BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-039063
Article Type:	Protocol
Date Submitted by the Author:	03-Apr-2020
Complete List of Authors:	Larinier, Nicolas; Université Grenoble Alpes Balaguier, Romain; Universite Grenoble Alpes, Vuillerme, Nicolas; Université Grenoble Alpes; Institut Universitaire de France
Keywords:	SPORTS MEDICINE, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, PUBLIC HEALTH

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How much do we know about the effectiveness of warm-up intervention on work related musculoskeletal disorders, physical and psychosocial functions: protocol for a systematic review.

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Key-words

Pain / injuries / intervention / workers / physical activity

Abstract

Introduction

Work related musculoskeletal disorders (WMSDs) are a growing worldwide burden and effective interventions to prevent them are needed. Physical activity at the workplace is now recognized as a relevant component of WMSDs prevention. Along these lines, warm-up interventions are now offered in a large number of companies to manage WMSDs. Although benefits of warm-up have been previously documented in sports context, to the best of our knowledge, the effectiveness of such intervention in workplaces still remains to be established. Within this context, the aim of the present review is to identify from published literature the available evidence regarding the effects of warm-up on WMSDs and physical and psychosocial functions.

Methods

We will search the following electronic databases (from inception onwards): MEDLINE, EMBASE, and Cochrane Library (Cochrane Database of Systematic Reviews and CENTRAL). Randomized and non-randomized controlled studies will be included in this review. Participants of the included studies should be adult employees without specific comorbidities. Interventions should include a warm-up physical intervention in real-workplaces. The primary outcomes will be pain, discomfort or fatigue. The secondary outcomes will be job control or motivation at work. This review will follow the PRISMA guidelines and two team members will independently screen all citations, full-text articles, and abstract data. A systematic narrative synthesis will be provided with information presented in the text and tables to summarize and explain the characteristics and findings of the included studies.

Discussion

This review will summarize the evidence on the effects of effects of warm-up intervention on WMSDs, physical or psychosocial functions. This information could help professionals and researchers in decision-making related to the use of warm-up intervention to prevent WMSDs and their adverse consequences. This review will further identify gaps in knowledge in this field that could be addressed in forthcoming studies.

Registration

This protocol has been registered in PROSPERO (CRD42019137211)

Strength and limitations of the study

- This study will be to the best of our knowledge the first review to critically appraise the effectiveness of warm-up exercises to prevent WMSDs in workplaces
- Reporting in accordance with the Preferred Reporting Items for Systematic Reviews and MetaAnalyses statement.
- This study will include both RCT and non-RCT
- A low number of studies and significant heterogeneity is expected that might prevent performing a meta-analysis of the results

Introduction

Work related musculoskeletal disorders (WMSDs) are conditions affecting muscles, tendons, nerves and bones[1]. They are now considered as a public health problem all over the world since their adverse consequences on quality of life and work participation are important[2–4]. This underlines the importance of finding effective prevention or curative strategies/interventions. In the last two decades, numerous researchers have identified workplace as an ideal setting to support the promotion of healthier lifestyle and to prevent WMSDs[5–7]. Hence, the use of workplace physical activity interventions for the management of WMSDs is now well supported by scientific evidence[8–14]. Interestingly, WMSDs are conditions commonly characterized by the presence of pain or decreased function[7]. Therefore, workplace physical activity interventions often focus on numerous outcomes related to the individual such as pain, discomfort or fatigue[8,13–15], physical function such as strength, flexibility or endurance[6] and psychosocial function such as quality of life, job satisfaction or well-being[16,17]. In theory, the workplace environment does offer the possibility to reach and to raise awareness of a large number of workers[18]. In reality, however, workplace physical activity programs are less often offered and performed to those and for those at risk of developing WMSDs, i.e. low-status, low income and blue-collar workers[5,19,20] . Furthermore, a 40-60% compliance is commonly observed whatever the duration of the programs[21–26]. It is presumable that these observations could partly stem from 'practical' barriers to offer physical activity at the workplace, such as time constraints, time of the day and duration of the training sessions[27–31]. In other words, programs should be easy to implement in the daily routine of the employees as well as of the employers. This application recommendation is supported by scientific results that shown that short bouts of exercises are easier to fit in organizational routines than long sessions[32,33]. For instance, Andersen et al[32] in a 10 weeks workplace physical activity program among office-workers, have compared the effects of a same weekly training volume, i.e. 1 hour performed with different training frequencies (from 1session per week to 9 sessions per week) on training adherence. These authors have reported that adherence among office-workers was significantly higher when the training volume was divided at least into 3 weekly training sessions.

In this sense and since a few years, the implementation of physical warm-up prior the beginning of the working days is increasingly adopted in companies to manage WMSDs (INRS 2018). In these companies, it is common to observe warm-up lasting between 5 and 15 minutes a day as well supervised by professionals (sport trainer, physiotherapist…) as trained

employees[34]. At this point, it is important to mention that previous reviews have provided evidence of positive effects of warm-up on performance[35] and injury prevention in sports[35–39]. However, it is surprising that data on the effects of warm-up on WMSD are scarce and, when available, lead to rather conflicting/inconclusive results[40–42]. Within this context, the aim of this systematic review will be to evaluate the effectiveness of warm-up on WMSDs and physical and psychosocial functions.

Methods

The present review protocol is being reported in accordance with the reporting guidance the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) statement [43](see PRISMA-P checklist in Additional file 1). This review protocol was registered within the International Prospective Register of Systematic Reviews (PROSPERO) (registration number: CRD42019137211) This review will be reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.

Criteria for considering studies for this review

Type of studies

Original quantitative research studies that assessed the effect of a warm-up intervention in a workplace setting aiming at preventing WMSDs or musculoskeletal pain or discomfort or fatigue in the worker will be included in the review.

As correctly argued, RCT are considered as the gold standard to assess the effectiveness of an intervention[44]. However, its implementation in occupational setting may not always be feasible and its implementation is called into question[1,45–49]. In that specific case, recent studies have suggested that non-RCT may maximize the body of evidence and have suggested including non-RCT in systematic-reviews[50–52]. For these reasons and as previously done in recent systematic reviews covering the scope of the present review[8,47], both randomized and non-randomized controlled studies will be included. Therefore, quasi-RCTs (participants not randomly allocated), cluster randomized trials (i.e. randomization of a group of people for example randomization at a company level) will be included.

Period of studies publication was defined from inception onwards to July 2019. Finally, to be eligible for inclusion, studies had to be published in English in peer-reviewed scientific

journals[17,47]. As only studies in English will be included and may lead to reporting bias, we will report potentially eligible studies in other languages.

The following types of studies will be ineligible: case reports, abstracts, editorials, conference abstracts, letters to the editor, reviews, and meta-analysis. Studies will be also excluded if the intervention was partially or totally implemented outside of the workplace, e.g. in a clinical setting and if the intervention was implemented in combination with another intervention, e.g. ergonomics. Therefore, studies will be excluded when differences can not only be attributed only to the warm-up intervention.

Types of participants

This review will include adult employees (18 years of age or older) and will exclude adults with specific comorbidities or diseases (such as diabetes, arthritis, cancer, stroke) and/or special populations (pregnant, severe or rare physical disability, or cognitive disability).

Types of intervention

This review will include studies which have implemented warm-up interventions in real workplaces. To facilitate the comprehension of a warm-up intervention, we will use the definition given by McCrary et al [35], i.e. "a warm-up is a protocol specifically undertaken to prepare the onset of subsequent physical activity", in our case a working activity.

As recently used in a systematic review by Luger et al[53], to describe work-break programs and a study by Slade and Keating[54] about exercise prescription, we will characterize the warm-up intervention with the following four components:

(1) duration: warm-up may lasted 5 minutes as well as 1 hour ;

(2) frequency: warm-up may differ in number;

(3) type: warm-up may be stretching as well as cardio-training exercises or combination of strengthening exercises; and

(4) intensity: warm-up may be performed with/without load or performed at a low or high percentage of the maximum heart rate.

Studies will be excluded from this review if the warm-up intervention was partially or totally implemented outside of the workplace, e.g. in a clinical setting or under laboratory conditions and if the warm-up intervention was implemented in combination with another intervention, e.g. ergonomics.

Comparator

Inclusion criteria: We will consider studies that compared the warm-up intervention with a non-treatment control group (e.g. no intervention or usual activity or another type of workplace physical activity) or a non-active comparator (e.g. leaflets on benefits of physical activity)

Exclusion criteria: Studies with no comparison measures.

Types of outcome measures

Main outcomes

WMSDs are defined as a group of conditions or health problems affecting the locomotor apparatus. These conditions are characterized by pain, impaired function, overall fatigue and stress[7,55]. Therefore, among primary outcomes we will include all the outcomes associated with work related musculoskeletal issues, that are (1) participant musculoskeletal pain through the use of pain scales (e.g. numeric rating scale (NRS) or visual analog scale (VAS)) or questionnaire (e.g. McGill pain questionnaire)[53] and (2) participant discomfort or fatigue[8,53] through validated scales and (3) physical function as measured or estimated by questionnaires, performance and/or specific tests.

Secondary outcomes

For the prevention of the consequences of WMSDs we will include – if possible – and as secondary outcomes, all the outcomes associated with psychosocial function such as the measure of quality of life, job satisfaction, job control or motivation at work. In this review job control is considered as an indicator of psychosocial stress at work [56]. This indicator is often measured with the job demand-control support model developed by Karasek [56].

Information sources and search strategy

Four electronic databases - Cochrane Central Register of Controlled Trials (CENTRAL), PubMed (Medline), Web of Science and Physiotherapy Evidence Database (PEDro) – will be searched systematically from inception onwards to identify studies satisfying the search criteria. Note that these databases have previously used in published reviews covering the scope of this review[47,53,57,58]. The proposed search strategy terms for Medline are listed in Table 1 and will be modified to fit the index system of other databases.

Table 1. Sample MEDLINE search strategy terms (ti: tittle ; ab: abstract)

	Keywords
	Workplace terms
1	Work* ti,ab
2	Employ* ti,ab
3	Compan* ti,ab
4	1 OR 2 OR 3
	Warm-up terms
5	Warm* ti,ab
6	Pre-exercise* ti,ab
7	Pre-activit* ti,ab
8	5 OR 6 OR 7
	WMSDs, physical and psychosocial terms
9	Musculoskeletal disord* ti,ab
10	Musculoskeletal injur* ti,ab
11	Musculoskeletal pain ti,ab
12	Musculoskeletal complaint* ti,ab
13	Pain ti,ab
14	(endurance or strength or flexibility) ti,ab
15	(quality of life or job satisfaction or work ability or well-being or stress or disabilit* or health or discomfort or comfort or fatigue or injur*) ti,ab
16	9 OR 10 OR 11 OR 12 OR 13 OR 14 OR 15
	Combining search terms
17	4 AND 8 AND 16

Additional intended information sources

To be sure not to miss relevant studies for the review, the reference list of for all eligible articles will be checked. Then, a grey literature search will be performed on ClinicalTrials.gov. Finally, we will contacts experts in this domain to collect information on unknown or ongoing studies

Data collection

Study selection process

All studies that met inclusion criteria passed through a data extraction and quality assessment process performed by two independent reviewers. A third reviewer will be requested to resolve disagreement when consensus could not be reached. Reviewers will not be blinded to

study author(s) or journal title. At stage 1, two independent reviewers will screen abstract and titles identified from the search strategy. At stage 2, the same two reviewers will screen the full-text articles for inclusion. At this stage, all reasons for exclusion of articles will be recorded and reported. Finally, the relevant studies, which respect eligibility criteria, will be screened by a senior review team member (NV) to be included in the systematic review.

Data extraction and management

First a data extraction form will be created and validated by the three team members. This data collection form will be fulfilled by one team member (NL) and corrected by another team member (RB). Any disagreement between the two reviewers will be resolved by consensus or discussion with the senior review team member (NV). This extraction form could be modified from the information collected in the eligible studies but should at least specify the following information[57,59,60]:

- General: authors, year of publication, journal's name, source of funding (if any) and country of the study;
- Methods: study design, total duration of study, follow-up when data were collected, study setting and withdrawals;
- Participants: number, age, gender, inclusion/exclusion criteria, type of workplace or job task, health of the workers/health status, i.e. asymptomatic or symptomatic, year of work experience;
- Interventions: description of the type, duration, frequency, intensity, supervision of the warm-up program, description/content of the comparison/control group and number of participants allocated to each group;
- Data collection: primary and secondary outcomes, measurement tools, questionnaires, tests;
- Statistical tests;
- Main results

Risk of bias (quality) assessment

Two team members (NL and RB) will independently assess the risk of bias for each included study. Any disagreement between team members will be solved by consensus or discussion with the third team member. As both randomized and non-randomized controlled studies will be included in this review, two risk of bias tools will be used.

For RCT

The Cochrane tool for assessing risk of bias from the Cochrane Handbook for Systematic Reviews of Interventions will be used to assess potential biases of the included studies. This tool is a well-known and validated instrument to assess the risk of bias in RCTs [61]. This tool has been revised in 2019 [62] and has now 5 domains to assess bias arising from: (1) randomization process, (2) deviation from the intended intervention, (3) missing outcome data, (4) measurement of the outcome and (5) selection of the reported result. Each domain will be scored as follow (see Table 2): "high risk of bias", "low risk of bias" and "some concerns".

For non RCT

The Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) will be used to asses potential biases of the included non-RCT[63]. This tool has 7 domains to assess bias arising from (1) confounding, (2) selection of participants, (3) classification of the intervention, (4) deviations from the intended intervention, (5) missing data, (6) measurement of outcomes and (7) selection of the reported result.

Table 2. Risk of bias judgement for a specific domain (from Sterne et al. 2019).

Overall risk of bias judgement	Criteria
Low risk of bias	The study is judged to be at low risk of bias for all domains for this result
Some concerns	The study is judged to be at high risk of bias in at least one domain for this result, but not to be at high risk of bias for any domain
High risk of bias	The study is judged to be at high risk of bias in at least one domain for this result Or The study is judged to have some concerns for multiple domains in a way that substantially lowers confidence in the result.

Measures of treatment effect

For studies using continuous data, treatment effect will be reported as mean difference with 95% CI. In case the studies evaluate the same outcome with different scales, standardized mean difference (SMD) with 95% CI will be calculated. Regarding dichotomous/categorical variables, the treatment effect will be calculated using the relative risk (RR) with 95% CI[64–67]. Since the number of included studies is greater than 5[65] and when these studies are considered as sufficiently homogeneous, outcome data will be synthesized using a random effect meta-analysis[53,66,68,69]. If meta-analysis is not possible due to heterogeneity or if we are unable to pool the outcomes a narrative synthesis will be performed using text and table formats. Results will be also presented in forest plots.

Assessment of statistical heterogeneity

Statistical heterogeneity, defined as variability in the intervention effects will be estimated using the Chi² test, with Chi² p>0.10 provides significant evidence of heterogeneity. Chi² assesses whether heterogeneity is only due to chance. To ensure a right comprehension of heterogeneity, Chi² will be completed with I^2 statistics particularly relevant when studies have small sample size or are few in numbers. Heterogeneity will be categorized as follows[69]:

- 0-40%: not be important
- 30-60%: moderate heterogeneity
- 50-90% substantial heterogeneity
- 75-100%: considerable heterogeneity

Quality assessment and strategy for data synthesis

To assess quality of evidence of the included studies we will use the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach[70]. This approach grades studies as followed: very low, low, moderate and high. As suggested by Bordado et al [17], the quality assessment will be based on the findings in data extraction, and will follow the domains of quality evaluation in the GRADE approach: risk of bias, inconsistency, indirectness and imprecision.

Analysis of subgroups or subsets

In case a sufficient number of studies are included in the review, a subgroup analysis will be performed. The latter will be carried out for each outcome and for the following factors: (1) participants' characteristics (e.g. sex, age. If possible we will compare participants aged 40

years and younger with participants aged 41 years and older), (2) WMSDs location (e.g. neck *versus* low back *versus* upper extremities), (3) occupational activity (e.g. active *versus* sedentary jobs), (4) length of intervention, (5) study design (e.g. RCT *versus* non-RCT) and (6) comparison group type (e.g. passive *versus* active control group)[53,67].

Discussion

Workplace physical activity is now well recognized as a potential intervention to prevent WMSDs[5,6,9–15]. Although benefits of a warm-up have been previously documented in sports context[35–39], to the best of our knowledge, the effectiveness of such intervention in workplaces remains to be established. Interestingly, the primary outcome analyzed in this review will be associated with WMSDs such as pain, discomfort or fatigue. The secondary outcomes will be related to physical or psychosocial functions. All these outcomes recognized to be decreased in case of WMSDs are also the main outcomes reported in studies assessing the effects on an intervention on WMSDs[8–14]. For these reasons, we believe that these findings could constitute a solid starting point to help clinicians, researchers, companies and policy-makers trying to reduce the burden of WMSDs.

Limitations and strengths

Our review presents several strengths. The major strength is the systematic procedure employed. In this sense, a large number of scientific databases will be searched. Then, two reviewers will independently screen articles, rate the quality of these studies and the risk of bias. Finally, the use of recommended standard reporting instruments such as PRISMA-P, ROBINS and GRADE will strengthened the recommendations that should be made at the end of the review. At this point, however, we are aware that the potential strength of this review could be reduced by the lack of high quality trials and high heterogeneity. Firstly, the recent scientific literature confirms that RCT in a workplace context are, of could possible but rare [32,71–73]. In this sense, numerous authors have concluded that considerable efforts had to be made to overcome difficulties to implement such study design, but also to recruit a large number of employees[1,44–46,74]. To deal with this heterogeneity, we have pre-planned to perform a subgroup and a sensitivity analysis. This choice will allow knowing whether or not the intervention effects differ between trials. Then, we are also aware that including both RCT

and non-RCT will therefore lead to downgrade the validity and strength of the review and will increase the risk of bias especially for the blinding and generation domains[67]. Secondly, a recent review of literature by Johnson et al[75] on how outcomes are measured in workplace physical activity interventions have reported heterogeneous measurement tools and data collection making comparisons between studies rather difficult. To conclude, although the researchers do not anticipate protocol amendments, issues that arise with the original protocol will be documented in the review paper under the methodology section.

Abbreviations

GRADE: Grading of Recommendations, Assessment, Development and Evaluation

NRS: Numeric rating scale

PRISMA-P: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols

RCT: Randomized controlled trial

ROBINS: Risk Of Bias In Non-randomized Studies - of Interventions

VAS: Visual analog scale

WMSDS: Work related musculoskeletal disorders

Declarations

Competing interests

Opti'Mouv is a company that provides workplace health promotion services as workplace physical activity programs.

Funding statement

This review is funding at 50% by Opti'Mouv and 50% by the University of Grenoble Alpes.

Authors'contribution

All listed authors have contributed and will continue to contribute meaningfully to the protocol and proposed review. NL, RB and NV conceived the proposed review and developed the search strategy. NL and RB are the two title and abstract reviewers, and NL and RB are

the two full- text reviewers. NV will be the third reviewer that will help resolve any discrepancy. MKH submitted the protocol to PROSPERO and is responsible for updating the registered protocol as needed. All authors read the final protocol manuscript and revised it for content; all also approved the final version.

Patient and public involvement

No patient involved.

Acknowledgements

Not applicable

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PRISMA-P 2015 Checklist

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	☒	☐	1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	☐	☒	
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	☒	☐	56
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	☒	☐	5-17
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	☒	☐	349
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	☐	☒	
Support					
Sources	5a	Indicate sources of financial or other support for the review	☒	☐	353
Sponsor	5b	Provide name for the review funder and/or sponsor	☒	☐	353
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	☒	☐	
INTRODUCTION					
Rationale	6	Describe the rationale for the review in the context of what is already known	☒	☐	67-105
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	☒	☐	103-105
METHODS					
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	☒	☐	114-187

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	☒	☐	190-205
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	☒	☐	199
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	☒	☐	218-238
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	☒	☐	208-216
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	☒	☐	208-238
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	☒	☐	177-186
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	☒	☐	171-187
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	☒	☐	240-261
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	☐	☒	
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2, Kendall's tau)	☐	☒	264-285
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	☒	☐	294-301
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	☒	☐	
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	☐	☒	
Confidence in cumulative evidence	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	☒	☐	286-292

BMJ Open

How much do we know about the effectiveness of warm-up intervention on work related musculoskeletal disorders, physical and psychosocial functions: protocol for a systematic review.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-039063.R1
Article Type:	Protocol
Date Submitted by the Author:	16-Aug-2020
Complete List of Authors:	Larinier, Nicolas; Université Grenoble Alpes Balaguier, Romain; Universite Grenoble Alpes, Vuillerme, Nicolas; Université Grenoble Alpes; Institut Universitaire de France
Primary Subject Heading:	Sports and exercise medicine
Secondary Subject Heading:	Occupational and environmental medicine, Public health
Keywords:	SPORTS MEDICINE, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, PUBLIC HEALTH

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How much do we know about the effectiveness of warm-up intervention on work related musculoskeletal disorders, physical and psychosocial functions: protocol for a systematic review.

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Key-words

Pain / injuries / intervention / workers / physical activity

Abstract

Introduction

Work related musculoskeletal disorders (WMSDs) are a growing worldwide burden and effective interventions to prevent them are needed. Physical activity at the workplace is now recognized as a relevant component of WMSDs prevention. Along these lines, warm-up interventions are now offered in a large number of companies to manage WMSDs. Although benefits of warm-up have been previously documented in sports context, to the best of our knowledge, the effectiveness of such intervention in workplaces still remains to be established. Within this context, the aim of the present review is to identify from published literature the available evidence regarding the effects of warm-up on WMSDs and physical and psychosocial functions.

Methods

The following electronic databases will be searched (from inception onwards): Cochrane Central Register of Controlled Trials (CENTRAL), PubMed (Medline), Web of Science and Physiotherapy Evidence Database (PEDro). Randomized and non-randomized controlled studies will be included in this review. Participants of the included studies should be adult employees without specific comorbidities. Interventions should include a warm-up physical intervention in real-workplaces. The primary outcomes will be pain, discomfort or fatigue. The secondary outcomes will be job control or motivation at work. This review will follow the PRISMA guidelines and two team members will independently screen all citations, full-text articles, and abstract data. A systematic narrative synthesis will be provided with information presented in the text and tables to summarize and explain the characteristics and findings of the included studies.

Discussion

This review will summarize the evidence on the effects of effects of warm-up intervention on WMSDs, physical or psychosocial functions. This information could help professionals and researchers in decision-making related to the use of warm-up intervention to prevent WMSDs and their adverse consequences. This review will further identify gaps in knowledge in this field that could be addressed in forthcoming studies.

Registration

This protocol has been registered in PROSPERO (CRD42019137211)

Strength and limitations of the study

- This study will be to the best of our knowledge the first review to critically appraise the effectiveness of warm-up exercises to prevent WMSDs in workplaces
- Reporting in accordance with the Preferred Reporting Items for Systematic Reviews and MetaAnalyses statement.
- This study will include both RCT and non-RCT
- A low number of studies and significant heterogeneity is expected that might prevent performing a meta-analysis of the results

Introduction

Work related musculoskeletal disorders (WMSDs) are conditions affecting muscles, tendons, nerves, ligaments, joints or spinal discs[1]. They are now considered as a public health problem all over the world since their adverse consequences on quality of life and work participation are important[2–6]. This underlines the importance of finding effective prevention or curative strategies/interventions. In the last two decades, numerous researchers have identified the workplace as an ideal setting to support the promotion of healthier lifestyle and to prevent WMSDs[7–9]. Hence, the use of workplace physical activity interventions for the management of WMSDs is now well supported by scientific evidence[10–16]. Interestingly, WMSDs are conditions commonly characterized by the presence of pain or decreased function[9]. Therefore, workplace physical activity interventions often focus on numerous outcomes related to the individual such as pain, discomfort or fatigue[10,15–17], physical function such as strength, flexibility or endurance[8] and psychosocial function such as quality of life, job satisfaction or well-being[18,19]. In theory, the workplace environment does offer the possibility to reach and to raise awareness of a large number of workers[20]. However, workplace physical activity programs are less often offered and performed by those at risk of developing WMSDs (i.e. low-status, low income and blue-collar workers[7,21,22]). Furthermore, a 40-60% compliance is commonly observed whatever the duration of the programs[23–28]. It is presumable that these observations could partly stem from 'practical' barriers to offer physical activity at the workplace, such as time constraints, time of the day and duration of the training sessions[29–33]. In other words, programs should be easy to implement in the daily routine of the employees as well as of the employers. This application recommendation is supported by scientific results that shown that short bouts of exercises are easier to fit in organizational routines than long sessions[34,35]. For instance, Andersen et al[34] in a 10 weeks workplace physical activity program among office-workers, have compared the effects of a same weekly training volume, i.e. 1 hour performed with different training frequencies (from 1session per week to 9 sessions per week) on training adherence. These authors have reported that adherence among office-workers was significantly higher when the training volume was divided at least into 3 weekly training sessions.

In the last few years, the implementation of physical warm-up prior the beginning of the working days is increasingly adopted in companies to manage WMSDs (INRS 2018). In these companies, it is common to observe warm-up lasting between 5 and 15 minutes a day as well supervised by professionals such as sport trainer or physiotherapist as trained employees[36].

Previous reviews have found positive effects of warm-up on performance[37] and injury prevention in sports[37–41]. However, it is surprising that data on the effects of warm-up on WMSD are scarce and, when available, lead to rather conflicting/inconclusive results[42–44]. Within this context, the aim of this systematic review will be to evaluate the effectiveness of workplace warm-up interventions on WMSDs and physical and psychosocial functions among workers.

Methods

The present review protocol is being reported in accordance with the reporting guidance the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) statement[45] (see PRISMA-P checklist in Additional file 1). This review protocol was registered within the International Prospective Register of Systematic Reviews (PROSPERO) (registration number: CRD42019137211) This review will be reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.

Criteria for considering studies for this review

Type of studies

Original quantitative research studies that assessed the effect of a warm-up intervention in a workplace setting aiming at preventing WMSDs or musculoskeletal pain or discomfort or fatigue in the worker will be included in the review.

As correctly argued, RCT are considered as the gold standard to assess the effectiveness of an intervention[46]. However, its implementation in occupational setting may not always be feasible and its implementation is called into question[1,47–51]. In that specific case, recent studies have suggested that non-RCT may maximize the body of evidence and have suggested including non-RCT in systematic-reviews[52–54]. For these reasons and as previously done in recent systematic reviews covering the scope of the present review[10,49], both randomized and non-randomized controlled studies will be included. Therefore, quasi-RCTs (participants not randomly allocated), cluster randomized trials (i.e. randomization of a group of people for example randomization at a company level), preference trials (patients can choose their treatment) and before-and-after study are design which will be included."

Period of studies publication was defined from inception onwards to June 2020. Finally, to be eligible for inclusion, studies had to be published in English in peer-reviewed scientific

journals[19,49]. As only studies in English will be included and may lead to reporting bias, we will report potentially eligible studies in other languages.

The following types of studies will be ineligible: case reports, abstracts, editorials, conference abstracts, letters to the editor, reviews, and meta-analysis. Studies will be also excluded if the intervention was partially or totally implemented outside of the workplace, e.g. in a clinical setting and if the intervention was implemented in combination with another intervention, e.g. ergonomics. Therefore, studies will be excluded when differences can not only be attributed only to the warm-up intervention.

Types of participants

This review will include adult employees (18 years of age or older) and will exclude adults with specific comorbidities or diseases (such as diabetes, arthritis, cancer, stroke) and/or special populations (pregnant, severe or rare physical disability, or cognitive disability).

Types of intervention

This review will include studies which have implemented warm-up interventions in real workplaces. To facilitate the comprehension of a warm-up intervention, we will use the definition given by McCrary et al [37], i.e. "a warm-up is a protocol specifically undertaken to prepare the onset of subsequent physical activity", in our case a working activity.

As recently used in a systematic review by Luger et al[55], to describe work-break programs and a study by Slade and Keating[56] about exercise prescription, we will characterize the warm-up intervention with the following four components:

(1) duration: warm-up may last from five minutes to one hour;

(2) frequency: warm-up may differ in number;

(3) type: warm-up may be stretching as well as cardio-training exercises or combination of strengthening exercises; and

(4) intensity: warm-up may be performed with/without load or performed at a low or high percentage of the maximum heart rate.

Studies will be excluded from this review if the warm-up intervention was partially or totally implemented outside of the workplace, e.g. in a clinical setting or under laboratory conditions and if the warm-up intervention was implemented in combination with another intervention, e.g. ergonomics.

Comparator

Inclusion criteria: We will consider studies that compared the warm-up intervention with a non-treatment control group (e.g. no intervention or usual activity or another type of workplace physical activity) or a non-active comparator (e.g. leaflets on benefits of physical activity)

Exclusion criteria: Studies with no comparison measures.

Types of outcome measures

Main outcomes

WMSDs are defined as a group of conditions or health problems affecting the locomotor apparatus. These conditions are characterized by pain, impaired function, overall fatigue and stress[9,57]. Therefore, among primary outcomes we will include all the outcomes associated with work related musculoskeletal issues, that are (1) participant's musculoskeletal pain through the use of pain scales (e.g. numeric rating scale (NRS) or visual analog scale (VAS)) or questionnaire (e.g. McGill pain questionnaire)[55] and (2) participant discomfort or fatigue[10,55] through validated scales and (3) physical function as measured or estimated by questionnaires, scales, performances and/or specific tests. Dichotomous data such as presence/absence of symptoms will be also considered.

Secondary outcomes

For the prevention of the consequences of WMSDs we will include – if possible – and as secondary outcomes, all the outcomes associated with psychosocial function such as the measure of quality of life, job satisfaction, job control or motivation at work. In this review job control is considered as an indicator of psychosocial stress at work [58]. This indicator is often measured with the job demand-control support model developed by Karasek [58].

Information sources and search strategy

Four electronic databases - Cochrane Central Register of Controlled Trials (CENTRAL), PubMed (Medline), Web of Science and Physiotherapy Evidence Database (PEDro) – will be searched systematically from inception onwards to identify studies satisfying the search criteria. Note that these databases have previously used in published reviews covering the scope of this review[49,55,59,60]. The proposed search strategy terms for Medline are listed in Table 1 and will be modified to fit the index system of other databases.

Table 1. Sample MEDLINE search strategy terms (Mesh: Mesh terms ; ti: tittle ; ab: abstract)

	Keywords
1	Workplace[Mesh]
2	Work* ti,ab
3	Employ* ti,ab
4	Compan* ti,ab
5	1 OR 2 OR 3 OR 4
6	Warm-Up Execise[Mesh]
7	Pre-shift ti,ab
8	Pre-exercise* ti,ab
9	Pre-activit* ti,ab
10	6 OR 7 OR 8 OR 9
11	Musculoskeletal diseases[Mesh]
12	Pain[Mesh]
13	Musculoskeletal Pain[Mesh]
14	WMSD* ti,ab
15	Pain ti,ab
16	(endurance or strength or flexibility) ti,ab
17	(quality of life or job satisfaction or work ability or well-being or stress or disabilit* or health or discomfort or comfort or fatigue or injur*) ti,ab
18	11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17
	Combining search terms
20	5 AND 10 AND 18

Additional intended information sources

To be sure not to miss relevant studies for the review, the reference list of for all eligible articles will be checked. Then, a grey literature search will be performed on ClinicalTrials.gov. Finally, experts in this domain will be contacted to collect information on unknown or ongoing studies

Data collection

Study selection process

All studies that met inclusion criteria passed through a data extraction and quality assessment process performed by two independent reviewers. A third reviewer will be requested to resolve disagreement when consensus could not be reached. Reviewers will not be blinded to study author(s) or journal title. At stage 1, two independent reviewers will screen abstract and

titles identified from the search strategy. At stage 2, the same two reviewers will screen the full-text articles for inclusion. At this stage, all reasons for exclusion of articles will be recorded and reported. Finally, the relevant studies, which respect eligibility criteria, will be screened by a senior review team member (NV) to be included in the systematic review.

Data extraction and management

First a data extraction form will be created and validated by the three team members. This data collection form will be fulfilled by one team member (NL) and corrected by another team member (RB). Any disagreement between the two reviewers will be resolved by consensus or discussion with the senior review team member (NV). This extraction form could be modified from the information collected in the eligible studies but should at least specify the following information[59,61,62]:

- General: authors, year of publication, journal's name, source of funding (if any) and country of the study;
- Methods: study design, total duration of study, follow-up when data were collected, study setting and withdrawals;
- Participants: number, age, gender, inclusion/exclusion criteria, type of workplace or job task, health of the workers/health status, i.e. asymptomatic or symptomatic, year of work experience;
- Interventions: description of the type, duration, frequency, intensity, supervision of the warm-up program, description/content of the comparison/control group and number of participants allocated to each group;
- Data collection: primary and secondary outcomes, measurement tools, questionnaires, tests;
- Statistical tests;
- Main results

Risk of bias (quality) assessment

Two team members (NL and RB) will independently assess the risk of bias for each included study. Any disagreement between team members will be solved by consensus or discussion with the third team member. As both randomized and non-randomized controlled studies will be included in this review, two risk of bias tools will be used.

For RCT

The Cochrane tool for assessing risk of bias from the Cochrane Handbook for Systematic Reviews of Interventions will be used to assess potential biases of the included studies. This tool is a well-known and validated instrument to assess the risk of bias in RCTs [63]. This tool has been revised in 2019 [64] and has now 5 domains to assess bias arising from: (1) randomization process, (2) deviation from the intended intervention, (3) missing outcome data, (4) measurement of the outcome and (5) selection of the reported result. Each domain will be scored as follow (see Table 2): "high risk of bias", "low risk of bias" and "some concerns".

For non RCT

The Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) will be used to asses potential biases of the included non-RCT[65]. This tool has 7 domains to assess bias arising from (1) confounding, (2) selection of participants, (3) classification of the intervention, (4) deviations from the intended intervention, (5) missing data, (6) measurement of outcomes and (7) selection of the reported result.

Table 2. Risk of bias judgement for a specific domain (from Sterne et al. 2019).

Overall risk of bias judgement	Criteria
Low risk of bias	The study is judged to be at low risk of bias for all domains for this result
Some concerns	The study is judged to be at high risk of bias in at least one domain for this result, but not to be at high risk of bias for any domain
High risk of bias	The study is judged to be at high risk of bias in at least one domain for this result Or The study is judged to have some concerns for multiple domains in a way that substantially lowers confidence in the result.

Measures of treatment effect

For studies using continuous data, treatment effect will be reported as mean difference with 95% CI. In case the studies evaluate the same outcome with different scales, standardized mean difference (SMD) with 95% CI will be calculated. Regarding dichotomous/categorical variables, the treatment effect will be calculated using the relative risk (RR) with 95% CI[66–69]. Since the number of included studies is greater than 5[67] and when these studies are considered as sufficiently homogeneous, outcome data will be synthesized using a random effect meta-analysis[55,68,70,71]. If meta-analysis is not possible due to heterogeneity or if the outcomes cannot be pooled, a narrative synthesis will be performed using text and table formats. Results will be also presented in forest plots.

Assessment of statistical heterogeneity

Statistical heterogeneity, defined as variability in the intervention effects will be estimated using the Chi² test, with Chi² p>0.10 provides significant evidence of heterogeneity. Chi² assesses whether heterogeneity is only due to chance. To ensure a right comprehension of heterogeneity, Chi² will be completed with I^2 statistics particularly relevant when studies have small sample size or are few in numbers. Heterogeneity will be categorized as follows[71]:

- 0-40%: not be important
- 30-60%: moderate heterogeneity
- 50-90% substantial heterogeneity
- 75-100%: considerable heterogeneity

Quality assessment and strategy for data synthesis

To assess quality of evidence of the included studies the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach[72] will be used. This approach grades studies as followed: very low, low, moderate and high. As suggested by Bordado et al [19], the quality assessment will be based on the findings in data extraction, and will follow the domains of quality evaluation in the GRADE approach: risk of bias, inconsistency, indirectness and imprecision. Two team members (NL and RB) will independently assess the quality of evidence of the included studies with the GRADE approach.

Analysis of subgroups or subsets

In case a sufficient number of studies are included in the review, a subgroup analysis will be performed. The latter will be carried out for each outcome and for the following factors: (1)

participants' characteristics (e.g. sex, age. If possible authors will compare participants aged 40 years and younger with participants aged 41 years and older), (2) WMSDs location (e.g. neck *versus* low back *versus* upper extremities), (3) occupational activity (e.g. active *versus* sedentary jobs), (4) length of intervention, (5) study design (e.g. RCT *versus* non-RCT) and (6) comparison group type (e.g. passive *versus* active control group)[55,69] and (7) implementation warm-up intervention (supervised versus non supervised)[73]."

Sensitivity analysis

The authors of the present systematic review planned to perform sensitivity analysis to determine whether our findings are affected by high risk of bias and baseline pain. They also planned to combine the outcomes concerning pain, discomfort or fatigue and physical function. To perform sensitivity analysis, studies will be considered to be at high risk of bias if one of the main biases would be rated unclear or high risk (i.e. random sequence allocation, allocation concealment, incomplete outcome data or selective outcome reporting[62]). Concerning pain, the low-intensity pain threshold was defined as 3 out of 10 on a pain intensity scale[74,75].

Discussion

Workplace physical activity is now well recognized as a potential intervention to prevent WMSDs[7,8,11–17]. Although benefits of a warm-up have been previously documented in sports context[37–41], to the best of our knowledge, the effectiveness of such intervention in workplaces remains to be established. Interestingly, the primary outcome analyzed in this review will be associated with WMSDs such as pain, discomfort or fatigue. The secondary outcomes will be related to physical or psychosocial functions. All these outcomes recognized to be decreased in case of WMSDs are also the main outcomes reported in studies assessing the effects on an intervention on WMSDs[10–16]. For these reasons, these findings could constitute a solid starting point to help clinicians, researchers, companies and policy-makers trying to reduce the burden of WMSDs.

Limitations and strengths

Our review presents several strengths. The major strength is the systematic procedure employed. In this sense, a large number of scientific databases will be searched. Then, two

reviewers will independently screen articles, rate the quality of these studies and the risk of bias. Finally, the use of recommended standard reporting instruments such as PRISMA-P, ROBINS-I and GRADE will strengthen the recommendations that should be made at the end of the review. At this point, however, we are aware that the potential strength of this review could be reduced by the lack of high quality trials and high heterogeneity. Firstly, the recent scientific literature confirms that RCT in a workplace context are, of course possible but rare [34,76–78]. In this sense, numerous authors have concluded that considerable efforts had to be made to overcome difficulties to implement such study design, but also to recruit a large number of employees[1,46–48,79]. To deal with this heterogeneity, the authors have pre-planned to perform a subgroup and a sensitivity analysis. This choice will allow knowing whether or not the intervention effects differ between trials. Then, we are also aware that including both RCT and non-RCT will therefore lead to downgrade the validity and strength of the review and will increase the risk of bias especially for the blinding and generation domains[69]. Secondly, a recent review of literature by Johnson et al[80] on how outcomes are measured in workplace physical activity interventions have reported heterogeneous measurement tools and data collection making comparisons between studies rather difficult. To conclude, although the researchers do not anticipate protocol amendments, issues that arise with the original protocol will be documented in the review paper under the methodology section.

Abbreviations

GRADE: Grading of Recommendations, Assessment, Development and Evaluation

NRS: Numeric rating scale

PRISMA-P: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols

RCT: Randomized controlled trial

ROBINS: Risk Of Bias In Non-randomized Studies - of Interventions

VAS: Visual analog scale

WMSDS: Work related musculoskeletal disorders

Declarations

Competing interests

Opti'Mouv is a company that provides workplace health promotion services as workplace physical activity programs.

Funding statement

This review is part of a PhD thesis-project conducted in the University of Grenoble Alpes and Opti'Mouv. The research project is promoted by the University of Grenoble Alpes and partially financed by the "Ministère de l'Enseignement Supérieur et de la Recherche" via the "Association Nationale Recherche Technologie" (ANRT) by means of the "Convention Industrielle de Formation par la Recherche" (CIFRE) grant (n° 2019/0488). The founding source has no role in the study design, data collection, results interpretation or manuscript writing.

Authors'contribution

All listed authors have contributed and will continue to contribute meaningfully to the protocol and proposed review. NL, RB and NV conceived the proposed review and developed the search strategy. NL and RB are the two title and abstract reviewers, and NL and RB are the two full- text reviewers. NV will be the third reviewer that will help resolve any discrepancy. RB submitted the protocol to PROSPERO and is responsible for updating the registered protocol as needed. All authors read the final protocol manuscript and revised it for content; all also approved the final version.

Patient and public involvement

No patient involved.

Acknowledgements

Not applicable

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PRISMA-P 2015 Checklist

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	☒	☐	1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	☐	☒	
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	☒	☐	56
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	☒	☐	5-17
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	☒	☐	349
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	☐	☒	
Support					
Sources	5a	Indicate sources of financial or other support for the review	☒	☐	353
Sponsor	5b	Provide name for the review funder and/or sponsor	☒	☐	353
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	☒	☐	
INTRODUCTION					
Rationale	6	Describe the rationale for the review in the context of what is already known	☒	☐	67-105
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	☒	☐	103-105
METHODS					

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	☒	☐	114-187
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	☒	☐	190-205
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	☒	☐	199
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	☒	☐	218-238
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	☒	☐	208-216
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	☒	☐	208-238
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	☒	☐	177-186
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	☒	☐	171-187
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	☒	☐	240-261
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	☐	☒	
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2, Kendall's tau)	☐	☒	264-285
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	☒	☐	294-301
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	☒	☐	
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	☐	☒	
Confidence in	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	☒	☐	286-292

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
cumulative evidence					

BMJ Open

How much do we know about the effectiveness of warm-up intervention on work related musculoskeletal disorders, physical and psychosocial functions: protocol for a systematic review.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-039063.R2
Article Type:	Protocol
Date Submitted by the Author:	12-Oct-2020
Complete List of Authors:	Larinier, Nicolas; Université Grenoble Alpes Balaguier, Romain; Universite Grenoble Alpes, Vuillerme, Nicolas; Université Grenoble Alpes; Institut Universitaire de France
Primary Subject Heading:	Sports and exercise medicine
Secondary Subject Heading:	Occupational and environmental medicine, Public health
Keywords:	SPORTS MEDICINE, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, PUBLIC HEALTH

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How much do we know about the effectiveness of warm-up intervention on work related musculoskeletal disorders, physical and psychosocial functions: protocol for a systematic review.

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Key-words

Pain / injuries / intervention / workers / physical activity

Abstract

Introduction

Work related musculoskeletal disorders (WMSDs) are a growing worldwide burden and effective interventions to prevent them are needed. Physical activity at the workplace is now recognized as a relevant component of WMSDs prevention. Along these lines, warm-up interventions are now offered in a large number of companies to manage WMSDs. Although benefits of warm-up have been previously documented in sports context, to the best of our knowledge, the effectiveness of such intervention in workplaces still remains to be established. Within this context, the aim of the present review is to identify from published literature the available evidence regarding the effects of warm-up on WMSDs and physical and psychosocial functions.

Methods

The following electronic databases will be searched (from inception onwards to June 2020): Cochrane Central Register of Controlled Trials (CENTRAL), PubMed (Medline), Web of Science and Physiotherapy Evidence Database (PEDro). Randomized and non-randomized controlled studies will be included in this review. Participants should be adult employees without specific comorbidities. Interventions should include a warm-up physical intervention in real-workplaces. The primary outcomes will be pain, discomfort or fatigue. The secondary outcomes will be job control or motivation at work. This review will follow the PRISMA guidelines and two team members will independently screen all citations, full-text articles, and abstract data. A systematic narrative synthesis will be provided with information presented in the text and tables to summarize the characteristics and findings of the included studies.

Ethics and Dissemination

The approval of an ethical committee is not required. All the included studies will comply with the current ethical standards. The results of this review will summarize the effects of warm-up intervention on WMSDs, physical or psychosocial functions. This information could help professionals in decision-making related to the use of these interventions to prevent WMSDs. Findings will be disseminated to academic audiences through peer-reviewed publications, as well as to policy makers.

Registration

This protocol has been registered in PROSPERO (CRD42019137211)

Strength and limitations of the study

- This study will be to the best of our knowledge the first review to critically appraise the effectiveness of warm-up exercises to prevent WMSDs in workplaces
- Reporting in accordance with the Preferred Reporting Items for Systematic Reviews and MetaAnalyses statement.
- This study will include both RCT and non-RCT
- A low number of studies and significant heterogeneity is expected that might prevent performing a meta-analysis of the results

Introduction

Work related musculoskeletal disorders (WMSDs) are conditions affecting muscles, tendons, nerves, ligaments, joints or spinal discs[1]. They are now considered as a public health problem all over the world since their adverse consequences on quality of life and work participation are important[2–6]. This underlines the importance of finding effective prevention or curative strategies/interventions. In the last two decades, numerous researchers have identified the workplace as an ideal setting to support the promotion of healthier lifestyle and to prevent WMSDs[7–9]. Hence, the use of workplace physical activity interventions for the management of WMSDs is now well supported by scientific evidence[10–16]. Interestingly, WMSDs are conditions commonly characterized by the presence of pain or decreased function[9]. Therefore, workplace physical activity interventions often focus on numerous outcomes related to the individual such as pain, discomfort or fatigue[10,15–17], physical function such as strength, flexibility or endurance[8] and psychosocial function such as quality of life, job satisfaction or well-being[18,19]. In theory, the workplace environment does offer the possibility to reach and to raise awareness of a large number of workers[20]. However, workplace physical activity programs are less often offered and performed by those at risk of developing WMSDs (i.e. low-status, low income and blue-collar workers[7,21,22]). Furthermore, a 40-60% compliance is commonly observed whatever the duration of the programs[23–28]. It is presumable that these observations could partly stem from 'practical' barriers to offer physical activity at the workplace, such as time constraints, time of the day and duration of the training sessions[29–33]. In other words, programs should be easy to implement in the daily routine of the employees as well as of the employers. This application recommendation is supported by scientific results that shown that short bouts of exercises are easier to fit in organizational routines than long sessions[34,35]. For instance, Andersen et al[34] in a 10 weeks workplace physical activity program among office-workers, have compared the effects of a same weekly training volume, i.e. 1 hour performed with different training frequencies (from 1session per week to 9 sessions per week) on training adherence. These authors have reported that adherence among office-workers was significantly higher when the training volume was divided at least into 3 weekly training sessions.

In the last few years, the implementation of physical warm-up prior the beginning of the working days is increasingly adopted in companies to manage WMSDs (INRS 2018). In these companies, it is common to observe warm-up lasting between 5 and 15 minutes a day as well supervised by professionals such as sport trainer or physiotherapist as trained employees[36].

Previous reviews have found positive effects of warm-up on performance[37] and injury prevention in sports[37–41]. However, it is surprising that data on the effects of warm-up on WMSD are scarce and, when available, lead to rather conflicting/inconclusive results[42–44]. Within this context, the aim of this systematic review will be to evaluate the effectiveness of workplace warm-up interventions on WMSDs and physical and psychosocial functions among workers.

Methods

The present review protocol is being reported in accordance with the reporting guidance the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols (PRISMA-P) statement[45] (see PRISMA-P checklist in Additional file 1). This review protocol was registered within the International Prospective Register of Systematic Reviews (PROSPERO) (registration number: CRD42019137211) This review will be reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.

Criteria for considering studies for this review

Type of studies

Original quantitative research studies that assessed the effect of a warm-up intervention in a workplace setting aiming at preventing WMSDs or musculoskeletal pain or discomfort or fatigue in the worker will be included in the review.

As correctly argued, RCT are considered as the gold standard to assess the effectiveness of an intervention[46]. However, its implementation in occupational setting may not always be feasible and its implementation is called into question[1,47–51]. In that specific case, recent studies have suggested that non-RCT may maximize the body of evidence and have suggested including non-RCT in systematic-reviews[52–54]. For these reasons and as previously done in recent systematic reviews covering the scope of the present review[10,49], both randomized and non-randomized controlled studies will be included. Therefore, quasi-RCTs (participants not randomly allocated), cluster randomized trials (i.e. randomization of a group of people for example randomization at a company level), preference trials (patients can choose their treatment) and before-and-after study are design which will be included."

Period of studies publication was defined from inception onwards to June 2020. Finally, to be eligible for inclusion, studies had to be published in English in peer-reviewed scientific

journals[19,49]. As only studies in English will be included and may lead to reporting bias, we will report potentially eligible studies in other languages.

The following types of studies will be ineligible: case reports, abstracts, editorials, conference abstracts, letters to the editor, reviews, and meta-analysis. Studies will be also excluded if the intervention was partially or totally implemented outside of the workplace, e.g. in a clinical setting and if the intervention was implemented in combination with another intervention, e.g. ergonomics. Therefore, studies will be excluded when differences can not only be attributed only to the warm-up intervention.

Types of participants

This review will include adult employees (18 years of age or older) and will exclude adults with specific comorbidities or diseases (such as diabetes, arthritis, cancer, stroke) and/or special populations (pregnant, severe or rare physical disability, or cognitive disability).

Types of intervention

This review will include studies which have implemented warm-up interventions in real workplaces. To facilitate the comprehension of a warm-up intervention, we will use the definition given by McCrary et al [37], i.e. "a warm-up is a protocol specifically undertaken to prepare the onset of subsequent physical activity", in our case a working activity.

As recently used in a systematic review by Luger et al[55], to describe work-break programs and a study by Slade and Keating[56] about exercise prescription, we will characterize the warm-up intervention with the following four components:

(1) duration: warm-up may last from five minutes to one hour;

(2) frequency: warm-up may differ in number;

(3) type: warm-up may be stretching as well as cardio-training exercises or combination of strengthening exercises; and

(4) intensity: warm-up may be performed with/without load or performed at a low or high percentage of the maximum heart rate.

Studies will be excluded from this review if the warm-up intervention was partially or totally implemented outside of the workplace, e.g. in a clinical setting or under laboratory conditions and if the warm-up intervention was implemented in combination with another intervention, e.g. ergonomics.

Comparator

Inclusion criteria: We will consider studies that compared the warm-up intervention with a non-treatment control group (e.g. no intervention or usual activity or another type of workplace physical activity) or a non-active comparator (e.g. leaflets on benefits of physical activity)

Exclusion criteria: Studies with no comparison measures.

Types of outcome measures

Main outcomes

WMSDs are defined as a group of conditions or health problems affecting the locomotor apparatus. These conditions are characterized by pain, impaired function, overall fatigue and stress[9,57]. Therefore, among primary outcomes we will include all the outcomes associated with work related musculoskeletal issues, that are (1) participant's musculoskeletal pain through the use of pain scales (e.g. numeric rating scale (NRS) or visual analog scale (VAS)) or questionnaire (e.g. McGill pain questionnaire)[55] and (2) participant discomfort or fatigue[10,55] through validated scales and (3) physical function as measured or estimated by questionnaires, scales, performances and/or specific tests. Dichotomous data such as presence/absence of symptoms will be also considered.

Secondary outcomes

For the prevention of the consequences of WMSDs we will include – if possible – and as secondary outcomes, all the outcomes associated with psychosocial function such as the measure of quality of life, job satisfaction, job control or motivation at work. In this review job control is considered as an indicator of psychosocial stress at work [58]. This indicator is often measured with the job demand-control support model developed by Karasek [58].

Information sources and search strategy

Four electronic databases - Cochrane Central Register of Controlled Trials (CENTRAL), PubMed (Medline), Web of Science and Physiotherapy Evidence Database (PEDro) – will be searched systematically from inception onwards to identify studies satisfying the search criteria. Note that these databases have previously used in published reviews covering the scope of this review[49,55,59,60]. The proposed search strategy terms for Medline are listed in Table 1 and will be modified to fit the index system of other databases.

Table 1. Sample MEDLINE search strategy terms (Mesh: Mesh terms ; ti: tittle ; ab: abstract)

	Keywords
1	Workplace[Mesh]
2	Work* ti,ab
3	Employ* ti,ab
4	Compan* ti,ab
5	1 OR 2 OR 3 OR 4
6	Warm-Up Execise[Mesh]
7	Pre-shift ti,ab
8	Pre-exercise* ti,ab
9	Pre-activit* ti,ab
10	6 OR 7 OR 8 OR 9
11	Musculoskeletal diseases[Mesh]
12	Pain[Mesh]
13	Musculoskeletal Pain[Mesh]
14	WMSD* ti,ab
15	Pain ti,ab
16	(endurance or strength or flexibility) ti,ab
17	(quality of life or job satisfaction or work ability or well-being or stress or disabilit* or health or discomfort or comfort or fatigue or injur*) ti,ab
18	11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17
	Combining search terms
20	5 AND 10 AND 18

Additional intended information sources

To be sure not to miss relevant studies for the review, the reference list of for all eligible articles will be checked. Then, a grey literature search will be performed on ClinicalTrials.gov. Finally, experts in this domain will be contacted to collect information on unknown or ongoing studies

Data collection

Study selection process

All studies that met inclusion criteria passed through a data extraction and quality assessment process performed by two independent reviewers. A third reviewer will be requested to resolve disagreement when consensus could not be reached. Reviewers will not be blinded to study author(s) or journal title. At stage 1, two independent reviewers will screen abstract and

titles identified from the search strategy. At stage 2, the same two reviewers will screen the full-text articles for inclusion. At this stage, all reasons for exclusion of articles will be recorded and reported. Finally, the relevant studies, which respect eligibility criteria, will be screened by a senior review team member (NV) to be included in the systematic review.

Data extraction and management

First a data extraction form will be created and validated by the three team members. This data collection form will be fulfilled by one team member (NL) and corrected by another team member (RB). Any disagreement between the two reviewers will be resolved by consensus or discussion with the senior review team member (NV). This extraction form could be modified from the information collected in the eligible studies but should at least specify the following information[59,61,62]:

- General: authors, year of publication, journal's name, source of funding (if any) and country of the study;
- Methods: study design, total duration of study, follow-up when data were collected, study setting and withdrawals;
- Participants: number, age, gender, inclusion/exclusion criteria, type of workplace or job task, health of the workers/health status, i.e. asymptomatic or symptomatic, year of work experience;
- Interventions: description of the type, duration, frequency, intensity, supervision of the warm-up program, description/content of the comparison/control group and number of participants allocated to each group;
- Data collection: primary and secondary outcomes, measurement tools, questionnaires, tests;
- Statistical tests;
- Main results

Risk of bias (quality) assessment

Two team members (NL and RB) will independently assess the risk of bias for each included study. Any disagreement between team members will be solved by consensus or discussion with the third team member. As both randomized and non-randomized controlled studies will be included in this review, two risk of bias tools will be used.

For RCT

The Cochrane tool for assessing risk of bias from the Cochrane Handbook for Systematic Reviews of Interventions will be used to assess potential biases of the included studies. This tool is a well-known and validated instrument to assess the risk of bias in RCTs [63]. This tool has been revised in 2019 [64] and has now 5 domains to assess bias arising from: (1) randomization process, (2) deviation from the intended intervention, (3) missing outcome data, (4) measurement of the outcome and (5) selection of the reported result. Each domain will be scored as follow (see Table 2): "high risk of bias", "low risk of bias" and "some concerns".

For non RCT

The Risk Of Bias In Non-randomized Studies - of Interventions (ROBINS-I) will be used to asses potential biases of the included non-RCT[65]. This tool has 7 domains to assess bias arising from (1) confounding, (2) selection of participants, (3) classification of the intervention, (4) deviations from the intended intervention, (5) missing data, (6) measurement of outcomes and (7) selection of the reported result.

Table 2. Risk of bias judgement for a specific domain (from Sterne et al. 2019).

Overall risk of bias judgement	Criteria
Low risk of bias	The study is judged to be at low risk of bias for all domains for this result
Some concerns	The study is judged to be at high risk of bias in at least one domain for this result, but not to be at high risk of bias for any domain
High risk of bias	The study is judged to be at high risk of bias in at least one domain for this result Or The study is judged to have some concerns for multiple domains in a way that substantially lowers confidence in the result.

Measures of treatment effect

For studies using continuous data, treatment effect will be reported as mean difference with 95% CI. In case the studies evaluate the same outcome with different scales, standardized mean difference (SMD) with 95% CI will be calculated. Regarding dichotomous/categorical variables, the treatment effect will be calculated using the relative risk (RR) with 95% CI[66–69]. Since the number of included studies is greater than 5[67] and when these studies are considered as sufficiently homogeneous, outcome data will be synthesized using a random effect meta-analysis[55,68,70,71]. If meta-analysis is not possible due to heterogeneity or if the outcomes cannot be pooled, a narrative synthesis will be performed using text and table formats. Results will be also presented in forest plots.

Assessment of statistical heterogeneity

Statistical heterogeneity, defined as variability in the intervention effects will be estimated using the Chi² test, with Chi² p>0.10 provides significant evidence of heterogeneity. Chi² assesses whether heterogeneity is only due to chance. To ensure a right comprehension of heterogeneity, Chi² will be completed with I^2 statistics particularly relevant when studies have small sample size or are few in numbers. Heterogeneity will be categorized as follows[71]:

- 0-40%: not be important
- 30-60%: moderate heterogeneity
- 50-90% substantial heterogeneity
- 75-100%: considerable heterogeneity

Quality assessment and strategy for data synthesis

To assess quality of evidence of the included studies the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach[72] will be used. This approach grades studies as followed: very low, low, moderate and high. As suggested by Bordado et al [19], the quality assessment will be based on the findings in data extraction, and will follow the domains of quality evaluation in the GRADE approach: risk of bias, inconsistency, indirectness and imprecision. Two team members (NL and RB) will independently assess the quality of evidence of the included studies with the GRADE approach.

Analysis of subgroups or subsets

In case a sufficient number of studies are included in the review, a subgroup analysis will be performed. The latter will be carried out for each outcome and for the following factors: (1)

participants' characteristics (e.g. sex, age. If possible authors will compare participants aged 40 years and younger with participants aged 41 years and older), (2) WMSDs location (e.g. neck *versus* low back *versus* upper extremities), (3) occupational activity (e.g. active *versus* sedentary jobs), (4) length of intervention, (5) study design (e.g. RCT *versus* non-RCT) and (6) comparison group type (e.g. passive *versus* active control group)[55,69] and (7) implementation warm-up intervention (supervised versus non supervised)[73]."

Sensitivity analysis

The authors of the present systematic review planned to perform sensitivity analysis to determine whether our findings are affected by high risk of bias and baseline pain. They also planned to combine the outcomes concerning pain, discomfort or fatigue and physical function. To perform sensitivity analysis, studies will be considered to be at high risk of bias if one of the main biases would be rated unclear or high risk (i.e. random sequence allocation, allocation concealment, incomplete outcome data or selective outcome reporting[62]). Concerning pain, the low-intensity pain threshold was defined as 3 out of 10 on a pain intensity scale[74,75].

Ethics and Dissemination

No ethic committee was required to conduct this review. However, all included studies in this review will follow current ethical standard and will be in accordance with the Declaration of Helsinki. The results of this review will be submitted for publication to a peer-reviewed high-impact academic journal. Other dissemination may include presentations at international conferences, seminars and note to social media to influence decision makers.

Discussion

Workplace physical activity is now well recognized as a potential intervention to prevent WMSDs[7,8,11–17]. Although benefits of a warm-up have been previously documented in sports context[37–41], to the best of our knowledge, the effectiveness of such intervention in workplaces remains to be established. Interestingly, the primary outcome analyzed in this review will be associated with WMSDs such as pain, discomfort or fatigue. The secondary outcomes will be

related to physical or psychosocial functions. All these outcomes recognized to be decreased in case of WMSDs are also the main outcomes reported in studies assessing the effects on an intervention on WMSDs[10–16]. For these reasons, these findings could constitute a solid starting point to help clinicians, researchers, companies and policy-makers trying to reduce the burden of WMSDs.

Limitations and strengths

Our review presents several strengths. The major strength is the systematic procedure employed. In this sense, a large number of scientific databases will be searched. Then, two reviewers will independently screen articles, rate the quality of these studies and the risk of bias. Finally, the use of recommended standard reporting instruments such as PRISMA-P, ROBINS-I and GRADE will strengthen the recommendations that should be made at the end of the review. At this point, however, we are aware that the potential strength of this review could be reduced by the lack of high quality trials and high heterogeneity. Firstly, the recent scientific literature confirms that RCT in a workplace context are, of course possible but rare [34,76–78]. In this sense, numerous authors have concluded that considerable efforts had to be made to overcome difficulties to implement such study design, but also to recruit a large number of employees[1,46–48,79]. To deal with this heterogeneity, the authors have pre-planned to perform a subgroup and a sensitivity analysis. This choice will allow knowing whether or not the intervention effects differ between trials. Then, we are also aware that including both RCT and non-RCT will therefore lead to downgrade the validity and strength of the review and will increase the risk of bias especially for the blinding and generation domains[69]. Secondly, a recent review of literature by Johnson et al[80] on how outcomes are measured in workplace physical activity interventions have reported heterogeneous measurement tools and data collection making comparisons between studies rather difficult. To conclude, although the researchers do not anticipate protocol amendments, issues that arise with the original protocol will be documented in the review paper under the methodology section.

Abbreviations

GRADE: Grading of Recommendations, Assessment, Development and Evaluation

NRS: Numeric rating scale

PRISMA-P: Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols

RCT: Randomized controlled trial

ROBINS: Risk Of Bias In Non-randomized Studies - of Interventions

VAS: Visual analog scale

WMSDS: Work related musculoskeletal disorders

Declarations

Competing interests

Opti'Mouv is a company that provides workplace health promotion services as workplace physical activity programs.

Funding statement

This review is part of a PhD thesis-project conducted in the University of Grenoble Alpes and Opti'Mouv. The research project is promoted by the University of Grenoble Alpes and partially financed by the "Ministère de l'Enseignement Supérieur et de la Recherche" via the "Association Nationale Recherche Technologie" (ANRT) by means of the "Convention Industrielle de Formation par la Recherche" (CIFRE) grant (n° 2019/0488). The founding source has no role in the study design, data collection, results interpretation or manuscript writing.

Authors'contribution

All listed authors have contributed and will continue to contribute meaningfully to the protocol and proposed review. NL, RB and NV conceived the proposed review and developed the search strategy. NL and RB are the two title and abstract reviewers, and NL and RB are the two full- text reviewers. NV will be the third reviewer that will help resolve any discrepancy. RB submitted the protocol to PROSPERO and is responsible for updating the registered protocol as needed. All authors read the final protocol manuscript and revised it for content; all also approved the final version.

Patient and public involvement

No patient involved.

Acknowledgements

Not applicable

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PRISMA-P 2015 Checklist

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
ADMINISTRATIVE INFORMATION					
Title					
Identification	1a	Identify the report as a protocol of a systematic review	☒	☐	1
Update	1b	If the protocol is for an update of a previous systematic review, identify as such	☐	☒	
Registration	2	If registered, provide the name of the registry (e.g., PROSPERO) and registration number in the Abstract	☒	☐	56
Authors					
Contact	3a	Provide name, institutional affiliation, and e-mail address of all protocol authors; provide physical mailing address of corresponding author	☒	☐	5-17
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review	☒	☐	349
Amendments	4	If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments	☐	☒	
Support					
Sources	5a	Indicate sources of financial or other support for the review	☒	☐	353
Sponsor	5b	Provide name for the review funder and/or sponsor	☒	☐	353
Role of sponsor/funder	5c	Describe roles of funder(s), sponsor(s), and/or institution(s), if any, in developing the protocol	☒	☐	
INTRODUCTION					
Rationale	6	Describe the rationale for the review in the context of what is already known	☒	☐	67-105
Objectives	7	Provide an explicit statement of the question(s) the review will address with reference to participants, interventions, comparators, and outcomes (PICO)	☒	☐	103-105
METHODS					

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
Eligibility criteria	8	Specify the study characteristics (e.g., PICO, study design, setting, time frame) and report characteristics (e.g., years considered, language, publication status) to be used as criteria for eligibility for the review	☒	☐	114-187
Information sources	9	Describe all intended information sources (e.g., electronic databases, contact with study authors, trial registers, or other grey literature sources) with planned dates of coverage	☒	☐	190-205
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated	☒	☐	199
STUDY RECORDS					
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review	☒	☐	218-238
Selection process	11b	State the process that will be used for selecting studies (e.g., two independent reviewers) through each phase of the review (i.e., screening, eligibility, and inclusion in meta-analysis)	☒	☐	208-216
Data collection process	11c	Describe planned method of extracting data from reports (e.g., piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators	☒	☐	208-238
Data items	12	List and define all variables for which data will be sought (e.g., PICO items, funding sources), any pre-planned data assumptions and simplifications	☒	☐	177-186
Outcomes and prioritization	13	List and define all outcomes for which data will be sought, including prioritization of main and additional outcomes, with rationale	☒	☐	171-187
Risk of bias in individual studies	14	Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis	☒	☐	240-261
DATA					
Synthesis	15a	Describe criteria under which study data will be quantitatively synthesized	☐	☒	
	15b	If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data, and methods of combining data from studies, including any planned exploration of consistency (e.g., I^2, Kendall's tau)	☐	☒	264-285
	15c	Describe any proposed additional analyses (e.g., sensitivity or subgroup analyses, meta-regression)	☒	☐	294-301
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned	☒	☐	
Meta-bias(es)	16	Specify any planned assessment of meta-bias(es) (e.g., publication bias across studies, selective reporting within studies)	☐	☒	
Confidence in	17	Describe how the strength of the body of evidence will be assessed (e.g., GRADE)	☒	☐	286-292

Section/topic	#	Checklist item	Information reported		Line number(s)
			Yes	No	
cumulative evidence					