INTERVENTIONS TO PREVENT MUSCULOSKELETAL DISORDERS AMONG INFORMAL SECTOR WORKERS: A LITERATURE REVIEW

Nisakorn Krungkraipetch[1,2], Kitti Krungkraipetch[3], Orawan Kaewboonchoo[1], Sara Arphorn[4] and Malcolm Sim[5]

[1]Department of Public Health Nursing, Faculty of Public Health, Mahidol University, Bangkok; [2]Department of Community Nursing, Faculty of Nursing, Burapha University, Chon Buri; [3]Faculty of Medicine, Burapha University, Chon Buri; [4]Department of Occupational Health, Faculty of Public Health, Mahidol University, Bangkok, Thailand; [5]Centre for Occupational and Environmental Health, School of Public Health and Preventive Medicine, Monash University, The Alfred Centre, Melbourne, Victoria, Australia

Abstract. Despite the increasing incidence of musculoskeletal injuries among informal sector workers due to exposure to workplace risk factors, there is a dearth of literature examining the effectiveness of interventions to prevent musculoskeletal disorders. The aim of this study was to investigate the effectiveness of interventions to prevent musculoskeletal health problems and/or reduce risk factors among informal sector workers. A systematic review of the literature was conducted using an appraisal checklist developed by the Joanna Briggs Institute. The heterogeneity of the studies precluded a meta-analysis, so a narrative synthesis method was used. Eight intervention studies met the inclusion criteria. This review identified three types of interventions: 1) mechanical exposure interventions, 2) production systems/organizational culture interventions and 3) modifier intervention. These interventions provided high and moderate evidence to support the use of these strategies for prevention of musculoskeletal injuries or workplace risk. The effects, whether positive, negative or none, was influenced by sample size, sampling technique, comparison group and time examined.

Keywords: work-related musculoskeletal disorder, informal sector worker, systematic review

INTRODUCTION

The informal economy plays an important role in employment creation, income generation and poverty reduction in many countries, especially developing countries. The majority of informal jobs are subcontracted parts of manufacturing work to private individuals. Since the sector does not have a registered workforce it is not governed by any laws, including health and safety laws, and no fixed patterns of safe work are followed in these types of jobs. Poor working conditions and occupational health hazards can exacerbate health problems among these workers.

Correspondence: Orawan Kaewboonchoo, Faculty of Public Health, Mahidol University, 420/1 Ratchawithi Road, Ratchathewi, Bangkok 10400, Thailand.
Tel/Fax: +66 (0) 2354 8542
E-mail: phokb@mahidol.ac.th

Information about occupational health in the informal sector is lacking, despite this group being relatively large and growing (Vandenberg, 2009). It is a vulnerable population at risk for long term disability due to a number of risk factors. Informal sector workers are at increased risk for musculoskeletal disorders due to poor working posture and conditions (Banerjee and Gangopadhyay, 2003; Bensa-ard *et al,* 2004; Choobineh *et al,* 2007; Naidoo *et al,* 2009), long work hours in static positions (Joeichum, 2008; Kongtiam and Duangsong, 2010), a poor physical working environment, high levels of stress, and low levels of work satisfaction and support (Lemasters *et al,* 1998). As these studies show, many factors can increase these workers' risk of musculoskeletal disorders, including biomechanical, psychosocial and individual factors.

Little is known about the efficacy of musculoskeletal disorder prevention strategies among informal sector workers, despite the high incidence of such injuries. A comprehensive search of the literature found no review that systematically examined the effectiveness of interventions for reducing/preventing work injuries in the informal sector.

The purpose of this systematic review was to investigate the effectiveness of interventions in reducing the incidence/prevalence of musculoskeletal health problems and/or reducing risk factors among informal sector workers. The main question evaluated in this review was: "Which preventive interventions had an effect on reducing musculoskeletal disorders in the informal sectors? This review may be of benefit to health care personnel who are involved in the prevention of musculoskeletal health problems and to informal sector workers themselves.

MATERIALS AND METHODS

Definition of terms used in the review

Informal sector worker. An informal sector worker is a worker in a small-scale industry, is self-employed, a subcontracted worker or a home-based worker. These workers may have no contract, fixed hours or employment benefits, such as sick pay or maternity leave. They are engaged in the production and distribution of goods and services with the main objective of generating employment and a basic income for the individual themselves.

Work-related musculoskeletal disorder. A work-related musculoskeletal disorder (WMSD) is defined as the presence of a problem (ache, pain, discomfort) with muscles, tendons, or nerves lasting at least one week of at least moderate intensity occurring at work or at rest. The review include neck, shoulder, back, upper limb and lower limb disorders and conditions with less formal diagnostic criteria, such as repetitive strain injuries and occupational overuse syndromes.

Intervention. A planned program or strategy aimed at preventing and/or reducing the incidence/prevalence of WMSDs, including programs focusing on education of workplace staff and/or programs focusing on administrative organizational factors.

Criteria for considering studies for this review

Type of study. To determine the effectiveness of an intervention in preventing WMSDs, a randomized controlled trial (RCT) is considered the study design of choice. However, due to the limited number of RCTs available, other experimental studies, such as quasi-RCT, and non-RCT, such as observational studies and action research, were included in our review.

Type of participants. In this review, relevant populations were comprised of: 1) workers in household enterprises owned by themselves or in partnership with members of the same or other households, who might employ other family workers or employees on an occasional basis; 2) workers employed in an informal small-scale industry. The age of informal sector workers in this review was ≥15 years. Our review did not include workers in agricultural activities, home care or construction.

Types of interventions. The interventions targeted biomechanical exposure in the workplace or the organization of work and included health beliefs and attitudes of workers. The types of interventions included both primary and secondary prevention.

Types of outcomes. The outcomes of interest were musculoskeletal disorders.

Search strategy

A three-step search strategy was carried out. An initial search was carried out using MEDLINE and CINAHL to determine key words, then a more detailed search was carried out using these key words. Finally, the references of all these papers were searched for other relevant papers.

Two reviewers screened the titles for eligibility. The following databases were searched for English publications: AMED, CINAHL Plus, EMBASE, F1,000, faculty of 1000 post-publication peer review, Joanna Briggs Institute, Medline/Ovid, OSH reference collection, ProQuest Health and Medical Complete, Quality web search tools, Google scholar, Agency for health care, Medscape, Institute for Work and Health (IWH), Health and Safety, SCOPUS, Science Direct, SCIRUS and Wiley online library.

Selection criteria included a) peer-reviewed scientific articles, and b) papers published in English between January 1991 and December 2010. Book chapters, dissertations, technical reports, and conference proceedings were excluded, as it was expected key findings would be published in the peer-reviewed literature.

The two authors screened the papers using the above inclusion and exclusion criteria. Disagreements regarding eligibility were resolved through discussions.

Quality assessment

Each article was evaluated using the Joanna Briggs Institute's (JBI) Critical Appraisal Checklist (Joanna Briggs Institute, 2008). This consists of nine judgments about such factor as selection, samples, confounding factors, outcomes, and data analysis; each requiring a yes or no response, with a yes response being assigned one point, and a no or unclear response being assigned no points. Quality of the study was assigned one of the following categories: 1-4 (low quality), 5-8 (moderate quality) and 9-10 (high quality). Studies of low quality were excluded from the analysis. Quality assessment was carried out independently by two reviewers. Any disagreement was resolved by discussion.

Levels of evidence

The levels of evidence used in the studies were categorized using the Australian National Health and Medical Research Council (NHMRC) levels of evidence (Table 2).

One reviewer obtained the data from each paper using a standardized data extraction form. The Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument (JBI-MAStARI) was used for data extraction

of quantitative studies and the Joanna Briggs Institute Qualitative Assessment and Review Instrument (JBI-QARI) was used for qualitative studies. Information about study design, randomization level, population, follow-up period, measurement tools, statistical analyses and outcomes were extracted. All extracted data were rechecked by a second reviewer. In cases of disagreement, a third reviewer was consulted. If situations where data were missing the primary author of the study was contacted to obtain the data.

Data analysis

Due to the heterogeneity of the studies, meta-analysis was considered unsuitable and a narrative synthesis method was used. This involved presenting narrative text and tables which summarize the data and allowing the reader to consider outcomes in light of differences in study designs and potential sources of bias for each study reviewed.

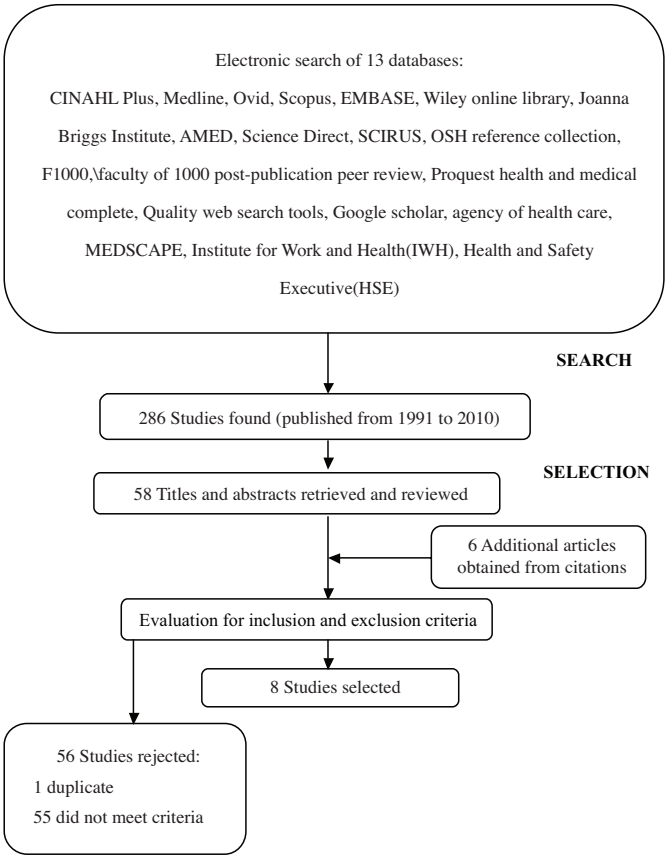

Fig 1–Overview of literature search and review.

RESULTS

In total, 286 titles were found during the search, of which 58 were potentially eligible studies. We also identified 6 additional potentially eligible studies from the reference lists of the 58 potentially eligible studies. Of these studies, 8 met inclusion criteria and were used in the review. The chance-adjusted between-reviewer agreement on the included studies was good (kappa=0.71) (Richard Landis and Koch, 1997). Fig 1 shows the search and selection results.

Description of included studies

Table 1 shows the characteristics of each study, most of which were conducted in developed countries. Four of the studies were conducted in Europe (Norway, Finland, Denmark, and The Netherlands), 2 in Iran, 1 in the United States of America, and 1 in Australia.

Participants. The number of participants in most studies was small, ranging from 21 (Pun *et al,* 2004) to 670 (Jensen and Friche, 2008) with an average sample size of 217. All studies gave information about gender

Table 1
Characteristics of included studies.

Author/ Year/ Country	Research question	Design type, intervention group, control group, inclusion/exclusion criteria	Statistical analyses	Results *versus* control
Carrivick *et al*, 2002, Australia.	To evaluate the effectiveness of a participatory workplace risk assessment team in reducing the rate and severity of musculoskeletal and non - musculoskeletal injuries among cleaners.	Prospective longitudinal cohort study of 137 cleaners in a hospital setting.Yes (without intervention). Inclusion criteria: none. Exclusion: none.	Paired *t*-test-GLMM	Reduction in both risk and severity of musculoskeletal injuries.Reduction in non - musculoskeletal injury rate but not in severity rate.
Pun *et al*, 2004, United States.	To describe the development and objectives of a program. To provide culturally relevant occupational health and safety education to reduce garment workers' musculoskeletal problems.	Case study with pre-and post-study evaluation without a comparison group.21 female garment workers. No control group. Inclusion criteria: none. Exclusion: none.	Descriptive statistics.	Perceived increase in energy level at the end of each class.
Choobineh *et al*, 2004a, Iran.	a) To investigate the effect of 2 design parameters (weaving height and seat type) on postural variables and subjective experience, b) to develop guidelines for workstation adjustments.	Quasi-experimental study. 15 male and 15 female carpet weavers. No control group. No. Inclusion criteria: none. Exclusion: none.	ANOVA for repeated measures, paired *t*-test, the Bonnferroni's multiple comparison test, the Friedman test, the Wilcoxon test.	Head, neck and shoulder postures were influenced by weaving height. Both design parameters influenced trunk and elbows postures.The determinant factor for weavers' perceptions about neck, shoulders and elbows was weaving height, and on the back and knees was seat type. Guidelines about appropriate workstation: a) weaving height should be ≥20 cm above elbow height, b) a 10^{o} forward-sloping seat.
Choobineh *et al*, 2004b, Iran.	a) To determine the prevalence of musculoskeletal problems in the mender population, b) to improve the working conditions.	a) Cross sectional population-based study, b) quasi-experimental study. 12 workshops (72 male menders) in 1st phase,30 menders in 2nd phase. No control group.	Descriptive statistics.	The new workstation was evaluated good or very good (better than usual conditions) by 57%. 75% stated their comfort increased.

Haukka *et al*, 2008, Finland.	To examine the efficacy of a participatory ergonomics interventions in preventing musculoskeletal disorders among kitchen workers.	Randomized controlled trial.504 kitchen workers, intervention 59, control 60.Inclusion: kitchen with at least 3 full-time employees working at least 6 hours per day. Exclusion: none.	Mixed and logistic regression models. Repeated measurement.	No significance differences in any outcome variables between the intervention and control groups during intervention or at 1-year follow-up.
Veiersted *et al*, 2008, Norway.	To describe, and analyze the effect of an intervention on the biomechanical workload of the neck and shoulder region of female hairdressers.	Quasi-experimental study, 38 hairdressers from 28 different salons divided into 2 intervention groups. Intervention I 18 subjects, Intervention II 20 subjects.No control group. Inclusion criteria:a) right handed females; b) 20-45 years old; c) working >30 h/wk; d) reporting < 2 weeks sick leave due to neck or shoulder pain in the previous year. Exclusion: none.	Mann-Whitney*U* test, Pearson's chi-square test. Wilcoxon signed-rank test. Paired *t*-test.	Reduction in workload from 4% to 2.5% of hairdressing time with elevated right arm in intervention I group.No effect with intervention II group.No effect detected on muscular load, neck or shoulder symptoms after intervention.
Heinrich *et al*, 2009, Netherlands.	To determine the effectiveness of physical training with and without a cognitive behavioral component and workplace specific exercises.	Randomized controlled trial. Self-employed persons. PT group: intervention= 53, control=50.PTCBWE group: intervention=76, control=75. Inclusion criteria:1) nonspecific musculoskeletal disorders; 2) unable to do job >25% of the time by medical assessment; 3) claim duration 1 day to 8 weeks; 4) musculoskeletal disorders should be treated with physical training. Exclusion: none.	Student's *t*-test, chi-square test, Mann-Whitney *U* test, Kaplan-Meier analysis, Cox regression analysis.	Training no effect on claim duration, pain severity or functional status at 12 months follow-up.
Jensen *et al*, 2011, Denmark.	To investigate whether implementation strategy had a long term effect on use of new working methods and musculoskeletal complaints when compared with using previous methods.	a) Cross sectional study; b) Prospective longitudinal cohort study. Intervention: 216 floor layers. Control: 454 floor layers. Inclusion criteria: 1) volunteered to participate; 2) employers supported. Exclusion criteria: 1) >60 yrs old or dead; 2) not in central address register.	Chi-square test, Adjusted odds ratio.	Reducing risk for developing more severe knee disorders and degree of knee pain in floor layers who had knee problems. The effect was greater if used > 1 year. Reduction in severe knee complaints was greatest using new method before knee problem developed.

Table 2
Level of evidence of included studies.

JBI level of evidence	Effectiveness	Number of included studies	Citation
1	Meta-analysis (with homogeneity) of experiment studies (*eg*, RCT with concealed randomization) OR. One or more large experimental studies with narrow confidence intervals.	0	
2	One or more smaller RCTs with wider confidence intervals OR. Quasi-experimental studies (without randomization).	6	Haukka *et al*, 2011; Heinrich *et al*, 2009; Carrivick *et al*, 2002; Veiersted *et al*, 2008; Choobineh *et al*, 2004 a,b
3	a) Cohort studies (with control group). b) Case-control studies. c) Observational studies (without control group).	2	Pun *et al*, 2004; Jensen *et al*, 2011.
4	Expert opinion, or physiology bench research, or consensus.	0	

RCT, randomized control trial

and age. Four studies included males and females, 2 studies (Choobineh *et al*, 2004b; Jensen and Friche, 2008) only included males and 2 studies (Pun *et al*, 2004; Veiersted *et al*, 2008) only included females. The ages of participants ranged from 17 to 63 years and the male to female ratio was 2.88:1.

Randomized of sampling was carried out when selecting participants in 4 studies (Choobineh *et al*, 2004b; Haukka *et al*, 2008; Veiersted *et al*, 2008; Heinrich *et al*, 2009) whilst convenience sampling and voluntary participation was carried out in the others (Carrivick *et al*, 2002; Choobineh *et al*, 2004a; Pun *et al*, 2004; Jensen and Friche, 2008). Participant selection criteria varied. Veiersted *et al* (2008) screened hairdressers asking about sick leave, and used the Standardized Nordic Questionnaire; they also asked about number of employees, customers and work hours. Haukka *et al* (2008) selected 119 municipal kitchens having at least 3 full-time workers working at least 6 work hours per day. Heinrich *et al* (2009) selected self-employed persons with new claims who fulfilled the selection criteria. Choobineh *et al* (2004b) randomly selected 30 of 72 in a cross sectional population based study.

Some studies used convenience sampling to select participants. Jensen and Friche (2008) included all participants who attended a training course in 2003. Carrivick *et al* (2002) selected

cleaners because they were employed during the study period and worked both before and after intervention. Pun *et al* (2004) selected 21 patients from an occupational health care clinic. Choobineh *et al* (2004a) selected the subjects from 50 weaving workshops.

Inclusion and exclusion criteria. Only four of the studies (Haukka *et al,* 2008; Jensen and Friche, 2008; Veiersted *et al*, 2008; Heinrich *et al,* 2009) provided inclusion criteria. Three of these studies included musculoskeletal risks (*eg*, work hours at least 6 hours per day or more than 30 hours per week), sick leave due to musculoskeletal problem, and musculoskeletal complaints, as inclusion criteria. Only 2 of the 8 studies listed exclusion criteria (Haukka *et al,* 2008; Jensen and Friche, 2008), such as age greater than 60 years, too few workers participating and not in central address register.

Types of study designs. All the articles adopted a repeated measures design with pre-post assessment (Carrivick *et al*, 2002; Choobineh *et al,* 2004 a,b; Pun *et al,* 2004) up to 5 times (Haukka *et al,* 2008). Four studies had only an intervention group (Choobineh *et al,* 2004 a, b; Pun *et al,* 2004; Veiersted *et al,* 2008). Veiersted *et al* (2008) had two comparison intervention groups. Haukka *et al* (2008) and Jensen and Friche (2008) had two comparison groups (experimental and control). Carrivick *et al* (2002) had four comparison groups two experimental groups and two control groups.

Level of evidence. The level of evidence for each study, following the Joanna Briggs Institute level of evidence is shown in Table 2.

Types of interventions. The types of interventions studied in the included papers were very diverse (Table 4). Westgaard and Winkel (1997) categorized intervention strategies into three main groups: mechanical exposure, production systems/organizational culture and modifier interventions. Choobineh *et al* (2004a, b) studied mechanical interventions involving changes in workstation design (*eg*, table height and seat type) and the introduction of ergonomic equipment (*eg*, an adjustable chair). The interventions in two studies (Jensen and Friche, 2008; Veiersted *et al*, 2008) were classified as production system/organizational culture involving organizational and work-task design changes. The intervention studied by Veiersted *et al* (2008) comprised of working technique recommendations with demonstrations and a discussion of the biomechanical load on the neck and shoulders. Jensen and Friche (2008) used a new working method and compared it with the conventional method. Four studies were classified as modifier interventions involving team building and increasing worker participation in problem-solving in the workplace (Carrivick *et al,* 2002; Haukka *et al,* 2008), specific exercise training for workers (Heinrich *et al*, 2009), and an educational program covering stretching exercises and ergonomics (Pun *et al,* 2004).

In two studies, the intervention length was not specified (Choobineh *et al,* 2004b; Pun *et al,* 2004). In the others the length of observation between baseline and the most recent follow-up varied from one month (Heinrich *et al,* 2009) to three years (Carrivick, *et al,* 2002).

Outcomes. Due to substantial variations in outcome measures and study designs, combining the results statistically proved impractical; therefore, narrative descriptions by outcome measures are provided. Outcomes of most of the studies we evaluated were measured by both subjective and objective data. Only Carrivick *et al* (2002) measured rate and severity of musculoskeletal and non-musculoskeletal injuries

Table 3
Quality assessment of studies.

Author, year	Was the assignment to treatment groups truly random?	Were participants blinded to treatment allocation?	Was allocation to treatment groups concealed from the allocator?	Were the outcomes of people who withdrew described and included in the analysis?	Were those assessing outcomes blind to the treatment allocation?	Were the control and treatment groups comparable at entry?	Were groups treated identically other than for the named interventions?	Were outcomes measured in the same way for all groups?	Were outcomes measured in a reliable way?	Was appropriate statistical analysis used?	Quality score?
Carrivick *et al*, 2002	1	0	0	1	1	NA	1	1	1	1	7
Pun *et al*, 2004	1	0	0	NA	1	NA	1	1	0	0	4
Choobineh *et al*, 2004a	1	0	0	NA	1	NA	1	1	1	1	6
Choobineh *et al*, 2004b	1	0	0	NA	1	NA	1	1	1	0	5
Haukka *et al*, 2008	1	0	0	0	1	1	1	1	1	1	7
Veiersted *et al*, 2008	1	1	0	0	1	1	1	1	1	1	8
Heinrich *et al*, 2009	1	1	0	1	1	1	1	1	1	1	9
Jensen *et al*, 2011	1	0	0	1	1	1	0	1	1	1	7

Key: yes = 1, no/unclear = 0, were the outcomes of people who withdrew described and included in the analysis?: NA, no dropout, but not stated. Were the control and treatment groups comparable at entry?: NA, one group only/case study.

using objective data (claim costs, duration of time lost per injury, hours worked and injury frequency rate). Immediate and short term outcomes were measured in most studies except that of Carrivick *et al* (2002) and Jensen and Friche (2008), who examined long term effects of intervention (3 and 2 years post-intervention follow-up, respectively).

The outcomes of interest were the prevalence rate of musculoskeletal disorders and musculoskeletal injury risk directly measured, such as on physical examination, the Weaving Posture Analyzing System (WEPAS), Rapid Upper Limb Assessment (RULA), electromyography (EMG) and inclinometry. Those indirectly measured included insurance data, sick leave, a perceived pain questionnaire, perceived physical work load, psychosocial factors and energy level questionnaire. Anatomical sites of musculoskeletal pain varied from study to study, depending on the workers' occupations. Jensen and Friche (2008) studied knee complaints and locking, Veiersted *et al* (2004) studied neck and shoulder complaints and biomechanical work load on the neck and shoulders.

Methodological quality

All the studies stated the participants were randomly assigned, but only 3 (Haukka *et al,* 2008; Veiersted *et al,* 2008; Heinrich *et al,* 2009) reported the method of randomization. Participant and researcher blinding was not possible due to the nature of the interventions and the studies. Blinding and the use of placebo treatments is impractical in studies of workplace ergonomic interventions. Half the studies (Carrivick *et al,* 2002; Choobineh *et al,* 2004 a, b; Pun *et al,* 2004) involved only the study group with no control group for comparison. Pun *et al* (2004) did not measure outcomes of interest reliably and carried out no statistical analysis. The other 7 studies reported the alpha levels used for statistical analysis (Table 3).

The effectiveness of the intervention

The effect of the intervention in 3 studies was derived by using univariate statistical tests (Choobineh *et al,* 2004 a, b; Veiersted *et al,* 2008), while 1 study used univariate statistics to describe participant perceptions (Pun *et al,* 2004). Two studies developed a multivariate model based on mixed and logistic regression models (Haukka *et al,* 2008; Jensen and Friche, 2008). Two studies used a combination of univariate and multivariate models to assess between group differences (Carrivick *et al,* 2002; Heinrich *et al,* 2009).

Seven of eight studies addressed the effectiveness of the intervention on WMSDs, but only 2 studies (Jensen and Friche, 2008; Veiersted *et al,* 2008) examined the effect of a new working method on musculoskeletal disorders and/ or risk factors.

Veiersted *et al* (2008) analyzed two interventions, written information only *versus* that information and personal follow-up regarding the technique as they related to complaints of the neck and shoulders. Results from a paired *t*-test revealed a significant decrease in the length of times hair dressers elevated their arms above 90^{o} from 4.0% to 2.5%, but no short term (1-2 months) effect was seen on neck and shoulders symptoms.

Jensen and Friche (2008) examined the effects of training among floor layers to reduce knee strain compared with a control group. The risk of having knee complaints for more than 30 days (adjusted OR 2.46; 95% CI 1.03-5.83) or locking of the knees (OR 2.89; 95% CI 1.11-7.5) was more than double among subjects who used the new

Table 4
Summary of intervention categories.

Categories of intervention	Author	Business type	Study design	Intervention component	Intervention description	Outcome	Quality assessment
Modifier intervention	Carrivick *et al*, 2002	Cleaners in hospital	Cohort	Safety audit and recommendation	a) Participatory ergonomics team were trained in assessment and control hazards. b) Identified risks from walk-through survey and discussion with cleaners. c) Team met bimonthly for 1 hour to consider injury/ hazards report, recommending risk reduction strategies.	The rate and severity of musculoskeletal and non - musculoskeletal injuries.	Moderate
Mechanical intervention	Choobineh *et al*, 2004a	Weaving workers	Quasi-randomized controlled trial	Workstation adjustment	Nine workstations with different combinations of "weaving height" and "seat type" with back rest.	Working posture and weavers' perceptions of experimental work station.	Moderate
Mechanical intervention	Choobineh *et al*, 2004b	Carpet mending	Quasi-randomized controlled trial	Workstation adjustment	a) Evaluated body postures and musculoskeletal problems. b) Job analysis and assessed working postures. c) Applied designed working table. d) Assessed applicability of mending table and work posture improvement.	Musculoskeletal complaints during 12 months.Working posture perceived the posture in with the new working conditions.	Moderate
Modifier intervention	Pun *et al*, 2004	Garment workers	Quasi-experimental study	Training	Educational classes had 2 parts (upper extremities and lower extremities) 90-120 min for each class every 1st and 3rd Wednesday.	Perceptions about energy level after completing stretching exercise.	Moderate

Modifier intervention	Haukka *et al*, 2008	Kitchen workers	Randomized controlled trial	Training, meeting, safety audit, recommendation, support from collaborators	Intervention: a) Workshop to indentify problem, plan and evaluate changes, and implement solutions. b) Visit other kitchens. c) Teamwork with participatory approach. Control: none.	The occurrence of and trouble caused by musculoskeletal pain in seven anatomical sites. Fatigue after work. Sick leave due to musculoskeletal disorders.	Moderate
Production system/organizational culture.	Veiersted *et al*, 2008	Hairdressers	Pre-post quasi randomized controlled trial	Work technique recommendation	a) Verbally informed about 5 simple recommendations for beneficial working technique. b) Visited by occupational therapy students. Intervention I get written information only. Intervention II get additional personal follow-up for longer time.	Muscular activity. Upper arm elevation and movements. Neck and shoulder complaints.	Moderate
Modifier intervention.	Heinrich *et al*, 2009	Self-employed	Randomized control trial	Training	Physical training with or without a cognitive behavioral component and workplace specific exercises; cardiovascular training, strengthening, relaxation and postural exercise 2-3 times/week 1-1.5 hours for 3 months.In PTCBWE class added cognitive-behavioral component about half an hour, the exercise developed after a workplace visit supported by video recording.	Claim duration during 12 months, pain severity and functional status.	High
Production system/organizational culture	Jensen *et al*, 2011	Floor layers	Cross sectional and cohort study	Training in the new working technique	Intervention: a) Giving information about new tool and health risk. b) Showing new methods at after-work meeting. c) Donation of tools free of charge. d) Training in used of tools during a two-day course. e) Providing experience for using new tools during training. Control: no intervention.	Knee complaints for >30 days during the previous 12 months.Locking of the knee.Knee complaint and decreased in knee pain. Difficulties in carrying out the work as a result of knee troubles. Sick leave. Self reported stress.	Moderate

method for less than one year compared to those who used the method greater than one year. However, there were no differences among workers who already had severe knee pain prior to the intervention (OR 0.85; 95% CI 0.38-1.92).

Two studies (Carrivick *et al*, 2002; Haukka *et al*, 2008) examined the effect of participatory ergonomics on preventing musculoskeletal disorders and/or reducing risk factors.

Carrivick *et al* (2002) conducted a cohort study to evaluate the effectiveness of a participatory workplace risk assessment team in reducing the rate and severity of musculoskeletal and non-musculoskeletal injuries 3 years post-intervention. There was an association between the participatory ergonomics intervention and a reduction in both risk and severity of musculoskeletal injuries, but the observed changes in non-musculoskeletal severity were not significant. The participatory approach reduced musculoskeletal injury duration and claim cost rates by 40% and 65%, respectively.

Haukka *et al* (2008) examined the efficacy of a participatory ergonomics intervention in preventing musculoskeletal disorders with a cluster RCT. Outcomes were obtained at baseline and every 3 months for 1year, they evaluated musculoskeletal pain at seven anatomical sites, level of fatigue after work and amount of sick leave taken due to musculoskeletal disorders. There were 402 ergonomic changes in the intervention group and 80 changes in the control group. They found no significant difference between the intervention and control group in the outcomes. The most common reasons for non-completion of ergonomic changes were lack of motivation or time; the changes made were not enough to influence the outcomes. The authors stated that because of inadequate funding, most of the changes were low-cost solutions. The authors suggested a more comprehensive redesign of work organization and processes is needed, taking into account the workers' physical and mental resources.

Two studies (Choobineh *et al*, 2004a,b) examined the effect of an engineering intervention on musculoskeletal disorders and risk factors.

Choobineh *et al* (2004a) conducted a quasi-experimental study to investigate the effect of two design parameters (weaving height and seat type) on postural variables and subjective experience. Working postures and weavers' perceptions were determined. They found weaving height influenced head, neck and shoulder postures, while weaving height and seat type influenced trunk and elbow postures. The determining factors for worker perceptions regarding the neck, shoulders and elbows was weaving height, and regarding the back and knees it was seat type.

Choobineh *et al* (2004b) developed a new workstation to improve work posture among carpet mending workers who had musculoskeletal complaints involving their knees, lower back, upper back and shoulders. Working posture was assessed by the rapid upper limb assessment (RULA) technique and the results were compared with the usual condition (sitting on the ground). Mender's perceptions about the new working condition was evaluated. The results showed working at a table improved neck, trunk and leg postures but caused the postures of upper arms and forearms to get worse. Fifty-seven percent of subjects said the new workstation was good or very good and the comfort was increased.

One study examined the effect of

exercise training on musculoskeletal disorders and risk factors (Heinrich *et al*, 2009) by conducting a pragmatic randomized controlled trial study to determine the effectiveness of physical training with a cognitive behavioral component with workplace specific exercises (PTCBWE) and without them (PT). Both types of training consisted of cardiovascular training, strengthening, relaxation and posture exercises for 3 months. Pain duration, severity and functional status were assessed at baseline and at 6 and 12 months. By 12 months there was no significant differences in pain duration between the PT and control group (Hazard ratio 0.7, 95%CI 0.4-1.1) or PTCBWE group. Both types of physical training had a non-significant improvement in pain and functional status over time.

DISCUSSION

This systematic review sought to answer the prime question: "Which preventive interventions for informal sector workers have an improved effect on musculoskeletal disorder status?" A limitation of this review was that the literature about preventive interventions for informal sector workers was heterogeneous in terms of the study design, types of exposure and outcomes; therefore, meta-analysis could not be performed. The review included only peer-reviewed literature in English.

The subject sampling technique of some studies was not random, but on a volunteer basis (Carrivick *et al*, 2002; Choobineh *et al*, 2004; Pun *et al*, 2004; Jensen and Friche, 2008). This may have led to selection bias towards subjects already experiencing WMSDs who were willing to try to reduce the severity of musculoskeletal disorders. It may be that workers with musculoskeletal health problems were over-represented among participants, this makes the generalization of findings difficult.

A control group is necessary to evaluate effectiveness. Five studies (Carrivick, *et al*, 2002; Choobineh *et al*, 2004 a,b; Pun *et al*, 2004; Veiersted *et al*, 2008), 3 with a quasi-experimental design, 1 with a cohort design and 1 with an observational design did not include a concurrent control group. They also did not control for confounding factors. For those studies which included a control group, the longer the time in the control group the more likely it is they will be contaminated by the intervention group. The study by Jensen *et al* (2008) was carried out for 2 years. It could have been strengthened if the control group participated with the intervention group. Viersted *et al* (2008) had a stronger study with two levels of intervention that reduced a possible attention (Hawthorne) effect over time.

In some studies, outcomes were evaluated via self-reporting, which could cause bias, especially with an ergonomic intervention study.

Univariate analysis is often employed to examine the effectiveness of intervention strategies in occupational health. Three studies used univariate (Choobineh *et al*, 2004 a, b; Veiersted *et al*, 2008) and 4 studies used multivariate analysis (Haukka *et al*, 2008; Jensen and Friche, 2008; Veiersted *et al*, 2008; Heinrich *et al*, 2009). Univariate analysis does not adjust for confounding factors or account for the underlying correlation structure which may result in spurious levels of significance.

Two studies (Choobineh *et al*, 2004a,b) classified as mechanical exposure interventions were of moderate quality. One of these studies found an overall

positive effect of posture on complaint at different body regions; neck, shoulder, back and knee. One quasi-experimental study of moderate quality examining a small intervention on working technique (Veiersted *et al*, 2008) and a cohort study of moderate quality measuring the long term effect of a new working method (Jensen and Friche, 2008) were classified as production systems/organizational culture interventions. Over the short term, the small intervention significantly decreased musculoskeletal disorders but by 2-3 months no benefit was seen. The second study did show a beneficial effect for knee conditions if the intervention was carried out for 1 year.

Four studies classified as modifier interventions included exercise (*ie*, physical training, workplace specific exercise and cognitive behavioral intervention). One RCT of high quality, 2 of moderate quality and 1 of low quality examined the effects of intervention strategies on outcomes. The RCT of high quality examined multiple modifier interventions, included physical training, exercise and a cognitive behavioral intervention found no statistically significant effect for improvement of pain severity and duration at 12 months follow-up (Heinrich *et al*, 2009). One RCT of moderate quality, which examined a participatory ergonomic intervention for preventing musculoskeletal disorder, also had no significant effect. In contrast, one moderate quality study found a significant effect for reduction of the risk and severity of musculoskeletal injuries. The observational study of low quality did not examine the effectiveness of an educational program on musculoskeletal disorders. Therefore, there was no evidence to support this strategy.

In conclusion, this systematic review found very limited evidence to support the use of three types of interventions, mechanical exposure, production systems/organizational culture and modifier interventions for reducing the incidence, prevalence and intensity of musculoskeletal disorders and to reduce risk factors among informal sector workers. The effect of the strategies (whether positive, negative or none) were influenced by sample size, sampling technique, comparison group and length of time examined (short or long term study). Future research into this important problem needs to address the design limitations identified in this review.

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