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Title: Exercise for the Primary, Secondary and Tertiary Prevention of Low Back Pain in the Workplace: A Systematic Review

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Abstract: Introduction: Low back pain (LBP) is one of the most costly conditions to manage in occupational health. Individuals with chronic or recurring LBP experience difficulties returning to work due to disability. Given the personal and financial cost of LBP, there is a need for effective interventions aimed at preventing LBP in the workplace. The aim of this systematic review was to examine the effectiveness of exercises in decreasing LBP incidence, LBP intensity and the impact of LBP and disability. Methods: A comprehensive literature search of controlled trials published between 1978 and 2006 was conducted and a total of 15 studies were subsequently reviewed and analyzed. Results: There was strong evidence that exercise was effective in reducing the severity and activity interference from LBP. However, due to the poor methodological quality of studies and conflicting results, there was only limited evidence supporting the use of exercise to prevent LBP episodes in the workplace. Other methodological limitations such as differing; combinations of exercise, study populations, participant presentation, workloads and outcome measures; levels of exercise adherence and a lack of reporting on effect sizes, adverse effects, and types of sub-groups, make it difficult to draw definitive conclusions on the efficacy of workplace exercise in preventing LBP. Conclusions: Only two out of the 15 studies reviewed were high in methodological quality and showed significant reductions in LBP intensity with exercise. Future research is needed to clarify which exercises are effective and the dose-response relationships regarding exercise and outcomes.

Exercise for the Primary, Secondary and Tertiary Prevention of Low Back Pain in the Workplace: A Systematic Review

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Abstract

Introduction: Low back pain (LBP) is one of the most costly conditions to manage in occupational health. Individuals with chronic or recurring LBP experience difficulties returning to work due to disability. Given the personal and financial cost of LBP, there is a need for effective interventions aimed at preventing LBP in the workplace. The aim of this systematic review was to examine the effectiveness of exercises in decreasing LBP incidence, LBP intensity and the impact of LBP and disability. **Methods:** A comprehensive literature search of controlled trials published between 1978 and 2007 was conducted and a total of 15 studies were subsequently reviewed and analyzed. **Results:** There was strong evidence that exercise was effective in reducing the severity and activity interference from LBP. However, due to the poor methodological quality of studies and conflicting results, there was only limited evidence supporting the use of exercise to prevent LBP episodes in the workplace. Other methodological limitations such as differing; combinations of exercise, study populations, participant presentation, workloads and outcome measures; levels of exercise adherence and a lack of reporting on effect sizes, adverse effects, and types of sub-groups, make it difficult to draw definitive conclusions on the efficacy of workplace exercise in preventing LBP. **Conclusions:** Only two out of the 15 studies reviewed were high in methodological quality and showed significant reductions in LBP intensity with exercise. Future research is needed to clarify which exercises are effective and the dose-response relationships regarding exercise and outcomes.

Keywords

Backache, physical activity, preventative exercise, workplace intervention, review

Introduction

Low back pain (LBP) is a major occupational health issue, and lower back injuries are one of the most costly conditions in musculoskeletal health care. The lifetime prevalence of LBP has been estimated to be approximately 60 to 90% [1, 2] and is commonly considered to be a biopsychosocial phenomenon [3, 4]. It has been estimated that approximately 90% of workers return to work within two months of a LBP episode [2]. However, there is evidence that long-term disability risk increases substantially with diminishing likelihood of returning to work as the duration of symptoms increase [5]. Preventing new episodes or recurrences of LBP and also predicting workers who develop chronic LBP seems to be a logical approach to potentially reducing the impact of long-term disability.

Prior to determining factors that need to be considered in any LBP prevention program, possible etiological factors should be identified [6]. In the workplace, the physical work environment (e.g. physical demands, mechanical loading, pace of work, ergonomics), organizational factors (e.g. support, lack of control), social contexts (e.g. physical activities, cultural values) and individual factors (e.g. age, gender, body mass index, smoking, genetics) may all play a role in the first episode and recurrence of LBP [7-9]. Psychosocial factors have been identified to be important in the progression of chronic LBP [10] although their specific role in the cause, and recurrence, of LBP at work is still unclear [8, 11, 12].

With respect to LBP, there is strong evidence that multidisciplinary interventions improve function, moderate evidence for the reduction of pain, and contradictory evidence with regards to vocational outcomes [13]. Exercise usually forms a part of multidisciplinary interventions and holds promise in LBP management. A summary of the European Guidelines for Prevention of LBP concurred that physical activity and exercise was recommended for workers [14]. Clinic-based functional exercise intervention and prevention programs have been recommended as an effective means of improving outcomes in LBP [15, 16]. Further, previous systematic reviews and meta-analyses have found that functional improvement [17-19] and reduced sick leave [16] can be achieved with exercise therapy in workers with LBP. Decreased adherence will most likely decrease the possibility of successful LBP outcomes [20]. Prescribing exercise to workers at their place of employment may improve matters such as adherence to an exercise program.

There is a clear lack of consensus on the type of exercise to prescribe when attempting to prevent LBP. For example, there has been limited evidence for the effectiveness of treatment approaches such as general exercise (muscle strengthening, flexibility training or cardiovascular endurance) [19, 21] and specific exercise (stabilization exercise) [22] as outlined in previous systematic reviews on LBP. Approaches to preventing LBP have also been examined in a sporting context. Exercise programs to improve core stability [23] and function of the deep stabilizers [24, 25] have been utilized with mixed success. However, a recent study [26] using an individualized specific exercise approach [27] as part of a multi-dimensional strategy was found to be effective in the prevention of LBP recurrence.

The aim of this systematic review was to examine the effectiveness of exercise programs conducted in the workplace (as a single modality or as part of a multifaceted approach) in decreasing LBP incidence, LBP intensity and the impact of LBP and disability.

Methods

This systematic review followed the Methodological Guidelines for Systematic Reviews from the Cochrane Collaboration Back Review Group [28, 29] and selected results-related items from the consolidated standards of reporting trials (CONSORT) statement [30, 31]. The extra items from the CONSORT statement in addition to the Cochrane framework were included as classification of LBP patients into homogenous sub-groups is known to be an important issue in the LBP literature [32, 33] and as the reporting of adverse effects [33] and effect sizes are also important considerations.

A search for relevant studies was performed using a number of electronic databases. Specifically, a computer-aided literature search using MEDLINE (1950 to 6 August 2007), CINAHL (1982 to July Week 4 2007), AMED (1985 to July 2007) and SPORTDiscus (1830 to May 2007) was conducted. OVID was used to search these databases. Searches were also undertaken on the Cochrane Central Register of Controlled Trials (1898 to July 2007) and PEDro (1929 to August 2007). The key terms used for the searches were: back pain, backache, back injury, spinal pain, exercise, stabilization, strengthening, stretching, flexibility, prevention, work, workplace, occupational and industrial (with various typographical modifications). Studies were limited to those published in English in peer-reviewed journals and available through the relevant institutional libraries.

Selection Criteria

From the above search strategy a total of 267 articles were identified. Abstracts from these studies were then screened for potential eligibility by the principal author (JN), and both authors examined the queries regarding doubtful papers. Conference abstracts and unpublished material were not considered for further analysis. Consistent with the scope of this review, controlled trials published in English involving exercise as an intervention to prevent first episode LBP, or to treat current back pain, or to prevent the recurrence of LBP, during work time or within the workplace were identified according to the abovementioned criteria. Studies including workers as well as non-workers were excluded if the worker cohort was not analyzed and reported separately. There was no restriction on the history of LBP and back injury, i.e. the scope of the search included the treatment of LBP (subjects who at the time of the study had LBP and the intervention implemented was intended to treat the problem), the prevention of LBP recurrence (subjects who had a history of LBP and the intervention was designed to prevent future episodes) and the prevention of LBP (subjects who have never had LBP and the intervention is used to prevent first-episode LBP). Furthermore, to be eligible, studies had to assess LBP and/or injury outcomes. Other variables of interest included functional status and time lost from work.

Study Selection

Full copies of articles identified by the search, and considered to meet the inclusion criteria, were obtained for data synthesis. Articles identified through the reference lists of these articles and other bibliographic searches were also considered for this component of the review. In studies where the eligibility was unclear from the title and abstract, the full text was obtained and the suitability of the article was subsequently assessed. The authors selected the representative paper, describing the full study (e.g. Hlobil et al. [34]), rather than interim reports (e.g. Staal et al. [35]) from multiple publications arising from single studies in the analysis.

Of the 267 articles identified, 15 full text articles were included for assessment in this review. The most common reasons for exclusion were that interventions had not been conducted during work time or within the workplace (although work interventions conducted with home-based exercise were included) and that outcome measures were not predominantly relevant to LBP.

Assessment of Methodological Quality and Selected Results-Related Items

The articles evaluated by the authors consisted of ten Randomized Controlled Trials (RCTs) and five Non-Randomized Controlled Trials (NCTs). Blinding the reviewers to the author and publication details was not possible as one of the reviewers had conducted the search and study selection. The two authors independently performed the assessment of methodological quality (Cochrane Back Review Group) [28] and selected results-related items (CONSORT statement items 17-19) [30, 31] (Table 1). There were no disagreements between reviewers; however the authors would have sought to resolve this via a third independent reviewer if necessary. These criteria were pilot tested by the reviewers on a related, but ineligible paper.

For each of the 15 articles included in this review, each of the criteria in Table I was scored as "yes" (1), "no" (0) or "don't know" (0). Studies were graded according to quality assessment scores as high (fulfilling six or more of the eleven criteria and having a low potential for bias) or low (fulfilling less than six quality criteria and having a high potential for bias) (Table II). Scoring of selected results-related criteria from CONSORT is shown in Table III.

Data Extraction and Analysis

Data pertaining to specific study characteristics were extracted and the summary of these studies are shown in Table IV. These characteristics were: setting and population (incidence of LBP), LBP severity and disability, LBP classification, interventions, compliance to exercise programs, outcomes and conclusions. A qualitative evaluation of outcomes was completed based on a rating system as recommended by the Cochrane Back Review Group [28]. This rating system is as follows:-

- Strong evidence: consistent evidence in two or more high quality randomized controlled trials.
- Moderate evidence: consistent findings in multiple low quality RCTs and/or NCTs and/or one high quality RCT.

- Limited evidence: one quality RCT and/or NCT
- Conflicting evidence: inconsistent findings among multiple trials (RCTs and/or NCTs)
- No evidence from trials: no RCTs or NCTs

The outcome of the studies was considered consistent if at least 75% of the trials reported statistically significant results in the same direction.

Results

The occupational groups investigated in the studies examined in this review included military staff [36, 37], nursing staff and hospital employees [38-44], airline workers [34], office workers [45], postal workers [46], factory staff [47], railroad workers [48] and copper smelter employees [49].

Examination of Primary Outcome Variables

Each of the primary outcome measures, namely the *incidence of LBP*, the *intensity of LBP* and the *impact of LBP and disability* are presented according to the methodological quality and strength of evidence.

Of the studies examined in this review, four low quality RCTs [41, 42, 47] and three NCTs [36, 39, 44, 49] reported positive and significant effects of exercise on the *incidence of LBP*. These studies were all characterized by poor randomization, unconcealed treatment allocation and a lack of blinding.

Two studies incorporated exercise interventions as part of military training [36, 39]. In the former study, incidence of injury was measured over the study period, and there were low subject numbers (15 of 901 recruits) that reported LBP. In the latter study, there was possible non-compliance issues as 89% of subjects reported problems in adhering to the exercises for a year. Instruction to exercise only seemed to be a minor component of a multidimensional intervention in a third study [49]. Examination of these three studies revealed low methodological quality including factors such as poor adherence and co-interventions which made drawing firm conclusions of exercise effects difficult. From the studies examined in this review, there is limited evidence for the overall effectiveness of exercise for the prevention of *LBP incidence*.

Six studies assessed *intensity of LBP*. Of these studies, two high quality RCTs [45, 48] and one low quality RCT [42] reported significant improvements in *LBP intensity*. In all three studies, exercise interventions were unidimensional. Two studies found positive results after establishing exercise programs during working hours [42, 45]. From this analysis there is strong evidence that exercise reduces the *intensity of LBP*.

The *impact of LBP and disability* were reported in studies with sick leave, activity interference and cost of LBP as outcomes. Four studies showed an effect of exercise on sick leave due to LBP as outcome measures, with two RCTs [42, 47] reporting significant effects. However, both studies had methodological weaknesses. There was limited evidence for a positive effect of exercise on *sick leave due to LBP*. Three studies reported on activity interference due to LBP, with two studies [44, 45] finding significant improvements with exercise as a unidimensional intervention. The third study [48] reported significant improvements in self-estimated work ability. There is strong evidence that exercise reduces *activity interference from LBP*. No evidence was found for measures such as *costs related to LBP*.

Types of Exercise Programs

Eight studies [34, 38, 40, 41, 43-45, 47] described general strength, stretching and/or cardiovascular exercises as differing exercise modalities utilized during the intervention studies. Heterogeneity of these exercise interventions was evidenced by the varied exercise duration (5 to 60 minutes), frequency (six times per month to every work day) and intensity (light to moderate). In two studies [46, 49], exercise was a component of a multidimensional intervention, and only instruction about exercise was given as a minor part of predominantly ergonomic and educational interventions. The follow up periods outlined in the studies examined in this review ranged between 3 – 18 months.

The type, intensity and frequency of exercise varied in all studies included in this review. In the articles reviewed, it was found that compliance rates (when reported) were approximately 76% (when considering attendance in all sessions) [37, 38, 40, 44, 45], and approximately 51% (when considering attendance of greater than 50% of sessions) [43, 48]. There was a lack of consistency in defining and reporting compliance and training compliance was not reported in eight of the fifteen studies examined in this review [34, 36, 39, 41, 42, 46, 47, 49].

Where possible, in studies that reported significant reductions in LBP intensity and incidence, the training dose (minutes per day) were calculated using the reported time spent exercising. One high quality study [45] found that five minutes of light resistance training each working day was effective. Training doses between five and seventeen minutes per day (mean = 10 minutes per day) were sufficient to produce significant decreases in LBP intensity and incidence in seven low quality studies [36, 39-42, 44, 47]. In exercise programs conducted during work time [42, 45, 47], an average training dose of 6 minutes per working day resulted in significant improvements in primary outcome measures (i.e. incidence and intensity).

Results-Related Items

Effect size for between group differences was not directly reported for primary outcomes variables in all the studies reviewed. Where possible, Cohen's d was calculated from descriptive statistics reported in these papers (Table IV). Previous studies have reported that with respect to back pain, minimal clinically important change within groups on the Visual Analogue Scale (VAS) was 18-19mm out of 100 mm [50] or 2 on a 10 point rating scale [51, 52]. Further, with respect to the Oswestry Disability Index (ODI), 5.2 (out of 100%) related to a clinically important change [53]. Clinically significant changes for levels of pain (as measured by the VAS) were found in Suni et al. [48] and Hlobil et al. [34]. None of the studies showed clinically important changes for levels of disability (as measured by the ODI).

Sub-group analyses were performed in six studies examined in this review [34, 37, 39, 43, 46, 48]. There was no consistency in the type of sub-groups analyzed in these studies. It was not possible to perform sub-group analyses based on clinically meaningful comparisons due to the small number of studies per comparison and the lack of reporting of effect sizes.

Despite the importance of reporting adverse effects when providing preventative measures or treatment it was interesting to note that only four studies made mention of this [34, 45, 47, 48].

Discussion

Although the role of exercise interventions in preventing LBP has yet to be proven [17-19, 54, 55], previous guidelines pertaining to the prevention of LBP [14] have recommended that exercise programs should be considered for the prevention of LBP and its recurrence in the workplace. These guidelines were based upon reviews [54-60] and evidence generated from studies not limited to specific workplace interventions [36, 39], but included hospital-based and centre-based approaches that measured LBP outcomes [61-64]. Research has shown that following work-related LBP, an individual's beliefs about his or her ability to return to work were the most predictive of workers at risk of prolonged work restrictions and work-related disability [65, 66]. Encouraging an early return to normal activity and providing support in the workplace has been shown to be beneficial in terms of costs [67] and reducing lost time due to fear-avoidance beliefs [68].

Generally speaking, the methodological quality of intervention studies involving exercise was low, with only four of the 15 studies rating high on internal validity according to the methodological guidelines for systematic reviews [28]. This was also found in recent studies [34, 37, 45, 48] when an increasing amount of literature had been put forward pertaining to methodological quality. One factor that clearly contributed to the studies being considered as being of low methodological quality was the absence of blinding in the research design (Criteria D-F, Table II). Blinding can be a logistical problem in exercise-related trials. In all interventions examined in this review, the care provider and the workers were not blinded to treatments. Participant blinding is an important internal validity criteria, as those in the exercise intervention groups may have reported less pain and/or better function because they were aware they were in the intervention group. However, unless two exercise interventions are being compared, it is not possible to blind study participants. Care-provider and assessor blinding is also important in preventing bias in the results of controlled trials. Other problems with methodology included: lack of randomization, non-concealment of treatment allocations, confounding co-interventions and a lack of intention-to-treat analyses.

There were varying levels of effectiveness reported with respect to exercise mode, duration, frequency and type. It was interesting to note that effectiveness was shown in four studies [36, 39, 42, 48] all of which implemented vastly differing exercise regimes. Exercise interventions reported in the studies reviewed included low and high intensity resistance training, cardiovascular training, stretching, calisthenics, general and individualized programs in addition to exercise being used as part of multidimensional programs. The generalized programs comprised predetermined sets of exercises which were carried out by all participants in the intervention groups. Some studies however, gradually increased exercise intensity according to subject performance levels [34, 37, 38, 42, 44, 45, 47]. Significant improvements in outcome measures were reported with general exercise in four studies [41, 42, 44, 47]. The only exercise intervention that utilized individually designed training programs based on clinical examinations, daily activities and goal setting [43] also reported similar, but non significant improvements. In this study, poor compliance with the home program may have influenced results. The abovementioned studies were similar in that the exercise sessions were of 20 minutes or more in duration. Conversely, one high quality RCT [45] reported significant reductions in LBP severity with high training adherence (69%) to a low dose light resistance training program (30% of 1RM, ~5 minutes per working day). Another recent study using regular, but short durations of back strengthening exercises [69] found that specific back exercises performed for 15 minutes, three times a week was effective in reducing LBP.

Despite exercise being widely utilized in the workplace as a modality to prevent LBP, there is a paucity of research on its effectiveness. The studies examined in this review showed strong evidence that exercise reduces the *severity of LBP* and *activity interference caused by LBP*. However, due to poor methodological quality of the studies and conflicting results, there was limited evidence supporting the use of exercise to *prevent LBP episodes* in the workplace. There has been strong evidence that most specific exercises programs to prevent LBP are ineffective in isolation [19]. However, exercise may be effective in combination with other modalities such as cognitive-behavioral interventions [70], functional movements, relaxation and the integration of coping skills [13]. A recent review examining exercise in nurses found that multidimensional strategies were effective in preventing LBP [71]. In the current review however, there was conflicting evidence for the efficacy of multidimensional interventions that include exercise.

There may be confounding factors that influence both the etiology of LBP and its prevention in workers. Factors relating to the individual, such as the magnitude of load required to bring on an episode of LBP, the specific movements to provoke or exacerbate pain [72] and an individual's responsiveness to an exercise intervention may be important. It should be considered that individuals are of differing genetic make-up and inherited factors such as determinants of structural disc degeneration have an important influence on LBP [73, 74]. According to previous research [75], although there is evidence to suggest that occupational exposures have an effect on disc degeneration, the contribution of this seems to be modest when compared with the effects of genes and early childhood environment.

Previous reviews have reported limited evidence for a positive effect of exercise on the *prevalence of LBP* [18, 54, 55, 59]. Similarly, our review found limited evidence in this respect and this was predominantly due to this outcome measure not being reported in two of the high quality RCTs [45, 48]. Further, no significant findings were found in two high quality RCTs [34, 37]. However, clinically important improvements in pain intensity and functional disability caused by LBP were found in one of these studies [37].

The specifics of exercise programs that are most effective for LBP prevention have yet to be determined. LBP is a complex musculoskeletal disorder and recent research has reported the existence of sub-groups of patient presentation within the biopsychosocial domain [72, 76-78]. Therefore, rather than a "one size fits all" approach it may be that specific intervention strategies are preferable for distinct sub-groups. The current state of evidence makes it difficult to draw any firm conclusions that clinically meaningful from sub-group analyses. The contradictory nature of the current literature should provide the impetus for more intervention studies investigating the efficacy of exercise-based approaches in preventing LBP to be conducted. Systematic collection and reporting (according to CONSORT guidelines) [30, 31] of benchmarked primary outcomes (such as those recommended by the Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials) [79] will allow evaluation and validation of clinically important changes in sub-groups of LBP and more meaningful comparisons between specific exercise interventions [80].

Other Considerations for Exercise Interventions

It has been acknowledged that intervention programs with multiple dimensions are necessary for successful application and implementation [81]. However, it is important to consider that participant motivation and program adherence are also key factors for successful outcomes [82-86]. In the studies reviewed, there was no consistency in the definition and reporting of compliance, and more than half the studies examined in this review did not report compliance rates. Interestingly, this was not a function of the date of publication, as the oldest two studies [38, 40] had reported compliance rates.

Although it still remains unclear what types of exercise are effective in preventing LBP in workers, an average training dose of 10 minutes per day resulted in significant improvements in primary outcome measures. Whatever approach to exercise intervention is utilized in the workplace, adherence to the program itself remains a significant factor to consider. Further, consideration should be given towards the length of work shifts, as lack of time has previously been identified as a common barrier to compliance in training interventions [82]. It seems that performing an exercise program of short duration would better suit workers on long shifts as opposed to longer exercise regimes [87]. This notion is supported by the findings of this review, where 6 minutes of exercise as part of a working day was found to be effective. Furthermore, "short and sharp" workplace interventions would be preferable as they would be likely not to decrease work productivity.

Exercise-based interventions aim to promote wellness rather than illness behavior [88]. In transitioning to maintenance phases of exercise, high compliance with exercise regimes has been reported at a one year follow-up [89]. Long term adherence to exercise, which may be required to prevent LBP over a long period [90] has been shown to be improved with social cognitive theory based training. Various strategies such as worksite training on self-regulation skills, self efficacy and outcome expectancy [91], cognitive-behavioral compliance enhancement [70], and an adjunct motivational program [92] have been shown to improve exercise adherence in workers. A previous study [48] also recommended counseling as means to improve adherence. It would seem that further research into the pairing of these strategies in worksite interventions would improve adherence and thus increase the possibly of significant findings in future studies.

Although an extensive search strategy was used in identifying relevant studies on the effectiveness of exercise, some studies may have been potentially missed through non-matching keywords, or articles being indexed in other databases. The two reviewers who assessed the methodological quality were not blinded to author and publication details studies.

Conclusions

Fifteen RCTs and NCTs were identified that investigated the use of exercise to prevent first episode or recurrent LBP in the workplace. With the exception of four RCTs, two of which showed no significant effects, the studies included in this review were of low methodological quality. These limitations, in addition to; diverse combinations of exercise, different study populations, differing participant presentation with respect to a biopsychosocial framework, varying workloads, heterogeneity of outcome measures and varying levels of exercise compliance make it difficult to draw definitive conclusions on the efficacy of exercise in preventing LBP in the workplace. Furthermore, it must be acknowledged that it is difficult to control for confounding factors such as pre-existing physical conditioning levels. This systematic review has demonstrated a clear need for more specific RCTs and NCTs that adequately report on items related to applicability and clinical relevance of results to identify specific types and doses of exercise.

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Conflict of Interest

None.

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Table I. Methodological Quality Criteria as outlined by the Cochrane Back Review Group (A – K) [28]and selected results-related items from the CONSORT Group (17-19) [30, 31].

CRITERIA	OPERATIONALIZATION
A. Was the method of randomization adequate?	A random (unpredictable) assignment sequence. Examples of adequate methods are computer generated random number table and use of sealed opaque envelopes. Methods of allocation using date of birth, date of admission, hospital numbers, or alternation should not be regarded as appropriate.
B. Was the treatment allocation concealed?	Assignment generated by an independent person not responsible for determining the eligibility of the workers. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the worker.
C. Were the groups similar at baseline regarding the most prognostic indicators?	In order to receive a "yes", groups have important to be similar at baseline regarding demographic factors, duration and severity of complaints, percentage of workers with neurologic symptoms, and value of main outcome measure(s).
D. Was the patient/worker blinded for the intervention?	The reviewer determines if enough information about the blinding is given in order to score a "yes".
E. Was the care provider blinded for the intervention?	The reviewer determines if enough information about the blinding is given in order to score a "yes".
F. Was the outcome assessor blinded for the intervention?	The reviewer determines if enough information about the blinding is given in order to score a "yes".
G. Were co-interventions avoided or similar?	Co-interventions should either be avoided in the trial design or similar between the index and control groups.
H. Was the compliance acceptable in all groups?	The reviewer determines if the compliance to the interventions is acceptable, based on the reported intensity, duration, number and frequency of sessions for both the index intervention and control intervention(s).
I. Was the drop-out rate described and acceptable?	The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawals and drop-outs does not exceed 20% for immediate and short-term follow-ups, 30% for intermediate and long-term follow-ups and does not lead to substantial bias, a "yes" is scored.
J. Was the timing of the outcome assessment in all groups similar?	Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments.
K. Did the analysis include an intention-to-treat analysis?	All randomized workers are reported/analyzed in the group they were allocated to by randomization for the most important moments of effect measurement (minus missing values) irrespective of non-compliance and co-interventions.
17. Outcomes and estimation (CONSORT item 17)	For each primary and secondary outcome, a summary of results for each group and the estimated effect size and its precision (e.g. 95% confidence interval)
18. Ancillary analyses (CONSORT item 18)	Address multiplicity by reporting any other analyses performed, including subgroup analyses and adjusted analyses, indicating those prespecified and those exploratory.
19. Adverse events (CONSORT item 19)	All important adverse events or side effects in each intervention group.

Table II. Methodological quality of Randomized Controlled Trials (RCTs) and Non-Randomized Controlled Trials (NCTs) examining the efficacy of exercise for the prevention of LBP, or the prevention of LBP recurrence in the workplace

Authors/*Study Designs*	A	B	C	D	E	F	G	H	I	J	K	Total	Quality
RCTs													
Sjogren et al. (2006)	0	1	1	0	0	1	1	1	1	1	1	8	High
Suni et al. (2006)	1	1	1	0	0	1	1	0	1	1	1	8	High
Hlobil et al. (2005)	1	0	1	1	0	1	1	0	1	1	1	8	High
Helmhout et al. (2004)	1	1	1	0	0	1	1	0	1	1	0	7	High
Larsen et al. (2002)	0	0	1	0	0	0	0	0	1	1	1	4	Low
Horneij et al. (2001)	0	0	1	0	0	0	1	1	0	1	0	4	Low
Daltroy et al. (1997)	0	0	0	0	0	0	0	1	1	1	0	3	Low
Gundewall et al. (1993)	0	0	1	0	0	0	0	0	1	1	0	3	Low
Kellett et al. (1991)	0	0	1	0	0	0	0	1	1	1	0	4	Low
Donchin et al. (1990)	0	0	0	0	0	0	0	0	0	1	0	1	Low
NCTs													
Amako et al. (2003)	0	0	0	0	0	0	0	0	0	1	0	1	Low
Oldervoll et al. (2001)	0	0	1	0	0	0	1	1	0	1	0	4	Low
Shinozaki et al. (2001)	0	0	0	0	0	0	0	0	0	1	0	1	Low
Delhin et al. (1981)	0	0	0	0	0	0	1	0	1	1	0	3	Low
Delhin et al. (1979)	0	0	0	0	0	0	1	0	1	1	0	3	Low

Table III. Assessment of selected results-related items from CONSORT [30, 31]. Items 17-19 are listed with detail also provided on sub-group analyses.

Authors/*Study Designs*	17	18	19	Effect Size/Clinical Significance	Sub-group Analyzed	Adverse Effects
RCTs						
Sjogren et al. (2006)	0	0	1			No harmful, health-related effects
Suni et al. (2006)	0	1	1	Clinical significant improvement: VAS >4/20	Median intensity of LBP in low & high baseline among INT and CTRL	Back pain, bulging disc
Hlobil et al. (2005)	0	1	1	Clinical significant improvement: VAS = 2.9, ODI = 8.5	Per-protocol analysis excluding non-compliant subjects, and male vs female return to work data	Reasons for sick leave
Helmhout et al. (2004)	1	1	0	No effect size reported for self-assessed % improvement Mean strength: INT: 0.56-0.65	Withdrawals, medium compliers, low compliers	
Larsen et al. (2002)	0	1	0		Worst case analysis	
Horneij et al. (2001)	0	1	0		Participants who indicated LBP at baseline	
Daltroy et al. (1997)	0	1	0		Seriousness of initial injury, time off from work resulting from the initial injury, sex	
Gundewall et al. (1993)	0	0	0			
Kellett et al. (1991)	0	0	1			Sick leave due to LBP
Donchin et al. (1990)	0	0	0			
NCTs						
Amako et al. (2003)	0	0	0			
Oldervoll et al. (2001)	0	0	0			
Shinozaki et al. (2001)	0	0	0			
Delhin et al. (1981)	0	0	0			
Delhin et al. (1979)	0	0	0			

Table IV. Summary of studies included in the review.

Author / Design[aims]	Setting / Population (incidence of pain)	LBP severity and disability	LBP Classification	Intervention(s) / Other components/ *Compliance (% of training sessions completed) & dose (if reported)*	Outcomes investigated*	Original authors main conclusions, effect size / *present reviewers' comments*
Sjogren et al. (2006); RCT – cross-over[1,2]	Office workers with LBP; N = 36 (100% with LBP in the preceding 12 months)	LBP symptoms during previous week: moderate (2.67 on Borg CR10 scale)	Non-specific, subacute or chronic	Unidimensional 15 weeks of light resistance training during work time *Compliance = 69%* *Training dose: 5 mins/working day*	LBP intensity, restriction in activity due to LBP @ 12 months	Significantly (p=0.02) reduced LBP intensity between groups Significant improvement in activity restriction between groups *Low dose, high response and high compliance with long term effects on LBP*
Suni et al. (2006); RCT[1,2]	Railroad workers with recurrent LBP; N = 106, INT = 52 (94% with LBP in last 3 months), CTRL = 54 (88% with LBP in last 3 months)	LBP symptoms during previous week: INT: 11.5, CTRL: 13.5 on 100 point VAS, Disability: INT: 5.5%, CTRL: 5.0% on ODI	Non-specific, LBP during the last 3 months	INT: unidimensional specific strength, balance, stretching and lumbar neutral zone exercises twice/week CTRL: no intervention *Compliance (attended >50%) self-kept exercise diary = 38%; guided training = 27%*	VAS (at 2 months), ODI, PDI, self-estimated work ability @ 6 & 12 months; *strength, flexibility*	Significant (p=0.052) difference in LBP intensity between groups Significant (p=0.028) improvement in self-estimated work ability *Poor training compliance in the last 6 months of study.*
Hlobil et al. (2005); RCT[1]	Airline workers; N = 134 (100% with LBP in	LBP symptoms during previous week: INT: 6.7, CTRL: 6.4 on	Non-specific, subacute to chronic	INT: unidimensional 1 hr exercise, twice/week; CTRL: usual physiotherapy care	LBP incidence, RDQ, VAS @ 3, 6 & 12	Non-significant improvement in LBP incidence Cohen's d (95% CI): 0.07 (-0.72

	the preceding 4 weeks), INT = 67, CTRL = 67	VAS, Disability: INT: 13.3, CTRL: 13.0 on RDQ		*Compliance not reported.*	Months, LBP sick leave	to 0.83), and sick days between groups,
Helmhout et al. (2004); RCT[1,2]	Male military and civilian employees; N = 81 (100% with LBP > 12 weeks), INT = 41, CTRL = 40	LBP disability: INT: 7.1, CTRL: 7.9 on RDQ	Non-specific, chronic (greater than 12 weeks)	INT: unidimensional 12 week high intensity progressive back strengthening (5 – 10 mins, 1-2 x/week CTRL: low intensity back strength *Compliance:* *INT = 71%, CTRL = 48%*	RDQ ODI SF-36 @ 1, 2, 3, 6 & 9 months; *muscle strength, kinesophobia*	No significant difference between groups in all primary outcome measures. Increase in INT mean isometric strength @ 1, 2, 3, 6 & 9 months and decline in kinesophobia score at 2 & 9 months *Both high & low intensity programs led to improvements in primary outcome measures*
Larsen et al. (2002); RCT[1,2,3]	Male military conscripts; N = 249 (23% with LBP in the preceding 3 weeks), INT = 132 (35% with LBP in the preceding year), CTRL = 117 (41% with LBP in the preceding year)	Not reported	Not reported	INT: multi-dimensional 40 mins McKenzie-based back school session, instructed to perform 15 back extensions, 2x/day for 10 months CTRL: no intervention *Compliance not reported.* *Training dose: ~ 5 mins/working day*	LBP incidence, contact with health care provider due to LBP, costs related to LBP @ 10 months	Significant improvement in LBP incidence (p=0.001) and need to consult infirmary (p=0.425) between groups *Comment made on compliance being high in first 3 months, but no figures given*
Horneij et al. (2001); RCT[1,2,3]	Female home care nursing aides; N = 282, INT1 =	Not reported	Duration of LBP not reported (those subjects that reported pain – pain at any	INT1: individual strength, stretching and cardiovascular exercises > 20mins INT2: Stress management	LBP incidence @ 12 & 18 months, LBP activity interference; *physical exertion, psychosocial*	Non significant improvements in LBP incidence for INT1 & 2 as compared to CTRL.

	90 (62% with LBP), INT2 = 93 (60% with LBP), CTRL = 99 (59% with LBP)		time during the preceding 12 months or incapacitating pain at any time during the preceding 12 months)	program CTRL: no intervention *Compliance (attended >50% of sessions): INT1 = 87.2% INT2 = 98.3%*	*factors*	INT1 had less activity interference than CTRL @ 12 months *No information given about the number of training sessions per week*
Daltroy et al. (1997) RCT[1,2,3]	Postal workers; N= ~4,000 (9% with LBP; 91% without LBP), INT = 2668	LBP injury rate of 2.4%/yr	Specific: N= 14, Acute: N= 335, Chronic: N= 11	INT: 2x15 hours multidimensional education sessions including stretching and strengthening & 3-4 reinforcement sessions *Compliance not reported.*	LBP incidence & recurrence over 5.5 years, LBP cost, LBP sick leave; *knowledge of safe behavior, related musculoskeletal injuries*	No reduction in all primary outcome measures and related musculoskeletal injuries. Knowledge of safe behavior improved from training.
Gundewall et al. (1993); RCT[1,2,3]	Geriatric nurses and nursing aides; N = 60 (% with LBP not reported) , INT = 28, CTRL = 32	Not reported	Duration of LBP not reported (light, moderate or severe LBP)	INT: 20 minute unidimensional back endurance, strength & coordination exercises during work hours (6x/month) CTRL: No intervention *Compliance not reported. Training dose: 6 mins/working day*	LBP intensity (data missing from article), LBP incidence, LBP sick leave over 13 months; *back strength, endurance, coordination*	Significantly reduced LBP intensity Cohen's d (95% CI): 0.386 (-0.13 to 0.90), incidence & lost work days between groups *Improved back strength / data missing from table on LBP intensity, no comment on compliance*
Kellet et al. (1991); RCT[1,2]	Manufacturing factory workers and managers; N = 111 (100% with current or previous LBP) INT = 58, CTRL = 53	Measured over 1.5 years: back pain episodes : INT: 0.54, CTRL: 0.33, & sick days due to back pain: INT: 5.59, CTRL: 2.50	Non-specific, duration of LBP not reported	INT: multidimensional instructor-led ~40 minute general stretching, strengthening and cardiovascular exercises and relaxation once a week during work hours CTRL = no intervention *Compliance not reported. Training dose: 8 mins/working day*	Back pain incidence & sick leave over 18 months; *cardiovascular fitness*	Significantly reduced back pain incidence Cohen's d (95% CI): 0.28 (-0.16 to 0.71) and number of sick days between groups by > 50% *No change in cardiovascular fitness / no comment on compliance or amount of exercise*

Donchin et al. (1990); RCT[1,2]	Hospital employees; N = 142, INT1 = 46 (80% with LBP in the last month), INT2 = 46 (52% with LBP in the last month), CTRL = 50 (54% with LBP in the last month)	≥ 3 annual episodes of back pain, LBP disability: INT1: 25.9, INT2: 29.0, CTRL: 26.0 on ODI	Specific/non-specific not reported, chronic or recurring (LBP duration 15+ years, episode in last month, >15 episodes/year)	INT1: 45 minutes, twice/week group calisthenics for 3 months INT2: multidimensional back school with exercise emphasis: 5x90 sessions CTRL: No treatment *Compliance not reported.* *Training dose: 13 mins/day*	LBP incidence @ 12 months; *strength and flexibility*	Significant reduction in incidence of LBP Cohen's d (95% CI): 0.69 (0.27 to 1.11) in INT1compared with INT2 and CTRL. No difference between INT2 and CTRL. *no comment on compliance*
Amako et al. (2003); NCT[3]	Male military recruits from 1996 – 1998; N = 901 (0% with LBP), INT = 518, CTRL = 383	Not reported	Not reported	INT: unidimensional 20 minute static stretching before & after physical training daily CTRL: no intervention *Compliance not reported.* *Training dose: 6 mins/day*	LBP incidence @ 1, 2 & 3 months	Significant ($p<0.05$) reduction in incidence of LBP between groups *Very low number of subjects with LBP & no information on compliance, but as INT was part of military training, it is assumed to be very high*
Oldervoll et al. (2001); NCT[1,2]	Female hospital staff; N = 65, INT1 = 22, INT2 = 24, CTRL = 19	≥ 3 months back pain in the last year and recurring pain during the past 30 days, mean pain index scores: INT 1: 13.5, INT 2: 12.3, CTRL: 12.9	Non-specific, duration of LBP not reported	15 weeks of: INT1: 1 hour, 2x/week cardiovascular exercise INT2: 1 hour, 2x/week general strengthening exercises CTRL: no intervention *Training compliance: INT1 = 81%, INT2 = 77%* *Training dose: 17 mins/ day*	LBP incidence & activity interference @ 15 weeks & 7 months post-intervention; *cardiovascular fitness*	@ 7 months, significant reduction in incidence of LBP in INT1 (from 2.3 to 1.7: $t=3.41$, $p=0.005$) & INT2 (from 2.1 to 1.6: $t=1.93$, $p=0.07$) as compared to CTRL. INT1 had significant improvements in cardiovascular fitness as compared with INT2

						& CTRL.
Shinozaki et al. (2001); NCT[1,2,3]	Male copper smelter employees with & without LBP; N = 315, INT = 27 forklift drivers (63% with LBP), CTRL1 = 233 manual shift workers (32% with LBP), CTRL2 = 55 sedentary workers (22% with LBP)	Not reported	Not reported	INT: multidimensional instructed to complete Williams exercise, wear arctic jacket and use lumbar support, then ergonomic intervention 9 months later CTRL1&2: no intervention *Compliance not reported.*	LBP incidence @ 15 and 24 months	Significant (0.008) reduction in incidence of LBP @ 15 months as compared to CTRL1 &2. *Authors concluded that ergonomic approach was more effective than personal approach, however carry-over effect, or combination of two interventions may have caused result. Further no information was provided about compliance and regularity of performing Williams exercises.*
Delhin et al. (1981); NCT[1,2]	Female nursing aides; N = 45 (100% with LBP for > 6 months), INT = 15, CTRL 1 = 14, CTRL 2 = 16	≥ 1x/week for > 6 months	Non-specific, chronic LBP	INT: Strengthening exercise 2x/week for 8 weeks general, cardiovascular & muscular endurance exercise during work hours. CTRL 1: Ergonomic and manual handling course 2x/week for 8 weeks during work hours. CTRL 2: No intervention. *Compliance: INT = 86.7%, CTRL1 = 78.6%, CTRL2 = 93.8%*	LBP intensity, frequency, duration, influence of LBP on working capacity; *psychological perception of work, cardiovascular fitness*	No significant differences in LBP or psychological perception of work between INT, CTRL 1 & CTRL 2.
Delhin et al. (1978); NCT[1,2]	Female nursing aides; N = 66, INT = 13 (100% with	≥ 1x/week non-specific LBP	Specific (lumbago and sciatica) & non-specific (low back insufficiency) LBP,	INT: Physiotherapist-led 45 minutes, 2x/week for 8 weeks functional back, abdomen and quadriceps femoris strength	LBP intensity, frequency, duration, influence of LBP on working capacity; *psychological perception*	Significant ($p<0.05$) reduction in LBP duration in INT as compared to CTRL 1,

	LBP), CTRL 1 = 14 (100% with LBP), CTRL 2 = 14 (100% with LBP), CTRL 3 = 20 (100% without LBP),	duration of LBP not reported	training during work hours. CTRL 1: 30 minute geriatric medicine and nursing care lectures 2x/week for 8 weeks during work hours. CTRL 2: No intervention for nursing aides with back pain. CTRL 3: No intervention for nursing aides without back pain. *Compliance: INT = 72.2%, CTRL1 = 100%,* *Training dose: 13 mins/ day*	*of work, isometric truck muscle strength, quadriceps femoris torque*	but not CTRL 2.

[1]treatment of LBP – subjects currently have LBP and the intervention is intended to treat this
[2]prevention of LBP recurrence – subjects have a history of LBP and the intervention is designed to prevent future episodes
[3]prevention of LBP – subjects have never had LBP and the intervention is used to prevent first-episode LBP
VAS indicates Visual Analogue Scale; RDQ, Roland Morris Disability Questionnaire; ODI, Oswestry Disability Index; PDI, Pain Disability Index; SF-36, 36-item Short Form Health Survey.

19 January 2009

Dr. Michael Feuerstein
Editor-in-Chief
Journal of Occupational Rehabilitation

Dear Dr Feuerstein,

RE: REVIEW OF "EXERCISE FOR THE PRIMARY, SECONDARY AND TERTIARY PREVENTION OF LOW BACK PAIN IN THE WORKPLACE: A SYSTEMATIC REVIEW" (#JOOR143)

Thank you for your correspondence dated 16 January 2009 and the additional feedback provided by the reviewer regarding our paper.

We have attempted to incorporate the reviewer's further suggestions. We trust that we have appropriately dealt with the concerns raised and thank you for the acceptance of our manuscript in *Journal of Occupational Rehabilitation*.

Additionally, I would like to request that my name be changed to Julie Ann Bell, as I am changing my name subsequent to getting married in the near future. Thank you.

Yours sincerely,

Julie Ann Netto
Lecturer
School of Occupational Therapy and Social Work
Faculty of Health Sciences
Curtin University of Technology

Reply to Reviewer 2

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Page 12: the terms minimally clinically important changes and
differences are both used by the study authors while the difference
between these two concepts is very important. Change refers to within
group improvement and difference to between group improvements. In my
view, within groups improvements are not very important since low back
pain is largely a selflimiting condition and within group improvement
might therefore reflect natural history.
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We have noted the reviewer's points regarding the distinction between the terms changes and differences, and have clarified the points raised in the article as clinically significant changes in pain and disability levels within groups.

Page 12, paragraph 2, line 3:
Previous studies have reported that with respect to back pain, minimal clinically important change within groups on the Visual Analogue Scale (VAS) was 18-19mm out of 100 mm [50] or 2 on a 10 point rating scale [51, 52]. Further, with respect to the Oswestry Disability Index (ODI), 5.2 (out of 100%) related to a clinically important change [53]. Clinically significant changes for levels of pain (as measured by the VAS) were found in Suni et al. [48] and Hlobil et al. [34].

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It is not clear from the text and also not from the tables whether the
effect sizes which have been calculated and reported, reflect within
group improvements or between group differences in improvement. Please
clarify this issue. Further, the conclusions with regards to the
effects of a trial need to be based on the between group comparisons (I
am aware that many authors try to 'improve' their results by reporting
significant within group improvements but this is wrong).
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We have now clarified that the effect sizes were between group differences as requested by the reviewer
Page 12, paragraph 2:
Effect size for between group differences was not directly reported for primary outcomes variables in all the studies reviewed.

We have also amended the last column in Table IV to clearly state that the main conclusions and effect sizes were between group differences. It now reads:

Original authors main conclusions, effect size / *present reviewers' comments*
Significantly (p=0.02) reduced LBP intensity between groups Significant improvement in activity restriction between groups *Low dose, high response and high compliance with long term effects on LBP*
Significant (p=0.052) difference in LBP intensity between groups Significant (p=0.028) improvement in self-estimated work ability *Poor training compliance in the last 6 months of study.*
Non-significant improvement in LBP incidence Cohen's d (95% CI): 0.07 (-0.72 to 0.83), and sick days

between groups,
No significant difference between groups in all primary outcome measures. Increase in INT mean isometric strength @ 1, 2, 3, 6 & 9 months and decline in kinesophobia score at 2 & 9 months *Both high & low intensity programs led to improvements in primary outcome measures*
Significant improvement in LBP incidence (p=0.001) and need to consult infirmary (p=0.425) between groups *Comment made on compliance being high in first 3 months, but no figures given*
Non significant improvements in LBP incidence for INT1 & 2 as compared to CTRL. INT1 had less activity interference than CTRL @ 12 months *No information given about the number of training sessions per week*
No reduction in all primary outcome measures and related musculoskeletal injuries. Knowledge of safe behavior improved from training.
Significantly reduced LBP intensity Cohen's d (95% CI): 0.386 (-0.13 to 0.90), incidence & lost work days between groups *Improved back strength / data missing from table on LBP intensity, no comment on compliance*
Significantly reduced back pain incidence Cohen's d (95% CI): 0.28 (-0.16 to 0.71) and number of sick days between groups by > 50% *No change in cardiovascular fitness / no comment on compliance or amount of exercise*
Significant reduction in incidence of LBP Cohen's d (95% CI): 0.69 (0.27 to 1.11) in INT1compared with INT2 and CTRL. No difference between INT2 and CTRL. *no comment on compliance*
Significant (p<0.05) reduction in incidence of LBP between groups *Very low number of subjects with LBP & no information on compliance, but as INT was part of military training, it is assumed to be very high*
@ 7 months, significant reduction in incidence of LBP in INT1 (from 2.3 to 1.7: t=3.41, p=0.005) & INT2 (from 2.1 to 1.6: t=1.93, p=0.07) as compared to CTRL. INT1 had significant improvements in cardiovascular fitness as compared with INT2 & CTRL.
Significant (0.008) reduction in incidence of LBP @ 15 months as compared to CTRL1 &2. *Authors concluded that ergonomic approach was more effective than personal approach, however carry-over effect, or combination of two interventions may have caused result. Further no information was provided about compliance and regularity of performing Williams exercises.*
No significant differences in LBP or psychological perception of work between INT, CTRL 1 & CTRL 2.
Significant (p<0.05) reduction in LBP duration in INT as compared to CTRL 1, but not CTRL 2.

The study by Hlobil et al did not use the ODI as outcome measure (the Roland Disability questionnaire was used).

Apologies for this mistake. This has now been amended
Page 12, 2nd last line:
None of the studies showed clinically important changes for levels of disability (as measured by the ODI).

Referencing
We have double checked the referencing from the on-line instructions for authors and we believe it is consistent with Vancouver style as requested.