdorf A, van der Beek A. Exposure assessment strategies for work-related risk factors for musculoskeletal disorders. Scand J Work Environ Hlth 1999;25(4):25–30.

Cory H. The effects of production changes on the musculoskeletal disorders in Brazil and South America. Int J Ind Ergon 1999;25:103–4.

Evanoff BA, Bohr PC, Wolf LD. Effects of a participatory ergonomics team among hospital orderlies. Am J Ind Med 1999;35(4):358–65.

Fine LJ, Punnett L, Keyserling WM. An epidemiological study of postural risk factors for back disorders in industry, In: Buckle P, editor. Muscular disorders at work. London: Taylor and Francis 1987, p. 108–9.

General Accounting Office. Private sector ergonomics programs. Washington, DC, Health, Education, and Human Services Division. Publication number 97-163, 1997.

Hagberg M, Wegman DH. Prevalence rates and odds ratios of shoulder–neck diseases in different occupational groups. Br J Ind Med 1987;44:602–10.

Haims MC, Carayon P. Theory and practice for the implemen-

tation of 'in-house', continuous improvement participatory ergonomic programs. Appl Ergon 1998;29(6):461–72.
Israel BA, Baker EA, Goldenhar LM, Heaney CA, Schurman SJ. Occupational stress, safety, and health: conceptual framework and principles for effective prevention interventions. J Occup Hlth Psychol 1996;1(3):261–86.
Israel BA, Schurman SJ, House JS. Action research on occupational stress: involving workers as researchers. Int J Hlth Serv 1989;19(1):135–55.
Jafry T, O'Neill DH. The application of ergonomics in rural development: a review. Appl Ergon 2000;31(3):263–8.
Kawakami T, Batino JM, Khai TT. Ergonomic strategies for improving working conditions in some developing countries in Asia. Ind Hlth 1999;37(2):187–98.
Koda S, Nakagiri S, Yasuda N, Toyota M, Ohara H. A follow-up study of preventive effects on low back pain at worksites by providing a participatory occupational safety and health program. Ind Hlth 1997;35(2):243–8.
Kogi K. Collaborative field research and training in occupational health and ergonomics. Int J Occup Hlth Environ 1998;4(3):189–95.
LaDou J. The role of multinational corporations in providing occupational health and safety in developing countries. Int Arch Occup Environ Hlth 1996;68(6):363–6.
Li G, Buckle P. Current techniques for assessing physical exposure to work-related musculoskeletal risks, with emphasis on posture-based methods. Ergonomics 1999;42(5):674–95.
May DR, Schwoerer CE. Employee health by design: using employee involvement teams in ergonomic job design. Personn Psychol 1994;47:861–76.
Moir S, Buchholz B. Emerging participatory approaches to ergonomic interventions in the construction industry. Am J Ind Med 1996;29(4):425–30.
Moore JS, Garg A. Use of participatory ergonomics teams to address musculoskeletal hazards in the red meat packing industry. Am J Ind Med 1996;29(4):402–8.
Moore JS, Garg A. Participatory ergonomics in a red meat packing plant. Part II: case studies. Am Ind Hyg Assoc J 1997;58(7):498–508.
National Research Council. Work-related musculoskeletal disorders: report, workshop summary, and workshop papers. Washington DC, National Research Council, 1999.
Noro, K and Imada, A, editors. Participatory ergonomics. London: Taylor and Francis; 1991.
Partanen TJ, Hogstedt C, Ahasan R, Aragon A, Arroyave ME, Jeyaratnam J, Kurppa K, Loewenson R, Lundberg I, Ngowi AV, Mbakaya CF, Stayner L, Steenland K, Weiderpass E, Wesseling C. Collaboration between developing and developed countries and between developing countries in occupational health research and surveillance. Scand J Work Environ Hlth 1999;25(3):296–300.
Rainbird G, O'Neill DH. Occupational disorders affecting agricultural workers in tropical developing countries. Appl Ergon 1995;26:185–7.
Rosecrance JC, Cook TM. The use of participatory action research and ergonomics in the prevention of work-related musculoskeletal disorders in the newspaper industry. Appl Occup Environ Hyg 2000;15(3):255–62.
Rosskam E. Preventing workplace injuries and illnesses through ergonomics. Geneva, International Labour Organization. World at Work 1997;21:5–8.
Rubio CA. Ergonomics for industrially developing countries: an alternative approach. J Hum Ergol 1995;24(1):119–23.
Shahnavaz H. Role of ergonomics in the transfer of technology to industrially developing countries. Ergonomics 2000;43(7):903–7.
Singleton WT, Whitfield D. The organisation and conduct of a World Health Organisation inter-regional course on ergonomics for developing countries. Human Fact 1968;10(6):633–40.
Stubbs DA. Ergonomics and occupational medicine: future challenges. Occup Med 2000;50(4):277–82.
Takala J. Introductory report of the International Labour Office, International Occupational Safety and Health Information Centre, Geneva, International Labour Office, 1999.
Tandhanskul N, Duangsa-Ad S, Pongpanich C, Pungok A, Punpeng T, Juengprasert W, Kawakami T. Experiences of successful action programmes for occupational health, safety, and ergonomics promotion in small scale enterprises in Thailand. J Hum Ergol 1995;24(1):105–15.
Tolley JC, Zalk DM, Custodian Quality Improvement Team. A custodian journal on grassroots ergonomics. In: Proceedings of the American Society of Safety Engineers (ASSE) International Professional Development Conference 1998, Seattle, 14–17 June, 1998:247–54.
Westgaard RH, Winkel J. Ergonomic intervention research for improved musculoskeletal health: a critical review. Int J Ind Ergon 1997;20:463–500.
Wisner A. Variety of physical characteristics in industrially developing countries — ergonomic consequences. Int J Ind Ergon 1989;4:117–38.
Zalk DM, Biggs TW, Perry CM, Tageson R, Tittiranonda P, Burastero S, Barsnick L. Participatory ergonomics approach to waste container handling utilizing a multidisciplinary team. In: Proceedings of the International Ergonomics Association 14th Triennial Congress/HFES 2000, San Diego, 31 July–4 August, 2000:324–7.
Zalk DM, Tolley JC, Kim Y. Grassroots ergonomics to modify custodial training procedures. Profess Safe 1997;42:21–5.