Industrial Health 2020, **58**, 503–519

Review Article

Effectiveness of workplace intervention strategies in lower back pain prevention: a review

Danuta ROMAN-LIU[1]*, Joanna KAMIŃSKA[1] and Tomasz TOKARSKI[1]

[1]Central Institute for Labour Protection, National Research Institute (CIOP-PIB), Poland

Received June 22, 2020 and accepted September 14, 2020
Published online in J-STAGE September 24, 2020

Abstract: The aim of this study was to identify effective work place intervention strategies for the prevention of low back pain (LBP). The study focused on interventions to two major groups: personal interventions and technical interventions. Data basis were searched for with inclusion criteria: study design based on randomised controlled trial; outcome measures including non-specific LBP occurrence expressed by prevalence or intensity; intervention met the definition of the technical and/or personal (physical exercises, behavioural training, educational) intervention programme. Eighteen papers were selected for full analysis. The diversification of quantitative indicators of differences between control and intervention groups were carried out using Cohen's d index. The results of analysis showed strong differences in effects among intervention strategies, as well as among different cases within similar intervention strategies. LBP severity before intervention and the length of intervention were discussed as potentially influencing factors. The results of the analysis suggest that the most effective strategies for LBP prevention include technical modifications of the workstand and education based on practical training. Behavioural and physical training seems to be of lesser importance. LBP severity before intervention and the time when the measurements of outcome measures take place play an important role in the effectiveness of intervention.

Key words: Personal intervention, Technical intervention, Behavioural training, Physical exercises

Introduction

Lower back pain (LBP) is one of the most cumbersome health problems in the modern world. The prevalence of LPB depends on such factors as gender, age, educational level or occupation[1)]. Furthermore, various factors such as socio-demographic, psychological and physical factors can enhance LBP development[2–5)]. Absenteeism and disability impact on medical costs and work productivity[6, 7)], which are associated with high costs for both individual patients and society as a whole[8)].

The management and prevention of LBP can result in higher productivity, higher job satisfaction and better safety at work[2)]. Management of LBP includes pharmacological and non-pharmacological approaches[9)]. One of the solutions to prevent and manage LBP includes workplace interventions. The risk of LBP is high if physical work demands and functional capacity are not balanced. This means that workplace intervention can focus on the workplace structure in order to reduce work demands, and/or on the worker in order to strengthen his/her capabilities to perform the work.

Work demands are associated with some of the most important occupational causes of illness that include performing repetitive physical tasks, wrong body posture, as well as stress due to local contact and standing position of the body, all of which take root while working[10–12)]. Other means of improving the balance of physical work demands

*To whom correspondence should be addressed.
E-mail: daliu@ciop.pl

and functional capacity is to enhance the physical capacity of the worker through physical training[13] or education, expanding their knowledge and skills. Various exercise intervention programmes, such as muscle strengthening, flexibility and aerobic fitness training, have been found to be beneficial for reducing LBP[14]. Exercises of low to moderate intensity have been shown to improve aerobic capacity and systolic/diastolic blood pressure in sedentary workers[15]. Also, programmes that make workers more aware of potential risk factors by teaching them how to perform work tasks properly or how to deal with problems, including psychosocial ones, have shown to be effective[16, 17].

In respect of LBP experienced at work, safe working conditions should be promoted in the workplace[18]. This denotes reliable ways in which workers' health in respect to LBP can be improved. Various studies have been conducted to evaluate the effectiveness of interventions in preventing LBP with varying effects. Recent reviews have presented the effectiveness of different strategies by the qualitative[19–22] or quantitative analysis[23, 24] of selected studies. Most dealt with one profession only and one type of intervention, compared with no intervention. Analysis in these reviews has been performed by presenting the ratio between outcome measures obtained for intervention and control groups at measurement points. Yet, knowledge on the most effective ways of intervention is still limited and there is no consensus on which elements make an intervention strategy successful. A comparison of the quantitatively expressed effects of intervention strategies in regards to differences between outcome measures obtained before and after intervention, and the differences between groups (intervention and control) seems to be a step in the right direction. A current overview of the effectiveness of intervention strategies can be obtained by a comprehensive high-quality review that includes the most recent publications.

The aim of this study was to identify the most effective intervention strategies for the prevention of episodes of LBP through a synthesis of the most recent evidence based on randomised controlled trials. The study focused on interventions to two major groups: personal and technical. Personal interventions included physical and behavioural approaches, as well as education. Technical interventions included workplace re-designing or a reduction in physical work demands. The aim of this review was achieved in three steps: literature search and comprehensive literature review, analysis of numerical data.

Methods

A comprehensive literature review was conducted in step with the review protocol including the formulation of a research question, the selection of bibliographic databases with search strings, and specific inclusion and exclusion criteria, to be applied both for searching the databases and for analysing the retrieved information.

A research question was formulated: how effective, according to quantitative measures, were the various implemented workplace intervention strategies, and which other factors influence intervention effectiveness?

Literature search strategy

The review process was framed in terms of PICO[27]: Population, Intervention, Comparison, Outcome. Two authors carried out title evaluation, abstract evaluation and full text evaluation independently. Disagreements were resolved through discussion, reaching a consensus or, if consensus was not reached, by consulting a third author.

ScienceDirect, ProQuest (all its databases) and PubMed were selected for the search, with one search string: ergonomic AND intervention AND musculoskeletal AND (return to work)) OR work AND intervention AND back) OR ergonomic AND intervention AND musculoskeletal AND back) OR work AND back AND intervention AND (randomized OR RCT)). The search included full-text articles published in English between January 2000 and July 2019.

In ProQuest, filters were set as: search done in abstract, language: English, source: scientific journals, document: article, duplicates removed; only reviewed. In ScienceDirect, filters were set as: article types: research article, search done in abstract, title and keywords. PubMed filters were set as: language: English, species: humans, article type: classical article and classical trial.

Inclusion and exclusion criteria

Retrieved articles were analysed further. Those which fulfilled the following inclusion criteria were selected for meta-analysis: study design was based on RCT; outcome measures included non-specific LBP occurrence expressed by prevalence or intensity; intervention met the definition of a technical and/or physical exercise intervention programme and/or behavioural training and/or education programme. The following were excluded: interventions that recruited disabled workers for rehabilitation or retired workers; studies in which more than half of the participants were not available for follow-up; studies that did not address a specific intervention and were related only to the treatment of LBP; literature reviews; non-scientific studies; and those lacking quantitative assessment of the intervention effect.

Quality appraisal of individual studies

Studies that met the selection criteria were assessed for bias according to quality criteria developed by the research team based on Brewer *et al.*[25] and Richards *et al*[26]. Each criterion was rated 0 or 1, for a maximum total score of 8 points: the higher the score, the lower the risk of bias. Studies were independently rated by two authors; disagreements were resolved through consensus or, if consensus was not reached, by consulting a third author. Quality assessment of the reviewed studies was performed by asking the following questions: Was the research question/objective clearly stated?; Were the eligibility criteria specified?; Were participants randomly allocated to intervention groups?; Were groups similar at baseline for the most important prognostic indicators?; Was the intervention implementation described?; Was the length of follow-up one month or greater?; Was loss to follow-up reported?; Were the results' statistical comparisons reported for the outcome measure?

Analysis of numerical data

The aim of the analysis of the numerical data was the comparison of the effects of intervention strategies (effect size) of different studies. For the analysis, variables were selected, which were presented as outcome measures registered at the specific measurement points: before intervention, post intervention and, optionally, at follow-up. The outcome measure included non-specific LBP occurrence, and prevalence or intensity of LBP. As different studies presented outcome measures in different ways, in order to unify the results, recalculations were performed where necessary. In cases where prevalence was the outcome measure, Confidence Interval was calculated based on the Clopper-Pearson method[28].

In the first stage of analysis, the differences in the given group of intervention outcome measures between measurement time points were crucial. This means that the numerical values under analysis were the differences in measurements between pre-intervention values and post-intervention/follow-up points obtained for each group under study, e.g. intervention group (IG) and control group (CG). In cases where such differences were not provided and the studies presented values of absolute outcome measures obtained before and after intervention, the differences between two points of measurement were calculated. The mean was calculated as a difference between means, while the confidence interval on the difference between means was computed using the following formula[29]:

$$\text{Lower Limit} = M1–M2 - 1.96*(S_{M1–M2})$$

$$\text{Upper Limit} = M1–M2 + 1.96*(S_{M1–M2})$$

where: M1 and M2 − the sample means; $S_{M1–M2}$ − the estimated standard error of the difference between sample means.

The differences pre- and post-intervention for each of the analysed groups were subjected to further analysis between the groups. Diversification of the quantitative indicators of the differences between the groups under study was carried out using Cohen's d index, which defines the effect size of differences between variables well[30]. Cohen's d was calculated as the difference between means of reference and control groups divided by the square root of the sum of squares of standard deviation. The calculated indicator gives quantitative information on the differentiation of individual intervention strategies between groups. For Cohen's d less than 0.2 the effect is small, between 0.2 and 0.5 it is medium, above 0.8 it is large and above 1.3 very large[30].

Weighted averages for Cohen's d were calculated to show the overall effect of the different intervention strategies. Weighted averages were calculated in two manners. In the first, it was calculated only for cases with one intervention strategy: technical, participatory, educational, physical or behavioural. In the second manner, the weighted average calculations combined Cohen' d, including mixed strategies cases, broken down into two groups of technical or a personal strategy.

Results

Literature search, relevance selection and quality assessment

The search produced 1,691 articles (250 from PubMed; 577 from ScienceDirect; and 864 from ProQuest) (Fig. 1). Screening of the titles and abstracts of potentially relevant articles delivered 93 publications qualified for a full-text review. This process ended up including only 18 studies for further analysis, with 7 items from other sources added. These 7 items were found from a reference list of articles from a systematic review or were known to the authors as relevant. Most of the studies were excluded from analysis

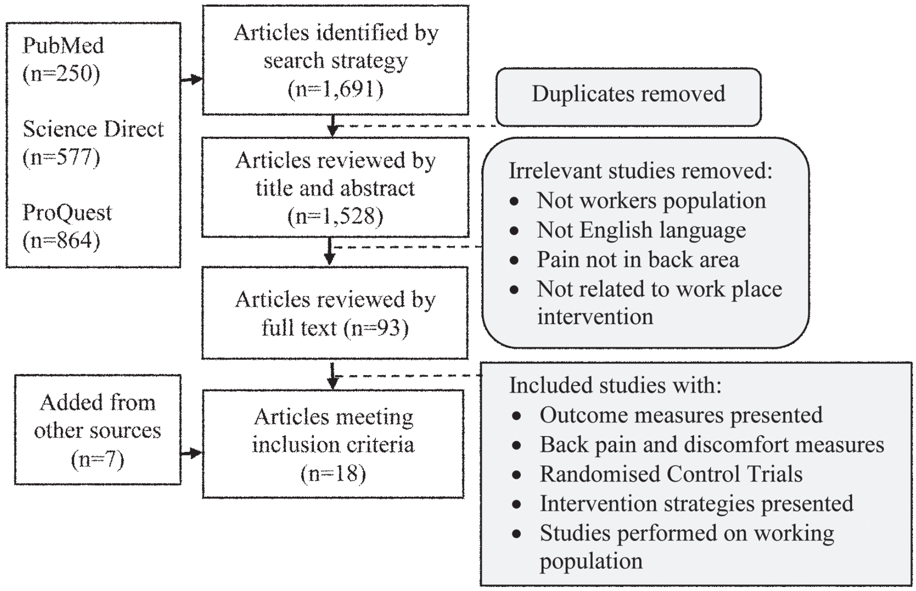

Fig. 1. Flow chart of study identification and selection.

because the study design was not a randomized controlled trial. The characteristics of the publications resulting from the systematic review are presented in Table 1.

The study focused mostly on office workers, nurses and a mixed population of workers that is undefined. The presented interventions can be divided into technical and personal (physical, behavioural, educational) interventions. The participatory type of intervention was also distinguished, which embraced technical solutions on the workstand. Any technical or engineering adjustments that included workplace re-design or a reduction in physical work demands by changes in time sequences and/or the external force exerted in the work process were treated as technical interventions in the workplace. Participatory ergonomics is usually defined as 'practical ergonomics with participation of the necessary actors in problem solving'[49]. Personal interventions include physical approaches like exercises that increase the physical capacity and activity levels of the worker. Another aspect was behavioural training dedicated to alter pain behaviour. The third element of personal intervention was the expansion of knowledge and the improvement of skills on ergonomics, through education, but also considering participatory aspects. Interventions were described as: technical (T), participatory (P), educational (E), physical (H) and behavioural (B). Some of the reviewed studies presented only one intervention strategy. There were studies, however, with more than a two-arm RTC design that treated one or a mix of those types of intervention. There were also studies that presented two or three types of intervention combined. There was quite strong diversification; nearly every strategy differed from the rest.

Studies on technical intervention dealt mostly with white-collar worker workstands. They focused on posture during work, securing less strenuous postures by modifying the workstand. There were four studies that referred to office workstand modifications by allowing workers the choice to switch between sitting and standing postures while working. In Graves study[34] IG participants received a sit-stand workstation installed on their existing workplace desk for a period of eight weeks. A single or dual monitor with worksurface + workstation and keyboard were housed on the workstation that could be quickly raised up and down. Upon the conclusion of the intervention, the workstations were uninstalled. In Ognibene *et al.*[43], IG participants were given a special workstation that allowed for both sitting and standing for a period of 12 wk. In both studies, the participants were not instructed to sit or stand at specific time intervals or for certain durations. In Pillastrini *et al.*[44], the IG received an adjustment of the workplace, which allowed for the modification of the existing furniture and equipment by adapting chair and desk height, backrest inclination, screen height inclination and orientation, mouse location, and keyboard inclination and location. Both IG and CG received an informative brochure. The intervention lasted for five months. A different technical intervention strategy was applied in Purepong *et al*[45]. In this study, IG participants had an

Table 1. Characteristics of randomized control trials under analysis in respect of types of interventions and results obtained

References	Profession/ IC/EC	Intervention and groups characteristics	Measurement points	Variables under analysis (V) / Results (R)
Aghilinejad *et al.*[31]	Various jobs; EC: workers who did extra job within their free time; with history of fracture or major trauma; workers with degenerative disk disease, spondylosis, spinal stenosis, neurological deficit, systemic illness and in vacation.	IG1 (n=84, age=30, F=?): pamphlet; IG2 (n=84, age=30, F=?): lectures; IG3 (n=84, age=30, F=?): workshop; CG (n=251, age=30 (2), F=?)	(T1: One year after): IG1 (n=61); IG2 (n=79); IG3 (n=60); CG (n=251)	V: LBP prevalence last week and last year / R: rate at T0, T1
Coole *et al.*[32]	General working population; IC: employed, expressed concern about ability to work due to back pain, a group treatment, able to read, write and speak in English.	IG (n=28, age= 41.46 (11.93), F=50%); CG (n=23, age= 48.30 (10.14), F=56.5%). Both groups had a group multidisciplinary back pain rehabilitation with self management and a cognitive behavioural approach. IG obtained individual work support by occupational therapist. A 16-wk period of individual work support.	(T1: 6 months): IG (n=19), CG (n=19)	V: LBP (VAS)/ R: Standardized outcome measure - difference T0 to T1, mean and 95% CI
Danquah *et al.*[33]	Office workers; IC: ≥ 18 yr old, understood Danish, and worked >4 d/wk (>30 hr/wk); EC: pregnancy, sickness, disabilities affecting the ability to stand or walk.	IG (n=173; age=47 (10); F=61): appointment of local ambassadors and management support; environmental changes; a lecture; a workshop aiming at ensuring local adaptation at individual; office and workplace level; e-mails and text messages; CG (n=144; age=46 (11); F=73): work as usual.	(T1: 1 month): IG (n=130), CG (n=161); (T2: 3 months): IG (n=126), CG (n=153)	V: LBP prevalence / R: rate at T0, T1 and T2.
Graves *et al.*[34]	Office workers; IC: full-time member of staff, access to a work telephone and desktop computer with internet; EC: cardiovascular or metabolic disease, taking any medication, pregnant, planned absence >1 wk during the trial.	IG (n=26, age=38.8 (9.8), F= 89%): work on the single or dual monitor WorkFit-A with Worksurface + workstation, participants received a web link to manufacturer ergonomic guidelines via an email; CG (n=21, age=38.4 (9.3), F=67%): maintaining normal work practices.	(T1: 8 wk): IG (n=20–25), CG (n=17–21)	V: LBP (VAS) / R: mean and SD at T0 and T1
Haufe *et al.*[35]	Various jobs; IC: between 18 and 67 yr; EC: acute or chronic infections, any diseases that preclude realization of an exercise, pregnancy or breast feeding.	IG (n=112, age=43.5 ± 9.7, F=43%): a 20-min exercises planed by physiotherapist, three times per week for 5-months; CG (n=114, age=41.9 ± 10.6, F=38%): continued current lifestyle.	(T1: after 5 months): IG (n=111), CG (n=114)	V: LBP (VAS) / R: mean and SD at T0 and T1.
Irvine *et al.*[36]	Workers population; IC: 18 to 65 yr of age, living in the US, employed at least half time, retired, or a family member of an employee at one of the four collaborating companies; one participant per family, experience LBP within the past 3 months but not interfering with everyday life no history of medical care for LBP pain, not participating in an exercise program for LBP, email and internet access, cleared of medical risks by a survey.	IG1 (n=199, age=?, F=58.3): used the FitBack intervention; IG2 (n=199, age=?, F=58.8): alternative care group, received 8 emails with links to websites with information about LBP; CG (n=199, age=?, F=62.8): usual care.	(T1: 2 months, T2: 4 months): IG1 (n=196), IG2 (n=196), CG (n=196)	V: LBP intensity (7 points scale) / R: mean and SD at T0, T1 and T2
Jakobsen *et al.*[37]	Healthcare workers; IC: Health care workers; EC: pregnancy, hypertension, a medical history of cardiovascular diseases, a medical history of life threatening disease.	IG1 (n=111, age=40 (12), F=100%): physical exercise at work; IG2 (n=89, age=44 (10), F=100%): physical exercise at home.	(T1: 10 wk intervention): (IG1 (n=101); IG2 (n=83)	V: LBP (VAS) / R: mean and 95% CI difference in groups from T0 to T1
Jaromi *et al.*[38]	Nurses: IC: under 60 yr of age; more than three months of LBP; having diagnosis of LBP; EC: pregnancy; previous spinal surgery; current nerve root entrapment accompanied by significant neurological deficit; spinal cord compression; tumours; severe structural deformity; severe instability; severe osteoporosis.	IG (n=57, age= 32.3 8.15, F=18%): ergonomics training and Back School programme; CG (n=55, age=31.5 8.25, F=15%): passive therapies such as electrotherapy, massage and manual therapy.	(T1: 6 wk), (T2: 6 months; T3: 12 months): IG (n=56), CG (n=55)	V: LBP (VAS)/ R: mean and SD at T0, T1, T2, F1; mean, SD, CI changes between T1 and T0, T2 and T0, T3 and T0.
Jay *et al.*[39]	Laboratory technicians; IC: female suffering from chronic LBP, fulfilling all of the criteria: the pain lasted at least 3 months, pain intensity of ≥3 VAS during the last week, and pain frequency of ≥3 d during the last week. EC: life-threatening disease, pregnancy.	IG (n=56; age=45.5 (9.0); F=100%): experimental intervention treatment with motor control training, resistance training and cognitive, behavioural modification education and general mindfulness; CG (n=56, age=47.6 (8.2), F=100%): encouragements to follow on-going company health initiatives.	T1 (10 wk follow up). IG (n=53); CG (n=53)	V: LBP intensity (VAS) / R: mean and 95% CI of difference between T0 and T1,
Jørgensen *et al.*[40]	Cleaners; A 3-armed cluster RCT; IC: employed for at least 20 h/wk at the workplace and primarily work during day hours. Their main work task had to be cleaning, but their job could also involve other service tasks such as washing, kitchen work or attending to patients. No EC.	IG1 (n=95; age=44 (9.1); F=100%): intensive physical coordination exercises providing high activation of stabilizing muscles around the trunk and shoulder girdle; IG2 (n=99, age=46(8.9), F=100%): cognitive behavioural training; CG (n=100, age=45(9.6), F=100%): received a health check of 1 h's duration, including a pulmonary-function test and an aerobic capacity test.	(T1: 12 months): IG1 (n=52), IG2 (n=47), CG (n=54)	V: LBP prevalence / R: rate at T0 and T1

References	Profession/ IC/EC	Intervention and groups characteristics	Measurement points	Variables under analysis (V) / Results (R)
Linton *et al.*[41]	Workers population; IC: suffering from musculoskeletal low back pain, elevated risk for developing chronic pain problems according to the questionnaire, consenting to have their supervisor contacted for participation in the study; EC: signs of a possibly serious underlying condition.	IG (n=82, age=49.65 (9.98), F=95.1%): participants received a manualized, short term, preventive intervention based on cognitive behavioural principles; CG (n=58, age=49.90 (10.38), F=93.1%): treatment as usual.	(T1: 4 wk; T2: 6 months): IG (n=82), CG (n=58)	V: LBP intensity last week and LBP last 3 months (VAS) / R: mean and SD at T0 and F1
Magalhães *et al.*[42]	Various jobs; IC: suffering with LBP, aged 18–65, with a minimum pain intensity score of 3 in the 11-point scale; EC: serious spinal pathology, nerve root compromise, spinal surgery, health conditions that could prevent exercise actives such as high blood pressure, pregnancy, or cardio-respiratory illnesses.	IG1 (n=33, age= 46.6 (9.5), F= 75.7%): Physiotherapy exercise program that comprised stretching of main muscle groups; IG2 (n=33, age=47.2 (10.5), F= 72.7%): Graded activity based on individual sessions of progressive and sub-maximal exercises aimed at improving physical fitness.	(T1: 6 wk): IG1 (n=30), IG2 (n=30); (T2: 3 months): IG1 (n=30), IG2 (n=30); (T3: 6 months): IG1 (n=28), IG2 (n=30)	V: LBP (VAS) / R: mean and SD at T0, T1, F1 and F2.
Ognibene *et al.*[43]	Office workers; IC: university employees 18 yr of age or older who spent at least 6 h out of an 8-h day sitting at a computer desk and reported at least a four of ten level back pain that had lasted a minimum of 3 months; EC: physically incapable of standing for at least 10 min, already using a seat-stand workstation.	IG (n=25, age=45 (25–62), F=84%): Participants were given a Work-Fit workstation; CG (n=21, age=49 (22–63), F=81%): work as usual.	(T1: 12 wk): IG (n=25), CG (n=21)	V: LBP intensity (VAS) / R: mean and 95% CI change from T0 to T1
Pillastrini *et al.*[44]	Office workers; IC: used VDTs for at least 20 h a week, all participants performed the same tasks	IG (n=100, age=44.8 (6.8), F=70%)): received an ergonomic intervention plus an informative brochure. CG (n=100, age=43.7 (8.4), F=72%): received only the brochure.	(T1: 5 months): IG (n=99) CG (n=97)	V: LBP prevalence / R: ratio at T0 and T1
Purepong *et al.*[45]	Office workers; IC: working in offices for at least 1 yr; aged 20–60 yr, diagnosed with chronic non-specific LBP, sat for at least 2 h. EC: BMI >25 kg/m^2, history of non-employment related LBP, indication of neurological deficit, traumatic spinal fracture or diseases such as cancer or tumours, previous spinal surgery, pregnancy, open wounds, contusions or swelling.	IG (n=32, age=39.81 (1.73), F=?): acupressure backrest was installed onto the office chairs of participants. CG (n=37, age=41.46 (1.72), F=?): no intervention was provided.	T1 (2-wk after backrest use), T2 (4-wk after backrest use), F1 (3-month follow up).	V: LBP (VAS) / R: mean and SE at T0, T1, T2 and F1.
Risør *et al.*[46]	Nurses, service assistants and therapists: IC: wards with a large number of patients who had different degrees of needs, with different specialties	IG (n=201, age=~40, F=95%): ergonomic intervention; CG (n=293, age=~40, F=92%): no actions.	(T1: 12 months): IC (n=172); CG (n=271)	V: LBP prevalence (within 12 months, within 7 d) / R: rate at T0 and T1
Staal *et al.*[47]	Workers employed *at air forces*. IC: full or partial absence from work due to LBP with a minimum duration of 4 wk in succession; EC: LBP with radiation below the knee with signs of nerve-root compression, cardiovascular contraindications for physical activity, conflict between worker and employer with legal involvement, pregnancy.	IG (n=67, age=20 (9), F=5%): graded activity; CG (n=67, age=37 (8), F=8%): usual care.	(T1: 3 months): IG (n=61), CG (n=61); T2 (6 months) IG (n=59), CG (n=59)	V: LBP within 7 d/ R: mean and SD of changes between T1 and T0, F1 and T0.
Yu *et al.*[48]	Workers population; IC: frontline workers and being employed in the current factory for at least 12 months; EC: employees in administration, design and logistics, illiterate and seasonal migrant workers.	IG (n=918, age=29.1 (7.3), F=41.1%): received participatory training; (CG1: n=966, age=28.9 (7.4), F=43.1%); (CG2: n=1,706, age=28.3 (7.1), F=44.7%). Control groups received didactic training, the training contents and materials were the same as used in participatory training, covering the same 4 areas/topics. However, only a short presentation was given, without group discussions, games or workplace visits.	(F1: 1 yr): IG (n=541), CG1 (n=516), CG2 (1,063)	V: LBP prevalence / R: rate at T0 and F1

IC: inclusion criteria; EC: exclusion criteria; IG: intervention group; CG: control group; F: females; T0: pre intervention measurement; T1: measurement point post intervention; VAS: Visual Analogue Scale for 0 to 10; LBP: intensity of low back pain.

acupressure backrest installed onto their office chairs for one month. A physical therapist explained how to sit properly on the office chair with the backrest, and visited the workplace twice a week in order to check the level of the acupressure point device and position of the backrest. Also, three short message signals were sent every other day in order to remind workers to sit in the correct posture while using the backrest. No intervention was provided to the CG; however, participants were able to contact the physical therapist, who provided treatment if they needed advice concerning back pain for the period of one month.

The intervention presented in Danquah *et al.*[33] included five elements, of which technical adjustments of a sit-stand workplace were one. The full intervention included an appointment with local ambassadors, environmental changes, a lecture and workshop, e-mails and text messages. Ambassadors were appointed to provide social support, and to make sure that the project and the common goals were discussed regularly. Environmental changes were executed by installing high meeting tables in meeting rooms, offices and corridors. Lectures were given at the start of the workshop and aimed at increasing participants' knowledge of sedentary behaviour and health. The aim of the workshop was to ensure local adaptation at the individual, office and workplace levels. The participants were guided through four strategies: using a sit-stand desk, interrupting prolonged periods of sitting, having standing and walking meetings, and setting common goals. For each strategy, the participants were given examples of changes they could implement, and examples were discussed. Also, in some studies workplace adjustments were only one aspect of a broader intervention strategy based on participatory ergonomics. In Risør *et al.*[46], the IG was placed in an ergonomic intervention programme that was developed during workshop sessions with the participation of safety managers, ergonomic experts, a scientist and a project manager. It consisted of: development and dissemination of patient-handling guidelines on the responsibilities of different staff groups; purchasing new patient-handling equipment; and a comprehensive training programme on how to use the assistive devices during patient handling. CG worked as usual. Similarly, in Yu *et al.*[48], the IG received participatory training, which focused on learning successful examples from other workplaces and consisted in four main steps: workers were given a brief introduction to the basic concepts of occupational health and safety with successful examples of improvements; they were divided into small groups in order to conduct a workplace inspection using a checklist, followed by a discussion to identify existing good and bad examples, and specify solutions for areas in need of improvement; workers reported to the whole group, with the manager joining in, on priority lists of action plans for improvements; employees and management representatives determined the priorities for both immediate and long-term improvement plans. The CG received didactic training; the training content and materials were the same as those used in the participatory training, covering the same four areas/topics. Only a short presentation was given, however, without group discussions, games or workplace visits.

There was quite a large number of studies that presented intervention strategies based on physical and/or behavioural training. Linton *et al.*[41] sought to minimise the impact of workplace-related psychosocial risk factors for developing LBP and to create a supportive work environment. During the intervention programme that lasted for four weeks, and was based on the self-management of work difficulties, IG participants received a preventive supervisory intervention based on cognitive behavioural principles to increase their ability to self-manage daily work-related obstacles. As usual, an intervention programme with treatment was allocated to the CG. Four studies presented interventions that were based only on physical exercises. The intervention with physical exercises described in Haufe *et al.*[35] lasted for five months. Non-supervised exercises, according to exercise planning and guidance provided by a physiotherapist, were performed three times per week in 20-min sessions at home or during regular pauses at work. The participants chose four to six exercises from a list in an illustrated manual, directed at the trunk musculature and particularly the lower back. During regular counselling, the physiotherapist supervised and corrected the execution of the exercises. Subjects in the CG continued their current working practices. In Jakobsen *et al.*[37], two intervention groups were prescribed strength training five times per week for ten weeks. Each training session lasted for 10 min. IG1 performed supervised exercises at work during working hours and IG2 did the same at home unsupervised. The training sessions at work were structured as a circuit-training programme. IG2, who performed physical exercises at home during their free time, were instructed to exercise using at least four out of the ten different exercises shown in three posters. In the study by Magalhães *et al.*[42], two intervention groups were also given physical exercises to do. One group was allocated to physical therapy (IG1) and the other to graded activity (IG2). The intervention lasted for six weeks, with one-hour exercise sessions implemented twice per week. The IG1 protocol comprised stretching exercises of main muscle groups and motor control exercises. All sessions had the same protocol exercise, with no progression of exercise levels implemented. The IG2 programme was based on individual sessions of progressive and submaximal exercises. It consisted of aerobic training on a treadmill and lower limb strengthening exercises. During the first two weeks of training, individuals exercised using 50% of their maximum load. On the third and fourth weeks, loads were increased to 60% maximum, and during the final two weeks, they were increased to 70% maximum. There was no control group in this study. Graded activity treatment was also implemented in Staal *et al*[47]. The IG participated in two one-hour sessions per week, supervised by a physiotherapist, until full return to regular work, with a maximal duration of three months. The IG performed general exercises (aerobic, abdominal, back and leg exercises) and individually tailored exercises to simulate and practise problematic tasks at work or problematic activities in daily life. Exercises started at a level below the average baseline value of functional capacity and were gradually increased. The participants in CG did not change their routine.

Some intervention strategies combined more than one element. In Jay *et al.*[39], the IG, consisting in laboratory technicians, was equipped with individually tailored physical training coupled with cognitive and behavioural elements. Individualised control and resistance trainings were supplemented with cognitive and behavioural modification education that emphasised specific individual concerns about pain and movement. Additionally, guided mindfulness sessions were offered consisting in meditation and body scans, together with gentle yoga techniques and encouragement to practise at home.

The CG was encouraged to follow the current company health initiatives, e.g. weekly elastic band group training sessions and to continue to take "active breaks" whenever needed, both of which were considered as "usual care". The intervention lasted for ten weeks.

Jaromi *et al.*[38] presented an intervention strategy that combined education and physical exercises. The IG received ergonomics training and participated in the Back School programme. The intervention lasted for six weeks and was carried out once a week in a 50-min session that was divided into ten-minute ergonomics training exercise, and a 20-min muscle strengthening and stretching session. The ergonomics training was directed to help with identifying and practising the right body posture when sitting, standing and lifting at work. The IG was also educated on anatomy and body mechanics, biomechanics, biomechanical risk factors, ergonomics theory and spine-friendly workstations. The CG was offered passive therapies such as electrotherapy, massage and manual therapy, which were based on a medical protocol. Irvine *et al.*[36] tested behavioural and educational intervention strategies. IG1 used FitBack, which is a multiple-visit online programme that provides people with LBP education and behavioural strategies to manage current pain and prevent future pain episodes. It is designed to allow users control over the cognitive and behavioural strategies they use to impact their LBP, and to develop and support users' self-efficacy related to pain management and prevention. IG2 received alternative care, consisting in eight emails with links to six websites with information about lower back pain. CG received usual care, which consisted only in emails requesting to complete the assessments. Three strategies were combined in Coole *et al*[32]. Study participants were offered group multidisciplinary back pain rehabilitation, focused on the self-management of back pain including education and physical conditioning, and the use of a cognitive behavioural approach. This was delivered on a weekly basis for 2–3 h per week for a maximum of ten weeks. Half of the participants were randomised to receive individual instructions. Individual work support was delivered by an occupational therapist with a background in back pain management and ergonomics.

Two intervention strategies (physical training and behavioural training) were presented in Jørgensen *et al.*[40], which focused on female cleaners. For IG1, the intervention aimed at improving muscular strength and postural stability. In the first intensive intervention phase that lasted for three months, weekly 20-min sessions were provided, where exercises were performed at the workplace with guidance from an instructor. In the second phase comprising the following nine months, the number of training sessions was gradually reduced. In the last six months, there was only one session per month. IG2 received cognitive behavioural training that mainly comprised group discussions of issues regarding pain-related dysfunctional attitudes. The training was divided into two phases. The first intensive intervention phase consisted of a two-hour session twice a month. In the second phase, there was only one session of one hour's duration per month during six months. The CG only received a health check of one hour's duration, including a pulmonary-function test and an aerobic capacity test.

Pure education as a way to improve workers' health was tested in Aghilinejad *et al*[31]. There were three intervention groups educated in different ways. Workers allocated to IG1 were educated by pamphlet (workers were given an educational pamphlet with black and white schematic diagrams); in IG2, workers were educated by lectures (a five-hour educational lecture on LBP and the related ergonomics aspects, followed by a discussion); and, in IG3, workers were educated by workshop (a five-hour workshop and discussion on various aspects of LBP and ergonomics). The CG did not receive any education. Measurements were performed before the interventions and after one-year of follow-up.

The quality assessment of the analysed studies is presented in Table 2. Most of the studies were of high quality.

Table 2. Quality assessment of selected studies

References	Question								Summary
	1	2	3	4	5	6	7	8	
Aghilinejad *et al.*[31]	+	+	+	+	+	+	+	+	8/8
Coole *et al.*[32]	+	+	+	+	+	+	+	–	7/8
Danquah *et al.*[33]	+	+	+	+	+	+	+	+	8/8
Graves *et al.*[34]	+	+	+	+	+	+	+	+	8/8
Haufe *et al.*[35]	+	+	+	+	+	+	+	+	8/8
Irvine *et al.*[36]	+	+	+	+	+	+	+	+	8/8
Jakobsen *et al.*[37]	+	+	+	+	+	+	+	+	8/8
Jaromi *et al.*[38]	+	+	+	+	+	+	+	+	8/8
Jay *et al.*[39]	+	+	+	+	+	+	+	+	8/8
Jørgensen *et al.*[40]	+	+	+	+	+	+	+	+	8/8
Linton *et al.*[41]	+	+	+	+	+	+	+	+	8/8
Magalhães *et al.*[42]	+	+	+	+	+	+	+	+	8/8
Ognibene *et al.*[43]	+	+	+	+	+	+	+	+	8/8
Pillastrini *et al.*[44]	+	+	+	+	+	+	+	+	8/8
Purepong *et al.*[45]	+	+	+	+	+	+	+	+	8/8
Risør *et al.*[46]	+	–	–	+	+	+	+	+	6/8
Staal *et al.*[47]	+	+	+	+	+	+	+	+	8/8
Yu *et al.*[48]	+	+	+	+	+	+	+	+	8/8

Quality assessment of the reviewed studies was performed according to the following questions:

1. Was the research question/objective clearly stated?
2. Were the eligibility criteria specified?
3. Were participants randomly allocated to intervention groups?
4. Were groups similar at baseline for the most important prognostic indicators?
5. Was the intervention implementation described?
6. Was the length of follow-up one month or greater?
7. Was the loss to follow-up reported?
8. Were the results' statistical comparisons reported for the outcome measure?

The lowest score obtained was by Risør *et al*[46]. The next lowest was by Coole *et al*[32].

Data extraction and analysis

The papers reviewed differed in the presentation of the outcome measures resulting from the interventions. Some papers presented values of measures registered at the measurement points as mean and standard error or standard deviation. Others presented differences in values between measurement points. Most of the studies had only one time point of checking the effects of intervention. Three studies[38, 42, 45] had three measurements, while three studies[32, 36, 47] had two such points.

Figure 2 presents the results, e.g. the outcome measures as means of differences between measurement pre- and post-intervention with 95% CI. The results presented on this figure differ in scales. LBP scales ranged from 0 to 10 cm, but not in all cases. Taking prevalence into account, values and differences between values are presented as decimals. This makes the results difficult to compare and means that they can be compared only within studies. In the majority of cases, the measures obtained pre-intervention showed higher values (stronger LBP) than measures post-intervention and follow-up.

Comparison between different intervention strategies is performed by effect size, which expresses differences in the impact of intervention among the groups under study (Fig. 3).

The effect size measure (Cohen's d) presents differences in the effects of intervention between intervention and control groups. Values are strongly diversified from 0.2 to more than 1.3. The lowest values of Cohen's d were obtained mostly for cases of physical exercises and behavioural intervention. Particularly in Irvine *et al.*[36], this was the case for measurements just after intervention. Also, Linton *et al.*[41] presented a small effect size. In two cases[32, 33], the results showed a worse situation after intervention than before. In Danquah *et al.*[33], such effect

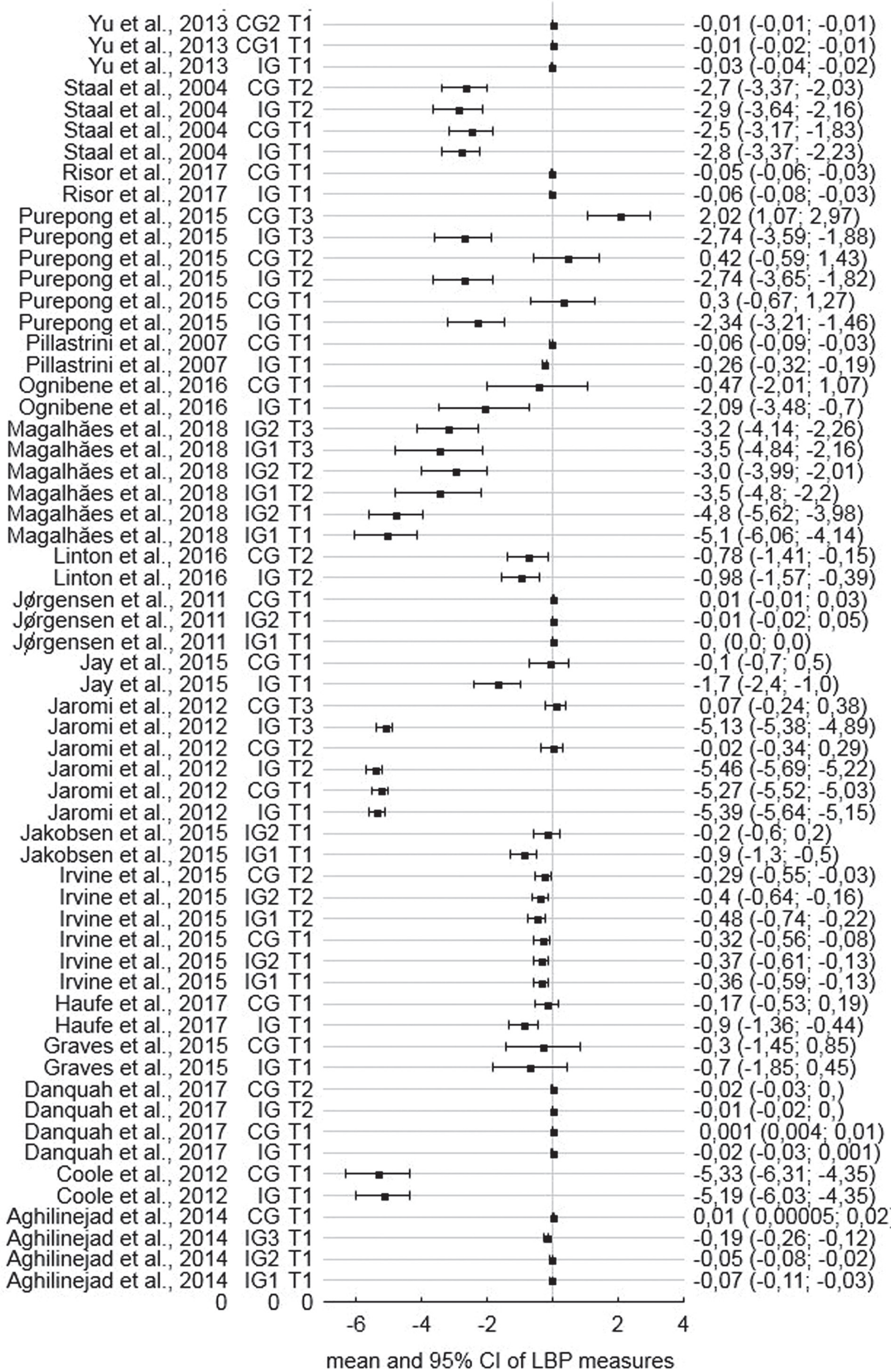

Fig. 2. Differences of outcome measures between measurement pre- and post-intervention (means and 95% CI).

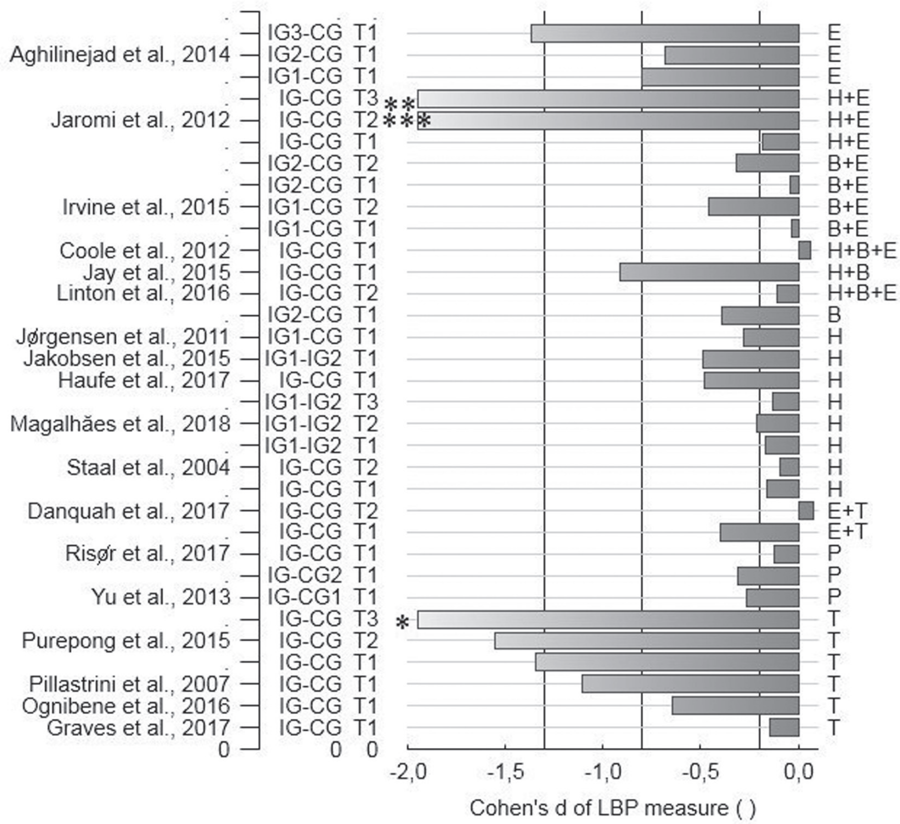

Fig. 3. Effect Size measure (Cohen's d) presenting differences in the effects of intervention between intervention and control groups (the intervention strategies. T: technical; P: participatory; E: educational; H: physical; B: behavioural; IG: intervention group; IC: control group; T1: measurement before intervention; T2, T3: measurements after intervention; *value equals −2.5; **value equals −6.9; * value equals −7.2.**

appeared one month after intervention. Four months after intervention, the effect size was at a low level. The highest effect size was obtained for technical and educational intervention strategies. Not all intervention strategies were related to control groups. In Magalhães *et al.*[42], the comparison between the two IG was low; however, in Jakobsen *et al.*[37] it was medium.

Figure 4 presents weighted average of Cohen's d measure. Figure 4 presents the weighted average calculated for cases presenting a single intervention strategy: technical, participatory, educational, physical or behavioural. Figure 5 presents the weighted average of strategies covering either a technical or a personal strategies including cases with mixed strategies.

Discussion

The aim of the systematic review and analysis presented in this paper was to compare the effects of intervention strategies, and to determine which characteristic features are meaningful from the perspective of reducing LBP. Strategies grouped into two types were compared: technical interventions (any technical or engineering adjustments that included workplace re-design or a reduction in physical work demands) and personal interventions (dealing with the personal capabilities of workers, which can be improved through physical exercise, behavioural modifications or education). The results of the meta-analysis showed strong differences in the effects among interventions types, as well as among different cases within similar intervention strategies. Interventions differed by workstand type, group under intervention, the more or less individualised attitude of personal interventions, the type of physical or behavioural training and teaching techniques. All these elements might have an impact on the effects of intervention. Therefore, apart from intervention strategies, the relation of intervention effects with such factors as LBP severity before intervention and the length of intervention understood in some cases also as the length between two measurement points were also discussed.

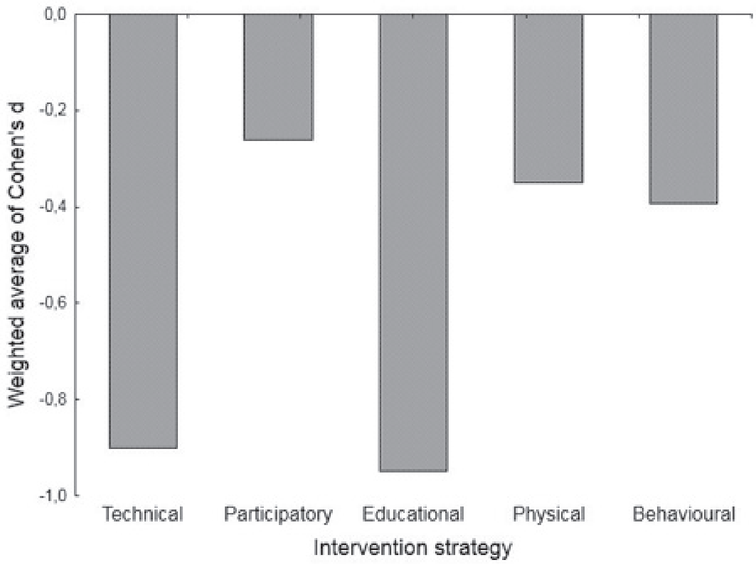

Fig. 4. Weighted average of Cohen's d measure pooled over all technical intervention cases and all personal intervention cases (participatory, educational, physical, behavioural).

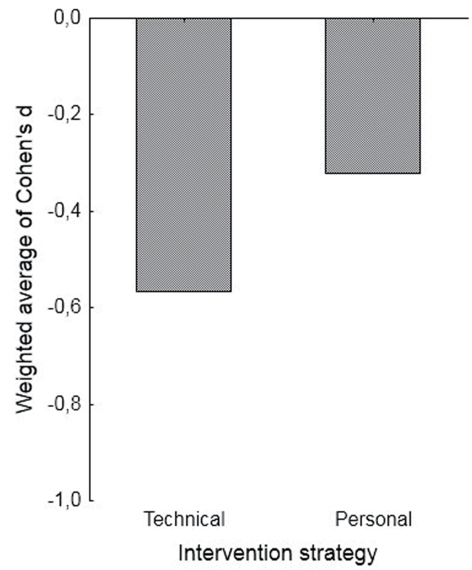

Fig. 5. Weighted average of Cohen's d measure pooled over cases involving one specific intervention strategy only.

Studies that presented technical interventions focused mostly on office workspaces. The results of those studies presented very large to low effect sizes[34, 43-45]. In Purepong *et al.*[45], acupressure backrests were installed onto the office chairs of IG participants. The effect size in this intervention strategy was very large. A different technical intervention strategy was applied in Pillastrini *et al.*[44], during which the IG received an adjustment of its workplace elements. In this case, the effect size was large. The other two studies showed results of intervention that focused on modifications allowing sitting or standing while working[34, 43]. The effect size between these two studies differed, with very low effect for Graves *et al.*[34] to medium in Ognibene *et al*[43]. The review of Stock *et al.*[22] suggests that the time schedule may have a significant effect on reducing symptom intensity in LBP. In all those four studies, participants were free to choose their work schedules and shift between a sitting and standing posture, which could be meaningful for effect size. The results of the intervention in Graves *et al.*[34] and Ognibene *et al.*[43], however, were weaker than in the case of the installation of the workplace acupressure backrest[45] or the workplace elements adjustment[44].

A multi-component approach was present in Danquah *et al.*[33], in which technical adjustments of sit-stand workspaces were just one of five intervention elements. The full intervention included social support, installation of high meeting tables in meeting rooms, offices and corridors, a lecture and a workshop on ergonomics behaviour. The effect size in this study was medium and significantly lower than in the case of studies that also deal with sit-stand workspaces, and where only technical intervention was present. In this study, the reduced sitting time at work was primarily replaced by increased standing time. In Purepong *et al.*[45] and Pillastrini *et al.*[44], the duration of sitting and standing was freely chosen by the study participants. This could suggest that the freely chosen duration of adopting a standing or sitting posture was an important element in reducing LBP development. In Ognibene *et al.*[43] and Graves *et al.*[34], however, participants were also not instructed to use the sit-stand station for a specific time period; however, the effect size of the intervention was small. Thus, the question arises as to which element of the intervention influenced the results strongly enough to result in differences in effect size. In Danquah *et al.*[33], the intervention lasted for one month and the second measurement had a low effect size, but still better that just after the intervention, which lasted for four months. Pillastrini *et al.*[44] had an even longer intervention of up to five months. In Ognibene *et al.*[43], the intervention lasted only for 12 weeks, while in Graves *et al.*[34] for eight weeks. In these three very similar intervention strategies, the effect size is proportional to the length of the intervention. This confirms that the length of intervention is a favourable factor.

It can be assumed that age group characteristics can also play a role in effect size magnitude. All the abovementioned intervention groups were of similar age and a comparison was made between the intervention and control groups. In three cases, the workplace modifications were exactly the same. As such, the severity of LBP prior to intervention could be important. Among those five studies, one presented LBP prevalence as a basic measure[44]. The rest used the VAS ten-point scale[34, 43, 45], while Danquah *et al.*[35] employed a six-point scale. Scores of LBP in Ognibene *et al.*[43], Danquah *et al.*[33] and Purepong *et al.*[45] were on a very similar level. In Graves *et al.*[34], this level was halved. Thus, it can be argued that LBP before intervention can be meaningful for the effect of technical intervention, and the higher the LBP the higher the potential for improvement.

Two papers, presenting three cases of intervention, used participatory ergonomics towards workplace intervention[46, 48]. In Yu *et al.*[48], the IG received participatory training, which focused on learning successful examples from other workplaces and, after inspecting the workplace divided in small groups, employees and management representatives determined the priorities for both immediate and long-term improvement plans. The results for this intervention group were compared with two control groups. Both comparisons resulted in a medium size effect. In the study of Risør *et al.*[46], the IG underwent an ergonomic intervention programme that was developed during workshop sessions with the participation of safety managers, ergonomic experts, a scientist and a project manager. In this study, however, the effect size was small. Intervention in Risør *et al.*[46] was broader and included new patient-handling equipment. Nevertheless, the effect size was stronger in Yu *et al*[48]. In these two studies, the effect size was weaker than in studies with only technical intervention[34, 43, 45]. The fact that pure workplace intervention without participatory ergonomics showed a stronger effect size of intervention is surprising. A systematic review of the literature on the effectiveness of participatory ergonomic interventions for improving workers' health[50] has provided moderate evidence that participatory ergonomic interventions reduce injuries and sick leave. On the contrary, the review of Stock *et al.*[22] showed that participatory ergonomic interventions have low to very low effects. This again suggests that the effectiveness of intervention depends on many factors that are both dependent on the intervention strategy and on the population of the workplace under intervention. In these two studies, the profession of the workers and the prevalence of LBP before intervention differed. In Yu *et al.*[48], this was about 20% higher than in Risør *et al*[46]. Risør *et al.*[46] presented a lower effect size. This can support the thesis that effect size is stronger when there is a higher level of pain before the intervention. In both these studies, the length of the measurement point from the intervention was the same.

Among personal interventions, those that focused on behavioural, physical and/or educational aspects can be distinguished. Intervention strategies aimed at behavioural aspects were presented in studies by Linton *et al.*[41] and Irvine *et al*[36]. In Linton *et al.*[41], IG participants received preventive supervisory intervention based on cognitive behavioural principles to increase their ability to self-manage daily work-related obstacles. There were no measurements taken just after the intervention, until six months later. Irvine *et al.*[36] tested two intervention strategies (a multiple-visit online programme that provides people with LBP education and behavioural strategies to manage pain; and emails with links to websites containing information about LBP). Measurements were taken just after intervention and four months later. A much higher effect size was obtained at the follow-up measurement that was four months after the intervention. A medium effect of the intervention was found in Jørgensen *et al.*[40], who presented two intervention strategies: one included physical exercises and the other cognitive behavioural training. Comparing these two attitudes, behavioural training was more effective than physical exercises. The former had elements similar to trainings in Linton *et al.*[41] with a small effect, and Irvine *et al.*[36] with a medium effect. The differences lay mostly in combining the behavioural programme with education and in the length of the intervention, which in the case of Jørgensen *et al.*[40] was 12 months. The length of time after the intervention also plays a role in effect size. Further, intervention by physical exercise in Jay *et al.*[39] also embraced cognitive elements. In this study, the IG was equipped with individually tailored physical training coupled with cognitive and behavioural training. As a result, the effect size of such training was large. It can then be argued that combining these two types of intervention strategies can yield a synergy effect.

In the case of intervention based on physical exercise, a quite high dispersion of effect size can be noted: large size effect for Jay *et al.*[39]; and low effect for Magalhães *et al.*[42] and Staal *et al*[47]. Intervention by physical exercise in Haufe *et al.*[35] and Jakobsen *et al.*[37] showed a similar medium effect size. In Haufe *et al.*[35], non-supervised exercises, according to exercise planning and guidance by a physiotherapist, were instructed. In Jakobsen *et al.*[37], one intervention group performed supervised exercises at work during working hours and another did so at home at their leisure. This means that Jakobsen *et al.*[37] showed an increased effect of the exercises at home over exercises at work. Also, in the study of Magalhães *et al.*[42] two intervention groups performed physical exercises: physical therapy and graded activity. The graded activity group was treated as the reference and showed a lower effect of intervention than the physical therapy group. Graded activity treatment was also implemented in Staal *et al*[47]. The participants in CG were under usual care. In the case of this study, the effect of the intervention was on a similar level as in the case of Magalhães *et al*[42]. This implies that graded activity is giving a better effect than the lack of any physical therapy; however, it is less effective than physical therapy.

The type of physical exercises can be meaningful. Some review studies have focused on the effectiveness of exercises at reducing pain compared to other treatments. Searle *et al.*[24] found a beneficial effect for strength/resistance and coordination/stabilisation exercise programmes over other interventions in the treatment of chronic lower back pain, where cardiorespiratory and combined exercise programmes are ineffective. In Staal *et al.*[47], the IG performed general exercises (aerobic, abdominal, back and leg exercises) and individually tailored exercises. Also, in the study of Magalhães *et al.*[42], physical exercises aimed at improving physical fitness. These two interventions showed a lower effect size than interventions based on strength exercises in Jakobsen *et al.*[37] and Jørgenssen *et al*[38]. This can support the conclusion that strength exercises are more effective in LBP protection than cardiorespiratory exercises. This can be linked to the fact that relative musculoskeletal load is lower in workers with higher physical capacity. Physical activity that does not increase workers' physical capacity may lead to little or no difference in objectively measured physical activity levels and does not impact LBP[18].

In Aghilinejad *et al.*[31], three intervention groups were educated by pamphlet, lectures or a workshop, and the outcome presented the prevalence of LBP in all three intervention groups with a large size effect. In Jaromi *et al.*[38], where the IG received intervention combining two strategies, e.g. education and physical exercises, the effect just after intervention was small. One year of follow-up differences, however, were large in favour of the education strategy. Compared with Aghilinejad *et al.*[31], where the effect was also tested after one year from the intervention, Jaromi *et al.*[38] showed a size effect, which was about five times stronger. Such an effect was probably due to fact that, in this study, education was expanded by practising ergonomic behaviour and physical exercises. Also, Aghilinejad *et al.*[31] showed that a workshop is much more effective than any other type of education, which can suggest that education by involvement and the practice of good behaviours give good effects. Maher *et al.*[49] suggest that workplace exercise is effective, whereas education intervention strategies are ineffective. This is contrary to the results presented by Jaromi *et al.*[38] and Aghilinejad *et al*[31]. It seems, however, that the benefits of interventions with educational programmes may be dependent on the method of education, but also on social support, encouraging self-management strategies or improving self-efficacy and coping skills[50]. The study shows that education supported by practice is especially effective. In Jaromi *et al.*[38], LBP by VAS, before intervention, was about six in both groups, and in Aghilinejad *et al.*[31] it was about 30% of the population. This means that the population under study was strongly affected by LBP and the size effect of the intervention can be amplified by this fact as well.

Strengths and limitations

The study investigated which intervention content (technical intervention, behaviour therapy, education or physical exercise) provides the greatest improvements. In this view, the influence of such factors as the time of intervention when the outcome measures were tested and the scale of LBP before intervention was also discussed. This review evaluated important outcomes and used well-established methods to assess the impact of intervention. Some weaknesses, however, need to be acknowledged. The strongest limitations of the study are mostly due to the relatively small number of publications that fulfilled the eligibility criteria and intervention type, the populations under study, and the measurement outcomes. Quantitative synthesis was limited to the outcomes of LBP. The eligibility criteria restricted the number of analysed studies but, conversely, made the results more homogeneous and allowed for quantitative assessment.

In the research presented in the analysed articles, LBP was assessed subjectively. There are two limitations here. First, subjective judgments stem from subjectivity in pain ratings, and second, that the definition of LBP may differ from study to study. Most often LBP is defined as pain and discomfort below the costal margin and above the inferior gluteal folds. Specific LBP correlates with a local infection, injury, trauma or structural deformity, whereas in the case of non-specific LBP, no causal pathology is found. This means that the subjective assessment may not have been accurate not only because of differences in subjective perception of pain, but also because of the cause of the pain.

There are aspects of this study that can be considered both as strengths and as limitations. The recalculations of data provided in the papers allowed for quantitative analysis of that data and expanded the number of papers under study. At the same time they could introduced some inaccuracies. The presentation of 18 papers in such a way that allowed results with two different indicators of LBP and different scales to be compared can be counted among the strengths of the study. The application of Cohen's d allowed for the unification and comparison of such results.

Conclusion

Due to the relatively low number of studies and the diversification of interventions even within the same strategy in the studies included, it is difficult to draw unambiguous conclusions as to the effectiveness of one of the three types of intervention. It can only be assumed that a specific programme component or a set of components drives effectiveness. Nevertheless, analysis of the reviewed studies suggests that the most effective strategies for LBP prevention are technical modifications of the workstand and education combined with practical training. Behavioural and physical training as methods of workplace intervention are of low impact on the reduction of LBP. More effective in this respect are strength exercises rather than cardiorespiratory ones. The results of the analysis support the argument that the timing of the intervention and especially the time lapsed after it, when measurements take place, favour intervention effects. LBP severity before intervention plays an important role in the effect size, which becomes more obvious in a worker population with stronger LBP. It seems that larger studies with explicit consideration of other factors that may influence intervention effectiveness are crucial for the evaluation of the effectiveness of intervention strategies.

Acknowledgements

The paper is based on the results of a research task carried out within the scope of the project Back-Up: Personalised Prognostic Models to Improve Well-being and Return to Work After Neck and Low Back Pain. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 777090.

References

1) Delitto A, George SZ, Van Dillen L, Whitman JM, Sowa G, Shekelle P, Denninger TR, Godges JJ, Orthopaedic Section of the American Physical Therapy Association (2012) Low back pain. J Orthop Sports Phys Ther **42**, A1–57.
2) Bernal D, Campos-Serna J, Tobias A, Vargas-Prada S, Benavides FG, Serra C (2015) Work-related psychosocial risk factors and musculoskeletal disorders in hospital nurses and nursing aides: a systematic review and meta-analysis. Int J Nurs Stud **52**, 635–48.
3) Dianat I, Kord M, Yahyazade P, Karimi MA, Stedmon AW (2015) Association of individual and work-related risk factors with musculoskeletal symptoms among Iranian sewing machine operators. Appl Ergon **51**, 180–8.
4) Alamam DM, Moloney N, Leaver A, Alsobayel HI, Mackey MG (2019) Multidimensional prognostic factors for chronic low back pain-related disability: a longitudinal study in a Saudi population. Spine J **19**, 1548–58.
5) Abdul Rahman H, Abdul-Mumin K, Naing L (2017) Psychosocial factors, musculoskeletal disorders and work-related fatigue amongst nurses in Brunei: structural equation model approach. Int Emerg Nurs **34**, 17–22.
6) Bevan S (2015) Economic impact of musculoskeletal disorders (MSDs) on work in Europe. Best Pract Res Clin Rheumatol **29**, 356–73.
7) Buchbinder R, Blyth FM, March LM, Brooks P, Woolf AD, Hoy DG (2013) Placing the global burden of low back pain in context. Best Pract Res Clin Rheumatol **27**, 575–89.
8) Saragiotto BT, Maher CG, Yamato TP, Costa LO, Costa LC, Ostelo RW, Macedo LG (2016) Motor control exercise for chronic non-specific low-back pain. A Cochrane Review. Spine **41**, 1284–95.
9) Zis P, Bernali N, Argira E, Siafaka I, Vadalouka A (2016) Effectiveness and impact of capsaicin 8% patch on quality of life in patients with lumbosacral pain: an open-label study. Pain Physician **19**, E1049–53.
10) Safari H, Ebrahimi E (2014) Using modified similarity multiple criteria decision making technique to rank countries in terms of human development index. J Ind Eng Manag **7**, 254–75.
11) Antwi–Afari MF, Li H, Edwards DJ, Pärn EA, Oh Seo JO (2017) Effects of different weights and lifting postures on balance control following repetitive lifting tasks in construction workers. Autom Construct **83**, 41–7.
12) Umer W, Li H, Szeto GPY, Wong AYL (2017) Identification of biomechanical risk factors for the development of lower–back disorders during manual rebar tying. J Constr Eng Manag. **143(1)**,1943–7862.
13) Sjøgaard G, Justesen JB, Murray M, Dalager T, Søgaard K (2014) A conceptual model for worksite intelligent physical exercise training—IPET—intervention for decreasing life style health risk indicators among employees: a randomized controlled trial. BMC Public Health **14**, 652.
14) Gordon R, Bloxham S (2016) A systematic review of the

effects of exercise and physical activity on non–specific chronic low back pain. Healthcare (Basel) **4**, E22.
15) Tschentscher M, Niederseer D, Niebauer J (2013) Health benefits of Nordic walking: a systematic review. Am J Prev Med **44**, 76–84.
16) Hall A, Richmond H, Copsey B, Hansen Z, Williamson E, Jones G, Fordham B, Cooper Z, Lamb S (2018) Physiotherapist-delivered cognitive-behavioural interventions are effective for low back pain, but can they be replicated in clinical practice? A systematic review. Disabil Rehabil **40**, 1–9.
17) Iwakiri K, Sotoyama M, Takahashi M, Liu X, Koda S, Ichikawa K (2018) Effectiveness of re-education based on appropriate care methods using welfare equipment on the prevention of low back pain among care workers: a 1.5 year follow-up study. Ind Health **56**, 419–26.
18) Zamri EN, Hoe VCW, Moy FM (2020) Predictors of low back pain among secondary school teachers in Malaysia: a longitudinal study. Ind Health **58**, 254–64.
19) Patti A, Bianco A, Paoli A, Messina G, Montalto MA, Bellafiore M, Battaglia G, Iovane A, Palma A (2015) Effects of Pilates exercise programs in people with chronic low back pain: a systematic review. Medicine (Baltimore) **94**, e383.
20) Oliveira CB, Franco MR, Maher CG, Christine Lin CW, Morelhão PK, Araújo AC, Negrão Filho RF, Pinto RZ (2016) Physical activity interventions for increasing objectively measured physical activity levels in patients with chronic musculoskeletal pain: a systematic review. Arthritis Care Res (Hoboken) **68**, 1832–42.
21) Van Hoof W, O’Sullivan K, O’Keeffe M, Verschueren S, O’Sullivan P, Dankaerts W (2018) The efficacy of interventions for low back pain in nurses: a systematic review. Int J Nurs Stud **77**, 222–31.
22) Stock SR, Nicolakakis N, Vézina N, Vézina M, Gilbert L, Turcot A, Sultan-Taïeb H, Sinden K, Denis MA, Delga C, Beaucage C (2018) Are work organization interventions effective in preventing or reducing work-related musculoskeletal disorders? A systematic review of the literature. Scand J Work Environ Health **44**, 113–33.
23) Driessen MT, Proper KI, van Tulder MW, Anema JR, Bongers PM, van der Beek AJ (2010) The effectiveness of physical and organisational ergonomic interventions on low back pain and neck pain: a systematic review. Occup Environ Med **67**, 277–85.
24) Searle A, Spink M, Ho A, Chuter V (2015) Exercise interventions for the treatment of chronic low back pain: a systematic review and meta-analysis of randomised controlled trials. Clin Rehabil **29**, 1155–67.
25) Brewer S, Van Eerd D, Amick BC 3rd, Irvin E, Daum KM, Gerr F, Moore JS, Cullen K, Rempel D (2006) Workplace interventions to prevent musculoskeletal and visual symptoms and disorders among computer users: a systematic review. J Occup Rehabil **16**, 325–58.
26) Richards MC, Ford JJ, Slater SL, Hahne AJ, Surkitt LD, Davidson M, McMeeken JM (2013) The effectiveness of physiotherapy functional restoration for post-acute low back pain: a systematic review. Man Ther **18**, 4–25.
27) Higgins JPT, Green S (Eds.) Cochrane handbook for systematic reviews of interventions. Wiley, 2008.
28) Clopper C, Pearson ES (1934) The use of confidence or fiducial limits illustrated in the case of the binomial. Biometrika **26**, 404–13 .
29) Online Statistics Education A Multimedia Course of Study. Project Leader: David M. Lane, Rice University. http://onlinestatbook.com/.
30) Lipsey M, Wilson D (2001) Practical meta-analysis. Sage, Thousand Oaks.
31) Aghilinejad M, Bahrami-Ahmadi A, Kabir-Mokamelkhah E, Sarebanha S, Hosseini HR, Sadeghi Z (2014) The effect of three ergonomics training programs on the prevalence of low-back pain among workers of an Iranian automobile factory: a randomized clinical trial. Int J Occup Environ Med **5**, 65–71.
32) Coole C, Drummond A, Watson PJ (2013) Individual work support for employed patients with low back pain: a randomized controlled pilot trial. Clin Rehabil **27**, 40–50.
33) Danquah IH, Kloster S, Holtermann A, Aadahl M, Tolstrup JS (2017) Effects on musculoskeletal pain from “Take a Stand!”—a cluster-randomized controlled trial reducing sitting time among office workers. Scand J Work Environ Health **43**, 350–7.
34) Graves LEF, Murphy RC, Shepherd SO, Cabot J, Hopkins ND (2015) Evaluation of sit-stand workstations in an office setting: a randomised controlled trial. BMC Public Health **15**, 1145.
35) Haufe S, Wiechmann K, Stein L, Kück M, Smith A, Meineke S, Zirkelbach Y, Rodriguez Duarte S, Drupp M, Tegtbur U (2017) Low-dose, non-supervised, health insurance initiated exercise for the treatment and prevention of chronic low back pain in employees. Results from a randomized controlled trial. PLoS One **12**, e0178585.
36) Irvine AB, Russell H, Manocchia M, Mino DE, Cox Glassen T, Morgan R, Gau JM, Birney AJ, Ary DV (2015) Mobile-Web app to self-manage low back pain: randomized controlled trial. J Med Internet Res **17**, e1.
37) Jakobsen MD, Sundstrup E, Brandt M, Andersen LL (2018) Effect of physical exercise on musculoskeletal pain in multiple body regions among healthcare workers: Secondary analysis of a cluster randomized controlled trial. Musculoskelet Sci Pract **34**, 89–96.
38) Jaromi M, Nemeth A, Kranicz J, Laczko T, Betlehem J (2012) Treatment and ergonomics training of work-related lower back pain and body posture problems for nurses. J Clin Nurs **21**, 1776–84.
39) Jay K, Brandt M, Hansen K, Sundstrup E, Jakobsen MD, Schraefel MC, Sjogaard G, Andersen LL (2015) Effect of individually tailored biopsychosocial workplace interventions on chronic musculoskeletal pain and stress among laboratory technicians: randomized controlled trial.

Pain Physician **18**, 459–71.

40) Jørgensen MB, Faber A, Hansen JV, Holtermann A, Søgaard K (2011) Effects on musculoskeletal pain, work ability and sickness absence in a 1-year randomised controlled trial among cleaners. BMC Public Health **11**, 840.
41) Linton SJ, Boersma K, Traczyk M, Shaw W, Nicholas M (2016) Early workplace communication and problem solving to prevent back disability: results of a randomized controlled trial among high-risk workers and their supervisors. J Occup Rehabil **26**, 150–9.
42) Magalhães MO, Comachio J, Ferreira PH, Pappas E, Marques AP (2018) Effectiveness of graded activity versus physiotherapy in patients with chronic nonspecific low back pain: midterm follow up results of a randomized controlled trial. Braz J Phys Ther **22**, 82–91.
43) Ognibene GT, Torres W, von Eyben R, Horst KC (2016) Impact of a sit-stand workstation on chronic low back pain: results of a randomized trial. J Occup Environ Med **58**, 287–93.
44) Pillastrini P, Mugnai R, Farneti C, Bertozzi L, Bonfiglioli R, Curti S, Mattioli S, Violante FS (2007) Evaluation of two preventive interventions for reducing musculoskeletal complaints in operators of video display terminals. Phys Ther **87**, 536–44.
45) Purepong N, Channak S, Boonyong S, Thaveeratitham P, Janwantanakul P (2015) The effect of an acupressure backrest on pain and disability in office workers with chronic low back pain: a randomized, controlled study and patients' preferences. Complement Ther Med **23**, 347–55.
46) Risør BW, Casper SD, Andersen LL, Sørensen J (2017) A multi-component patient-handling intervention improves attitudes and behaviors for safe patient handling and reduces aggression experienced by nursing staff: a controlled before-after study. Appl Ergon **60**, 74–82.
47) Staal JB, Hlobil H, Twisk JW, Smid T, Köke AJ, van Mechelen W (2004) Graded activity for low back pain in occupational health care: a randomized, controlled trial. Ann Intern Med **140**, 77–84.
48) Yu W, Yu IT, Wang X, Li Z, Wan S, Qiu H, Lin H, Xie S, Sun T (2013) Effectiveness of participatory training for prevention of musculoskeletal disorders: a randomized controlled trial. Int Arch Occup Environ Health **86**, 431–40.
49) Maher CG (2000) A systematic review of workplace interventions to prevent low back pain. Aust J Physiother **46**, 259–269.
50) Rivilis I, Van Eerd D, Cullen K, Cole DC, Irvin E, Tyson J, Mahood Q (2008) Effectiveness of participatory ergonomic interventions on health outcomes: a systematic review. Appl Ergon **39**, 342–58.