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Interventions for musculoskeletal disorders in computer-intense office work: a framework for evaluation

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Workplace interventions for work-related musculoskeletal disorders (WMSDs) are usually multifaceted. These interventions tend to deal with multiple work organizational and physical risk factors and have components occurring at different organizational levels. The organizations are often changing, with shifting initiatives and priorities. Evaluation of such interventions poses challenges in documentation of implementation, reduction in exposures, and assessment of improved health outcomes. We describe a means-outcomes framework for evaluating field interventions that includes strategies, activities, objectives and metrics for outcomes using quantitative and qualitative methods. We demonstrate application of the framework to our work with a large newspaper, which builds on existing laboratory, aetiological and best practice evidence to improve musculoskeletal health. The newspaper had adopted several organizational strategies aimed at improving financial performance, including restructuring into teams, a major set of moves/renovations and introduction of new software. Concomitant WMSD-related organizational strategies include an ergonomics policy, human resources activities, promotion of team work, changes in environment and equipment specifications and development of information systems. We have found the framework useful for focusing the purpose of data collection and ensuring coverage of important components. At the same time, it provides sufficient flexibility to respond to the changing process of implementation.

1. Introduction

Work-related musculoskeletal disorders (WMSDs) among office workers engaged in intense computer work are increasingly understood by researchers to be associated with inadequate workplace design, excessive psychosocial stress and inappropriate work organization, mediated through a variety of biological pathways (Moon & Sauter, 1996; Sandsjö & Kadefors, 2001). Development of research programmes on interventions to reduce WMSDs has become increasingly urgent as our understanding of risks improves and the persistence of burden remains (Norman & Wells, 2000). A program of intervention research to deal with

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such a broad range of aetiological factors should ideally comprise: (1) developmental studies, including efficacy of particular equipment or manoeuvres in reducing exposures; (2) implementation studies, which document the extent to which particular interventions are appropriate and/or feasible; and (3) effectiveness studies on the impact of interventions in a number of workplaces (Goldenhar, LaMontagne, Katz, Heaney, & Landsbergis, 2001).

A number of efficacy studies have been conducted on workplace equipment and design. These include comparisons of the effects of different kinds of keyboards and mice on posture and discomfort (see Lincoln, Vernick, Ogaitis, Smith, Mitchell, & Agnew, 2000 for a review) and studies of the role of forearm support in reducing musculoskeletal discomfort in laboratory and field settings (see review by Aarås & Ro, 2001). In addition, tests of the effects of changes in limited aspects of work organization, such as different durations and distributions of work breaks on shoulder discomfort, lend themselves to efficacy evaluations.

Evaluations of implementation and effectiveness generally require field work with organizations that engage in multiple-component interventions as part of ongoing operational changes or organizational initiatives (e.g. case studies in Kompier & Cooper, 1999, best practices in Panel on Musculoskeletal Disorders and the Workplace, 2001). Such interventions may not be very informed by relevant existing evidence (Colarelli, 1998) or demonstrated effectiveness of the growing number of commercial remedies (Lincoln *et al.*, 2000). Interventions may be aimed at different levels: individual coping strategies versus organizational initiatives (Callan, 1993); or person-based task restructuring versus work organization or work environment changes (Karasek, 1992). They may address different kinds of stressors associated with different organizational initiatives, such as role changes with team work implementation (in Parker, Jackson, Sprigg, & Whybrow, 1998) or layoffs with organizational mergers (reviewed in Burke, 1993). Finally, they can use vastly different processes, from participatory action research (Hugentobler, Israel, & Schurman, 1992; Mikkelsen, Saksvig, & Landsbergis, 2000) to controlled trials of expert designed packages (Pelletier, Rodenburg, Chikamoto, Vinther, King, & Farquhar, 1998).

For health researchers, this means the evaluation requires conceptually structuring both the process and outcomes of multiple-component interventions, i.e. linking particular elements of the process to particular shorter- and longer-term outcomes. Documentation of the implementation of each component, measurement of the more proximal effects of those components on exposure, and assessment of overall improvements in health is required. The organization's management team often requires the evaluation to include some monitoring of performance (output, quality and financial), particularly if work organization changes are expected to impact on both health and productivity. Hence the fundamental challenge of such field research is how to make sure that such studies both build on existing laboratory and field studies and produce multiple kinds of evidence. They need to link with efficacy studies, delineate contributions of different intervention components and document relevant impacts for organization partners. In this paper, we describe a framework for evaluating field interventions. Drawing on work currently in progress, we demonstrate its application in a field intervention to reduce WMSD among office workers at a large newspaper.

2. Formulation of an evaluation framework

Westlander (1995) set out a clear means-goals framework by which to evaluate the impacts of a comprehensive organizational change programme to improve the health of telephone operators. Her framework has similar components to those in 'logic charts' used in designing

and evaluating health promotion programmes (Dwyer & Makin, 1997) and in 'logical frameworks' used by international development project managers (McLean, 1988). Key ingredients are specific objectives and metrics for each component or activity area. Shorter-term or intermediate measures are most directly linked to the specific changes planned or occurring in the organization. Such measures are crucial to understanding both extent of implementation and effectiveness of reduction in exposures.

It is unfortunate and far too common in occupational health that interventions do not reduce exposures, either due to inadequate implementation and consequent lack of intensity or other organizational/operational changes unrelated to the specific interventions (Åborg, Fernstrom, & Ericson, 1998). The mixed relationships found between interventions and reductions of discomfort or strain in office settings (Brisson, Montreuil, & Punnett, 1999; Cahill, 1992; Demure, Mundt, Bigelow, Luippold, Ali, & Liese, 2000) may be attributable to problems of implementation and intensity. The failures of intentional organizational change efforts, which aimed to improve health, have been attributed to other financially motivated organizational changes (Nytrø, Saksvik, Mikkelsen, Bohle, & Quinlan, 2000).

The dynamics of interventions and organizational changes, both those motivated by financial goals and those motivated by health goals, raise important additional questions about the processes of implementation. Westlander (1995) proposed an additional stream of documentation and analysis of implementation. Other researchers have argued for the importance of collecting substantial qualitative (as well as quantitative) data in action research (Hugentobler *et al.*, 1992) and evaluation of the diffusion of innovations in organizations (Van de Ven & Poole, 1995). Qualitative methods can put a human face to abstractions. We agree that collection of data via multiple means and their integration or 'triangulation' are essential to improve our knowledge of workplace change processes or the 'how' of intervention. This approach works best with a multidisciplinary team with a multipronged approach. As such, our team includes researchers from a variety of disciplines and the evaluation framework includes a variety of methods to collect data on both processes and outcomes.

3. Case study

Since 1995, we have collaborated with a large metropolitan newspaper on a research project on repetitive strain injury (RSI). RSI is the generally preferred term for WMSD among workplace parties (that is, management and union representatives, and workers) in Ontario. The newspaper employs over 1200 office workers who use computers extensively. Our early assessments of these workers involved a cross-workforce survey (Polanyi *et al.* 1997) followed by more detailed examination of particular work-related risks factors for musculoskeletal health. Our results were presented to a joint management-union committee, representing the workplace parties at the newspaper. Subsequently, a series of recommendations were developed based on our findings, interpretations by the workplace parties, existing best practices, and scientific literature (e.g. that in the Panel on Musculoskeletal Disorders and the Workplace, 2001). These recommendations are set out in table 1. They were later incorporated into agreements between newspaper management and union representatives (Polanyi & Cole, in press).

Simultaneously with the research, the newspaper hired a large management consulting firm to recommend changes in organizational structure and operations with a goal of improved profitability. The consultants initiated a restructuring process, with extensive team development. In addition, ongoing technological changes at the newspaper included

Table 1. Research team's recommendations to newspaper management and labour representatives on musculoskeletal disorders (RSI).

WORKPLACE RISK FACTORS FOR RSI

Equipment and workstations

- Develop a standardized procedure to allow workers to initiate and participate in the selection of workstation equipment.
- Establish protocol for assessment of individual workstation environments:
  - upon request
  - upon report of a case to RSI Committee
  - during technological change
  - by reviewing departments on a regular basis.
- Base assessment on user input and recent authoritative guidelines.
- Develop education sessions including discussion of RSI Committee results and use of equipment.

Time-related factors

- Consider redesign of work organization and jobs to minimize keyboarding as a dominant job component.
- Improve mutual understanding of tasks in the organization to assist in synchronization/co-ordination of work and minimization of workload peaks.
- Provide appropriate levels of technical support and training.
- Bolster computer system support and minimize computer system down time especially during periods of rapid technological change.
- Review scheduling and assignment of work to maximize resources at deadline.

Work volume

- Develop a strategy to address workload demands including adequate/appropriate staffing and task distribution.
- Examine the pros and cons of bonus/incentive schemes (in terms of RSI).

Other work organization factors

- Educate supervisors and co-workers about the role that social relations at work and work organization play in RSI.
- Explore ways to increase worker control over work, e.g. job enrichment, work groups, flexible scheduling.
- Establish a mechanism for employees to have input into decision-making on factors related to RSI.

REPORTING RSI

Reporting procedure

- Decrease confusion or uncertainty over symptoms and definition of RSI and develop a simple, visible procedure for reporting.
- Provide information or guidelines (5–10 points) about RSI, based on knowledge of health professionals and experiences of employees.
- Educate managers and employees about symptoms in the broadest sense (e.g. RSI can be caused or aggravated by work; importance of watching for early symptoms).
- Use existing or expanded RSI Committee to develop a systematic reporting procedure based on a data system.

Support for RSI reporting

- Encourage greater support for recognition and reporting of RSI.
- Encourage meetings among employees with RSI, union, supervisors and caregivers to discuss RSI.
- Expand education efforts with a campaign on 'RSI is real'.
- Develop strategies suitable for each department.
- Foster peer-support networks on RSI.

(*table 1 continues*)

Table 1. (*Continued*).

DEALING WITH RSI
Clinical management
• Adopt a more flexible and evidence-based approach to the clinical management of RSI.
• Formally expand range of RSI treatment paid for through the established procedures.
• Track the progress of employees getting various treatments.
• Monitor the clinical literature for evidence on effective treatment of RSI.
Assisting those with RSI
• Identify range of 'influential persons' that those with RSI can go to for support.
• '...being supportive and giving the power and control over their own lives is always a better way to reach people. Respecting them'.
Monitoring
• Develop a systematic work assessment and workplace follow-up strategy to document successes and failures.
• Potential role for the newspaper's Joint Health & Safety Committee* or RSI Committee members trained in ergonomics.

*Joint Health & Safety Committees are mandated under the Province of Ontario's Occupational Health and Safety Act to carry out health and safety duties in all workplaces of 20 employees or more.

introduction of new Windows 8-based software in several major departments to permit a more co-ordinated assembly of newspaper content.

Considerable connections can be drawn between the research assessment processes and the organizational change processes. For example, our initial questionnaire survey indicated that employees who often worked to weekly and daily deadlines were more likely to report symptoms meeting our case definition of WMSD than employees without such pressure (Polanyi *et al.*, 1997). Subsequent research found that poor co-ordination between sections and highly variable workflow compounded individuals' problems in meeting deadlines. The reorganization effort in one department aimed to build internal buffers to higher demands through closer communication and load-sharing among team members. These changes might be expected to reduce peak loads, based on the findings of other work re-design studies (Burke, 1993; Mikkelsen *et al.*, 2000; Polanyi, Eakin, Frank, Shannon, & Sullivan, 1998). Similarly, new software aimed at smoother workflows between sections to facilitate meeting deadlines more easily and efficiently. Although initiated primarily for business reasons such a technology change had the potential to reduce WMSD risk.

The research team and joint management-union committee brainstormed strategies and activities (or components) that they believed would have an effect upon musculoskeletal health in the computer-intense work engaged in by newspaper workers. The strategies and a representative subset of all activities for each strategy are summarized in table 2, along with metrics for intermediate-and longer-term outcomes. Here we briefly describe each of the strategies.

An *ergonomics policy*, negotiated by the workplace parties, provided an overarching agreement on activities most directly associated with improvement in musculoskeletal health. The ergonomics policy includes: (1) a mission statement and objectives; (2) a summary of risk factors for WMSD, including work organizational (e.g. low social support) and physical (e.g. non-optimal workstation set-up); (3) a set of responsibilities for WMSD risk identification, assessment and control; and (4) provisions for information systems and consultation. These components are linked to other strategies and activities listed in table 2.

Preliminary analysis of interviews with joint committee members (intermediate outcome metric) indicated awareness of the ergonomics policy and some indications of its use

Table 2. Means-outcomes framework for multi-component intervention in computer-intense work. The broad goals of the changes are improved musculoskeletal health and better organizational performance.

Means		Intermediate outcomes		Longer term outcomes	
Strategies	Activity area	Objectives	Metric	Objectives	Metric
Policy	Formulation of ergonomic policy	Employees/managers aware of ergonomic policy and its contents	Interviews	Policy used to guide actions	Document analysis. Interviews. Questionnaire.
Human resources	Definition of employer and employee responsibilities	Each aware of their responsibilities	Interviews and document review	Each fulfilling their responsibilities	Joint committees' document review. Questionnaire
	'Stop RSI'* training	Entire office workforce has been part of group or individual training	% trained by department	Part of orientation of new staff	Questionnaire to measure changes in knowledge, attitudes and practices
	Knowledge of WMSD** risk factors (including work organization & physical)	Employees/managers aware of such factors and attempting to deal with them	Interviews. Observations during researcher participation in joint committees. Document review	Managers incorporating consideration of such factors in work design & operations decision-making	Interviews. Participation in joint committees. Questionnaire

(*table continues*)

Table 2. (*Continued*).

Means		Intermediate outcomes		Longer term outcomes	
Strategies	Activity area	Objectives	Metric	Objectives	Metric
Team Work	Team training	Consideration of work organization and physical WMSD risk factors in training	Document review. Interviews	Ongoing training and new team structures incorporating WMSD risk factor considerations	Document review. Interviews
	Team formation and implementation	Multi-skilling, increased variety, improved productivity	Interviews. Diary for number of tasks & % time in tasks. Variation in muscle activation via surface electromyography. Departmental workload/productivity data	Improved working relationships; synchronization of tasks, handling of deadlines, work-flow allocation. Improved productivity	Interviews. Diary for number of tasks and % time in tasks. Questionnaire. Departmental workload/productivity data
Equipment and environment	New spatial layout of workstation	Allows adequate space for work and improves contact between team members	Observation. Interview	Workflow improvement and increased teamwork	Interviews
	New adjustable workstations	Improved 'ergonomic design' of workstations	Measurement of workstation dimensions. Observational data (video & observer) on postures. Muscle activation	Purchasing policies revised to include 'ergonomic' considerations. Ongoing improvement of existing workstations	Interviews. Ergonomic assessment data. Questionnaire

(*table continues*)

Table 2. (*Continued*).

Means		Intermediate outcomes		Longer term outcomes	
Strategies	Activity area	Objectives	Metric	Objectives	Metric
Information systems	New software	Improved workflows & productivity	Interviews. Observations. Productivity data in departments	New software designs incorporating WMSD considerations	Interviews with system staff. Questionnaire. Productivity data in departments
	Human resource (HR) information systems	Improve ongoing surveillance of WMSD risk factors (ergonomic assessments) and reporting	Data from relevant HR data bases to joint committees	Reduce overall risk factors and severity of WMSD	Decline in WMSD severity on injury reports and regular ergonomic assessments

*RSI—repetitive strain injury (term used by workplace parties).
**WMSD—work-related musculoskeletal disorder (term preferred by research team).

to guide actions (Polanyi & Cole, in press). Awareness and use of the policy remains to be assessed in the broader workforce (longer-term outcomes).

A key *human resource* (HR) activity has been training the vast majority of the workforce about risk factors for WMSD and what managers and employees can do about them, entitled the 'Stop RSI' program. Training materials were developed based on research findings and best practices by the health and safety manager in conjunction with a training consultant. In 2-h sessions, trainers became acquainted with the audiovisual (overheads) and written materials, asked questions of the researchers and resource people, and practised delivery of parts of the material. The trainers then delivered 1-h training sessions in each of their departments. A follow-up session with the research team part way through the intervention gave the trainers the opportunity to discuss questions that had been raised and to problem-solve responses. Although simple coverage estimates form an intermediate outcome, changes in knowledge, attitudes and practices among managers and employees are also important (longer-term outcome).

Our participation in joint committees, particularly the RSI Committee (metric for intermediate outcomes) provided a window on gaps in awareness of WMSD risk factors. For example, some managers have been less than conscious of the potential impacts of their decisions, such as understaffing, leading to increased workload and reduced breaks. Similarly, some employees have been slow to accept that some work practices, such as less than ideal body postures, can engender WMSDs. In initial interviews, RSI Committee members noted challenges associated with influencing work organization policies and practices to incorporate consideration of WMSD risk factors (Polanyi & Cole, in press). Whether such considerations will become part of the managers' operational decision-making (longer-term outcome) remains to be seen.

Promotion of *team work*, particularly in one department, provided additional opportunities for discussion of WMSD risk factors during team training (metrics—interview with departmental assistant manager responsible for training and documents from training sessions). Team formation offered the potential to increase skills in communication and joint problem-solving around workflow, thus decreasing peak job demands, and to diversify the mix of tasks carried out by any one team member. The intervention promises to improve the mechanical exposure to risk by improving the time variation pattern, reducing static postures and allowing muscle rest, as well as reducing cases of moderate loads due to awkward postures. To document changes in exposure, we have completed detailed observations on approximately 40 volunteer participants. Our measures include: postures recorded by trained observers; self-reported number of tasks and number of task transitions via diaries; and technical measures using surface electromyography (EMG) of the forearms and shoulders to measure the amount of muscle activity and the number of EMG 'gaps'. Each of these aims to capture improvements in both amplitude and time variation of exposures on a subset of employees and managers. The link between work organization changes and decreases in static physical exposures known to be of pathophysiological concern is an important one to demonstrate. For the organization, changes in productivity, observed earlier in pilot teams, should become observable across the department, particularly as the teams mature (both intermediate and longer-term outcomes).

The same subset of employees is being monitored for changes in *environment and equipment* that accompanied the departmental move. The extent to which workstation layouts have been designed to match work organization requirements (O'Neill, 1998) was partly observable but also required interviews with employees (intermediate-outcome metric). New adjustable desks and chairs that met a basic 'ergonomic' standard acceptable to health and safety personnel were purchased with the goal of allowing a better

anthropometric fit (intermediate metric—direct measurements). They should also reduce static loads in the activation profile of shoulder and forearm musculature on surface EMG. For this subgroup, observable, self-report and biological measures were taken before the intervention, after physical changes, and after team training and work organization changes to determine the relative impact of each change. Initial results of the physical changes on direct workstation measures indicate better alignment of mouse and keyboard heights and improved arm support (Moore, 2001). The extent to which policies on both retrofits to existing workstations and purchase of new workstations and equipment continue and their impact on workstation-person matches for the entire workforce remain to be determined (longer-term outcomes).

Finally, *information systems* are both essential work tools in office work, which can facilitate or impede work flow, and ways of monitoring implementation and outcomes. Initial interview data (intermediate outcome metric) indicate that their impact on workflow may vary considerably across employees. For example, some editorial employees appreciate the flexibility of a new microcomputer, Windows 8-based 'front-end system' (versus older mainframe-linked system) to move between functions and more rapidly communicate with co-workers and managers. Others are frustrated by the large number of steps required to carry out simple word-processing tasks.

Information systems also played an important role in monitoring WMSD through the development of a computerized reporting system and a new 'ergonomic report'. The latter was developed by the RSI Committee to rapidly assess both WMSD risk factors and severity. Over 20 assessors (a subset of all 'Stop RSI' trainers) have been trained in its use. They have conducted over 500 assessments, predominantly among members of the workforce who had not complained of musculoskeletal problems. They plan to complete assessments of the entire workforce every 2 years. The assessments have been inputted into a customized MicroSoft 8ACCESS database developed by the research team with feedback of query results to joint committee members (intermediate objectives). Active discussion of preliminary results at the joint RSI Committee have been indicative of avid interest among workplace parties in knowing the extent to which hazards are being reduced, e.g. optimal location of monitor, adequate arm and wrist support. Such human resource information systems should provide an ongoing monitoring capacity for both WMSD risk factors and severity as a form of active surveillance (longer-term objectives—metric).

4. Discussion

Application of the evaluation framework has helped the members of the research team to ensure adequate coverage of the complex range of activities and outcomes occurring in the workplace. Further, the framework forces us to focus on the purpose of the different types of qualitative and quantitative data that we and the workplace parties collect. To some organizational researchers, the framework may appear overly rigid for the fluid processes of innovation and change that occur in organizations. To some ergonomists, the framework may seem inadequately rigorous with respect to clear exposure contrasts of more structured designs. Yet we feel that the framework sets an appropriate balance between flexibility and structure, permitting us to capture both broad and highly specific changes in the organization (Colarelli, 1998).

Further, we have attempted to make sure that the intervention research process pays heed to the recommendations of other researchers (Karasek, 1992; Kompier & Cooper, 1999; Nytrø *et al.*, 2000). We have sought: (1) collaborative governance; (2) integration with other organizational activities; (3) clear implementation plans with clarification of

roles and responsibilities; and (4) adequate resource commitments on the part of workplace parties and researchers. Given the uncertainties involved in such collaborative intervention research processes, we have also built in ongoing learning for all involved. Information emerging from our research and workplace parties' experience has been important for adapting implementation (Polanyi & Cole, in press). Hopefully, our intervention research process will reduce the likelihood that our evaluation framework will serve us poorly for reasons not related to our measures. We must await further experience with the framework, both for ourselves and other field intervention researchers, before we can fully appraise its utility.

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