A systematic review on workplace interventions to manage chronic musculoskeletal disorders

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Original citation & hyperlink:
Skamagki, G, King, A, Duncan, M & Wahlin, C 2018, 'A systematic review on workplace interventions to manage chronic musculoskeletal disorders' Physiotherapy Research International, vol. 23, no. 4, e1738.
https://dx.doi.org/10.1002/pri.1738

DOI 10.1002/pri.1738
ISSN 1358-2267
ESSN 1471-2865

Publisher: Wiley

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ABSTRACT

Background and Purpose: A review to investigate whether there are effective workplace interventions that manage chronic musculoskeletal disorders.

Methods: The literature search included published articles between 2008 and 2017. The databases used in this search were MEDLINE, Scopus, CINAHL, AMED, PsycINFO, Academic Search Complete, Cochrane, and PEDro. A limited search on websites for relevant grey literature was also conducted.

Results: The review included 12 studies that investigated effectiveness of a specific strength exercise programme or interventions provided by health professionals at the workplace when compared with controls or interventions not at the workplace. Seven studies were classified as high quality (>85% of criteria met) and five studies were classified as acceptable. Studies were heterogeneous preventing a meta-analysis. No intervention was clearly superior to another.

Discussion: There was some consistency in the results of the selected studies, suggesting that workplace interventions such as high-intensity strength exercises and/or integrated health care can decrease pain and symptoms for employees who experience long-term musculoskeletal disorders. However, the current research is limited.

Key Words: Chronic Musculoskeletal Disorders, Management, Systematic Review, Workplace

INTRODUCTION

A healthy work environment influences the physical, mental and socioeconomic behaviours of its employees (Waddell & Burton, 2006) and can promote the well-being of their families and communities. It can also increase productivity, and reduce absenteeism or presenteeism (the practice of coming to work with an injury or medical condition) (Johns, 2009; Tehrani, Humpage, Willmott, & Haslam, 2007). The focus of this review is the workplace, as the place for providing management and treatment for employees who have long-term musculoskeletal disorders.

Musculoskeletal disorders (MSDs) cover a heterogeneous range of health conditions such as low back pain and upper or lower limb injuries, which have a big impact on productivity (Buckley, 2015; Walker-Bone & Linaker, 2016). Long-term musculoskeletal disorders have an even greater impact on people’s lives as they are a source of long-term pain and increase the number of lost working days (Arthritis Reasearch UK, 2014; Arthritis Research UK, 2017; McGee, Bevan, & Quadrello, 2011). ‘Long-term musculoskeletal disorders’ are those that do not resolve and have a long-term or progressive course (Goodwin & Naylor, 2010). ‘Chronic’ is defined in this paper as conditions that have lasted for over three months. The World Health Organization (WHO) has highlighted that long-term and chronic conditions require continuous management over many years or decades (World Health Organization, 2002). The morbidity cost is notable as stretched health care services around the world face further financial pressures due to increasing numbers of people affected by chronic MSDs (MacKenzie and de Melo-Martin 2015). In addition, the aging workforce in Europe will mean increasing numbers of these people in the workforce, with implications for health care.

Worldwide, a variety of models and recommendations have been suggested to shift the need for healthcare and sick leave from the healthcare system to the employer (McGillivray, 2005; NICE, 2015; Wynne-Jones, Mallen, Mottram, Main, & Dunn, 2009). Some of these models have been tried without success: for example in the UK, workplace capability assessments were unsuccessful (Safety and Health Practitioner, 2016). But lack of effectiveness may have been due to employer and employee ignorance of their roles in managing those chronic conditions.

The WHO (WHO, 2016) has identified three main categories of health interventions that can be used to manage the risk of MSDs at the workplace. These categories relate to prevention, return to work, and long-term management, and can include specific services, actions or products developed and implemented to change or improve health, behaviors and awareness. A variety of Cochrane systematic reviews have summarised scientific evidence about the effectiveness of workplace interventions for the first two categories, prevention and return to work (Aas, Tuntland, Ka, Røe, & Labriola, 2009, 2011; Mulimani et al., 2014; Parry, Coenen, O'Sullivan, Maher, & Straker, 2017; Rla, Cumpston, Peeters, & Sa, 2013; Shrestha, Ijaz, Kt, Kumar, & Cp, 2015). This study focuses on the third category (Proper et al., 2003) which includes management at the workplace of individuals with existing conditions. The aim of this systematic review was to identify the workplace management strategies for individuals with existing long-term musculoskeletal disorders and to highlight whether these interventions are effective.

MAIN TEXT

Methods

Search strategy

This review used methods from traditional systematic review approaches (Cochrane Handbook for Systematic Reviews of Interventions) for the literature search phase, and then assessed, analysed and synthesised the relevant data (Higgins & Green, 2011). The PICO approach was used to structure the research question (Table 1) and identify the inclusion and exclusion criteria (Stern, Jordan, & McArthur, 2014).

The literature search included articles that were published between 2008 and 2017. The strategy searched MEDLINE, CINAHL, AMED, Cochrane, PsycINFO, Academic Search Complete and PEDro (Appendix 1). A limited search for Grey literature examined relevant websites including the Institute for Work and Health, the Return to Work Knowledge, the Institution of Occupational Safety and Health, and the European Agency for Safety and Health at Work. Search strategies used Boolean operators (AND/OR/NOT), Subject Headings, alternative spellings, acronyms, and wild cards. In addition, Scopus was used to perform post-publication citation searching on identified articles.

Selection of studies

Eligibility criteria

Inclusion criteria

The primary criterion was the testing of effectiveness of workplace interventions to manage employees with long-term multi-joint conditions and chronic musculoskeletal disorders (12 weeks or more). Participants' age was between 18-68 years (common working age range) and both males and females were included. Interventions included strategies or specific activities that were conducted individually or in groups to manage chronic MSDs. The period searched was from 2008 to the present, since scoping searches indicated that earlier studies were of a very low quality (Aas et al., 2009, 2011; Hoe, Urquhart, Kelsall, & Sim, 2012) and focused on prevention and return to work rather than management.

Exclusion criteria

Workplace interventions focusing purely on prevention and return-to-work strategies were not included in this review. This review excluded studies including people with acute MSDs or other serious pathologies (Blangsted, Søgaard, Hansen, Hannerz, & Sjøgaard, 2008), and those which did not aim to compare the effectiveness of the interventions used in the workplace arena. In addition, guidelines, policies and other recommendations were also excluded. The inclusion and exclusion criteria used in this review are summarised in Table 2.

Outcome

The review's outcomes of interest are symptom modification, pain severity, presenteeism, and sickness absence at individual, worksite and service level, reflecting the ICF focus on function and disability (WHO, 2001). Some outcomes can be only measured subjectively (e.g. pain or presenteeism), so it is important to analyse other outcomes like sickness absence that can be observed objectively.

Data collection

The titles and abstracts of all identified studies were collected and duplicates were removed before study selection. Data from the relevant studies were extracted independently by two reviewers; characteristics of studies were collected including study design, country where intervention was implemented, participant details, type of intervention, outcome measures and results.

Risk of bias assessment

Many critical appraisal systems and tools are available and can be used to assess the rigour of the design, the strength of the resulting evidence and the implementation of the identified studies. However, disagreement between researchers is common, since differences in intention, components, construction and psychometric properties of published critical appraisal tools for research reports have been identified (Katrak, Bialocerkowski, Massy-Westropp, Kumar, & Grimmer, 2004). Since there is no "gold standard" critical appraisal tool (Katrak et al., 2004), a systematic and transparent approach was used to assess both internal and external validity of the studies, identify their relevance to practice, prevent errors, and facilitate judgments (Figure 1). A recent review of the grading systems produced by medical specialties (Baker, Young, Potter, & Madan, 2010), highlighted that the Scottish Intercollegiate Guidelines Network (SIGN) can be selected and used for RCTs as it is an established and validated tool. The SIGN tool (checklist and an explanation sheet) was selected for this review. The overall assessment of the strength of the evidence within each paper was based on grading criteria of "(+) acceptable", "(++) high quality", "(-) low quality" or "(0) un-acceptable/reject".

RESULTS

Selection of studies

Studies selected were published between 2008 and 2017. One of the advantages of reviewing studies conducted after 2008 was the higher quality of the RCTs identified. The search identified 257 references, 21 references in AMED, 108 in Academic Search Complete, 36 in MEDLINE, 29 in CINAHL, 18 references in PsycINFO, 10 in COCHRANE, 17 references in Scopus, and 18 references in PEDro. After removing duplicates, 159 references remained (Figure 1). The titles and abstracts were reviewed and, when needed, the full-text articles were read. The full text of 29 articles was obtained but only nine were included in the review, as none of the others met the inclusion and exclusion criteria. Hand-searching the reference lists identified nine more studies that were also assessed; however only three of them were included in the final review. In summary, 12 articles were included in the review and consensus on the final results was achieved by a second researcher (AK) who reviewed and replicated the search strategy identifying the same results.

Study characteristics

Of the 12 selected studies one study was conducted in the USA, 8 in Denmark, one in Finland and two in the Netherlands. All studies followed a randomised or a cluster randomised controlled trial design, and ethical approval was granted from local ethics committees. There were no differences within studies in the baseline characteristics of groups of participants (except in Zebis et al. 2011). Detailed inclusion and exclusion criteria were outlined to ensure patient safety and homogeneity. The characteristics of studies for this review are presented in Table 3.

Quality appraisal

The quality of evidence for each outcome was assessed using the SIGN tool for the appraisal of RCTs. Seven studies were classified as (++) high quality (>85% of criteria met) and 5 studies were classified as (+) acceptable. Overall, the studies were of a very good quality (table 4), minimising the risk of bias for the 'true' effect of the interventions. Randomisation was achieved with either preratification, labelled paper and selection from an opaque plastic or with random computer-generated numbers. Participants were randomly allocated into clusters with the use of a computer-generated random numbers table and only one study used a coin toss (Zebis et al., 2011). All the authors conducted a power analysis identifying the appropriate sample size that would detect a 15% or a 10% change for the selected outcome. However, in one study the drop-out rates reached almost 40% leading to limited interpretation of findings (Hutting et al., 2015). The primary outcome measures were clearly stated in the studies. Patient outcomes were analysed per the group to which they were originally allocated, but in one study (Jay et al., 2011) analysis was based solely on participants who completed the trial. Lastly, statistical analysis was clearly explained, and appropriate values were given in most of the studies in both texts and tables. Some of the studies only provided results on histograms making it difficult to identify the true values (Blangsted et al., 2008; Lambeek et al., 2010). Other the studies identified more outcomes such as job satisfaction rates, psychological well-being, which are not included in this review. The quality appraisal of the studies is presented in Table 4.

Outcome measures

The outcome measures identified and reviewed for this study were pain and function (Numeric Pain Rating Scales, Revised Arthritis Impact Measurement Scales), absenteeism/sick leave days (Work Ability Index Score, DASH work module), Health status (DASH general module) and presenteeism (Stanford Presenteeism Scale). These are reliable, validated and responsive instruments that can be used in an occupational health care setting (Meenan, Mason, Anderson, Guccione, & Kazis, 1992; Roy et al., 2011; Tuomi, Ilmarinen, Jahkola, Katajarinne, & Tulkki, 1998; Williamson & Hoggart, 2005).

The interventions and the outcomes of the studies are presented in Table 5. Some studies were explicitly interested in the workplace venue: for example, Jakobsen (2015) compared strength training at the workplace with physical exercise in the home. Other studies were looking at the workplace primarily as the venue for a form of intervention such as strength training to be compared with another intervention: for example, Andersen's group (2012) looked at three different exercise regimes all provided at the workplace, but also included a no physical training control group. In this study, between groups comparisons with the control group would have been useful, but these were not available. Because of the nature of the study design it would be difficult to draw any conclusions about the benefits of the workplace as a venue over any other venues for interventions.

Effectiveness of the interventions

Effect of different physical exercise interventions at the workplace

Two studies, (L. L. Andersen et al., 2008, 2010) investigated the effect of different physical exercise interventions on musculoskeletal pain in all regions of the body and their association with specifically the neck and the shoulder. As an example, in one of these studies (L. L. Andersen et al., 2010), 549 office workers were allocated to 3 separate groups;

a specific resistance training group (dumbbell exercises of front raise, lateral raise, reverse flies, shrugs and wrist extension), an all-around exercise group and a reference intervention group. The results demonstrated that pain for the strength training group decreased with a statistically significant difference for neck pain ($p<0.01$–0.05). The authors of these studies conducted another randomised controlled trial (Andersen et al., 2012) to measure the effects of strength training in three different regimes (the first group trained for 1 hour per week, the second group trained 20 minutes three times a week and the 3rd group trained 7 minutes nine times a week). The results demonstrated reduction ($p<0.005$) of neck and shoulder pain in office workers for the weekly one-hour program.

A study by the same team (Zebis et al., 2011) evaluated the effect of a strength training intervention at the workplace on non-specific neck and shoulder pain among industrial workers, highlighting a reduction of pain in the intervention group. However, despite randomisation, baseline differences between groups were found for pain intensity which may have affected the outcome of this study. Another study investigated a different strength exercise training program for the management of chronic musculoskeletal pain at the workplace (Jay et al., 2011) and showed that progressive kettlebell training 3 times per week can reduce the pain intensity of neck and shoulder ($p<0.02$) and the pain intensity of the lower back ($p<0.05$). In addition, more studies from Denmark (Blangsted et al., 2008) demonstrated the reduction in intensity ($p<0.0318$) and duration of the pain ($p<0.0565$) of a resistance training group and an all-around physical exercise group compared to a reference group (general health-promoting activities not including physical activity). However, no significant changes were identified between the different active interventions (e.g. Nordic walking and running, step count).

Effect of physical exercise interventions at the workplace compared to other interventions

Jakobsen et al., (2015) investigated the effectiveness of a workplace versus a home-based exercise program for chronic musculoskeletal neck and back pain conditions. The 200 participants were allocated into two groups and were encouraged to perform a strengthening exercise program (TheraBand, kettlebells) at the workplace for 10 weeks whereas the control group performed physical exercises at their houses following instructions and recommendations from illustrated posters. Although results showed a significant decrease in pain for both groups ($p<0.0001$), the workplace chronic MSD group experienced higher reduction of pain compared with the control group ($p=0.003$). Baldwin et al., (2012) compared the use of a self-management manual at home with the use of the same self-management manual at the workplace in combination with an individual ergonomic intervention. Employees with rheumatoid arthritis (RA) and osteoarthritis (OA) followed an intervention that consisted of workstation equipment modifications, person-specific exercises, postural control or lifestyle changes given by an occupational therapist trained in ergonomics. The results demonstrated only a within-group statistically significant improvement in physical functioning and pain for the workplace treatment group after a 12 month ($p < 0.04$) and 24 months ($p < 0.01$). The results however could have been affected by the heterogeneity in pain intensity and the varying severity of RA and OA at the beginning of the study.

Effect of usual care /ergonomics at the workplace compared to other interventions

Hutting et al., (2015) compared a self-management program with a usual care group at the workplace and identified significant differences in work-status ($p=0.04$) measured by the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire. However, no significant differences emerged from the study for pain intensity and functional status. Sundstrup et al., (2014), compared a strength training program to an ergonomic training and education program among slaughterhouse workers with chronic musculoskeletal pain. Similarly, no significant differences in pain and function were identified between or within the two groups during the 10 weeks of testing. Interestingly, the overall score of the Work Ability Index in the ergonomic group got worse after the intervention ($p = 0.012$) but the authors have challenged this conclusion as the ergonomic program was based on worksite analysis and a health and safety systems developed by managers rather than health professionals with specific knowledge and training in occupational health. In a different study a physiotherapist assessed the effect of an ergonomic intervention on pain and sickness absence caused by upper-extremity musculoskeletal disorders (Shiri et al., 2011). There was a decrease in pain intensity ($p<0.05$) in the first two weeks but no significant differences at the end of a yearly follow up. Unfortunately, this study experienced a lot of drop-outs and loss of participants at follow-up which could have affected the results. The use of specific health professionals in this study is echoed by Lambeek et al., (2010) that assessed the effectiveness of integrated care with usual care at the workplace for employees with chronic low back pain. All the workplace interventions were provided by health care professionals, such as a clinical occupational physician, a manual therapist, an occupational therapist and a physiotherapist. Although pain and functional status improved in both two groups, the integrated care group demonstrated statistically significant improvement ($p<0.001$) regarding the functional status.

DISCUSSION

The current review gathered and synthesised updated evidence from the scientific literature to identify the workplace management strategies for individuals with existing chronic musculoskeletal disorders, and investigated their effectiveness. Studies included in this review were assessed for bias and were also rated for their quality. Twelve studies were categorised with high or acceptable quality and they were selected for the final review. The RCTs included were highly heterogeneous: they varied in the type of interventions, type of jobs and outcome measures. The conclusion of this systematic review is that the use of physical activity and/or the integrated health care at the workplace can decrease pain and symptoms for employees who experience chronic musculoskeletal disorders. Findings of these studies highlighted that the type of the exercise program used, the way of delivery and the regime may affect the outcome. An example providing supervised exercise and supplementary manuals for self-management, telephone calls for reinforcement and face-to-face instructions with other supplements showed a positive influence on levels of pain, function, motivation and lifestyle changes. The use of a specific strength exercise program appeared to have better effects on pain and functional activity in comparison to other types of exercises, but all the exercise programs at the workplace showed within-group improvements.

A few systematic reviews (Aas et al., 2011; Hoe et al., 2012; Mischke et al., 2013; Mulimani et al., 2014) have assessed the effects of workplace ergonomic training interventions or exercise interventions, but focus only on the prevention of MSK conditions. Similarly, peer-reviewed literature (Hoe et al., 2012; Menta et al., 2015; Nastasia, Coutu, & Tcaciuc, 2014) regarding workplace prevention of upper limb musculoskeletal disorders described a variety of interventions of which only a few showed effectiveness (e.g. resistance training, stretching or forearm support). These results were inconclusive due to the inclusion of low quality RCTs, poor internal validity and lack of generalisability to the wider population.

Levels of evidence for specific ergonomic interventions emerged also from another systematic review (Leyshon, 2010) for office workers with musculoskeletal disorders.

There was also poor evidence to suggest that self-management programmes are effective in improving pain and managing MSDs at the workplace, while in some studies the improvement rate dropped after a year (Blangsted et al., 2008; Hutting et al., 2015; Jay et al., 2011). On the other hand, the review found positive changes in pain perception and intensity in response to strength training. However, other type of interventions that could affect pain were not identified in the literature. As an example, cognitive behavioural therapy has not been evaluated in a lot of RCTs and results from some moderate quality studies do not show effectiveness when CBT is applied alone (Basler, Bertalanffy, Quint, Wilke, & Wolf, 2007; Jørgensen, Faber, Hansen, Holtermann, & Søgaard, 2011). Nevertheless, the present review identified a number of studies that recorded improvements in pain levels and functional status following a structured and well-delivered exercise programme at the workplace among employees with chronic musculoskeletal pain.

Another important finding from this review was the significant improvement in functional status and the decrease in pain with the use of a workplace integrated care program by an allied health professional (e.g. physiotherapist, occupational therapist with ergonomic training). Our review concluded that the use of private medical insurance with direct access or other health care services at the workplace (e.g. physiotherapy services) can have a positive effect in managing long-term MSDs (e.g. Lambeek et al.,2010, Shiri et al., 2011) but further research is necessary to investigate the success of those programs in the health care environment of different countries. In some countries like the Netherlands the implementation of a workplace program would not be difficult as the costs of workplace interventions are covered by the patient's health insurance. In other countries implementation could be more problematic without financial support by the government or employers.

Additionally, healthcare professionals, like physiotherapists, are able to provide a well-structured exercise program as part of their role. It is well recognised that a physiotherapist could be suitable equipped to manage chronic conditions and help employees to remain healthy at work (Johnston & Shaw, 2013). But, there is as yet no evidence to show the effectiveness of physiotherapy at the workplace. The grey literature has identified some one-off successes in individual workplaces, but it is unknown if all branches of the same company follow the same protocol, if there are long-term results of the interventions or if these workplaces are still providing the service.

Four studies in the review used self-management strategies either as the primary intervention (Hutting et al., 2015) or as a control group (L. L. Andersen et al., 2008, 2010; Baldwin et al., 2012). Self-management programmes can include leaflets and manuals, e-learning modules to prepare people to manage their health conditions or change their lifestyle. There were no significant differences in any of the selected outcome between the groups but a small improvement was found within the self-management group. Although self-management strategies are cost effective (Haas et al., 2005), there is still poor evidence on the effectiveness of these programs for people with chronic MSDs (Nolte & Osborne, 2013).

Sick leave was measured in some of the studies included (Baldwin et al., 2012; Shiri et al., 2011; Sundstrup et al., 2016) but there were no significant differences after the completion or at follow-up. One possible explanation would be that the intensity or frequency of the interventions did not meet the level that would result in a positive effect on reducing sick leave. Another explanation could be that the population size was not big enough for a change or the fact that pain level in these studies was also very different in the beginning of each experiment. One study has shown that workers with higher aerobic capacity had a higher Work Ability Index (WAI) score ($p<0.004$) and thereby a decreased risk of having a sick leave episode (Strijk et al., 2011). However, this was an observational study based on the fact that high levels of aerobic capacity are associated with a reduced incidence of chronic diseases and therefore might be associated with reduced sick leave (Kellett, Kellett, & Nordholm, 1991; Macedo, Oakley, Panayi, & Kirkham, 2009). On the other hand, one study (Sundstrup et al., 2014) found an important deterioration of the employees' Work Ability Index score results following ergonomic interventions at the workplace implemented by employers/managers and not by health professionals. Their results question the role of employers and line managers in this process. Similarly, presenteeism was measured (Hutting et al., 2015) only in one study without showing important improvements in the decrease of this phenomenon.

Recent research has focused on the effectiveness of interventions in community and workplace settings to reduce sick leave and job loss among workers with musculoskeletal disorders (Palmer et al., 2012). The current study has separated the workplace interventions found at individual, worksite and service level from workplace ergonomic interventions and/or psychosocial risk assessments, control of the workplace risks, ergonomic changes to the work environment and advice offered by employers. The results of this systematic review agree with the conclusions of previous systematic reviews (Maher, 2000; Palmer et al., 2015; Rw, Tuntland, Ka, Røe, & Labriola, 2010) and suggest that a physical activity program and/or integrated care at the workplace can be effective in the management of chronic MSK disorders. In addition, the studies in this review showed also clinically and significantly important differences in favour of some secondary outcomes for the workplace groups such as well-being, job satisfaction, desire to exercise, energy for family and friends, motivation to eat better and socializing more with their colleagues.

STUDY STRENGTHS AND LIMITATIONS

A rigorous systematic search of the literature from 2008 to March 2017 was used to examine study design, biases, outcome measures and methods of analysis. Strengths of this review comprise the inclusion of high quality RCTs that investigated workplace interventions for the management of chronic musculoskeletal disorders. Also, the review excluded studies before 2008 as previous systematic reviews showed that RCTs from the past decade cannot be used as supportive evidence due to low quality and poor external validity for their results to be generalised to the wider population. The likelihood of publication bias was not assessed but several relevant peer-reviewed studies that reported no effects for important outcomes were also included in this review. The association of pain with other factors (e.g. environmental, social, personal, psychological) could have influenced the results of some studies about the change of the pain levels. Lastly, a meta-analysis was not performed because the studies demonstrated such heterogeneity: some characteristics like pain intensity, pain duration, occupation or education at the entry level (Baldwin et al., 2012; Jakobsen et al., 2015; Jay et al., 2014) were so lacking in comparability that such an analysis would have been meaningless.

CONCLUSION

There was some consistency in the results of the selected studies, suggesting that high intensity strength exercises and/or integrated health care at the workplace may decrease pain and symptoms for employees who experience chronic musculoskeletal disorders. Exercise interventions reported in this review included specific muscle strengthening, kettlebell training, stretching, and all-round- exercises. Clearly, there are other types of exercises, such as stabilization exercises, proprioceptive re-education and coordination (e.g. Tai-Chi, yoga), which might be beneficial for chronic musculoskeletal pain but their effectiveness at the workplace has not been evaluated. In addition, none of the studies included psychologically-informed therapy/interventions (e.g. Cognitive behaviour therapy, motivational interviewing etc.) although the link between mental health, stress, anxiety and MSDs is now recognised (Magnavita, Elovainio, de Nardis, Heponiemi, & Bergamaschi, 2011). None of the studies in this review identified significant results for sick leave, presenteeism rates and the use of a self-management programme alone, showing again the consistency of the findings. There is need for more research since the included studies showed variety in methodology, intervention, and population, and were conducted in a variety of countries with different health systems (it is not clear if all employees have access to the same systems of support at the workplace). This can limit the generalisability of the results to countries like the UK where health care is usually provided outside the workplace. Lastly, further research needs to consider the study design carefully due to the complexity of the work environment and the biopsychosocial framework for health. The results of this literature review suggest the implementation of a multi-component workplace intervention for the management of long-term MSDs. However, it is crucial to look at this complex topic with an all-inclusive approach considering the differences within the workforce as this will benefit both the stakeholders and the providers.

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Tables

Table 1: PICO approach

Population/problem	Employees with chronic/ long-term MSDs
Intervention	Workplace strategies/interventions to manage MSDs
Comparison	Any or none
Outcome	Pain severity, work status, symptoms, presenteeism and sickness absence

Table 2: Inclusion and exclusion criteria

Participant inclusion criteria	Participant exclusion criteria
Working age male and female adults (18 to 68 years)	Specific pathological conditions (e.g. tumours, infections, fractures)
All sectors and types of jobs	Hypertension or cardiovascular diseases, symptomatic disc prolapses or severe disorders of the cervical spine, postoperative conditions in the neck and shoulder region, history of severe trauma, and pregnancy.
Workers with reported long-term musculoskeletal disorders / chronic MSK conditions (12 weeks or more) at any area of the body	Acute MSK disorders
Group-based and individual interventions conducted at the workplace	Guidelines, policies, recommendations
Interventions focused on management of chronic MSK conditions	Interventions focused on prevention and return to work
RCT design or cluster RCT design	Surveys and qualitative studies

Table 3: Study Characteristics

First Author, year	Country	Study design	Sample size	Age in years (mean)	Diagnosis	Occupation	Intervention Provider, Frequency, duration, length	Main Outcomes
Andersen, et al. 2008	Denmark	RCT	N=48 baseline N=48 follow-up	43,6	Neck muscle pain	7 different workplaces	**Provider** Experienced instructors **Frequency** 3 times/week **Duration** 20 min **Length of observation** 10 weeks	**Pain intensity** (in the trapezius muscle 0-100)
Andersen, et al. 2012	Denmark	RCT	N= 449 baseline N=280 follow-up	46	Neck and shoulder pain	Office workers	**Frequency/duration Intervention group 1:** 1 hour, once a week **Frequency/duration Intervention group 2:** 20 mins three times a week **Frequency/duration Intervention group 3:** 7 mins nine times a week **Length of observation** 20-week intervention	**Pain intensity** Neck and shoulders **Health Status** (DASH, 1-25)

Andersen, et al. 2010	Denmark	Cluster RCT	N=222 baseline N=173 follow-up	46.5	Musculoskeletal pain symptoms in all regions of the body	Office workers from 12 geographically different units	**Provider** Experienced instructors **Frequency** 3 times/week **Duration** 20 min **Length of observation** 10 weeks	**Pain intensity** (0-9)
Baldwin et al. 2012	USA	RCT	N=89 baseline N=75 follow-up	50.54	Rheumatoid Arthritis and Osteoarthritis	Office workers, health care practitioners, business and financial operations, manual workers, other categories	**Provider** occupational therapist (ergonomist) **Duration** 2x 2.5 hours ergonomic sessions **Length of observation** 12 and 24 months	**Functional status** AIMS2 physical component score (0-10 range) **Pain** AIMS2 symptom component score (0-10 range)
Blangsted et al. 2008	Denmark	RCT	N= 616 baseline N=440 follow up	45.15	Chronic musculoskeletal symptoms in neck and shoulders	Office workers	**Intervention group 1:** **Frequency** 3 sessions per week **Duration** 20 min	**Pain intensity** (0-9) **Pain duration** (days) **Work ability Index(**7-49)

							Intervention group 2 **Frequency** Visits from instructors 1 to 4 times per month **Length of observation** 12 months	
Hutting et al. 2015	Netherlands	RCT	N= 129 baseline N=88 follow up	46.33	Non-specific complaints of the arm, neck or shoulder	Participants from different organisations	**Provider:** Physical therapist **Frequency** 6 weekly sessions **Duration** 2.5h **Length of observation** 3, 6 and 12 months	**Health Status** (DASH general module) **Work Status** (DASH work module) **Absenteeism** (Days) **Pain** (NPRS)
Jakobsen et al. 2015	Denmark	RCT	N=200 baseline N=184 follow up N chronic workers in follow up=97	42.5	Musculoskeletal pain	Healthcare workers With acute pain and with chronic pain	**Provider** Training instructor **Frequency** 5 times x 10 min/week **Duration** 45-50min total **Length of observation** 10 weeks	**Pain** (0-10)

Jay et al. 2011	Denmark	RCT	N=40 baseline N=33 follow-up	43.5	Neck/shoulder and low-back pain	Laboratory technicians	**Provider** Experienced kettlebell instructor **Frequency** 3 days /week **Duration** 20min sessions **Length of observation** 8-week follow-up	**Pain intensity of the neck/shoulder** (0-10) **Pain intensity of low back** (0-10)
Lambeek et al. 2010	Netherlands	RCT	N=134 baseline N=126 follow-up	46.15	Chronic low back pain	Any full time or part time paid work	**Intervention group Provider:** -employer, clinicians and OT ergonomists (multilevel focus) **Control group Provider:** **-**medical specialist, occupational physician, general practitioner, and/or allied health professionals **Length of observation** 3-6-12 months of follow-up	**Neck Pain** (0-10) **Functional status** (Roland disability questionnaire, 0-24) **Sick leave** (Days)

Shiri et al. 2011	Finland	RCT	N=222 baseline N=173 follow-up	45.2	Upper-extremity musculoskeletal disorders	Healthcare workers, clerical workers and warehouse workers	**Provider:** occupational therapist or physiotherapist **Length of observation** 8-12-52 weeks	**Neck Pain** (0-10)
Sundstrup et al. 2014	Denmark	RCT	N=66 baseline N=66 follow-up	45.5	Upper-limb chronic pain	Slaughterhouse workers	**Provider** skilled instructor **Frequency** 3 sessions/week **Duration** 10 min/session **Length of observation** 10 weeks follow up	**Work ability index (WAI)** (7-49) Item 5: Sick leave (1-5)
Zebis et al., 2011	Denmark	RCT	N=537 baseline N=448 follow-up	41	Non-specific neck and shoulder pain	Industrial workers	**Provider** Educated supervisors on the manual **Frequency** 3 sessions/week **Duration** 20 min per session **Length of observation** 20-week period	**Neck pain intensity** (0-9) **Right shoulder pain intensity** (0-9) **Left shoulder pain intensity** (0-9)

Table 4: Quality Appraisal using SIGN appraisal tool for RCTs

Checklist for RCTs: SIGN items / Authors	Appropriate and clearly focused question	Randomised allocation	Adequate concealment method is used	Blind treatment allocation	Treatment and control groups are similar at the start of the trial.	The only difference between groups is the treatment under investigation	All relevant outcomes are measured in a standard, valid and reliable way.	Drop-out rates	Intention to treat analysis	Results are comparable for all sites.	How well was the study done to minimise bias?	Are the results of this study directly applicable to the patient group targeted by this review?	The overall effect is due to the study
Andersen et al. 2008	Yes	Yes	Yes	Yes	Yes	Can’t say	Yes	<20 %	Yes	Yes	++	Yes	Yes
Andersen et al. 2010	Yes	Yes	Yes	Yes	Yes	Can’t say	Yes	<20 %	Yes	Yes	++	Yes	Yes
Andersen et al. 2012	Yes	Yes	Yes	Yes	Yes	Can’t say	Yes	<20 %	Yes	Yes	++	Yes	Yes
Baldwin et al. 2012	Yes	Can’t say	Can’t say	Yes	No	No	Yes	15.70%	Yes	Yes	+	Yes	Can’t say
Blangsted et al. 2008	Yes	Yes	Yes	No	Yes	Yes	Yes	19.80%	Can’t say	Yes	++	Yes	Yes

Hutting et al. 2015	Yes	Yes	Yes	No	Yes	Yes	Yes	40%	Yes	Yes	++	Yes	Yes
Checklist for RCTs: SIGN items **Authors**	**Appropriate and clearly focused question**	**Randomised allocation**	**Adequate concealment method is used**	**Blind treatment allocation**	**Treatment and control groups are similar at the start of the trial.**	**The only difference between groups is the treatment under investigation**	**All relevant outcomes are measured in a standard, valid and reliable way.**	**Drop-out rates**	**Intention to treat analysis**	**Results are comparable for all sites.**	**How well was the study done to minimise bias?**	**Are the results of this study directly applicable to the patient group targeted by this review?**	**The overall effect is due to the study**
Jakobsen et al. 2015	Yes	Yes	Yes	Yes	Yes	No	Yes	<20 %	Yes	Yes	++	Yes	Yes
Jay et al. 2011	Yes	Yes	Yes	No	Yes	Yes	Yes	17.5 %	No	N/A	+	Yes	Can’t say
Lambeek et al.2010	Yes	Yes	Yes	No	Yes	Yes	Yes	13%	Yes	Yes	++	Yes	Yes
Shiri et al. 2011	Yes	Yes	Yes	Can’t say	Yes	No	Yes	<20 %	Can’t say	Yes	+	Yes	Yes
Sundstrup et al. 2014	Yes	Can’t say	Yes	No	Yes	Yes	Yes	8%	Yes	N/A	+	Yes	Yes

Zebis et al. 2011	Yes	Yes	Yes	Can’t say	Yes	No	Yes	15%	Yes	Can’t say	+	Yes	Yes

Table 5: Results and Outcomes

Author, Year	**Intervention**	**Results**			
Andersen et al. 2008	**Intervention group 1** Specific strength training (SST) **Intervention group 2** General fitness training (GFT) **Control group** Health counselling	**Intervention group 1** (SST)	**Intervention group 2** (GFT)	**Control group**	**Between groups comparison**
		General pain (in Trapezius muscle 0-100)			
		10-weeks Δ=-12 Rate of decrease =1.03 (±0.30) $p < 0.0001$**	**10-weeks** Δ=-6	**10-weeks** Δ=-1	**No between groups comparisons**
		Worst pain (in Trapezius muscle 0-100)			
		10-weeks Δ=-25 Rate of decrease=-0.58 (±0.22) $p < 0.0001$ *	**10-weeks** Δ=-11	**10-weeks** Δ=-5	**No between groups comparisons**
		Acute pain (in Trapezius muscle 0-100)			
		10-weeks Rate of decrease= 4.8 $p < 0.05$* The acute adverse effect lasted 2 hours	**10-weeks** Rate of decrease = 5.3 $p < 0.01$**	**10-weeks**	**No between groups comparisons**

Andersen et al. 2010	**Intervention group 1** Specific resistance training (SRT) **Intervention group 2** All-round physical exercise (APE) **Control group** Reference group (REF): Encouragement and advice	**Intervention group 1**	**Intervention group 2**	**Control group**	**Between groups comparison**
		Neck pain (0-9)			
		Δ=-0.73±0.36 p<0.05*	Δ=-0.91±0.31 p<0.01**	Δ=0.40±0.32 P>0.05	Intervention groups 1 and 2 vs Control
Andersen et al. 2012	**Intervention group 1** Specific strength training 1 hour, once a week **Intervention group 2** Specific strength training 20 min three times a week **Intervention group 3** Specific strength training 7 min nine times a week **Control group** No physical training	**Intervention group 1**	**Intervention group 2**	**Intervention group 3**	**Between groups comparison**
		Neck pain (0-10)			
		20 weeks Δ=-0.74 p<0.01**	**20 weeks** 0.78 p<0.01**	**20 weeks** 0.71	**No between groups comparisons**
		Right shoulder pain (0-10)			
		Δ=- 0.94 p<0.01**	Δ=-0.61	Δ=-0.83 p<0.01**	**No between groups comparisons**
		Left shoulder pain (0-10)			
		Δ=-0.69 p<0.01**	Δ=-0.32	Δ=-0.62	**No between groups comparisons**

		Health Status (DASH, 1-25)			
		Δ=-6 p<0.01**	Δ=-9 p<0.05*	Δ=-2	**No between groups comparisons**

Baldwin et al. 2012	**Intervention group** 1 session of workplace ergonomic assessment and intervention (ergonomic, exercises, workstation equipment modifications and a self-management manual) 1 follow up session Follow-up phone call after a month to determine if modifications to the work plan were desired A resource manual with guides for self-management of arthritis and possible ergonomic interventions in the work setting **Control group** Written educational materials (same resource manual that was provided for the intervention group)	**Intervention group**	**Control group**	**Between groups comparison**
		Functional status (AIMS2 physical component 0-10)		
		12 months Δ=-0.24 (±0.94) p < 0.04*	**12 months** Δ=-0.09 (±0.66) p < 0.26	**12 months** 1.63 (±1.27) intervention 1.26 (±1.23) control p =0.45
		24 months Δ=-0.29 (±0.80) p < 0.01**	**24 months** Δ=-0.12 (±0.82) p < 0.25	**24 months** 1.58 (±1.09) intervention 1.23 (±1.18) control p =0.76
		Pain (AIMS2 symptom component 0-10)		
		12 months Δ=-1.27(± 2.00) p < 0.01**	**12 months** Δ=-0.61(±1.93) p < 0.07	**12 months** 4.60 (±2.44) intervention 4.16 (±2.37) control p=0.58
		24 months Δ=-1.25 (±2.16) p < 0.01**	**24 months** Δ=-0.29 (±1.94) p < 0.34	**24 months** 4.62 (±2.22) intervention 4.48 (±2.31) control p = 0.42

	Intervention group 1	**Between groups comparisons only**

Blangsted et al. 2008	Specific resistance training	No specific numerical values provided for changes in each group: Values were presented only on a histogram		
	Intervention group 2 All-round physical exercise daily to increase physical activity both at the worksite and during leisure time **Control group** Education on general health-promoting activities	**12 months** **Comparison of both intervention (group 1 and 2) vs Control group** **Pain intensity** (p=0.0318) * *in favour of the activity interventions* **Pain duration** (p=0.0565) **Work ability** (p = 0.3073) **Comparison of intervention group 1 vs intervention group 2** **Pain intensity** (p=0.5327) **Pain duration** (p=0.4046) **Work ability** (p = 0.3073)		
Hutting et al. 2015	**Intervention group** Moderated self-management interventions at the workplace within group sessions E-module on Health (available for 12 months)	**Self-management group (SU)**	**Usual care group (UCG)**	**Between groups comparison**
		Health status (DASH general module 0-5)		
		12 months Δ=-7.96	**12 months** Δ=-7.22	**12 months** -0.73 p < 0.10

	Control group Usual care and information available within the organisation or outside the organisation.			
		Work Status (DASH work module 0-5)		
		12 months Δ=-0.27	**12 months** Δ=-1.63	**12 months** p=0.04* *in favour of the self-management group*
		Absenteeism (days)		
		12 months Δ=-0.27	**12 months** Δ=-1.63	**12 months** 4.19 p=0.29
		Pain the last week (NPRS)		
		12 months Δ=-0.61	**12 months** Δ=-1.2	**12 months** -0.63 p=0.47
Jakobsen et al. 2015	**Intervention group** Strength training at the workplace Ergonomic training and education **Control group** Physical exercise intervention at home with the help of posters and instructions Ergonomic training and education	**Intervention group**	**Control group**	**Between groups comparison**
		Average Pain (0-10) (Only the results of the chronic pain groups are reported)		
		10 Weeks Δ=-1.7 p < 0.0001**	**10 Weeks** Δ=-0.8 p < 0.0001**	**10 Weeks** -1.0 p <0.0003** *in favour of the intervention group*
Jay et al. 2011	**Intervention group**	**Intervention group**	**Control group**	**Between groups comparison**
		Pain intensity of the neck/shoulder (0-10)		

	Progressive worksite intervention using Kettlebell training **Control group** Recommendations	**8-weeks** Δ=-1.7	**8-weeks** Δ=0.3	**8-weeks** -2.1 p=0.02* *in favour of the intervention group*
		Pain intensity of the low back (0-10)		
		8-weeks Δ=-1.6	**8-weeks** Δ=-0.2	**8-weeks** -1.4 p=0.05* *in favour of the intervention group*
Lambeek et al. 2010	**Intervention group** Integrated care **Control group** Usual care	**Intervention group**	**Control group**	**Between groups comparison**
		Neck pain (0-10)		
		3 months Δ=-1.11 (±0.39) **12 months** Δ=-1.64 (±0.35)	**3 months** Δ=-1.59 (±0.38) **12 months** Δ=-1.85 (±0.36)	**3 months** -0.99 p < 0.08 **12 months** Δ=-0.21 p < 0.67
		Functional Status (Roland disability questionnaire 0-24)		
		3 months Δ=-3.76 (±0.86) **12 months** Δ=-7.16 (±0.71)	**3 months** Δ=-3.82 (±0.85) **12 months** Δ=-4.43 (±0.72)	**3 months** Δ=-0.11 p < 0.93 **12 months** Δ=-2.86 p < 0.001** *in favour of the intervention group*

		Sick leave (days)		
		3 months 88 days **12 months** 82 days	**3 months** 208 days **12 months** 175 days	**3 months** p=0.003** *in favour of the intervention group* **12 months** p=0.003** *in favour of the intervention group*
Shiri et al. 2011	**Intervention group** Workplace assessment by an occupational therapist or physiotherapist **Control group** No intervention	**Intervention group**	**Control group**	**Between groups comparison**
		Pain intensity (0-10)		
		2 Weeks Δ=-1.27	**2 Weeks** Δ=-0.69	**2 Weeks** -0.58 p=0.05* *in favour of the intervention group*
Sundstrup et al. 2014	**Intervention group** High intensity strength training **Control group** Ergonomic training and education	**Intervention group**	**Control group**	**Between groups comparison**
		WAI Item 5: Sick leave (1-5)		
		10 weeks Δ=-0.2	**10 weeks** Δ=-0.5	**10 weeks** -2.3 p = 0.2
		WAI Index Total (7-49)		
		10 weeks Δ=-0.3	**10 weeks** Δ=-2.2 WAI decreased (i.e. worsened) in the ergonomic group p<0.01**	**10 weeks** -2.3 p = 0.012** *in favour of the intervention group*

Zebis et al. 2011	**Intervention group** High-intensity specific strength training at the workplace **Control group** Advice to stay physically active, weekly consultation	**Intervention group**	**Control group**	**Between groups comparison**
		Neck pain (0-9)		
		20 weeks Δ=-1.8 (±1.9)	**20 weeks** Δ=-2.9 (±2.3)	**20 weeks** -1.1 P < 0.001** *in favour of the intervention group*
		Shoulder pain (0-9)		
		20 weeks **Right Shoulder pain** Δ=-1.4 (±1.7) **Left Shoulder pain** Δ=-0.9 (±1.3)	**20 weeks** **Right Shoulder pain** Δ=-2.5 (±2.6) **Left Shoulder pain** Δ=-2.2 (±2.6)	**20 weeks** **Right Shoulder pain** -1.1 **Left Shoulder pain** Δ=-1.3
Results are presented in mean values and/or standard error, Δ demonstrates the difference between the baseline values and the time of the relevant measurement, * highlights significant difference of p<0.05, ** highlights significant difference of p<0.01				

Appendix 1

Words (and synonyms) used for Search Strategy

randomized controlled trial	system*
worker*	improve
employe*	decrease
staff	cope
personnel	manage
workforce OR “work force”	prevent
“labour force”	control
strateg*	avoid
tactic*	reduce
intervention*	stop
practice	“deal with”
Policy	musculoskeletal
treatment*	MSK
plan*	chronic
approach*	condition*
method*	disease*
protocol*	disorder*
musculoskeletal disorders	“ill health”
process*	illness*

system*	pathosis
improve	complaint

MEDLINE Search Strategy example

Search ID#	Search Terms	Results
S1 AND S2 AND S3 AND S4 AND S5 AND S6 AND S7		203
S1 AND S2 AND S3 AND S4 AND S5 AND S6 AND S7 AND S8 AND S9		5
S9	(MM "Therapeutics+")	1,956,742
S8	(MM "Health Personnel+") OR (MM "Health Manpower")	320,520
S7	workplace OR work	826,220
S6	chronic	1,135,779
S5	condition* OR disease* OR disorder* OR “ill health “OR pathosis OR illness* OR complaint*	8,207,606

S4	MSK OR musculoskeletal OR "chronic MSK" or "chronic musculoskeletal"	64,994
S3	manage* OR Prevent* OR cope* OR decrease* OR improve* OR control* OR handle* OR avoid* OR reduce* OR stop* OR “deal with “	9,043,205
S2	(strateg* OR tactic*) OR intervention* OR practice* OR polic* OR treatment* OR plan* OR approach* OR method* OR protocol* OR process* OR system*	13,445,401
S1	employer OR employee* OR worker* OR (workforce OR workforce) OR staff OR personnel OR (“labour force” OR labor force)	908,429