

Are interventions targeting work organization or the psychosocial work environment effective in preventing or reducing work-related musculoskeletal disorders (WMSD)? A systematic review of the literature ¹

By Susan R Stock, MD, MSc, FRCPC, ² Nektaria Nicolakakis, PhD, Nicole Vézina, PhD, Michel Vézina, MD, MPH, FRCPC, Louis Gilbert, DESS, Alice Turcot, MD, MSc, FRCPC, Hélène Sultan-Taïeb, PhD, Kathryn Sinden, R Kin, PhD, Marie-Agnès Denis, MD, Céline Delga, MSc, Clément Beaucage, MD

1 Supplementary tables

2 Correspondence to: Susan R Stock, MD, MSc, FRCPC, Institut national de santé publique du Québec, 190 Crémazie E. Montréal, QC, H2P 1E2, Canada. [email: susan.stock@inspq.qc.ca]

Table S1. Medline search strategy. Terms from different concepts were combined with the Boolean operator ‘AND’. The natural language-based search strategy was the same for all databases. Search strategies differed with respect to database-specific controlled vocabulary, in this case Medical Subject Heading (MeSH) terms (ending with /).

Concept	Search phrase using natural language and MeSH terms
Psychosocial or organizational interventions	((interven* or strateg* or solution* or chang* or ((reorganis* or reorganiz* or re-organis* or re-organiz* or redesign or re-design) adj2 (work or workplace or work-place)) or "change* in work organi#ation" or "change* in working condition*" or "organi#ational change*" or "change* in the organi#ation of work") adj5 (psychosocial or psychosocial or "psychosocial work factor*" or "psychosocial working condition*" or organi#ational or psychological or social or "emotionally demanding work" or "emotional demand*" or (mental adj (workload or work-load)) or (task adj (restructuring or re-structuring)) or (Job adj (control or demands or strain)) or iso-strain or (quantitative adj1 demands) or "psychological strain" or "stress at work" or "stressful working condition*" or (decision* adj (latitude or authority

or autonomy)) or (skill adj (discretion or utilization)) or harassment or violence or bullying or effort-reward or ((colleague* or coworker* or co-worker* or supervisor* or superior* or manager* or management) adj support) or "safety climate" or (corporate adj (climate or culture)) or "flexible working conditions")).ti,ab.

OR human engineering/ or man-machine systems/ or organizational innovation/

Evaluation of effectiveness

(effectiveness or efficacy).ti,ab.

OR ((assess* or evaluat* or study* or studies or investigat* or determin*) adj4 (effective or impact* or effect* or change* or modify* or difference* or improv* or reduc* or increas* or decreas*)).ti,ab.

OR (randomi#ed adj2 (trial* or study or studies)).ti,ab.

OR (control?ed adj (trial* or study or studies)).ti,ab.

OR (intervention adj2 (study or studies or trial*)).ti,ab.

OR ("Before and After Stud*" or "Before-After Stud*").ti,ab.

OR comparative effectiveness research/ OR evaluation studies as topic/
OR clinical trials as topic/ OR exp controlled clinical trials as topic/
OR program evaluation/ OR intervention studies/ OR Epidemiologic studies/ OR Controlled Before-After Studies/ OR exp randomized controlled trial/ OR exp randomized controlled trials as topic/

Musculoskeletal disorders

((musculoskeletal or musculo-skeletal) adj4 (disorder* or disease* or injur* or pain or symptom*)).ti,ab.

OR ((back*1 or neck*1 or limb*1 or extremi* or hand*1 or wrist* or elbow* or shoulder*) adj4 (disorder* or injur* or pain or symptom*)).ti,ab.

OR ("cumulative trauma disorder*" or (repetiti* adj1 (strain or motion) adj1 (disorder* or injur*)) or ((overuse or over-use or overexertion or over-exertion) adj2 syndrome*)).ti,ab.

OR musculoskeletal diseases/ OR arm injuries/ OR forearm injuries/

OR tennis elbow/ OR wrist injuries/ OR back injuries/ OR spinal injuries/ OR hand injuries/ OR neck injuries/ OR occupational diseases/ OR back pain/ OR low back pain/ OR neck pain/ OR exp "sprains and strains"/ OR exp cumulative trauma disorders/

Workplace

(occupation* or work* or company or companies or industry or industries or job or jobs).ti,ab.

OR work/ OR employment/ OR workplace/ OR occupations/

Review

((systematic or scoping or critical or state-of-the-art or evidence) adj2 (review* or overview*)) or (scoping adj (study or studies)) or meta-analys#s or metaanalys#s).ti,ab.

OR review literature as topic/ or review/ or meta-analysis as topic/ or meta-analysis/

Table S2. Results of the methodologic quality appraisal of individual studies. ^a See Table 1; ^b H: high quality, M: medium quality, L: low quality

Study	Methodologic quality criteria ^a															/30	%	Rating ^b
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15			
Faucett et al., 2007, (study 1) (53)	2	2	2	1	1	2	2	2	2	2	2	2	1	2	1	26	87	H
Faucett et al., 2007, (study 2) (53)	2	2	2	1	1	2	2	2	2	2	2	2	1	2	1	26	87	H
Eklöf & Hagberg, 2006 (61)	2	1	2	2	1	2	1	2	1	2	2	2	1	1	0	22	73	M
McLean et al., 2001 (56)	2	2	2	1	0	2	2	2	0	2	2	2	1	0	2	22	73	M
Galinsky et al., 2007 (55)	2	2	2	1	2	2	1	2	2	0	0	2	1	0	2	21	70	M
Haukka et al., 2008; 2010 (47,48)	2	2	2	1	1	2	1	2	1	0	0	2	2	1	2	21	70	M
Yassi et al., 2001 (60)	2	2	2	2	1	2	1	2	2	1	0	2	0	1	1	21	70	M
Driessen et al., 2011 (50,62)	2	2	2	1	1	2	1	2	0	0	2	1	1	2	2	21	70	M
Von Thiele Schwarz et al., 2008 (54)	2	2	2	0	0	2	0	2	2	2	2	1	0	0	1	18	60	M
Gilbert-Ouimet et al., 2011 (58)	2	0	0	1	1	1	1	2	2	0	0	2	1	2	2	17	57	M
Laing et al., 2007; 2005 (57,63)	2	1	1	1	1	2	1	1	0	0	0	2	1	2	1	16	53	M
Caspi et al., 2013 (59)	2	0	0	1	1	2	1	1	1	1	0	2	1	1	2	16	53	M
Kuijjer et al., 2005 (79)	2	1	1	0	0	1	1	1	2	0	2	2	1	0	1	15	50	L
Engkvist, 2006 (80)	2	1	1	1	1	1	1	1	1	0	0	2	1	0	2	15	50	L
Engst et al., 2005 (81)	2	1	1	2	1	2	1	2	0	0	0	2	0	0	1	15	50	L
Engst, 2004 (82)	2	1	1	1	1	1	1	2	0	0	0	2	0	1	1	14	47	L
Wergeland et al., 2003 (66)	2	1	1	0	0	1	1	2	2	0	0	1	1	1	1	14	47	L
Black et al., 2011 (83)	2	1	0	0	0	1	1	2	0	0	0	2	1	1	2	13	43	L
Carrivick et al., 2002 (72)	2	0	0	0	0	2	2	2	0	0	0	2	1	0	2	13	43	L
Dababneh et al., 2001 (65)	2	0	0	1	0	2	2	2	0	0	0	2	0	0	2	13	43	L
Nelson et al., 2006 (74)	2	0	0	1	1	1	1	1	1	0	0	1	1	1	1	12	40	L
Ronald et al., 2002; Chhokar et al., 2005 (51,52)	2	0	0	1	1	1	1	2	0	0	0	2	0	1	1	12	40	L
Lee et al., 2015 (84)	2	0	0	1	1	1	1	1	0	0	0	1	1	0	1	10	33	L
Guthrie et al., 2004 (73)	2	0	0	1	1	1	1	1	0	0	0	2	0	0	1	10	33	L
Donaldson, 2000 (85)	1	0	0	0	0	1	1	2	2	0	0	2	0	0	1	10	33	L
Charney, 2006 (86)	1	0	0	0	0	1	1	2	0	0	0	2	0	1	1	9	30	L
Kutash et al., 2009 (87)	2	0	0	0	0	1	2	2	0	0	0	1	0	1	0	9	30	L
Sedlak et al., 2009 (88)	2	0	0	0	0	1	1	1	0	0	0	1	0	0	1	7	23	L
% studies with 2 points on criterion																		
High- & medium-quality studies	100	67	75	17	8	92	25	83	50	42	50	83	8	42	50			
Low-quality studies	88	0	0	6	0	19	19	63	19	0	6	69	0	0	25			

Table S3. Description of the 11 medium- and high-quality studies included in evidence synthesis, continued from Table 2.

Study	Response rate at recruitment	Loss to follow-up rate	Effects of intervention on physical work exposures	Effects of intervention on psychosocial work exposures	Confounders/ effect modifiers	Compliance/ Intervention implementation	Co-interventions & Contextual factors
<i>Interventions targeting the work-rest cycle through supplementary pauses</i>							
Faucett et al., 2007 (study 1) (53)	100% (72 out of 72 eligible)	8%	≠ productivity: number of flats of strawberries picked/day/worker	ND	Controlled for age	None of the workers opted out of any breaks	Language, literacy & cultural characteristics of workers were taken into account in the ergonomics training & outcome measures. Inter-group competition may have influenced measures of productivity, particularly for C groups
Faucett et al., 2007 (study 2) (53)	100% (none of the 33 workers declined to participate)	3%	≠ productivity: number of trees processed/ day by each worker pair (but test underpowered)	ND	Controlled for group order and productivity in ANCOVA	None of the workers opted out of any breaks	Language, literacy & cultural characteristics of workers were taken into account in the ergonomics training & outcome measures
Galinsky et al., 2007 (55)	89% (90 out of 101 eligible workers)	43% (completers not compared to drop-outs)	≠ productivity: – ↑number of keystrokes/hr – ≠ number of documents entered/day	ND	Discomfort ratings attributed to non-job factors (e.g. playing sports, gardening, accidents, prescription medications, bereavement) treated as missing values	Electronically-recorded duration of data entry on terminal suggested close compliance to assigned break schedules (I vs. C: 386 vs. 405 min/day). Self-reports indicated 1 additional unassigned 5-min break/day was taken by control participants	ND
McLean et al., 2001 (56)	ND	0%	↓ <i>NS</i> productivity: electronically-recorded number of words typed	ND	None considered in analysis. Discussed are possible effects of postural sway & in-chair movement on MSK	Workers & authors monitored breaks taken by control group. Authors report number of breaks taken under each protocol	ND

indicators & potential confounding effect of participants rating discomfort when they are anticipating end of work session

PE interventions based on training groups of workers to analyze work, identify problems and propose solutions

Driessen et al., 2011 (50,62)	I: 55% (1,472 out of 2,669 eligible meeting inclusion criteria) C: 55% (1,575 out of 2,841 eligible meeting inclusion criteria)	After 12 months: I: 40% C: 37%	<ul style="list-style-type: none">– ↑ work with trunk in heavily awkward posture for prolonged time– ↓ NS often manually carry load >20 kg (p=0.05)– ≠ in other physical exposure measures Standardised Dutch MSK Questionnaire (yes/no), 8 measures for low back, including exposure to various postures, loads & driving; 3 posture measures for neck	At 12 months: <ul style="list-style-type: none">– ≠ decision latitude– ≠ decision authority– ≠ skill discretion– ≠ psychosocial job demands– ≠ supervisor support– ≠ coworker support– ≠ overall social support JCQ (Dutch version) 4-point response scale, totally disagree to totally agree, various items combined	For effects on work exposures: gender, age, education & work hrs/week in current function (the latter for physical exposures only) were considered. For effects on MSK outcomes: gender, age, education, work hrs/week in current function physical & psychosocial work exposures were considered. Adding them to the models did not change effect estimates by more than 10%, therefore final analyses adjusted only for baseline outcome differences	Of 66 suggested measures in I group, 26% were perceived as implemented by the workers in the departments and 34% were perceived as implemented by the implementers. Authors state that implementation was low, hampered by factors such as a shortage of financial/personnel resources, lack of time to implement ergonomic changes, insufficient stakeholder involvement, and that ergocoaches played a less effective role than expected	Department managers were asked about all other ongoing studies, planned reorganizations & other innovations or company health interventions (i.e. fitness programs, back schools, chair massages, lifestyle programs). During the follow-up period, ergonomic measures were implemented that were unrelated to the intervention, in similar numbers in I (n=442) & C departments (n=483). No departmental reorganizations occurred during follow-up
Haukka et al., 2008; 2010 (47,48)	60% of eligible kitchens; % eligible workers recruited ND	39% of workers I: 30% C: 29% 3% of kitchens	≠ physical workload index of perceived strenuousness of 7 tasks (7-point response scale, mean used in analyses)	At 12 months post-intervention, for workers who underwent intervention & organizational reform: <ul style="list-style-type: none">– ↑ mental strenuousness– ↑ hurry at work– ↑ low job control	Models of MSK pain adjusted for: baseline MSK pain, age, gender, job satisfaction, smoking, physical exercise, body mass index & permanent vs. fixed-term employment.	402 ergonomic changes were implemented during the intervention phase; 101 additional changes took place during the 1-year follow-up period; 113 planned changes not completed	80 ergonomic changes implemented in C kitchens; major reforms in foodservice in 2 of 4 participating cities (1/2 the kitchens): food preparation centralized to large production kitchens for distribution by other kitchens. Plans for

				<ul style="list-style-type: none"> – ↑ poor coworker relationships – ↑ low supervisor support – ↓ skill discretion Occupational stress questionnaire, FIOH (1 item each, 5-point response scale, dichotomized yes/no)	Models of psychosocial factors adjusted for: baseline level of psychosocial outcome measure, age, MSK pain, physical workload & city		outsourcing food services discussed; personnel decrease in 11 C & 4 I kitchens; number of food portions prepared per worker increased in about 1/3 of both C & I kitchens; reasons for interruption or delay of the implementation included problems with collaborative partners, technical problems & lack of financial resources
Laing et al., 2007; 2005 (57,63)	I: 84% (81 out of 97 eligible) C: ND	<p>For psychosocial outcomes (2007 paper): I: 31% C: ND</p> <p>For perceived effort & MSK outcome (2005 paper): I: 46% C: ND</p>	<ul style="list-style-type: none"> – ≠ perceived effort for back, shoulder & legs/feet (Borg CR-10 scale) – ↓ peak &/or cumulative mechanical exposure for some of the physical change projects (based on 1 worker), measured with electromyography, accelerometry, biomechanical modelling & expert opinion of research group 	<ul style="list-style-type: none"> – ≠ decision latitude (JCQ, combining skill discretion (6 items) & decision authority (3 items) weighted equally & re-scaled to 100) – ≠ workplace influence (Greenberger, sum of 11 items, 5-point response scale, very little to very much, re-scaled to 100) – Workplace communication dynamics, administered only post-intervention 	Age and seniority were measured but not considered in analyses	Project steering committee met every 6 weeks to review progress, ensure adequate resources for intervention & determine methods of communication within & between different plants & levels in the organization. 9 of 10 physical change projects implemented; 7 of 9 workplace “psychosocial interventions” implemented (except 1-minute surveys & short-term user trials) at all 3 production departments	Removal of employee incentive program; plant shut downs & layoffs; transfer of plant manager from C to I plant and new plant manager brought into C plant; increased conveyance system speed, compensated for by an additional worker at C plant but not at I plant; disruption in production demands due to border closures following September 11 2001 attacks; process-related quality problems; negotiation of collective bargaining agreement between labour & management throughout intervention period

Interventions to reduce patient lifting in a hospital setting through safe lifting programs and equipment

Caspi et al., 2013 (59)	I: 75% (374 out of 501 eligible workers); No C group	I: 28% (completers not compared to drop- outs); No C group	↓ prevalence lifts over 100 lbs	<ul style="list-style-type: none">– ↑ supervisor support (3 items, 5-point response scale, never to always)– ≠ coworker support (2 items, 5-point response scale, never to always)– ↑ safe patient handling score (OSHA scale, never to always)– ↓ unsafe patient handling score (OSHA, never to always)– ↓ patient repositioning score (OSHA, never to always)– ↑ safety practice score (Patient Care Worker Survey, mean of 5 items, 5-point response scale, strongly agree to strongly disagree)	Models were adjusted for whether workers responded to baseline and post-intervention questionnaires	84% participation rate in safe patient handling training & mentoring sessions, and improvements on the unit were implemented as a result of the safety audits; physical fitness promotion component not implemented	Authors discussed that floor champions may be responsible for multiple unit initiatives, which may be competing with other patient-centered care activities. But such potential co-interventions were not documented. No contextual factors were documented
Yassi et al., 2001 (60)	100% out of 346 I ₁ : 127 I ₂ : 116 C: 103 (assumed because equipment & training available to all staff)	I ₁ : 26% I ₂ : 27% C: 20%	<ul style="list-style-type: none">– ↓ number of manual patient lifts & transfers/shift (~7-9 less) in I₁ & I₂ groups– ≠ physical demands (VAS, 0-100, work is not at all to extremely physically demanding)	<ul style="list-style-type: none">– ↑ perceived safety from injury with respect to patient lifting & transferring, compared to 1 year ago in I₁ & I₂ (VAS, 0- 100, much more to much less safe)	ND	Nature and number of devices available in each room were documented & equipment purchases & staff training confirmed by authors. Initial increase in equipment use at 6 months not sustained at 1 year, except in one of the I ₂ wards	Authors discussed contextual factors that could influence musculoskeletal outcomes (e.g. staffing levels, workload, increased patient handling associated with bed shortages & more acute patients), but did not document these in any of the wards or take them into account in analyses

Participatory organizational intervention targeting psychosocial work exposures

Gilbert-Ouimet et al., 2011 (58)	80% (1,330 of 1,659 workers)	ND	ND	<p>At 6 & 30 months:</p> <ul style="list-style-type: none">– ↓ psychological demands (JCQ Adapted French translation, 9 items, dichotomized at median observed in survey sample of QC workers)– ↓ low coworker support (JCQ, 6 items, tertiles)– ↓ lack of respect & esteem (Siegrist French translation, 5 items)– ≠ decision latitude (JCQ, 9 items, median cut-off)– ≠ job strain (JCQ, high psychological demands & low decision latitude)– ≠ supervisor support (JCQ, 5 items, tertiles)– ≠ reward (Siegrist, 11 items)– ≠ promotions & salary (Siegrist, 4 items)– ≠ job security (Siegrist, 2 items)– ≠ effort-reward imbalance (in part	Analyses were adjusted for age, gender & education (confounders were included when they introduced a change of more than 10% in effect estimates)	Documented through logbooks kept by key informants appointed by the head manager in every department targeted for intervention and through focus group meetings with workers. For example, the department A logbook described 48 activities implemented as part of the intervention, and 6 main changes were identified according to the focus group workers	Employer independently put an ergonomic program in place during the course of the intervention, which may have reduced postural risk factors (posture, position of computer screen & keyboard). No contextual factors documented
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from Siegrist, tertiles)

Feedback about computer workstation set-up & psychosocial aspects of work

Eklöf & Hagberg, 2006 (61)	75% (9 of 12 organizations invited)	I ₁ : 14% I ₂ : 17% I ₃ : 10% C: 14%	– ≠ comfort with ergonomics during computer work last month (mean of 6 items, 9-point response scale, very, very bad to very, very good)	– I ₂ & I ₃ : ↑ social support (JCQ, 6 items) – ≠ psychological demands (JCQ, 5 items) – ≠ decision latitude (JCQ, 6 items)	Following variables measured but not taken into account in analyses: sex, age, education, conditional employment, work time, hrs overtime last month, % working time on computer, number of not optimal workplace design & working technique aspects per individual, worker participation in efforts to improve the working environment & integration of working environment & organizational issues	The proportion of workers in each group who reported modifications in the work environment or working technique did not change from baseline or decreased. At baseline, it ranged from 67% to 90% across I & C groups. Similarly, average number of changes per individual at baseline ranged from 1.2 to 2.8 and tended to decrease at follow-up	Possible contamination of C groups due to their proximity to I groups (within the same organization). No contextual factors documented
% eligible workers recruited ND							

≠ : no change, C: control, FIOH: Finnish Institute of Occupational Health, I: intervention, JCQ: Job Content Questionnaire, PE: participatory ergonomics, MSK: musculoskeletal, ND: not documented, NS: not significant, OSHA: Occupational Safety & Health Administration, QC: Québec