Master of Public Health

Master de Santé Publique

What is the current evidence for musculoskeletal disorders (MSDs) intervention for sedentary/office workers: a scoping review

---

Ngoun Chhim LAY

Class and year of the master:
European Master of Public Health
2020-2022

Date : June 08, 2022

Location of Practicum:
Organsation for Economic and Co-operation and Development (OECD)
Paris, France

Professional advisor:
Marion DEVAUX, OECD

Academic advisor:
Aurore GELY-PENOT, EHESP

Acknowledgement

First and foremost, I would like to express my gratitude to my professional supervisor, Marion Devaux, for providing me with an amazing opportunity to work with her and her team in the Health Division on the topic of workplace health promotion and providing me with advice, guidance, and support throughout my internship with the OECD in the Directorate of Employment, Labour, and Social Affairs and throughout the process of this scoping review.

Second, I would like to thank my academic supervisor, Aurore Gely-Penot, for giving me guidance on my work and introducing me to the wider research community. As well as her continuous support and encouragement throughout this past academic year.

Third, I would like to thank and express my deepest appreciation for the experts that were consulted for this study for their time and knowledge. Their expertise in the field of occupational health and policy was deeply valued.

And last but not least, I would like to thank all my friends who have supported me throughout the process and for giving support, strength, and resilience to complete this scoping review through challenging time.

Table of Content

List of acronyms

CMDQ: Cornell Musculoskeletal Discomfort Questionnaire

EU-OSHA: European Agency for Safety and Health at Work

GDP: Gross Domestic Product

MSDs: Musculoskeletal Disorders

NMQ: Nordic Musculoskeletal Questionnaire—a standardized questionnaire to compare pain and general complaints

OECD: Organisation for Economic Co-operation and Development

OHSCO: Occupational Health and Safety Council of Ontario (Canada)

SF-36: Short-Form 36—measurement of health status and quality of life

VAS: Visual Analogue Scales—measurement of acute and chronic pain

WMSD: Work-related Musculoskeletal Disorders

Abstract (English)

Background. Musculoskeletal disorders (MSDs) are the most prominent occupational health problems and affect all working populations in all sectors of the economy and society. MSDs are costly and adds a significant burden on the workforce especially in office and sedentary workers. There have been studies that look at the effectiveness of different types of MSD interventions. However, there is yet a study that look at the gaps in research and policy for MSDs intervention for this population.

Objective. The aim of this scoping review is to systematically map out the current literature and evidence available on different MSDs interventions, to identify gaps in existing research and to collect recommendations from experts in the field. To complete the aim of this scoping review the following question was generated: “What is the current evidence for MSDs intervention for sedentary/office workers?”

Methods. To answer the objective of this study, we conducted a scoping review following the Arksey and O’Malley methodological framework with suggestions from Levac et al. and Peters et al..Scientific databases (PubMed, Scopus, and Web of Science) and gray literature searches were carried out and the results were analyzed for available interventions and gaps in research and in policies associated to MSDs. Expert interviews were conducted to seek recommendations and to gather further knowledge and identify gaps and possible solutions to address MSD interventions for office workers.

Results. Through our research, we included a total of 36 literatures and four of which are gray literatures. We found that there is a mixed of evidence for the effectiveness for MSDs intervention for office workers. This is due to the biases of these studies include in the review corresponding, but not limited to lack of blinding, sample size, short-term study, and self-reporting surveys. According to experts, a multidisciplinary approach is needed. While in policies, MSD interventions lack strong leadership and continuity of the intervention project.

Conclusion. Future research needs to not only focus on pain as the outcomes of MSD interventions, but as well as the psychosocial wellbeing related to MSDs. A multidisciplinary approach in research and MSDs intervention policy is needed in order to address current gaps. Furthermore, it will help to address and provide effective recommendation for the prevention of musculoskeletal disorders.

Keywords: Musculoskeletal Disorders (MSDs), Interventions, Effectiveness, Gaps, Research, Recommendation, Policies, Scoping Review

Abstract (French)

Contexte. Les troubles musculosquelettiques (TMS) sont les problèmes de santé au travail les plus importants et touchent toutes les populations actives dans tous les secteurs de l'économie et de la société. Les TMS sont coûteux et représentent une charge importante pour la population active, en particulier pour les employés de bureau et les travailleurs sédentaires. Certaines études ont examiné l'efficacité de différents types d'interventions sur les TMS. Cependant, aucune étude n'a protée sur leur lacune et les politiques d'intervention sur les TMS pour cette population. **Objectif**. L'objectif de cette revue est de recenser la littérature actuelle et les preuves disponibles sur les différentes interventions en matière de TMS, d'identifier les lacunes de la recherche existante et de recueillir les recommandations des experts dans ce domaine. Une question générale, "Quelles sont les preuves actuelles de l'intervention sur les TMS pour les travailleurs sédentaires/de bureau ?" a été générée pour aider à atteindre l'objectif de cette revue exploratoire. **Méthodes**. Pour répondre à l'objectif de cette étude, nous avons effectué une étude de la portée en suivant le cadre méthodologique d'Arksey et O'Malley avec des suggestions de Levac et al. et de Peters et al.. Des recherches dans les bases de données scientifiques (PubMed, Scopus et Web of Science) et dans la littérature grise ont été effectuées et les résultats ont été analysés pour déterminer les interventions disponibles et les lacunes dans la recherche et dans les politiques associées aux TMS. Des entretiens avec des experts ont été menés afin d'obtenir des recommandations, de rassembler des connaissances supplémentaires et d'identifier les lacunes et les solutions possibles en matière d'interventions sur les TMS pour les employés de bureau. **Résultats**. Grâce à notre recherche, nous avons inclus un total de 36 littératures, dont quatre sont des littératures grises. Nous avons découvert qu'il existe des preuves mitigées de l'efficacité des interventions contre les TMS pour les employés de bureau. Ceci résulte de biais présents dans les études incluent dans la revue, notamment, l'anonymat, la taille de l'échantillon, les études à court terme et les enquêtes d'auto-évaluation. Selon les experts, une approche multidisciplinaire est nécessaire. Les politiques menées et les interventions sur les TMS manquent d'un leadership fort et d'une continuité du projet d'intervention. **Conclusion**. Les recherches futures doivent se concentrer non seulement sur la douleur comme résultat des interventions sur les TMS, mais aussi sur le bien-être psychosocial lié aux TMS. Une approche multidisciplinaire de la recherche et de la politique d'intervention matière des TMS misent en œuvre est nécessaire pour combler les lacunes actuelles. En outre, elle permettra d'aborder et de fournir des recommandations efficaces pour la prévention des troubles musculosquelettiques.

Mots-clés. Troubles musculosquelettiques (TMS), Interventions, Efficacité, Lacunes, Recherche, Recommandation, Politiques, Scoping Review

1. Introduction

Musculoskeletal disorders (MSDs) is a term that encompasses a variety of conditions that affect the muscles, tendons, joints, ligaments, nerves, and other blood vessels in the body (1). MSDs are associated with occupational musculoskeletal problems, otherwise known as work-related musculoskeletal disorders (WMSDs). MSDs can be divided into four specific conditions with clear diagnostic criteria and pathological symptoms: tendonitis (tendon-related disorders), carpal tunnel syndrome (peripheral-nerve entrapment), hand-arm vibration syndrome (neurovascular/vascular disorders), osteoarthritis (joint-capsule disorders), as well as other non-specific conditions where the main complaint is pain or tenderness (2). The presentation of MSDs ranges from acute onset pain to chronic pain, both of which can have a lifelong effect on people's health.

MSDs are costly and place a significant burden on the workforce. They are among the most prominent occupational health problems and affect all working populations in all sectors of the economy and society. Many factors of MSDs come from the workforce. In the last few decades, there has been an association between biopsychosocial factors and increased incidences of MSDs, including psychological factors, such as health beliefs, sleep problems, pain sensitivity, mental comorbidities, psychosocial factors (stress, social support, and job satisfaction), and work-related physical risk factors (3). WMSDs are caused by several high-risk activities like manual lifting, repetitive hand/arm movement including computer and office based work, and awkward body postures.

MSDs are inseparable from the context of work and have economic and social implications that should not be underestimated. Both the prevalence of and the associated cost from MSDs are higher among working-age groups (3). According to the European Agency for Safety and Health at Work (EU-OSHA), in the European Union about three out of every five workers complain about MSDs, in particular backache and muscular pains in the upper limb, one out of five people reported that they have suffered from chronic back and neck disorder in the past year (4). In terms of neck pain, office workers have the highest incidence rate among other occupations at 17% to 21% according to one study (5) and the annual prevalence of neck pain in office workers range between 42% to 63% according to another study (6).

As proxy, this can also be quantified in terms of economic impact. There are four ways to assess the economic costs of MSDs: Direct costs, indirect costs, total costs, and intangible costs (7,8). Direct costs are measured through direct expenses on treatment to individuals that have developed MSDs, including medical expenditure on prevention, detection, treatment, rehabilitation, long-term care, and ongoing medical and private expenditure.

Indirect costs are measured by loss of days at work such as absenteeism, presenteeism, and includes the lost work output attributed to a reduced capacity for activity, including lost productivity and loss of earnings for family members. Total costs are measured by healthcare expenditure and the total amount spent by healthcare system on treatment of people with MSDs. While intangible costs are measured by the burden caused by psychosocial job stressed, economic hardship, family stress, and suffering from health problems resulting in a reduced quality of life (9).

Across the pre-2004 EU-15 nations, the total cost of WMSDs was estimated EUR 240 billion, or about 2% of its gross domestic product (GDP) (8). In the United States between 2004 and 2006, the direct (medical) cost of MSDs was USD 576 billion, or 4.5% of US GDP, and USD 373 billion in indirect costs, calculated as lost wages, or 2.9% of US GDP (8).

There are many types of intervention to prevent MSDs, such as ergonomics, education, work breaks, exercise, and increase of walking and standing in workplace. Different research methodologies, including systematic reviews like Cochrane Reviews and other studies that have looked into the effectiveness of MSDs interventions. However, there is still much more to explore about the overall effectiveness of MSDs intervention in particularly sedentary workers such as office workers to provide a full picture of MSD interventions in workplaces, especially in countries that are part of the Organization for Economic Cooperation and Development (OECD) or any high-income countries. Furthermore, even though there are systematic reviews available that look at the evidence for the effectiveness of different MSD interventions, these reviews focus mainly on the effectiveness of pain but not particularly in the cost effectiveness of the interventions, nor the gaps that address the challenges of these interventions for its effectiveness. Additionally, other reviews have been done to address MSD gaps and effectiveness of interventions before but not specifically for office worker or sedentary workers. It is crucial to understand current evidence and gaps in this sector of work because MSDs is an umbrella term that focuses on a variety of issues and different work sectors; however, in order to provide effective MSD interventions for office/sedentary workers, a comprehensive study is needed in this field.

The objective of this scoping review is to review and synthesise current research, strategies, policies, and interventions in place used for the prevention of MSDs for sedentary/office workers and identify the effectiveness of MSDs intervention, address gaps in research for MSDs in OECD member states, and to gather recommendations from experts in the field of occupational health on how to address these gaps that have been identified and analyzed. A general question, “What is the current evidence for musculoskeletal disorders (MSDs) intervention for sedentary/office workers?” was generated to help with the objective of the

study. This study will be a deep drive which will cover the full breadth of research including recent studies published in 2022 and gray literature available from occupational health institutions and other organizations.

2. Methods and Materials

A scoping review was chosen as the main methodology of the study, which intended to identify gaps and evaluate the robustness of current evidence in the literature which aligns with the objective of this research (10). This scoping review followed the methodological framework of Arksey and O'Malley (10) with additional suggestions provided by Levac et al. (11) and Peters et al. (12). The framework was complemented by Tricco et la. (13) for the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Review, also known as the PRISMA-ScR checklist. The use of the PRISMA-ScR checklist was to ensure quality reporting and to warrant its completeness (Appendix I) (13). The Arksey and O'Malley framework with suggestions from Levac et al. and Peters et al. is divided into six methodological steps that are summarized below.

2.1 Identifying the Research Question

The broad research question for this scoping review was formulated as: "What is the current evidence for musculoskeletal disorders (MSDs) intervention for sedentary/office workers?" The purpose of this research question is to systematically map out the current literature and evidence available on different MSDs interventions and to identify gaps in existing research and to collect recommendations from experts in the field. More specific sub-questions were formulated to assist with the literature search:

- What are the different MSD interventions for sedentary/office workers?
- What are the tools used to measure the effectiveness of the intervention in place? What are the challenges of these measurements?
- What type of MSDs are associated with sedentary/office workers?
- What are the current policies in place to prevent MSDs in the workplace?

2.2 Identifying Relevant Studies

Preliminary research was utilized in different scholarly databases to understand the scope of the literature available. A gray literature search was conducted to gain a review of national policies in place available in a few OECD countries. The preliminary research was to assist with key words and vocabulary related to musculoskeletal disorder, office worker, sedentary worker, effective/ness, and intervention/prevention. A list of synonyms was created based on four key concepts to form a search string. Refer to Appendix II, which depicts the word string for each database. Searches were conducted in Scopus, PubMed, and Web of Science. While

gray literature was conducted using a snowball method through the EU-OSHA, Safe Work Australia, and Ontario Workers Health & Safety Centre web page. The search strategy included articles that are ten years old starting from 2012 until April 2022. For consistency, all studies must be open access articles and must be published in English. Although the study focused on high-income countries or OECD countries, all studies that were related to MSDs interventions of office/sedentary are included as MSDs, for this population is similar regardless of the countries' economic status.

2.3 Study Selection

To select the studies for the research, literature from the systematic search had to pass an eligibility criterion. Both inclusion and exclusion criteria were developed to reduce and remove studies from the search that did not address the scope, context, and objective of this scoping review. All studies were searched on three databases and results of each database were transferred to Mendeley (bibliographic management software) and duplicates were removed. Following the searches from the databases, titles, and abstracts were reviewed. After the reviewed, the second round of the studies were then fully read and scrutinized. The inclusion and exclusion criteria are listed in Table 1.

Table 1: List of Inclusion and Exclusion Criteria

Inclusion Criteria	• Studies that are in English and open access • Studies that are from 2012 until April 2022 • Studies that are primarily looking at MSD interventions and outcomes (effectiveness and/or cost-effectiveness) • Studies need to focus primarily on MSD interventions and can include other factor as secondary intervention • Studies that mainly focus on workplace interventions for office/sedentary worker as participants • Studies that do not involved healthcare professional or clinical intervention in the workplace (acupuncture etc.)
Exclusion Criteria	• Studies that focus on clinical interventions (surgeries, dental, nursing, healthcare professional) not workplace based • Studies that mainly focus on mental health and other work disability • Studies that are looking at prevalence and risk of MSDs • Studies that is a protocol study • Studies that are on return to work and/or rehabilitation

	program • Studies that are focus on healthcare professional or other occupation does not consider as office or sedentary workers

2.4 Charting the Data

Literature that met the eligible inclusion criteria was transferred into an excel sheet where information about the studies was recorded and sorted by title, author, year of publication, objectives, methodology, outcomes, and theme of the studies. The literatures were categorized under relevant themes such as MSDs interventions, types of MSDs intended to treat, outcome, results, and authors' recommendations.

2.5 Collating Reporting and Summarizing the Results

Results of this scoping review is presented according to the main theme of MSD interventions. The purpose of this review was to present a clear finding about the existing research on different types of MSD interventions, lay out different findings for the interventions (both in term of effectiveness and cost-effectiveness), gaps in research, implementation of the intervention in the workplace, and to provide recommendations to address these gaps in research and policy implementation.

2.6 Consultation/Interview

Semi-structured interviews were conducted via video call, specifically on Google Meet, with researchers and experts identified from their MSDs research and/or in MSDs intervention both at the organizational level and policies level. These interview/consultations were done to provide valuable insight on issues and challenges of MSDs policies, research, and implementation that may otherwise not collected from the literature review. The objective of the interview and consultation was to gather further knowledge and identify gaps and possible solutions to address MSD interventions for office workers and relevant details about policies and research for OECD countries.

Results from the interview/consultations were integrated in the results section of this scoping review. The interviews were transcribed and anonymized, while information gathered was sorted into different theme of the results section. Personal information about the interviewee remained anonymous and was identified in the study as "Expert 1, 2, 3" and so on. A list of questions that were asked to the participants can be found in Appendix IV.

This study received ethical approval from the University of Sheffield. The University of Sheffield ensured proper care and storage of primary data collected from the interviews. Each participant was contacted by e-mail and was given consent form and participation information

sheet. Each participant was given written and verbal consent before participating in the interview.

3. Results

3.1 Summary of Search

After combining results, 988 articles were found in all three databases and gray literature searches. After checking for duplicates, there were 638 eligible documents. A large number of studies were removed if the title or abstract mentioned certain exclusion criteria as mentioned in Table 1. 54 studies were eligible for full text screening and were scrutinized. Out of those 54 studies. 18 were excluded due to one article was not a publicly accessible article. While 17 articles were mixed population not specifically related to office/sedentary workers, rehabilitation programs and outcomes, therapy interventions, not workplace related intervention and mental health related. After the reduction of 18 studies, 36 articles were finally included for this scoping review. Figure 1 showcases the findings of the included articles. The numbers of included studies are summarized in the PRISMA flow chart as shown in Figure 2.

The overall themes of the documents can be individual into five common themes. These themes include ergonomic intervention, work-break as intervention, physical activity as intervention (these includes but no limited to exercise, stretching, increase of walking and standing), the use of mobile or computer application as a reminder to exercise or having break, or mobile application that provide exercising and stretching programs, mixed or combination interventions, and policy, challenges, and recommendation for MSD interventions in the workplace. The most common studies are those of ergonomic intervention in the workplace followed by physical activity.

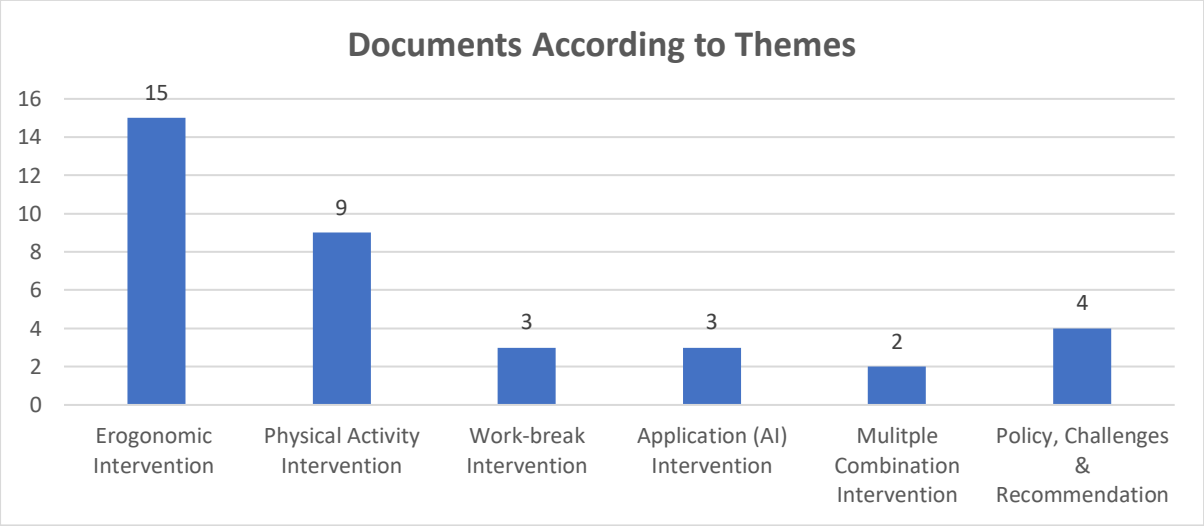


Figure 1: Documents according to themes as found through the literature

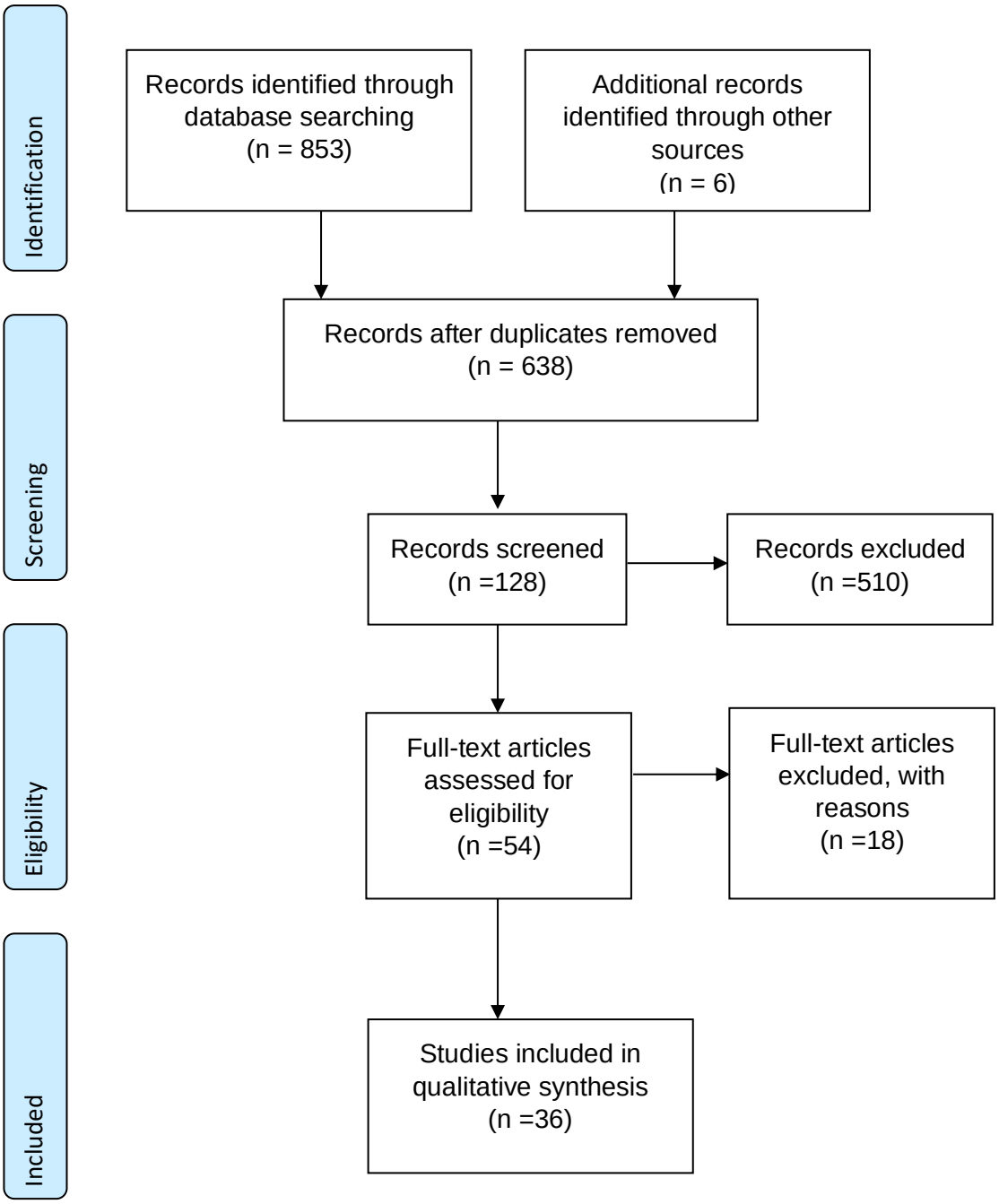


Figure 2: PRISMA Flowchart of the studies included and excluded

3.2 Ergonomic Intervention

Majority of the studies looked at ergonomic intervention and the effect of MSDs in the workplace for office/sedentary workers. The principles of ergonomics—the interaction of workers and their working environment, which includes physical, organizational, and cognitive component—are widely used as MSD interventions. Physical interventions are methods that requires the improvement or alteration of office equipment and workplace environment.

Organizational intervention are methods that tries to reduce physical strain, injury, and risks by allowing musculoskeletal system to recover from fatigue through policies and processes of an entire organization. While cognitive interventions are methods that aims to improve mental health.

When looking at the effectiveness of these interventions—alteration to workstation and promotion of education training—different outcomes are measured. These outcomes include pain severity, body postural, sick leave, presenteeism, productivity, and medical care. Different MSDs are measured in terms of neck pain, shoulder pain, upper extremity, and lower back pain. Most studies that look at the effectiveness of these interventions look for these outcomes through self-reporting tools such as the Nordic Musculoskeletal Questionnaire (NMQ), Quality of Life through a form called Short Form 36, the Cornell Musculoskeletal Discomfort Questionnaire, or different forms of dichotomized score. The Nordic Musculoskeletal Questionnaire contain question such as “Have you at any time during the last 12 months has trouble (ache, pain, discomfort) in the neck, shoulder, elbow, wrist, back, and other part of the body?” Individual can respond by answering yes or no to a specific region of the body that feel pain. Refer to Appendix V for more sample questions of the Nordic Musculoskeletal Questionnaire and the Cornell Musculoskeletal Discomfort Questionnaire. The Short Form 36 to assess quality of life include question such as moderate activity or vigorous activity they carried out and can have different physical, mental, and emotional health aspect. While the Cornell Musculoskeletal Questionnaire is similar to the NMQ but participants can respond through checking a list such as never, 1-2 time a week, to several time a day.

Studies that looked into the effectiveness of these interventions, specifically office ergonomic found that there are mixed results on the effectiveness (14–19). Some studies found that ergonomic interventions are effective in the studied population, but it cannot be generalized to other population (16,17,20). A systematic review found that the quality of studies that looked into the effectiveness of ergonomic interventions are of moderate to low-quality; thus no conclusion was drawn on the effectiveness (2). However, other randomized controlled studies found that some ergonomic interventions might be effectiveness in the studies population. They found that ergonomic interventions can reduce pain level and improve MSDs discomfort (21,22). Although, these studies found some effectiveness of ergonomic interventions, further studies are needed to assess the quality of these studies.

Studies that investigated ergonomic training and participatory ergonomic also found mixed results or inconclusive evidence for the effectiveness of the interventions. Some studies found that some interventions are not effective, might be effective, or it is effective in the study, but cannot be generalized to the general population (20–26). These studies used self-reporting

tools as a before and after the intervention. A case study by the Workers Health & Safety Centre (27) also looked into participatory ergonomic and noted that the most important factors for the success of ergonomic intervention is through group support and communication. This means that ergonomic intervention needs the participation and involvement of workers to have a direct impact to prevent MSDs. Ergonomic intervention is sometime hard to monitor as it is left to the individual to follow guideline and adhere to the correct usage of the ergonomic tools. Although, individual might say that they use the tool correctly, but sometimes they might not be. Thus, strong participant and willingness to follow guideline is needed in order to see the effectiveness of ergonomic intervention.

Hoe et al. 2018 (2) conducted a systematic review and meta-analysis on the effectiveness of these three interventions and found that there are moderate to low quality evidence. There are no available studies that assess the effectiveness of cognitive ergonomic.

Although other studies tried to look at different outcomes besides MSDs pain, but it was difficult to assess presenteeism, productivity, and other outcomes. These might be due to the short term of the studies and other bias in the study that made it a challenge to understand these factors. Bias in the studies gave the quality of the study as low and thus, it was hard to provide concrete evidence about its effectiveness. In term of cost-effectiveness, no study really assesses the cost-effectiveness of ergonomic intervention.

3.3 Physical Activity Intervention: Exercise, Stretching, Standing, and Massage

The second intervention that tried to tackle MSDs in the workplace for office/sedentary workers are physical activities. These can be in the category of exercise, stretching, resistance training, massage, increase of standing and or walking in the workplace. These interventions tried to reduce specific areas of musculoskeletal pain in the area of the neck, shoulder, spinal column, dorsal region, and upper and lower back (28–32). These exercise interventions come in many different types of programs and varied in term of amount of time, types of exercise, and stretches. Another option for MSDs intervention is the relaxation of the muscle and breaking up sedentary behavior such as massage done in the workplace and the increase of standing and walking.

When looking at the effectiveness of these interventions, different types of outcomes are measured. Primary outcome of these interventions is level of pain, which are measured through self-report using either VAS (Visual analogue scales), NMQ (Nordic Musculoskeletal Questionnaire), or the CMDQ (Cornell Musculoskeletal Discomfort Questionnaire). While secondary outcomes are dependent on the studies which can range from work performance, quality of life, and sickness absenteeism.

The effectiveness of these exercising, stretching, and strengthening programs in the workplace provide a mixed or inconclusive evidence to prove of its effectiveness to prevent and reduce musculoskeletal pain. Some studies shown that strengthening exercise might be effective to reduce pain for symptomatic workers, but not in the general population (33). Two studies found that exercise that are personalized for the individual's need can improved upper and lower back pain (29,31). More specifically, a study that look at massage chair in the workplace did found a reduction of lower and upper spine area but not in other MSDs (32). When looking at the reduction of sitting time on the intensity of MSDs pain and increase in standing at work, result over time were not significant—pain outcome measured made no differences on intensity between before the intervention and after the intervention (34). The results of these evidence varied between studies and depending on the types of physical activity interventions either increase of standing, walking, exercising, and/or stretching.

A larger number of studies on the effectiveness of these interventions found that it did improve musculoskeletal pain in some way, but those results are not significant, or these studies are of low quality due to bias and blinding. It is important to note that lost to follow up and small sample size can give the study low-quality rating. Thus, evidence of these studies cannot be generalized, nor can it provide concrete evidence on the effectiveness of these interventions. Parry et al. 2019 (35) tried to look for outcome such as sickness absenteeism, but no studies report on those measures.

3.4 Work-break Intervention

Two studies investigated work-break as an intervention to prevent MSDs for office/sedentary workers in the workplace. One consists of a systematic review and meta-analysis and the other was a randomized controlled trail. The frequency of work-breaks, the duration of work-breaks, or the combination of both work-break and frequency suggested that it can be effectiveness to prevent MSDs in the workplace. It is generally assumed that work-break may provide a recovery period for muscles and tissues that are stressed during work; thus, maintain consistent work performance. However, there are still questions about the quality of the evidence provided by many studies that investigated these interventions.

Studies that used work-break as intervention looked at different outcomes for the effectiveness of these interventions such as: MSD pain, newly diagnosed MSD, discomfort or fatigue, and productivity at work. When looking at MSD pain as the outcome for the effectiveness of the intervention, self-reported pain scale such as the visual analogue scale (VAS) or the Nordic MSD questionnaire were used. Furthermore, when conducting research on the intervention, physical factors and psychosocial work characteristics were considered when looking at the outcome.

Luger et al. 2019 (36) conducted a systematic review on the effectiveness of work-break intervention to tackle work-related MSDs among workers and assessed its quality of the evidence. After comparing five high quality studies and their results, there is a low-quality evidence that suggests that the implementation of different work-break frequencies could have an effect on reducing musculoskeletal pain, discomfort, and fatigue as compared to no additional break (36). Likewise, when comparing no additional work-break to additional work-break for work productivity, there are also no positive effect.

Recent research by Waongenngam et al. 2021 (37), evaluated the effect of promotion of active work-breaks and postural shifts on new onset of neck and low-back pain in office worker found interesting results. Active break and postural shift intervention reduced new onset of neck and low-back pain. However, there are no differences in pain intensity and disability for those that have already experienced MSDs pain.

Although, work-break intervention has no clear effect to prevent MSDs in office/sedentary population, however, it may be effective for other working population. Studies suggested that different types of work-breaks may be more effective in occupations and sectors that required workers to bear high physical loads, such nurses and assembly line workers. This might be that sedentary workers developed MSDs due to inactivity, prolonged sitting, and repetitive motion such as the wrist when operating a computer; however, other occupations are more likely to developed MSDs due to long standing hours or stress from physical workload (38). Consequently, work-break would provide sometimes for these muscles to rest and recover from a lot of pressure as compared to office/sedentary workers.

Challenges in research related to work-break intervention are subjective reporting which pose the risk of bias in the estimation of exposure and health outcome.

3.5 Application (AI) as Intervention

Using mobile or computer application for the promotion of health and outcomes is another aspect for the prevention of MSDs. The use of mobile or computer application has a variety of use such as a reminder to take break, active break, exercise reminder software program, or a follow along application for exercise and stretching. These applications aimed to help to reduce MSDs pain such as upper limb, lower back, and upper back pain. Improvements in MSD symptoms in these areas are measured after the promotion of increase physical activity or work-break for sedentary office workers.

When conducting the studies for the effectiveness of these interventions, outcome such as subjective severity of pain using Nordic Questionnaire or VAS, subjective pain improvement, eyestrain, physical activity, quality of life by using the form QoL SF-36, work performance, and

psychological status are measured to provide a full extend of the problems. However, not all studies provide these factors in their research.

Anan et al. 2021 (39) aimed to evaluate the improvement of MSD symptoms for workers with neck, shoulder, lower back pain after an AI assisted health program. The study shown that short exercise given by AI-assisted program do improved neck, shoulder, and lower back pain after 12 weeks of used (39). Lanhers et al. 2016 (40) conducted a randomized trials to determine the effectiveness of a computer application program to promote active break. The study found that the program is effective in the short term to reduce MSDs of the neck, lower and upper back, and shoulder due to its ability to allow workers to pick exercise tailor to their needs in the workplace. However, adherence use of the application decreases over time. Irmak et al. 2012 (41) looked at the effectiveness of exercise reminder program to evaluate office workers' perceived pain level, work performance, and quality of life. The study found that application might reduce short-term MSDs pain; however, it has no effect on work performance nor quality of life.

The challenges with application programs are the adherence use. This could decline over time. Social support and high adherence are needed to have effective results. Additionally, further studies are needed to support these finding because these studies did not look into the cause and effect of those MSD pains. The reduction of observed pain may cause by both the intervention, the occupational factors, and other bias in the studied population.

3.6 Multiple Combination of Intervention

A combination of intervention is another way to tackle MSDs for office workers in the workplace. Combination of intervention can combine different aspects of ergonomic and different exercises for the reduction of MSD pain. One study by Shariat et al. 2018 (42) looked at this combination intervention for neck, shoulder, and lower back pain by using the Cornell Musculoskeletal Questionnaire (CMDQ). When comparing exercise intervention, combination of exercise and ergonomic, and ergonomic alone between four months and six months, all three interventions are effective, but only exercise and combination interventions are shown to be effective after six months. However, there were no significant differences between the intervention groups.

Another study by Pereira et al. 2017 (43) conducted a randomized trial to assess the effect of workstation ergonomic combined with neck specific exercise for health-related productivity. The study found that by combining these two interventions, there is a possible benefit to reduce sickness presenteeism and productivity loss. However, the study design might cause the result to be of low-quality due to low follow-up rate and overestimate of human capital to quantify productivity loss.

Some of the reported challenges to perform this research is the limitation with the ergonomic modification as it is only adjustable equipment—desk, chairs, keyboards, monitor, and mouse—and not the replacement of these materials. Second, there are different types of exercise that can be investigate for the effectiveness of MSD interventions. This particular study only looks into stretching exercise without loading.

3.7 Evidence from Policies and Challenges

3.7.1 Challenges in Policy

Across the world, there are national strategies in place to prevent MSDs. However, these strategies provide a framework for MSDs in general not only for sedentary or office workers. Many high-income countries rely on their health institution, institution for labour, occupational health administration, or related to handle different national initiatives for MSD intervention in the workplace. High-income countries that have MSD interventions includes but not limited to Austria, Australia, Belgium, Canada, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, United Kingdom, and United States.

According to the EU-OSHA (44), although these countries have initiatives and strategies to prevent and manage MSDs, there are still challenges to better understand the effectiveness of the strategies. From the perspective of field research on MSDs, some organizations fail to realize the inter-connectivity of MSDs risks and thus considered their responsibility to be limited (44). There is lack of interventions in the workplace, which means that there is a lack of evaluation of any interventions to see the effectiveness of MSDs programs. Furthermore, with the lack of intervention programs in the workplace, there is a lack of risk assessment. According to Expert 1 who is an auditor for health promotion in the workplace, in order to limit the lack of risk assessment, workplace needs to promote strong leadership and develop a strong sense of health promotion culture in the workplace.

The lack of risk assessment in the workplace means that organizations might not have the knowledge to assess the risks (44). A survey conducted by EU-OSHA found that large organizations are more likely to carry out risk assessment, while small and medium enterprise lack the resources to carry out the assessment. Although large enterprise carries out risk assessment, the qualitative data collected are not always compliant. According to Expert 1, these are due to the lack managerial support, financial needs, and expertise to support the program in the workplace.

The most challenging factor for MSDs prevention is the lack of data collected from both the national and workplace level. Data collected for policy evaluation does not inform prevention activities and are often not available. Therefore, a good occupational health surveillance

system is required. Furthermore, evaluation of the impact of intervention programs are also not measured unless it is carried out in a research project (44). So far, only two countries—Germany and the United Kingdom—have planned to evaluate their MSDs strategies interventions, while other countries evaluation system is either limited or non-existing.

The second challenge for MSDs intervention gap is the inadequacy of risk assessments. Risks assessment report by EU countries only reported risks that are in the EU directives but did not recognize wider range of risks. EU-OSHA reported that risk assessment is carried out after something had already occurred rather than the beginning of the work. Thus, the assessment only looked at the physical risk factors and neglected factors such as gender, age, or mental health and other psychosocial factors. Not only that risk assessment is carried out after the event occurred, research for the effectiveness of interventions uses self-reporting tools. These tools are another main gap in MSDs intervention research. Self-reporting tools are not always accurate to describe MSD pain. According to Expert 1, when researcher gave self-reporting tools to participant to describe their pain, there is the problem of participant not understanding or not knowing how to describe their pain. One recommendation from Expert 1 is to have an additional aspect in addition to self-reporting tools such as interview to have a better interaction with the workers.

These barriers and challenges align with report from Safe Work Australia (45). Safe Work Australia identified six challenges that affect the effectiveness of MSD interventions (Table 2).

Table 2: Barriers and challenges identified by Safe Work Australia

Failure to adopt a systems approach to risk management
Inadequate adherence to hierarchy of risk control
The lack of management commitment, organization culture
Role of legislation, codes for practice and other safety documents
Lack of priority and understanding about worker participation
Competencies in MSD risk management

Understanding these challenges, EU-OSHA recommended a few recommendations. The scope of risk assessment should incorporate wider range of risk such as gender and other potential cause. Prevention activities needs to focus on work designs and ergonomics by removing risks at the source. Usable and useful data tool should design to help evaluation at the national and organizational level. These can inform evaluation both at the policy level and in the workplace. Ergonomic interventions and knowledge should be kept to date and needs

to apply in the workplace. However, ergonomic tools used in the workplace should be tools that have been studies before that shown to have some effectiveness.

In order to assess and manage MSD risks in the workplace, some countries like the United Kingdom and Canada created a toolkit in order for different enterprise to assess their own MSD risks at the workplace and to provide recommendation of interventions that is most suited for their employees and work environment (46,47). In the United Kingdom, the development of the *Musculoskeletal Health Toolkit for Employer* is framework to assist employers to manage and prevent MSDs risk in the workplace. The toolkit provided template risk assessments for the employers regardless of small, medium, or large enterprise to assess MSD risks int eh workplace. The Occupational Health and Safety Council of Ontario (OHSCO) published a series of toolkits to provider employers with information and to provide standardized guidance on how to assess MSDs risk in the workplace. These toolkits further provide guidelines and how organizations can tailor their MSD interventions in a way that is unique to their working environment. However, these toolkits would require strong leadership and management from the organization to initiate the process of MSDs assessment.

3.7.2 Policy level intervention and recommendations

After conducting a review of research on work-related MSDs on different policy and practice in the European Union, the EU-OSHA recommended eight area that future policy on MSD interventions should focus on (44,48). These eight areas have been identified through field research that explore what was happening in the workplace, organizational, and national level (Table 3).

Table 3: Eight areas for future MSDs policy implementation

Top-level priority, commitment, and resourcing	For MSD intervention policy to be successful, there is a need for commitment from all actors starting from the top level. In term of national policies, government need to be fully committed. While for industry-specific initiatives, commitment from stakeholders in the industry need to be well involved.
Collaboration with stakeholders	Involvement from all stakeholders is fundamental for an effective MSD prevention. Stakeholders can help identify risks and introduce risk controls or preventative strategies in the workplace.

Incentive	Positive and negative incentives can be effective for changes in the workplace. Direct support and guidance including financial supports can provide positive actions from employers.
Coherent planning	Many interventions are carried without the consideration of theory of change and why change needs to happen. Coherent planning needs to be clearly thought out in a logical way.
Wider perspective	Worker cannot be isolated from being an individual and a task performer at work. When looking at MSD interventions, the concept of physical, psychological, or social aspect needs to be included. Recognition is needed that workers exposed to MSD not only at the workplace, but also outside.
Continuity	Policy and implementation of strategies should not be stop after its initial completion. Intervention needs to be continually evaluated and analysed in order to improve the effectiveness and efficacy.
Preventative approach	Rather than a responsive approach to MSD at work, strategies need to be more preventative. Action plans that take step with prevention can tackle the problem before it has taken place.
Role of ergonomic and ergonomic teaching	The role of ergonomic is important in the workplace as it is not only concern with physical hazards, but because it provides a systematic approach. Ergonomic will explore the role of work organization and the environment of wider organization.

4. Discussion

This scoping review identified five themes for the intervention of MSDs in office and sedentary workers. These themes include ergonomic intervention, physical activity, work-break, the use of mobile or computer application, combination of interventions, and using policies and strategies to tackle MSDs in the workplace. There is mixed evidence on the effectiveness of these interventions to tackle MSDs which means that some studies found that it might be effective, effectiveness but not generalizable, or low-quality evidence that researchers cannot

conclude on the effectiveness. Research that looked into different types of interventions recognized that bias in the research and how the design of the study can contribute to low quality of the evidence for MSDs intervention effectiveness. Furthermore, most of the studies that look at the outcome of MSD interventions use self-reporting tools which can contribute to reporting bias and other misconception of pain. As one expert pointed out, musculoskeletal disorders is an umbrella term. This might create the challenge of how one understands what the meaning of MSDs is or what does MSD encompass and even what kind of pain might be considered MSDs related to work.

In term of policies and strategies that are in place created by different occupational health organizations, there are the challenges of management, risks, leadership, priorities, worker participations, good practices, and risk controls. These challenges are important to address in order to provide a comprehensive approach to tackle MSDs.

4.1 MSD Research

The above results show that there are a few different types of interventions to tackle MSDs for office workers and sedentary worker in the workplace and there are national and organizational strategies for MSDs prevention. Most OECD countries have their own national strategies to prevent MSDs in the workplace; however, there are challenges with standardization of the implementation and reporting from the organizational level to the governmental level. Many researchers have investigated the effectiveness of different types of intervention for MSDs in office workers, but evidence for these interventions is inconclusive or that the evidence for the effectiveness of these interventions varies greatly from one study to another.

Many studies have investigated the effectiveness of ergonomic intervention, work-break intervention, increase of physical activity intervention, using application on mobile and computer devices for reminder to take break and exercise, and combination between ergonomic intervention and other types of interventions. As highlighted by numerous studies, biases in individual studies made it almost impossible to understand the relationship between the effect of the intervention to MSDs pain or other outcomes. For example, due to bias such as non-blinding and lost to follow-up in the study and the tool used for assessment it made those studies to have low-quality evidence. Those studies, furthermore, stated that although some interventions might be effective to prevent MSDs pain, it was not statistically significant to fully conclude that it can be effective in the general population besides the population that was included in the study (33).

Although some studies such as the one looking at physical activity and using application on mobile phone and computer as a reminder, found some effectiveness but those effectiveness

was not long term (39). Most studies tried to find the effectiveness of the intervention ranges between three months to one years. However, the best solution for MSDs research is to carry it out longer term studies as short studies cannot investigate the effect of MSDs pain as it takes some time for MSDs pain to develop while working in an awkward position.

The assessment tool of different type of MSDs pain can also contribute to the challenges in research for its effectiveness and bias of the study. Almost all researchers that look into the effectiveness of these interventions use self-reporting tools for before and after intervention such as the CMDQ, VAS, and NMQ. Self-reporting tool is great to use, however, it created the problem with bias in term of how researcher knows if the individual understands what they should report on and reporting bias from the participants. For example, question that is used in the Nordic Musculoskeletal Questionnaire can be, “Have you at any time during the last 12 months had trouble (such as aches, pain, discomfort, numbness) in the neck, shoulder, upper back and so on?” Individual that is responding to this question can answer them honestly or they might forget what kind of pain they felt in the last 12 months. There are different types and level of pain or if the individual understand what MSD pain is. Furthermore, different research uses different tools for the assessment of MSDs pain. This created the problem of different standard of assessment. To address this gap there needs to be a standardized tools where researcher can use; additionally, there should be a supplementary way to assess MSDs pain besides self-reporting. According to Expert 1, they believe that interview with each participant before and after the intervention can provide another way to gauge with their understanding of pain and how they can report these issues. While according to Expert 2, they believed that the problem with the self-reporting tools is the open term of MSDs. MSDs is an umbrella term. Everyone has their own definition of what is pain, what is MSDs, and how to address these issues. One recommendation that Expert 2 recommended is to have open culture. Open culture is a way to allow workers to openly discuss their problem without any negative consequences in the workplace.

Majority of the studies presented above mainly investigated the effect of the intervention on pain. There are a few that looked into the secondary outcome such as quality of life, productivity at work, sickness absence, presenteeism, and sometime even mental health (20,23,36,49–51). But the results were similar to the MSDs pain, or it was not reported. It was interesting to see that the studies above did not investigate the cost-effectiveness aspect of the intervention. It is known that MSDs in the working population have negative consequence to the economy at the employer level, national level, and individual level (8). It is crucial for future research to have a multidisciplinary approach in term of research methodology. In order to reduce biases in the study and to provide quality evidence, larger sample size, longer

duration of research period, and better reporting tools is compulsory to fully understand the effect of MSD interventions on MSDs in the workplace.

4.2 Future Research

Further studies need to be able to provide and analyse the cost-effectiveness of the intervention. Current literatures that examine the effectiveness of MSD interventions did not look at cost-effectiveness or they provided limited data on how to measure the effectiveness in terms of cost. These might be due to the current inconsistencies in the evidence of the effectiveness of these interventions it is impractical. However, cost-effectiveness can be evaluated from a bigger perspective when looking at health promotion in the workplace. These can include but not limited to rehabilitation programs and understanding how the countries' policies works for health promote and intervention works (52). Although this scoping review does not cover rehabilitation for MSDs in the workplace, but future research can keep this in mind when looking at MSDs intervention and its effectiveness. When looking at cost-effectiveness for intervention such as MSDs, outcomes that need to be measured can be sickness absence, capability to work, and presenteeism (52). This might provide insight and ways to analyse cost-effectiveness. Again, research needs to be long-term not only ranges between six months to one year. When there are cost benefit analysis on different types of interventions, organizations, and employers maybe are more incline to buy into these intervention strategies. According to Expert 3, If there is a demonstration of cost benefit analysis for different interventions, it can provide companies and other employers some evidence that these MSD interventions are cost-saving in the future.

Furthermore, future studies need to take a full breath of approach for the effectiveness of MSD intervention. Looking at pain as the primary outcome is not the only way for assess the effectiveness. There is a need for a holistic approach to MSDs research because workers are not only getting MSDs from work but also other factors as well. Psychosocial risks at work is needed when looking at MSD physical risks (53). Another aspect that is missing in translation between research and the implementation of MSDs intervention is the failure to connect the ideal situation versus the practical aspect. Expert 3 noted that research that try to look at MSD interventions need to realize about the feasibility of these interventions into everyday practice and how it will playout in the working area.

According to Expert 2 on the relationship between psychosocial risks and MSDs, there is some evidence that MSDs are not only caused by physical factors. Expert 2 give an example that back pain might be associated with psychosocial factors. When a person is stressed at work, they might sit in a certain position that put stress on their back muscle and thus developed MSDs pain. Again, one solution suggested by Expert 2 is to promote open culture in the

workplace where workers can discuss these health issues with their manager. This means that to have a better MSDs intervention, future research needs to include this psychosocial factor in the research. Furthermore, universal ergonomic design is recommended. It is important to have a multidisciplinary focus on research when looking at MSD interventions. If future research does not include area of focus such as psychosocial risk in research, evidence gathered cannot be truly inform its effectiveness to prevent MSDs in the workplace nor will the evidence be practical and feasible in the working environment where there are both physical and psychosocial risk factors associated with MSDs. Furthermore, when evaluating different types of interventions and preventions of MSDs, there is a need to recognize the context and extent of the workplace. According to Expert 3, it is more important to have a realist evaluation of certain interventions and recognizing that different types of interventions can be tailored toward different workplaces even for office and sedentary workers.

4.3 Strategies and Policies

In the national strategies for MSD interventions, there are a guideline for the overall MSD intervention in the workforce. However, it lacks the intervention for specific sector of the workforce. There are a few challenges and gaps for MSD prevention strategies. These challenges include the funding, risk assessment and reporting, lack of continuity, stakeholders' involvement, leadership, and promotion of safety culture (48).

As mentioned above, the lack of leadership and risk assessment and reporting made MSDs intervention a challenge. This is due to the reason that without an assessment report from the enterprise, there is not enough data to assess the effectiveness of the intervention. Furthermore, even with the risk assessment provided to these organization, there is a lack of expert and leadership to encourage the reporting of these issues. One example is based on the financial availability of the enterprise. Larger enterprise has the resources to have a health promotion department to carry these risk assessments and work on the reporting. However, smaller, and medium enterprise do not have the financial resources to carry out these strategies as set by the guideline. Regardless of financial availability, one concept that needs to be carried out is the standardized definition and meaning of MSDs. Since MSDs is an umbrella term, different country and even organization have different approach to tackle the problem. Thus, it is even harder to compare risk assessment for MSDs.

One solution to this lack of resources and unequal reporting between large enterprise versus small and medium enterprise, is that there is a need to have strong leadership and involvement from all stakeholders. When providing national strategy for MSDs intervention, there is a need for financial incentive especially from government so that at least there are resources for these small and medium enterprise to implement and assess the intervention (44). Having financial

resources is the first step to have better strategies and policies. However, a good leadership is needed for the implementation. Leadership and an expert in occupational health is required in order to foresee the entire program. A good leadership for occupation health promotion can create a strong safety culture and reduce fear in workers and promote open communication. As stated by expert 1, a good leader can destigmatize fear in workers and allow open communication about their health issues at work instead of the fear that if they tell their manager about the pain, they might be fired or will be looked down upon.

Although the EU-OSHA provided eight important areas to inform future policy for MSDs intervention, there is still one aspect of MSDs gap that has to be address in both policy and research: psychosocial risk of MSDs in the workplace. In a report that conducted a literature review on MSDs found that there is a combined factor between physical risk and psychosocial risk for the cause of MSDs (53). Psychosocial risk and physical risk in the workplace have a causal role in the development of MSDs. However, the association between physical and psychosocial risks are not yet clear and thus it is not possible to identify the pattern in the association (53) for any specific MSDs.

However, it is important to note that the association between psychosocial factors and MSDs work both ways. Psychosocial risk factor can contribute to MSDs as a causal relationship, or developing MSDs can intensify the development of psychosocial risk factors (53). The effect of psychosocial factors is not always negative. According to the report by EU-OSHA, psychosocial factor can also be a positive effect. There are some evidence that suggest that a good job control can mitigate the negative effect of high job demands (53).

There is limited research on psychosocial risk factors and MSDs. Current research does not show any specific psychosocial risk factors to be associated with a specific MSD. Future research is needed in order to have a full understanding of psychosocial risk in the workplace and its impact on MSDs. Furthermore, when conducting research for MSDs intervention, psychosocial risk factor needs to be considered when looking at the effectiveness of the intervention and not just physical risk factors alone. Holistic approach and promoting participatory approach in all levels can positively contribute to better effectiveness of MSDs intervention.

Additionally, engagement from all stakeholders is fundamental for the success of the strategy (44,45). This will allow better communication and support from all main stakeholders not only the organization level, national level, but also the managers, and the workers themselves. Which means that there will be continuity for MSDs intervention after the initial program has ended. Strong commitment for MSDs intervention in both the workplace and national program is needed to prevent MSDs for office workers and sedentary workers.

5. Conclusion

Musculoskeletal disorders are a global occupational health issue in office workers and sedentary workers and not only in OECD countries, but in the world. However, as the number of workers turn to office-base work increase dramatically in the last century and recently the Covid-19 pandemic also changed how office workers are working remotely and thus health promotion and MSDs interventions are needed. With the use of the scoping review methodology, the search through scientific databases and gray literature, and interview with experts, there are interesting findings of the current evidence and gaps in research and in policy. There are different types of intervention to prevent MSDs in this population such as ergonomic, work-break, increase of physical activity, the use of application as reminder to take break or stretch, and combination of intervention to prevent MSDs. However, the evidence for the effectiveness of these interventions varied from one study to another due to the bias, challenges with conducting the research, and from not looking at the interventions from a multidisciplinary perspective. Some interventions are effective in the short-term, but no study have looked at the long-term effect of these interventions. Many countries especially those of high-income have implemented national strategies to tackle MSD. However, there is a need for standardized reporting, financial incentive, and better leadership in order for the strategies to work and prevent MSDs in sedentary workers. It is very important to address the issue of MSDs and health at work at the national level, organizational level, and local level. A strong leadership is needed to promote health and safety at work and also to encourage open communication about health promotion. As quoted by one expert in the field of ergonomic, “There is no country that is saved from MSDs as every country has about 50% of MSDs in the working population, so if we don’t address it now, we might find ourselves facing financial consequences as no company can support 70% of medical expenses and the absence of employees. We must do something now.”

6. Limitation

The main limitation of this study is the low number of expert consultations for recommendation and gaps that happened in research and policy implementation. Although the research highlighted different aspect of MSDs intervention in the workplace for office workers and sedentary workers for its effectiveness, there is a lack of literature on the cost-effectiveness of these interventions and other outcomes such as quality of life, presenteeism, and sick leave.

Additionally, the aim and scope of this study could lead to the exclusion of studies that could be other factors of MSDs at work such as mental health and psychosocial effect on this population. Furthermore, this study focuses on workplace intervention only, other MSD

preventions such as occupational therapy is not included nor any studies that look at rehabilitation programs. However, including these aspects would have strayed from the objective of assessing current for workplace MSDs intervention. Recently, due to Covid-19 pandemic, a lot of the workforce have moved to teleworking, thus, this might add another aspect of sedentary aspect for MSDs.

7. Funding

This scoping review received no financial support for the research.

References

1. Woolf AD, Pfleger B. Burden of major musculoskeletal conditions. Bull World Health Organ [Internet]. 2003 [cited 2022 May 16];81(9):646. Available from: /pmc/articles/PMC2572542/?report=abstract

2. Hoe VC, Urquhart DM, Kelsall HL, Zamri EN, Sim MR. Ergonomic interventions for preventing work-related musculoskeletal disorders of the upper limb and neck among office workers. Cochrane database Syst Rev. 2018 Oct;10(10):CD008570.

3. Van Der Beek AJ, Dennerlein JT, Huysmans MA, Mathiassen SE, Burdorf A, Van Mechelen W, et al. A research framework for the development and implementation of interventions preventing work-related musculoskeletal disorders. Scand J Work Environ Health [Internet]. 2017 [cited 2022 May 16];43(6):526–39. Available from: https://pubmed.ncbi.nlm.nih.gov/28945263/

4. European Agency for Safety and Health at Work. Work-related musculoskeletal disorders: prevalence, costs and demographics in the EU [Internet]. Publications Office of the European Union. 2019. Available from: http://europa.eu

5. Sihawong R, Sitthipornvorakul E, Paksaichol A, Janwantanakul P. Predictors for chronic neck and low back pain in office workers: a 1-year prospective cohort study. J Occup Health [Internet]. 2016 [cited 2022 May 16];58(1):16–24. Available from: https://pubmed.ncbi.nlm.nih.gov/26498979/

6. Sihawong R, Janwantanakul P, Jiamjarasrangsi W. A prospective, cluster-randomized controlled trial of exercise program to prevent low back pain in office workers. Eur Spine J. 2014;23(4):786–93.

7. Tompa E, Mofidi A, van den Heuvel S, van Bree T, Michaelsen F, Jung Y, et al. Economic burden of work injuries and diseases: a framework and application in five European Union countries. BMC Public Health [Internet]. 2021 Dec 1 [cited 2022 May 26];21(1):1–10. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-020-10050-7

8. Summers K, Jinnett K, Bevan S. Musculoskeletal Disorders, Workforce Health and Productivity in the United States. 2015 [cited 2022 May 16]; Available from: www.theworkfoundation.com.

9. Bevan S. Economic impact of musculoskeletal disorders (MSDs) on work in Europe. Best Pract Res Clin Rheumatol. 2015 Jun 1;29(3):356–73.

10. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. https://doi.org/101080/1364557032000119616 [Internet]. 2007 Feb [cited 2022 May 5];8(1):19–32. Available from: https://www.tandfonline.com/doi/abs/10.1080/1364557032000119616

11. Levac D, Colquhoun H, O'Brien KK. Scoping studies: Advancing the methodology. Implement Sci [Internet]. 2010 Sep 20 [cited 2022 May 5];5(1):1–9. Available from: https://implementationscience.biomedcentral.com/articles/10.1186/1748-5908-5-69

12. Peters MDJ, Marnie C, Tricco AC, Pollock D, Munn Z, Alexander L, et al. Updated methodological guidance for the conduct of scoping reviews. JBI Evid Synth [Internet]. 2020 Oct 1 [cited 2022 May 5];18(10):2119–26. Available from: https://pubmed.ncbi.nlm.nih.gov/33038124/

13. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med [Internet]. 2018 Oct 2 [cited 2022 May 5];169(7):467–73. Available from:

https://pubmed.ncbi.nlm.nih.gov/30178033/

14. Dropkin J, Kim H, Punnett L, Wegman DH, Warren N, Buchholz B. Effect of an office ergonomic randomised controlled trial among workers with neck and upper extremity pain. Occup Environ Med. 2015;72(1):6–14.

15. Danquah IH, Kloster S, Holtermann A, Aadahl M, Tolstrup JS. Effects on musculoskeletal pain from “Take a stand!” – A cluster-randomized controlled trial reducing sitting time among office workers. Scand J Work Environ Heal. 2017;43(4):350–7.

16. van Niekerk S-M, Louw QA, Hillier S. The effectiveness of a chair intervention in the workplace to reduce musculoskeletal symptoms. A systematic review. BMC Musculoskelet Disord. 2012 Aug;13:145.

17. Lee J, Kim H-RH-R, Lee D-WD-W, Kang M-Y. Interaction between occupational physical burdens and low job control on musculoskeletal pain: Analysis of the 5th Korean Working Environment Survey. J Occup Health. 2021 Jan;63(1):e12244.

18. Samsuddin NA, Daruis DDI. A STUDY OF MUSCULOSKELETAL DISORDERS AMONG VISUAL DISPLAY TERMINAL WORKERS. Yusuff RM, Ahmad SA, Daruis DDI, Deros BM, Dawal SZM, editors. Vol. 10, CURRENT TRENDS IN ERGONOMICS. 2013. p. 300-+.

19. Channak S, Klinsophon T, Janwantanakul P. The effects of chair intervention on lower back pain, discomfort and trunk muscle activation in office workers: a systematic review. Int J Occup Saf Ergon. 2021 Jun;1–10.

20. Sohrabi MS, Babamiri M. Effectiveness of an ergonomics training program on musculoskeletal disorders, job stress, quality of work-life and productivity in office workers: a quasi-randomized control trial study. Int J Occup Saf Ergon. 2021 May;1–8.

21. Madhwani KP, Nag PK. Web-based kap intervention on office ergonomics: A unique technique for prevention of musculoskeletal discomfort in global corporate offices. Indian J Occup Environ Med. 2017;21(1):18–22.

22. Bazazan A, Dianat I, Feizollahi N, Mombeini Z, Shirazi AM, Castellucci HI. Effect of a posture correction-based intervention on musculoskeletal symptoms and fatigue among control room operators. Appl Ergon. 2019 Apr;76:12–9.

23. Esmaeilzadeh S, Ozcan E, Capan N. Effects of ergonomic intervention on work-related upper extremity musculoskeletal disorders among computer workers: a randomized controlled trial. Int Arch Occup Environ Health. 2014 Jan;87(1):73–83.

24. Baydur H, Ergör A, Demiral Y, Akalın E. Effects of participatory ergonomic intervention on the development of upper extremity musculoskeletal disorders and disability in office employees using a computer. J Occup Health. 2016 Jun;58(3):297–309.

25. Levanon Y, Gefen A, Lerman Y, Givon U, Ratzon NZ. Reducing musculoskeletal disorders among computer operators: comparison between ergonomics interventions at the workplace. Ergonomics. 2012;55(12):1571–85.

26. Heidarimoghadam R, Mohammadfam I, Babamiri M, Soltanian AR, Khotanlou H, Sohrabi MS. What do the different ergonomic interventions accomplish in the workplace? A systematic review. Int J Occup Saf Ergon. 2022 Mar;28(1):600–24.

27. Workers Health & Safety Centre. The case for worker involvment: Participatory Ergonomics. Workers Health & Safety Centre. 2019.

28. Chen C, Dieterich AV, Koh JJE, Akksilp K, Tong EH, Budtarad N, et al. The physical activity at work (PAW) study protocol: A cluster randomised trial of a multicomponent short-break intervention to reduce sitting time and increase physical activity among office workers in Thailand. BMC Public Health. 2020;20(1).

29. Holzgreve F, Maltry L, Lampe J, Schmidt H, Bader A, Rey J, et al. The office work and stretch training (OST) study: An individualized and standardized approach for reducing musculoskeletal disorders in office workers. J Occup Med Toxicol. 2018;13(1).

30. Machado-Matos M, Arezes PM. Impact of a workplace exercise program on neck and shoulder segments in office workers | Impacto de un programa de ejercicio en el trabajo en los segmentos de cuello y hombros en los trabajadores de oficina. DYNA. 2016;83(196):63–8.

31. Rodrigues EV, Gomes ARS, Tanhoffer AIP, Leite N. Effects of exercise on pain of musculoskeletal disorders: A systematic review. Acta Ortop Bras. 2014;22(6):334–8.

32. Cabak A, Kotynia P, Banasiński M, Obmiński Z, Tomaszewski W. The Concept of "Chair Massage" in the Workplace as Prevention of Musculoskeletal Overload and Pain. Ortop Traumatol Rehabil. 2016 May;18(3):279–88.

33. Chen J, Mullins CD, Novak P, Thomas SB. Personalized Strategies to Activate and Empower Patients in Health Care and Reduce Health Disparities. Heal Educ Behav [Internet]. 2016 Feb 1 [cited 2021 May 27];43(1):25–34. Available from: /pmc/articles/PMC4681678/

34. Brakenridge CL, Chong YY, Winkler EAH, Hadgraft NT, Fjeldsoe BS, Johnston V, et al. Evaluating short-term musculoskeletal pain changes in desk-based workers receiving a workplace sitting-reduction intervention. Int J Environ Res Public Health. 2018;15(9).

35. Parry SP, Coenen P, Shrestha N, O'Sullivan PB, Maher CG, Straker LM. Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers. Cochrane database Syst Rev. 2019 Nov;2019(11).

36. Luger T, Maher CGCG, Rieger MAMA, Steinhilber B. Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers. Cochrane database Syst Rev. 2019 Jul;7(7):CD012886.

37. Waongenngarm P, van der Beek AJ, Akkarakittichoke N, Janwantanakul P. Effects of an active break and postural shift intervention on preventing neck and low-back pain among high-risk office workers: A 3-arm cluster-randomized controlled trial. Scand J Work Environ Heal. 2021;47(4):306–17.

38. Wagner V, Pfaffstaller E, Kallus KW, Wagner V, Pfaffstaller E, Kallus KW. How to Implement an Effective Intervention for Breaks during Working Days—A Field Study. Psychology [Internet]. 2017 Mar 31 [cited 2022 May 26];8(5):728–45. Available from: http://www.scirp.org/journal/PaperInformation.aspx?PaperID=75047

39. Anan T, Kajiki S, Oka H, Fujii T, Kawamata K, Mori K, et al. Effects of an Artificial Intelligence-Assisted Health Program on Workers With Neck/Shoulder Pain/Stiffness and Low Back Pain: Randomized Controlled Trial. JMIR MHEALTH UHEALTH. 2021;9(9).

40. Lanhers C, Pereira B, Garde G, Maublant C, Dutheil F, Coudeyre E. Evaluation of "I-Preventive": a digital preventive tool for musculoskeletal disorders in computer workers-a pilot cluster randomised trial. BMJ Open. 2016 Sep;6(9):e011304.

41. Irmak A, Buming G, Irmak R, Bumin G, Irmak R. The effects of exercise reminder software program on office workers' perceived pain level, work performance and quality of life. Work. 2012;41 Suppl 1(SUPPL.1):5692–5.

42. Shariat A, Cleland JA, Danaee M, Kargarfard M, Sangelaji B, Tamrin SBM. Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts of office workers: a randomized controlled trial. Brazilian J Phys Ther. 2018;22(2):144–53.

43. Pereira MJ, Johnston V, Straker LM, Sjogaard G, Melloh M, O'Leary SP, et al. An Investigation of Self-reported Health-related Productivity Loss in Office Workers and Associations With Individual and Work-related Factors Using an Employer's Perspective. J Occup Environ Med. 2017;59(7):e138–44.

44. European Agency for Safety and Health at Work. Prevention policy and practice : approaches to tackling work-related musculoskeletal disorders [Internet]. 2020. 1–53 p. Available from: http://europa.eu

45. Oakman J, Clune S, Stuckey R., Kinsman N, Macdonald W. Work-related Musculoskeletal Disorders in Australia. 2019.

46. Health and Safety Executive. Toolkit for assessing musculoskeletal disorders risk [Internet]. [cited 2022 May 26]. Available from: https://www.hse.gov.uk/msd/toolkit.htm

47. Occupational Health and Safety Council of Ontario. MSD Prevention Series [Internet]. [cited 2022 May 26]. Available from: https://www.iwh.on.ca/publications/msd-prevention-series

48. European Agency for Safety and Health at Work. Work-related musculoskeletal disorders: from research to practice. What can be learnt? European Risk Observatory Report [Internet]. Publications Office of the European Union. European Agency for Safety and Health at Work – EU-OSHA. 2020. 1–51 p. Available from: https://osha.europa.eu/pt/publications/work-related-musculoskeletal-disorders-research-practice-what-can-be-learnt/view

49. Holzgreve F, Maltry L, Hänel J, Schmidt H, Bader A, Frei M, et al. The Office Work and Stretch Training (OST) Study: An Individualized and Standardized Approach to Improve the Quality of Life in Office Workers. Int J Environ Res Public Health. 2020 Jun;17(12):1–15.

50. Irmak A, Buming G, Irmak R. The effects of exercise reminder software program on office workers' perceived pain level, work performance and quality of life. Work. 2012;41(SUPPL.1):5692–5.

51. Daneshmandi H, Kee D, Kamalinia M, Oliaei M, Mohammadi H. An ergonomic intervention to relieve musculoskeletal symptoms of assembly line workers at an electronic parts manufacturer in Iran. Work. 2018;61(4):515–21.

52. National Institute for Health and Care Excellence. Workplace health: long-term sickness absence and capacity to work [Internet]. 2019 [cited 2022 May 20]. Available from: https://www.nice.org.uk/terms-and-

53. Graveling R, Smith A, Hanson M. Musculoskeletal Disorders: Association with Psychosocial Risk Factors at Work. European Agency for Safety and Health at Work. 2021. 76 p.

54. Cornelius KM, Turin FC, Wiehagen WJ, Gallagher S. An approach to identify jobs for ergonomic analysis . Natl Inst Occup Saf Heal [Internet]. [cited 2022 Jun 3]; Available from: https://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/aatij.pdf

55. CUergo: Musculoskeletal Discomfort Questionnaires [Internet]. [cited 2022 Jun 3]. Available from: https://ergo.human.cornell.edu/ahmsquest.html

List of Appendices

Appendix I

Below is the completed Preferred Reporting Items for Systematic reviews and Meta-analyses extension for Scoping Review (PRISMA-ScR) checklist, retrieved from Tricco et al. 2018 (13).

Section	Item	PRISMA-ScR Checklist Item	Reported on Page #
Title			
Title	1	Identity the report as a scoping review	title page
Abstract			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	iv-v
Introduction			
Rational	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	2
Objective	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	2
Methods			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	3
Eligibility Criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	4
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3-4
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	c
Selection of source of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	3-4
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been	3-4

		tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	3-4
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	3-4
Results			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	6-7
Characteristics of sources of evidence	15	For each source of evidence, present characteristic for which data were charted and provide the citations.	b-g
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	7-16
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	7-16
Discussion			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	16-17
Limitation	20	Discuss the limitations of the scoping review process.	22-23
Conclusion	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	21-22
Funding			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	23

Appendix II

Word strings for database searches

Scopus:

((TITLE-ABS-KEY (musculoskeletal AND disorders) OR TITLE-ABS-KEY (musculoskeletal AND symptoms) OR TITLE-ABS-KEY (musculoskeletal AND pain) OR TITLE-ABS-KEY (musculoskeletal AND disease))) AND ((TITLE-ABS-KEY (workplace) OR TITLE-ABS-KEY (officeworkers) OR TITLE-ABS-KEY (sedentary AND workers) OR TITLE-ABS-KEY (worksite))) AND ((TITLE-ABS-KEY (intervention) OR TITLE-ABS-KEY (program) OR TITLE-ABS-KEY (control) OR TITLE-ABS-KEY (ergonomic) OR TITLE-ABS-KEY (prevention))) AND ((TITLE-ABS-KEY (effectiveness) OR TITLE-ABS-KEY (assessment) OR TITLE-ABS-KEY (impact) OR TITLE-ABS-KEY (economic) OR TITLE-ABS-KEY (evaluation))) AND NOT ((TITLE-ABS-KEY (factory AND workers) OR TITLE-ABS-KEY (industry AND workers) OR TITLE-ABS-KEY (construction AND workers) OR TITLE-ABS-KEY (nurse) OR TITLE-ABS-KEY (healthcare AND professionals) OR TITLE-ABS-KEY (surgeons))) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012)) AND (LIMIT-TO (LANGUAGE , "English"))

381 articles

Web of science:
#1 AND #2 AND #3 AND #4 NOT
#5 and 2012 or 2013 or 2014 or 2015 or 2016 or 2017 or 2018 or 2019 or 2020 or 2021 or 2022 (Publication Years) and Open Access

#1 = TS=(musculoskeletal disorders OR musculoskeletal symptoms OR musculoskeletal pain OR musculoskeletal disease)
#2 = TS=(workplace OR office workers OR sedentary workers OR worksite)
#3 = TS=(intervention OR program OR control OR ergonomic OR prevention)
#4 = TS=(intervention OR program OR control OR ergonomic OR prevention)) AND TS=(effectiveness OR assessment OR impact OR economic OR evaluation)
#5 = TS=(factory worker OR industry workers OR construction workers OR nurse OR healthcare professionals OR surgeons)

329 articles

Pubmed
((("musculoskeletal disorders"[Title/Abstract] OR "musculoskeletal symptoms"[Title/Abstract] OR "musculoskeletal pain"[Title/Abstract] OR "musculoskeletal disease"[Title/Abstract]) AND ("workplace"[Title/Abstract] OR "office workers"[Title/Abstract] OR "sedentary workers"[Title/Abstract] OR "worksite"[Title/Abstract]) AND ("intervention"[Title/Abstract] OR "program*"[Title/Abstract] OR "control"[Title/Abstract] OR "ergonomic"[Title/Abstract] OR "prevention"[Title/Abstract]) AND ("effectiveness"[Title/Abstract] OR "assessment"[Title/Abstract] OR "impact"[Title/Abstract] OR "economic"[Title/Abstract] OR "evaluation"[Title/Abstract])) NOT ("factory worker"[Title/Abstract] OR "industry workers"[Title/Abstract] OR "construction workers"[Title/Abstract] OR "nurse"[Title/Abstract] OR "healthcare professionals"[Title/Abstract] OR "surgeons"[Title/Abstract])) AND (2012:2022[pdat])

233 articles

Other sources n= 6

Appendix III

Title	Authors	Year	Journal	Category
Workplace-Based Interventions for Neck Pain in Office Workers: Systematic Review and Meta-Analysis	Chen et al.	2017	Physical Therapy	Physical Activity
The office work and stretch training (OST) study: an individualized and standardized approach for reducing musculoskeletal disorders in office workers	Holzgreve et al.	2018	Journal of Occupational Medicine and Toxicology	Physical Activity
Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts of office workers: a randomized controlled trial	Shariat et al.	2018	Brazilian Journal of Physical Therapy	Combination
Impact of a workplace exercise program on neck and shoulder segments in office workers	Machado-Matos & Arezes	2016	--	Physical Activity
Effect of an office ergonomic randomised controlled trial among workers with neck and upper extremity pain	Dropkin et al.	2015	Occupational & Environmental Medicine	Ergonomic
Effects of exercise on pain of musculoskeletal disorders: a systematic review	Rodrigues et al.	2014	Acta Ortopedia Brasileira	Physical Activity
The Concept of "Chair Massage" in the Workplace as Prevention of Musculoskeletal Overload and Pain	Cabak et al.	2016	--	Physical Activity
Effects on musculoskeletal pain from "Take a Stand!" - a cluster-randomized controlled trial reducing sitting time among office workers	Danquah et al.	2017	Scand J Work Environment Health	Ergonomic
Effect of a Long Exercise Program in the Reduction of Musculoskeletal Discomfort in Office Workers	Villanueva et al.	2020	Environmental Research and Public Health	Physical Activity
Effects of an Artificial Intelligence-Assisted Health Program on Workers With Neck/Shoulder Pain/Stiffness and Low Back Pain: Randomized Controlled Trial	Anan et al.	2021	JMIR mHealth and uHealth	AI application
Evaluating Short-Term Musculoskeletal Pain Changes in Desk-Based Workers Receiving a	Brakenridge et al.	2015	Int J Environ Res Public Health	Physical Activity

Workplace Sitting-Reduction Intervention				
Effects of ergonomic intervention on work-related upper extremity musculoskeletal disorders among computer workers: a randomized controlled trial	Esmaeilzadeh et al.	2012	International Archives of Occupational and Environmental Health	Ergonomic
Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers	Parry et al.	2019	Cochrane Database Syst Rev.	Physical Activity
Effects of participatory ergonomic intervention on the development of upper extremity musculoskeletal disorders and disability in office employees using a computer	Baydur et al.	2016	Journal of Occupational Health	Ergonomic
Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers	Luger et al.	2019	Cochrane Database Syst Rev.	Work-break
Evaluation of 'I-Preventive': a digital preventive tool for musculoskeletal disorders in computer workers—a pilot cluster randomised trial	Lanhers et al.	2016	BMJ	AI Application
The impact of workplace ergonomics and neck-specific exercise versus ergonomics and health promotion interventions on office worker productivity: A cluster-randomized trial	Pereira et al.	2018	Scand J Work Environ Health	Combination
Ergonomic interventions for preventing work-related musculoskeletal disorders of the upper limb and neck among office workers	Hoe et al.	2018	Cochrane Database Syst Rev.	Ergonomic
Effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders in office workers: a systematic review	Tersa-Miralles et al.	2022	BMJ	Physical Activity
The effectiveness of a chair intervention in the workplace to reduce musculoskeletal symptoms. A systematic review	van Niekerk, Louw, & Hiller	2012	BMC Musculoskeletal Disorder	Ergonomic
Reducing musculoskeletal disorders among computer operators: comparison between ergonomics interventions at the workplace	Levanon et al.	2012	Ergonomics	Ergonomic
The effects of exercise reminder software program on office workers' perceived	Irmak et al.	2012	--	AI application

pain level, work performance and quality of life				
Effect of an ergonomic intervention involving workstation adjustments on musculoskeletal pain in office workers—a randomized controlled clinical trial	Lee et al.	2021	Industrial Health	Ergonomic
A Study of Musculoskeletal Disorders among Visual Display Terminal Workers	Samsuddin et al.	2013	--	Ergonomic
Effectiveness of an ergonomics training program on musculoskeletal disorders, job stress, quality of work-life and productivity in office workers: a quasi-randomized control trial study	Sohrabi & Babamiri	2021	Int J Occup Saf Ergon	Ergonomic
Effects of an active break and postural shift intervention on preventing neck and low-back pain among high-risk office workers: a 3-arm cluster-randomized controlled trial	Waongenngarm et al.	2021	Scand J Work Environ Health	Work-break
Web-based KAP Intervention on Office Ergonomics: A Unique Technique for Prevention of Musculoskeletal Discomfort in Global Corporate Offices	Madhwani & Nag	2017	Indian J Occup Environ Med	Ergonomic
The effects of breaks on low back pain, discomfort, and work productivity in office workers: A systematic review of randomized and non-randomized controlled trials	Waongenngarm et al.	2018	Applied Ergonomics	Workbreak
Effect of a posture correction–based intervention on musculoskeletal symptoms and fatigue among control room operators	Bazazan et al.	2019	--	Ergonomic
What do the different ergonomic interventions accomplish in the workplace? A systematic review	Heidarimoghadam et al.	2020	JOSE	Ergonomic
The effects of chair intervention on lower back pain, discomfort and trunk muscle activation in office workers: a systematic review	Channak, Klinsophon, & Janwantanakul	2021	Int J Occup Saf Ergon.	Ergonomic

Prevention policy and practice: approaches to tackling work-related musculoskeletal disorders	EU-OSHA	2020	--	Policy, Research, & Recommendation
Work-related musculoskeletal disorders: from research to practice. What can be learnt?	EU-OSHA	2020	--	Policy, Research, & Recommendation
Work-related Musculoskeletal Disorders in Australia	Oakman et al.	2019	Safe Work Australia	Policy, Research, & Recommendation
The case for worker involvement Participatory Ergonomic	Workers Health & Safety Centre	2019	--	Ergonomic
Musculoskeletal disorders: association with psychosocial risk factors at work	EU-OSHA	2021	--	Policy, Research, & Recommendation

Appendix IV

List of questions used during interview:

When MSD intervention is mentioned, it refers to MSD interventions for office/sedentary workers

These are the general questions. Other questions can be included depending on how the interviewee responded to the questions and their experiences.

1. What do you think the biggest gaps have been for research/policies implementation for MSD interventions in the workplace?
2. What do you think the biggest barriers have been for research/policies implementation into MSD interventions to address gaps?
3. What do you think the biggest opportunities are for research/policies implementation for MSD interventions?
4. Since there are mixed evidence for MSD intervention in the workplace, how can researcher/policy maker, provide recommendations for these interventions?
5. What makes MSD a unique area of public health compared to other public health issues?
    a. For example, most solutions and interventions come from the workplace – what impact does that have on the outcome of the interventions?
6. Most research that looked into MSD intervention, uses self-reporting tools such as Nordic MSD tool, how does that affect our understanding of MSD and their solution?

Appendix V

Nordic Musculoskeletal Questionnaire (54) and the Cornell Musculoskeletal Discomfort Questionnaire (55)

Nordic Musculoskeletal Questionnaire:

To be answered by everyone:	If Yes to first question...	If Yes to first question...
Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in:	Have you at any time during the last 12 months been prevented from doing your normal work (at home or away from home) because of the trouble?	Have you had trouble at any time during the last 7 days?
Neck ▵ No ▵ Yes	▵ No ▵ Yes	▵ No ▵ Yes
Shoulders ▵ No ▵ Yes, right shoulder ▵ Yes, left shoulder ▵ Yes, both shoulders	▵ No ▵ Yes	▵ No ▵ Yes
Elbows ▵ No ▵ Yes, right elbow ▵ Yes, left elbow ▵ Yes, both elbows	▵ No ▵ Yes	▵ No ▵ Yes
Wrists/Hands ▵ No ▵ Yes, right wrist/hand ▵ Yes, left wrist/hand ▵ Yes, both wrists/hands	▵ No ▵ Yes	▵ No ▵ Yes
Upper Back ▵ No ▵ Yes	▵ No ▵ Yes	▵ No ▵ Yes
Lower Back (small of back) ▵ No ▵ Yes	▵ No ▵ Yes	▵ No ▵ Yes
One or both hips/thighs ▵ No ▵ Yes	▵ No ▵ Yes	▵ No ▵ Yes
One or both knees ▵ No ▵ Yes	▵ No ▵ Yes	▵ No ▵ Yes
One or both ankles/feet ▵ No ▵ Yes	▵ No ▵ Yes	▵ No ▵ Yes

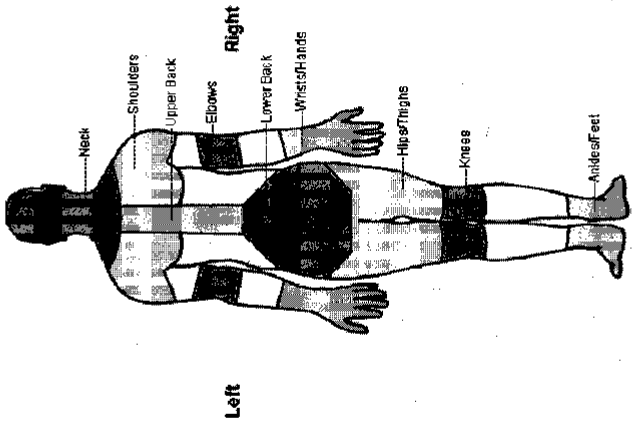
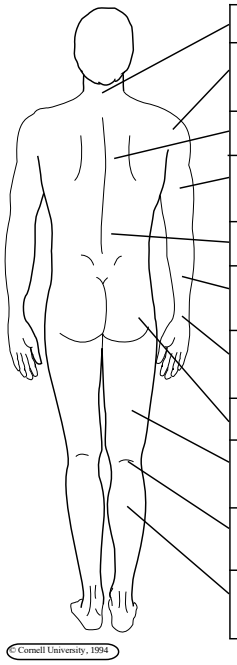


Figure 1. Sample Nordic Questionnaire.

Cornell Musculoskeletal Discomfort Questionnaire:

The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.



	During the last work week how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
	Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Shoulder (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Shoulder (Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Back	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Arm (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Arm (Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Back	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forearm (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Forearm (Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wrist (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wrist (Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hip/Buttocks	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Thigh (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Thigh (Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Knee (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Knee (Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Leg (Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Leg (Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐