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Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers (Review)

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[Intervention Review]

Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers

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ABSTRACT

Background

Work-related musculoskeletal disorders are a group of musculoskeletal disorders that comprise one of the most common disorders related to occupational sick leave worldwide. Musculoskeletal disorders accounted for 21% to 28% of work absenteeism days in 2017/2018 in the Netherlands, Germany and the UK. There are several interventions that may be effective in tackling the high prevalence of work-related musculoskeletal disorders among workers, such as physical, cognitive and organisational interventions. In this review, we will focus on work breaks as a measure of primary prevention, which are a type of organisational intervention.

Objectives

To compare the effectiveness of different work-break schedules for preventing work-related musculoskeletal symptoms and disorders in healthy workers, when compared to conventional or alternate work-break schedules.

Search methods

We searched the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, Embase, CINAHL, PsycINFO, SCOPUS, Web of Science, ClinicalTrials.gov and the World Health Organization International Clinical Trials Registry Platform, to April/May 2019. In addition, we searched references of the included studies and of relevant literature reviews.

Selection criteria

We included randomised controlled trials (RCTs) of work-break interventions for preventing work-related musculoskeletal symptoms and disorders among workers. The studies were eligible for inclusion when intervening on work-break frequency, duration and/or type, compared to conventional or an alternate work-break intervention. We included only those studies in which the investigated population included healthy, adult workers, who were free of musculoskeletal complaints during study enrolment, without restrictions to sex or occupation. The primary outcomes were newly diagnosed musculoskeletal disorders, self-reported musculoskeletal pain, discomfort or fatigue, and productivity or work performance. We considered workload changes as secondary outcomes.

Data collection and analysis

Two review authors independently screened titles, abstracts and full texts for study eligibility, extracted data and assessed risk of bias. We contacted authors for additional study data where required. We performed meta-analyses, where possible, and we assessed the overall quality of the evidence for each outcome of each comparison using the five GRADE considerations.

Main results

We included six studies (373 workers), four parallel RCTs, one cross-over RCT, and one combined parallel plus cross-over RCT. At least 295 of the employees were female and at least 39 male; for the remaining 39 employees, the sex was not specified in the study trial. The studies investigated different work-break frequencies (five studies) and different work-break types (two studies). None of the studies investigated different work-break durations. We judged all studies to have a high risk of bias. The quality of the evidence for the primary outcomes of self-reported musculoskeletal pain, discomfort and fatigue was low; the quality of the evidence for the primary outcomes of productivity and work performance was very low. The studies were executed in Europe or Northern America, with none from low- to middle-income countries. One study could not be included in the data analyses, because no detailed results have been reported.

Changes in the frequency of work breaks

There is low-quality evidence that additional work breaks may not have a considerable effect on musculoskeletal pain, discomfort or fatigue, when compared with no additional work breaks (standardised mean difference (SMD) -0.08; 95% CI -0.35 to 0.18; three studies; 225 participants). Additional breaks may not have a positive effect on productivity or work performance, when compared with no additional work breaks (SMD -0.07; 95% CI -0.33 to 0.19; three studies; 225 participants; very low-quality evidence).

We found low-quality evidence that additional work breaks may not have a considerable effect on participant-reported musculoskeletal pain, discomfort or fatigue (MD 1.80 on a 100-mm VAS scale; 95% CI -41.07 to 64.37; one study; 15 participants), when compared to work breaks as needed (i.e. microbreaks taken at own discretion). There is very low-quality evidence that additional work breaks may have a positive effect on productivity or work performance, when compared to work breaks as needed (MD 542.5 number of words typed per 3-hour recording session; 95% CI 177.22 to 907.78; one study; 15 participants).

Additional higher frequency work breaks may not have a considerable effect on participant-reported musculoskeletal pain, discomfort or fatigue (MD 11.65 on a 100-mm VAS scale; 95% CI -41.07 to 64.37; one study; 10 participants; low-quality evidence), when compared to additional lower frequency work breaks. We found very low-quality evidence that additional higher frequency work breaks may not have a considerable effect on productivity or work performance (MD -83.00 number of words typed per 3-hour recording session; 95% CI -305.27 to 139.27; one study; 10 participants), when compared to additional lower frequency work breaks.

Changes in the duration of work breaks

No trials were identified that assessed the effect of different durations of work breaks.

Changes in the type of work break

We found low-quality evidence that active breaks may not have a considerable positive effect on participant-reported musculoskeletal pain, discomfort and fatigue (MD -0.17 on a 1-7 NRS scale; 95% CI -0.71 to 0.37; one study; 153 participants), when compared to passive work breaks.

Relaxation work breaks may not have a considerable effect on participant-reported musculoskeletal pain, discomfort or fatigue, when compared to physical work breaks (MD 0.20 on a 1-7 NRS scale; 95% CI -0.43 to 0.82; one study; 97 participants; low-quality evidence).

Authors' conclusions

We found low-quality evidence that different work-break frequencies may have no effect on participant-reported musculoskeletal pain, discomfort and fatigue. For productivity and work performance, evidence was of very low-quality that different work-break frequencies may have a positive effect. For different types of break, there may be no effect on participant-reported musculoskeletal pain, discomfort and fatigue according to low-quality evidence. Further high-quality studies are needed to determine the effectiveness of frequency, duration and type of work-break interventions among workers, if possible, with much higher sample sizes than the studies included in the current review. Furthermore, work-break interventions should be reconsidered, taking into account worker populations other than office workers, and taking into account the possibility of combining work-break intervention with other interventions such as ergonomic training or counselling, which may possibly have an effect on musculoskeletal outcomes and work performance.

PLAIN LANGUAGE SUMMARY

Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers

The number of workers suffering from work-related musculoskeletal disorders is estimated to account for 21% to 28% of all days of occupational sick leave in 2017/2018 in the UK, Germany and the Netherlands. These numbers indicate that work-related musculoskeletal disorders are a major problem for society as well as for employers. Interventions may counteract this problem, for example, by making changes to the workplace or work organisation. Many interventions have been investigated, such as training in ergonomics principles (*work designs to increase productivity and comfort at the workplace*), information and counselling, workstation adjustment, work-break schedule adjustment, and job rotation. The current review focused on the effect of different work-break schedules on outcomes related to work-related musculoskeletal symptoms, since a systematic overview on this particular intervention is currently lacking. Different work-break schedules may lead to an interruption or a decrease of long periods of repetitive or monotonous workloads. They may also lead

to interruption of longer periods in which workers have to adopt static or awkward body postures, factors recognised as risk factors for developing work-related musculoskeletal disorders.

Aim

We wanted to find out whether different frequencies, durations and types of work breaks can prevent work-related musculoskeletal symptoms and disorders among healthy workers. We considered workers as healthy when they were free of musculoskeletal complaints at study enrolment.

Studies

We selected several primary outcome measures, including newly diagnosed musculoskeletal disorders, participant-reported musculoskeletal symptoms including pain, discomfort and fatigue, and productivity and work performance. The latter measure is not directly relevant to the worker but rather to the employer when it comes to maintaining business output. We selected changes in workload as a secondary outcome measure, which may include force output changes, electromyographic (*recording of the electrical activity of muscles using electrodes*) manifestations of muscle fatigue, or subjective change in workload (NASA-TLX). None of the included studies reported any newly diagnosed musculoskeletal disorders or workload changes.

We searched the literature until 2 May 2019 to find randomised controlled trials (RCTs), quasi-RCTs, cluster-RCTs and cross-over RCTs of work-break interventions aimed at preventing work-related musculoskeletal disorders at work. We analysed all relevant studies to answer the research question and found six studies involving 373 workers, the majority of whom were female ($\geq 78\%$), with a follow-up period of two to 10 weeks.

Key results

Effect of different work-break frequencies

Five of the six studies evaluated different work-break frequencies. The implementation of additional work breaks (three studies) may not have an effect on musculoskeletal pain, discomfort or fatigue when compared to no additional work breaks or work breaks taken as needed. Additional work breaks (three studies) may have a positive effect on productivity and work performance when compared to a conventional work-break schedule. Additional higher frequency work breaks have been compared with additional lower frequency work breaks in one study, which resulted in no differences in participant-reported musculoskeletal pain, discomfort and fatigue, nor in productivity and work performance.

Effect of different work-break durations

None of the studies evaluated the effect of duration of work breaks.

Effect of different work-break types

Two of the six studies evaluated different work-break types. Active work breaks (one study) may not reduce nor increase the incidence of participant-reported musculoskeletal pain, discomfort and fatigue, or productivity and work performance. Similarly, different active work breaks have been compared with one another (one study), i.e. relaxation and physical active work breaks, which revealed no differences in participant-reported musculoskeletal pain, discomfort and fatigue, nor in productivity and work performance.

Conclusions

At present, we conclude that there is very low- to low-quality evidence that different work-break frequencies and types may not considerably reduce the incidence of musculoskeletal disorders. Although the results suggest that there may be a positive effect of different work-break frequencies on productivity and work performance, there is a need for high-quality studies with large enough sample sizes to assess the effectiveness of different work-break interventions. Furthermore, work-break interventions should be reconsidered, taking into account worker populations other than office workers and the possibility of combining work-break interventions with other interventions such as ergonomic training or counselling, which may possibly prevent musculoskeletal disorders.

SUMMARY OF FINDINGS

Summary of findings for the main comparison. Additional work breaks compared to no additional work breaks for preventing musculoskeletal symptoms and disorders in workers

Additional work breaks compared to no additional work breaks for preventing musculoskeletal symptoms and disorders in workers

Patient or population: office workers

Setting: office setting including a computer

Intervention: additional work breaks

Comparison: no additional work breaks

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	N° of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	No additional work breaks	Additional work breaks				
Participant-reported musculoskeletal pain, discomfort or fatigue Method: 0-100 mm VAS or 1-5 NRS Follow-up: 4 or 10 weeks	The mean participant-reported musculoskeletal pain, discomfort or fatigue (4 or 10 weeks) ranged across control groups from 1.38 - 3.80 ¹	The mean after shift/after intervention participant-reported musculoskeletal pain, discomfort or fatigue (4 or 10 weeks) 0.08 standard deviations lower (0.35 lower to 0.18 higher)	-	225 (3 RCTs)	⊕⊕⊕⊕ low ^{3,4}	
Productivity or work performance Method: total number of documents entered per day, or keystrokes per hour, or WRFQ Follow-up: 4 or 10 weeks	The mean productivity or work performance (4 or 10 weeks) ranged across control groups from -4.25 - 209.09 ²	The mean after shift/after intervention productivity or work performance (4 or 10 weeks) was 0.07 standard deviations lower (0.33 lower to 0.19 higher)	-	225 (3 RCTs)	⊕⊕⊕⊕ very low ^{3,4,5}	

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval.

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

NRS: Numeric Rating Scale.

VAS: Visual Analogue Scale.

WRFQ: Work Role Functioning Questionnaire.

1 Data include estimates based on *Table 2* and *Figure 2* in [Galinsky 2000](#) and *Figure 1* in [Galinsky 2007](#).

2 Data include estimates based on *Section 3.3* in [Galinsky 2000](#) and *Section Data Entry Performance > Rest break schedule* in [Galinsky 2007](#).

3 Downgraded one level because of a potential risk of bias.

4 Downgraded one level because the total number of participants was less than 300 (small sample size for a continuous variable).

5 Downgraded one level because of surrogate outcome that is not important in itself but assumed indirectly important for the intervention's evaluation.

Summary of findings 2. Additional work breaks compared to work breaks as needed for preventing musculoskeletal symptoms and disorders in workers

Additional work breaks compared to work breaks as needed for preventing musculoskeletal symptoms and disorders in workers

Patient or population: office workers

Setting: office setting including a computer

Intervention: additional work breaks

Comparison: work breaks as needed (i.e. microbreaks taken at own discretion)

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	Nº of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Work breaks as needed	Additional work breaks				
Participant-reported musculoskeletal pain, discomfort or fatigue Method: 0-100 mm VAS Follow-up: 4 weeks	The mean participant-reported musculoskeletal pain, discomfort or fatigue (4 weeks) was 25.10	The mean after intervention participant-reported musculoskeletal pain, discomfort or fatigue (4 weeks) in the intervention group was 1.80 higher (38.15 lower to 41.75 higher)	-	15 (1 RCT)	⊕⊕⊕⊕ very low ^{1,2,3}	
Productivity or work performance	The mean productivity or work performance (4 weeks) was -317.00 compared to no breaks	The mean after intervention productivity or work performance (4 weeks) in the intervention group was 542.50 higher (177.22 higher to 907.78 higher)	-	15 (1 RCT)	⊕⊕⊕⊕ very low ^{1,2,3}	

Method: number of words typed per 3 hours

Follow-up: 4 weeks

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval.

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

VAS: Visual Analogue Scale.

1 Downgraded one level because of a potential risk of bias.

2 Downgraded two levels because the total number of participants was less than 50 (small sample size for a continuous variable) and because of low precision of the effect estimate (0.5 was included in the 95% CI of the SMD).

3 Downgraded one level because of surrogate outcome that was not important in itself but assumed indirectly important for the intervention's evaluation.

Summary of findings 3. Additional higher frequency work breaks compared to additional lower frequency work breaks for preventing musculoskeletal symptoms and disorders in workers

Additional higher frequency work breaks compared to additional lower frequency work breaks for preventing musculoskeletal symptoms and disorders in workers

Patient or population: office workers

Setting: office setting including a computer

Intervention: additional higher frequency work breaks

Comparison: additional lower frequency work breaks

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	N° of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Additional <i>lower</i> frequency work breaks	Additional <i>higher</i> frequency work breaks				

Participant-report- ed musculoskeletal pain, discomfort or fatigue Method: 0-100 mm VAS Follow-up: 4 weeks	The mean participant-re- ported musculoskeletal pain, discomfort or fatigue (4 weeks) was 21.08	The mean after intervention partici- pant-reported musculoskeletal pain, discomfort or fatigue (4 weeks) was 11.65 higher (41.07 lower to 64.37 higher)	-	10 (1 RCT)	⊕⊕⊕⊕ very low ^{1,2}
Productivity or work performance Method: number of words typed per 3 hours Follow-up: 4 weeks	The mean productivity or work performance (4 weeks) was 267.00 com- pared to no breaks	The mean after intervention produc- tivity or work performance (4 weeks) in the intervention group was 83.00 lower (305.27 lower to 139.27 higher)	-	10 (1 RCT)	⊕⊕⊕⊕ very low ^{1,2,3}

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval.

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

VAS: Visual Analogue Scale.

¹ Downgraded one level because of a potential risk of bias.

² Downgraded two levels because the total number of participants was less than 25 (small sample size for a continuous variable) and because of low precision of the effect estimate (0.5 was included in the 95% CI of the SMD).

³ Downgraded one level because of surrogate outcome that was not important in itself but assumed indirectly important for the intervention's evaluation.

Summary of findings 4. Active work breaks compared to passive work breaks for preventing musculoskeletal symptoms and disorders in workers

Active work breaks compared to passive work breaks for preventing musculoskeletal symptoms and disorders in workers

Patient or population: office workers

Setting: office setting including a computer

Intervention: active work breaks

Comparison: passive work breaks

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	Nº of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Passive work breaks	Active work breaks				
Participant-reported musculoskeletal pain, discomfort or fatigue Method: 1-7 NRS Follow-up: 5 weeks	The mean participant-reported musculoskeletal pain, discomfort or fatigue (5 weeks) was 4.15	The mean difference after intervention participant-reported musculoskeletal pain, discomfort or fatigue (5 weeks) in the intervention group was 0.17 lower (0.71 lower to 0.37 higher)	-	153 (1 RCT)	⊕⊕⊕⊖ low ^{1,2}	

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval.

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

NRS: Numeric Rating Scale.

¹ Downgraded one level because of a potential risk of bias.

² Downgraded one level because the total number of participants was less than 200 (small sample size for a continuous variable).

Summary of findings 5. Relaxation work breaks compared to physical work breaks for preventing musculoskeletal symptoms and disorders in workers

Relaxation work breaks compared to physical work breaks for preventing musculoskeletal symptoms and disorders in workers

Patient or population: office workers

Setting: office setting including a computer

Intervention: relaxation work breaks

Comparison: physical work breaks

Outcomes	Anticipated absolute effects* (95% CI)	Relative effect (95% CI)	Nº of participants	Certainty of the evidence	Comments
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	Assumed risk	Corresponding risk	(studies)	(GRADE)
	Physical work breaks	Relaxation work breaks		
Participant-reported musculoskeletal pain ,discomfort or fatigue Method: 1-7 NRS Follow-up: 5 weeks	The mean participant-reported musculoskeletal pain, discomfort or fatigue (5 weeks) was 3.88	The mean difference after intervention participant-reported musculoskeletal pain, discomfort or fatigue (5 weeks) in the intervention group was 0.20 higher (0.43 lower to 0.82 higher)	- 97 (1 RCT)	⊕⊕⊕⊖ low ^{1,2}

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

CI: Confidence interval.

GRADE Working Group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

NRS: Numeric Rating Scale.

¹ Downgraded one level because of a potential risk of bias.

² Downgraded one level because the total number of participants was less than 100 (small sample size for a continuous variable).

BACKGROUND

Description of the condition

Over the past decades, companies in the industrial sector have automated and standardised their operations (Docherty 2002), resulting in work tasks becoming more similar, and employees being exposed to more repetitive and monotonous work (Mathiassen 2006). Repetition and monotony are two important characteristics of work that increase the risks of an employee developing work-related musculoskeletal disorders (Buckle 2002). Vulnerable body sites for work-related musculoskeletal disorders include, among others, the back, arms, hands, wrists (Barr 2004), shoulders and neck (Eltayeb 2009). Several work-related site-specific disorders have been identified in the literature, including low back pain (Irwin 2007), epicondylitis (Herquelot 2013), carpal tunnel syndrome (Palmer 2007), thoracic outlet syndrome (Laulan 2011), meniscal tears (Snoeker 2013), knee osteoarthritis (Ezzat 2014) and plantar fasciitis (Foye 2007). For de Quervain's synovitis this has been suspected but this was not confirmed in studies (Stahl 2015).

Work-related musculoskeletal disorders place a heavy burden on current society, not only because of their prevalence but also because of the costs associated with work absenteeism due to such disorders. Prevalence rates and lost working days vary across countries due to differences in the economic situation. For example, musculoskeletal disorders accounted for about 24% of all work-related illnesses in 2017/2018 in the UK and resulted in 6.6 million working days lost (HSE 2019). In the Netherlands, musculoskeletal disorders accounted for an average of about 28% of work absenteeism days and for an average of about 20% of work disability days in 2017 (ArboNed 2019). In Germany, musculoskeletal disorders accounted for about 21% of work absenteeism days in 2018 (DAK 2019). In general, the prevalence of work-related musculoskeletal disorders increases with age and is higher in males than in females (ArboNed 2019; HSE 2019).

Description of the intervention

A potential solution for reducing the incidence of work-related musculoskeletal disorders is to design interventions that prevent exposure to factors that increase risk of developing a work-related musculoskeletal disorder. Due to the multifactorial aetiology of such disorders (Armstrong 1993; Kraatz 2013; Roquelaure 2009), this is quite a challenge. Nevertheless, several studies have suggested conducting interventions at the level of work-break frequency or duration or both, or type of exposure at work (Burger 1959) and have investigated the efficacy (laboratory studies) or effectiveness (studies at true workplaces) of increasing break frequency, or changing the pattern of breaks whilst measuring effects on musculoskeletal fatigue, discomfort level and work performance (e.g. Galinsky 2007; Luger 2015; Sundelin 1993).

This review will focus on work-break schedule interventions specifically aimed at preventing work-related musculoskeletal symptoms and disorders among workers. The goal of work-break schedules is to interrupt or decrease long periods of repetitive or monotonous workloads and the periods in which workers have to adopt awkward postures. We define a work break as a temporary disengagement from work, with the following characteristics.

- Frequency: work breaks provided over a working period or working day may differ in number.
- Duration: work breaks may be provided as: microbreaks, such as breaks lasting up to two minutes; short breaks, such as a coffee break; or longer breaks, such as a lunch break.
- Type: different types of work breaks may be provided, such as passive or rest breaks (Brewer 2006), active breaks involving high-intensity or stretching exercises, and walking (Falla 2007) or cognitive breaks (Mathiassen 2014).

How the intervention might work

In situations where work-related musculoskeletal symptoms or disorders are prevalent, it may be advantageous to apply work breaks. It is generally assumed that work breaks may provide a recovery period for any musculoskeletal structure that is stressed during the working process (the process thought to precede the pathogenesis of work-related musculoskeletal disorders (Rashedi 2015)), thus helping to maintain work performance (Tucker 2003). However, work breaks may differ in frequency, duration and type.

Frequency of work breaks

On a regular working day, employees are often offered one or more coffee breaks and a longer meal break, which differs for each country with regards to legal prescriptions and wage agreements. Studies have investigated whether providing more frequent breaks could be beneficial. For example, in a field cross-over study among field workers who completed three days of strawberry harvesting while in a stooped position, workers were exposed to either the regular-break pattern (i.e. two 10-minute rest breaks and one 30-minute lunch break) or to the intervention rest-break pattern (i.e. four extra five-minute breaks in addition to the regular-break pattern) (Faucett 2007). The study focused on both primary and secondary prevention, because workers with musculoskeletal symptoms were also included and randomised. The intervention rest-break pattern improved musculoskeletal symptoms and fatigue scores among workers, and their productivity did not differ from that of workers using the regular-break pattern. A recent field study among workers from companies in various sectors showed that a higher frequency of rest breaks is associated with less work-related fatigue and distress (Blasche 2017), however, nothing was mentioned about whether total break duration changed accordingly. While both of these studies provide subjective results in favour of more frequent work breaks, objective findings are currently scarce and make it difficult to give practical advice on an effective work-break pattern.

Duration of work breaks

The duration of work breaks may play a crucial role in the recovery of tissues and muscles. A multicentre cohort study among surgeons investigated the effectiveness of intraoperative microbreaks lasting about 1.5 to 2 minutes, provided at 20- to 40-minute intervals (Park 2017). This field study showed that microbreaks can be practical and efficient in reducing musculoskeletal pain without prolonging the overall operative time. A field cross-over study showed that musculoskeletal fatigue was lower among surgeons taking 20-second microbreaks than among surgeons who did not take such breaks (Dorion 2013). In both of these studies, task duration and work accuracy were not affected, an important factor in surgical work since other human lives are at stake. Additionally, it has been shown in a field study that 30-second microbreaks

in computer work provided every 20 or 40 minutes improved perceived discomfort in all body areas and had no detrimental effect on productivity (McLean 2001). Hence, a number of studies have shown promising results for the provision of work breaks of varying durations. However, studies are still lacking that would aim to identify the optimal duration of work breaks by comparing different break durations.

Type of work breaks

Finally, the type of work break may play a role in the amount of recovery the tissues and muscles actually receive. In general, there are two types of work breaks that can be implemented: passive breaks in which workers just rest, or active breaks in which workers are instructed to, for example, stretch, walk or perform a cognitive task. A randomised controlled trial (RCT) involving visual display unit workers with musculoskeletal symptoms investigated two types of break activities (stretching or dynamic contractions) to be conducted during three-minute work breaks (Nakphet 2014). The results showed that both types of break activities had a favourable and similar effect on muscle discomfort and productivity. Such promising results were, however, not evident in a recent laboratory cross-over trial in which individuals performing a one-hour pick-and-place task received one-minute active or passive breaks every 12 minutes (Luger 2015). Neither type of supplementary break influenced perceived discomfort when compared with one hour of work without breaks. Hence, the literature provides some information regarding the most suitable types of work breaks, but the studies providing this information vary in study design and in the settings in which the types of breaks were investigated.

Hence, although there is some knowledge on the efficacy and effectiveness of work-break schedules based on their frequency, duration and type, an overview of the results of studies investigating one or more of these aspects of work-break schedules is lacking.

The drawback of work breaks is that their implementation is highly dependent on the type of work being carried out (i.e. not all work settings allow for a flexible arrangement of work and breaks). Additionally, the employer and employee both need to accept the changes required by the work-break pattern: (1) the employer by organising extra time for breaks, and (2) the employee by accepting a longer presence at work to cover more break time but the same amount of work time. The diversity of study populations may give more insight into the effectiveness of work-break interventions with regard to employees' age and gender, since the prevalence of work-related musculoskeletal disorders differs with age and gender (HSE 2019). Acceptability, gender and age may also impact the effectiveness of work-break interventions.

Why it is important to do this review

Musculoskeletal disorders pose a large burden on current society due to their high prevalence but also due to the substantial costs associated with the lost work days and lost productivity associated with these disorders (March 2014). This underlines the importance of finding effective interventions to prevent work-related musculoskeletal symptoms and disorders, of which work breaks may provide one potential option.

A systematic review on the use of workplace interventions for preventing musculoskeletal disorders in computer users identified work breaks as one possible type of intervention (Brewer 2006).

In this review, four of six studies with observation periods ranging from two weeks to up to seven months found the effects of passive work breaks on musculoskeletal health to be inconsistent. The remaining two studies found moderate evidence that active work breaks do not influence musculoskeletal health. A more recent cluster RCT investigated the use of a prevention programme that included a work-break tool to improve the balance between work and recovery among construction workers (Oude Hengel 2013). This study found that, although not statistically significant, the prevention programme was associated with a decline in the prevalence of musculoskeletal symptoms and long-term sick leave. However, the work-break tool was only one of three tools comprising the prevention programme, which also included physical therapy sessions to lower the physical workload and empowerment training sessions to increase the influence of workers at the work-site (Oude Hengel 2013). Hence, the results of the prevention programme cannot be attributed solely to any of the three components of the programme. Another RCT investigated a 10-week active rest programme among workers, consisting of a warm-up, cognitive functional training, aerobic exercise, resistance training and a cool-down, for 10 minutes per day and three times per week (Michishita 2017b). The intervention programme was implemented in employees' lunch breaks and aimed to improve personal relationships, mental and physical health, and work ability. Several, but not all, aspects related to personal relationships and mental health improved after the programme, which the authors attributed to the increased activity during lunch breaks.

Overall, the evidence for the application of work-break interventions is not straightforward and, although work-related musculoskeletal symptoms and disorders are a clear worldwide problem, there is currently no systematic review focusing solely on the effectiveness of work-break interventions for preventing work-related musculoskeletal symptoms and disorders. With this review, we aim to investigate the available RCT evidence for the effectiveness of work-break interventions in order to provide direction for optimising current prevention approaches and to help prioritise future research directions.

OBJECTIVES

To compare the effectiveness of different work-break schedules for preventing work-related musculoskeletal symptoms and disorders in healthy workers, when compared to conventional or alternate work-break schedules.

METHODS

Criteria for considering studies for this review

Types of studies

We included RCTs, quasi-RCTs (in which the method used for the allocation of participants is not random, such as alternate allocation, allocation by date of birth, or day of the week), cluster-randomised trials (randomisation of a group of people such as a work group or workplace rather than randomisation of the individual) and cross-over RCTs. We included only studies conducted in a real workplace, excluding studies conducted under laboratory conditions. We included studies reported as full-text, those published in abstract form only, and unpublished data.

Types of participants

We included trials that enrolled healthy adult workers (aged 18 years or above). The health status of the worker was determined when the worker was free of musculoskeletal disorders during study enrolment. There were no restrictions on sex and no restrictions on occupation.

Types of interventions

We included studies that evaluated one or more of the following types of work-break interventions realised at work and during working hours.

- Changes in the frequency of work breaks
 - Intervention: higher (i.e. > 3 per day)
 - Control: low (i.e. ≤ 3 per day)
- Changes in the duration of work breaks
 - Intervention: short (i.e. ≤ 15 minute) or micro (i.e. ≤ 1 minute)
 - Control: 15 to 30 minutes (15-minute breaks during the morning and afternoon shifts, 30-minute breaks halving the 8-hour working day; see the study by [Galinsky 2000](#) for a discussion about conventional work-break schedules)
- Changes in the type of work break
 - Intervention: active or cognitive
 - Control: passive

These work-break interventions were tested or applied at work in real work situations, meaning that 'breaks' such as vacation, weekend or the evening after work ([Fritz 2013](#)) were not included in the work breaks that we evaluated in the current review. To be included, a study had to compare the intervention with a control (no intervention or conventional break pattern ([Galinsky 2000](#)) or another type of work-break intervention).

Types of outcome measures

We included studies that assessed the effect of a work-break schedule on at least one of the following primary outcomes.

Primary outcomes

1. Newly diagnosed musculoskeletal disorders
 - a. Medical assessment by an occupational physician
 - b. Scales assessing newly diagnosed musculoskeletal disorders referring to injuries that affect musculoskeletal, peripheral nervous and neurovascular systems caused or aggravated by occupational exposure
2. Participant-reported musculoskeletal symptoms, including pain, discomfort and fatigue
 - a. Assessing of pain, discomfort or fatigue by a visual analogue scale (VAS) or numeric rating scales (NRS)
3. Productivity or work performance
 - a. Assessment of the level of work functioning, change in work productivity or work time loss as assessed by outcome measures such as the Health and Work Performance Questionnaire ([Kessler 2003](#)) or similar instruments

Tracking the development of musculoskeletal disorders is time-consuming, and such longer-duration longitudinal studies are scarce. Therefore, besides the first primary outcome category (newly diagnosed musculoskeletal disorders), we added the second primary outcome category including participant-reported

musculoskeletal symptoms such as pain, discomfort and fatigue. These three symptoms are surrogates of musculoskeletal disorders and recognised precursors of developing musculoskeletal disorders ([Burger 1959](#); [Van der Beek 1998](#); [Westgaard 1996](#)).

Secondary outcomes

1. Workload changes
 - a. Objective measurements of force or force reduction, muscular load or electromyographic manifestations of muscular fatigue, or endurance time as measured by strain gauge force transducers, dynamometers or electromyography; subjective measurements of workload, such as those assessed using questionnaires (e.g. the NASA TLX questionnaire ([Hart 1988](#)))

Among secondary outcomes, we included workload changes, since these are often indirectly related to the musculoskeletal symptoms, such as pain, discomfort and fatigue, and therefore also with development of musculoskeletal disorders ([Burger 1959](#); [Van der Beek 1998](#); [Westgaard 1996](#)).

Search methods for identification of studies

Electronic searches

We systematically searched for all eligible published and unpublished trials. We imposed no restrictions on language of publication, which means we arranged for the translation of key sections of foreign-language studies or attempted to find native speakers or people who are proficient in the publications' language to assist with translating these studies for potential inclusion.

Our search strategy for the MEDLINE database is shown in ([Appendix 1](#)); this search strategy was adjusted to the formats of other databases, when necessary. We searched the following electronic databases to identify potentially eligible studies that were already published:

- Cochrane Central Register of Controlled Trials (CENTRAL; Wiley Online Library) ([Appendix 2](#));
- MEDLINE (PubMed) ([Appendix 1](#));
- Embase (OVID) ([Appendix 3](#));
- CINAHL (EBSCO) ([Appendix 4](#));
- PsycINFO (EBSCO) ([Appendix 5](#));
- SCOPUS (Elsevier) ([Appendix 6](#));
- Web of Science (Thomson Reuters) ([Appendix 7](#)).

We also conducted a search for unpublished trials in ClinicalTrials.gov ([ClinicalTrials.gov](#)) ([Appendix 8](#)) and the World Health Organization International Clinical Trials Registry Platform ([who.int/ictpr/en/](#)) ([Appendix 9](#)).

Searching other resources

We checked the reference lists of all primary studies included and those of review articles for additional references. We contacted experts in the field to identify additional unpublished studies.

Data collection and analysis

Selection of studies

We followed a two-stage plan for selecting studies for inclusion in the review, using Covidence software ([Covidence 2019](#)). In stage

one, two review authors (TL, BS) independently screened the titles and abstracts of the identified citations, and obtained the full text of all studies that at least one author deemed potentially eligible. In stage two, two review authors (TL, BS) independently assessed the full publication for eligibility and compared their results. We tabulated the characteristics of excluded studies in the '[Characteristics of excluded studies](#)' table. We resolved any

disagreement through discussion or, if required, by consulting a third review author (MR). We identified and excluded duplicates, and collated multiple reports of the same study so that each study, rather than each report, was the unit of interest in the review. We recorded the selection process in sufficient detail to complete a PRISMA flow diagram ([Moher 2009](#)) ([Figure 1](#)).

Figure 1. Study flow diagram.

Figure 1. (Continued)

When our systematic searches identified studies conducted by one of the review authors, we avoided a conflict of interest by having all decisions concerning inclusion and exclusion made by review authors who were not involved with the study.

Data extraction and management

We entered study characteristics and outcome data into a data collection form that we tested on at least one study in the review. One review author (TL) extracted the following study characteristics from the included studies.

- General: authors and year of publication.
- Methods: study design, total duration of study, study location, study setting, withdrawals, and date of study.
- Participants: number, randomisation, mean age or age range, sex/gender, occupation/working activity, health status, inclusion criteria, and exclusion criteria.
- Interventions: description of intervention, comparison, duration, intensity, content of both intervention and control condition, co-interventions, and washout period, including the length between the application of the intervention and the control or vice versa (applicable to cross-over RCTs).
- Outcomes: description of primary and secondary outcomes specified and collected, and time points reported.
- Notes: funding for trial, and notable conflicts of interest of trial authors.

Two review authors (TL, BS) independently extracted outcome data from the included studies. We noted in the 'Characteristics

of included studies' table if outcome data were not reported in a usable way. We resolved disagreements by consensus or by consulting a third review author (MR). One review author (TL) transferred data into Review Manager 5 (Review Manager 2014); a second review author (BS) spot-checked study characteristics for accuracy against the trial report. Should we have decided to include studies published in a language in which our author team was not proficient, we arranged for a native speaker or someone sufficiently proficient in the language to fill in the data extraction form for us.

Assessment of risk of bias in included studies

Two review authors (TL, BS) independently assessed the risk of bias in each study using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011a). We resolved any disagreements through discussion or by involving a third review author (MR). We assessed the risk of bias according to the following domains:

1. random sequence generation;
2. allocation concealment;
3. blinding of participants and personnel;
4. blinding of outcome assessment;
5. incomplete outcome data;
6. selective outcome reporting;
7. carry-over.

We graded each potential source of bias as high, low or unclear, and provided a quote from the study report together with a justification for our judgement in the 'Risk of bias' table. We summarised the

'Risk of bias' judgements across different studies for each of the domains listed. We considered blinding separately for different key outcomes where necessary (e.g. for the assessment of blinding of outcomes, the risk of bias for a diagnosis of musculoskeletal disorder may be very different than that for a participant-reported discomfort scale). Where information on risk of bias related to unpublished data or to correspondence with a trialist, we noted this in the 'Risk of bias' table.

We considered random sequence generation, allocation concealment, incomplete outcome data, selective outcome reporting, and carry-over (applicable to cross-over RCTs) to be key domains. We judged a study to have an overall high risk of bias when we judged one or more key domains to have a high risk of bias. Conversely, we judged a study to have an overall low risk of bias when we judged all key domains to have a low risk of bias.

Assessment of bias in conducting the systematic review

We conducted the review according to a published protocol and reported any deviations from it in the 'Differences between protocol and review' section of the systematic review.

Measures of treatment effect

We entered the outcome data for each study into the data tables in [Review Manager 2014](#) in order to calculate the treatment effects. We used mean differences or standardised mean differences for continuous outcomes. We planned to use risk ratios for dichotomous outcomes and hazard ratios for time to event data, if we had outcomes with such data. If only effect estimates and their 95% confidence intervals or standard errors were reported in studies, we entered these data into [Review Manager 2014](#) using the generic inverse variance method. We ensured that higher scores for continuous outcomes had the same meaning for each outcome, explained the direction to the reader, and reported where the directions were reversed, if necessary. When the results could not be entered in either way, we described them in the '[Characteristics of included studies](#)' tables, or entered the data into 'Additional tables'.

For cross-over trials that reported continuous outcomes, we used the paired analysis as reported by the authors and included the mean difference between the intervention and control conditions and its standard error into [Review Manager 2014](#) using the generic inverse variance method for calculating the effect estimate. In cases where the authors did not report paired analysis, we conducted the analysis ourselves based on the reported or imputed correlation between the outcomes of the intervention and the control conditions, as advised in Chapter 16 of the *Cochrane Handbook for Systematic Reviews of Interventions* ([Higgins 2011c](#)).

Unit of analysis issues

We did not locate any cluster-randomised trials to include in this review. If we had located such studies, we planned to calculate the design effect based on a fairly large assumed intra-cluster correlation of 0.10. We considered 0.10 to be a realistic estimate based on intra-cluster correlation values typically seen in cluster RCTs ([Campbell 2001](#)). For the calculations, we would follow the methods as stated in the *Cochrane Handbook for Systematic Reviews of Interventions* ([Higgins 2011a](#)).

Dealing with missing data

We contacted investigators or study sponsors in order to verify key study characteristics and obtain missing numerical outcome data, where possible (e.g. when a study was published in abstract form only). Where this was not possible and the missing data were thought to introduce serious bias, we explored the impact of including such studies in the overall assessment of results using sensitivity analysis. If we were unable to obtain these data even after contacting authors, we listed such studies under 'Studies awaiting classification'.

If numerical outcome data, such as standard deviations or correlation coefficients, were missing and could not be obtained from the authors, we calculated them from other available statistics, such as P values, according to the methods described in the *Cochrane Handbook for Systematic Reviews of Interventions* ([Higgins 2011a](#)).

Assessment of heterogeneity

We assessed the clinical homogeneity of the results of the included studies based on similarity of population, intervention, outcome and follow-up. We followed the algorithm provided by ([Verbeek 2012](#)).

We considered populations as similar when they were exposed to similar physical demands in their job.

We considered interventions as similar when they belonged to one of the three intervention categories as defined in the section '[Types of interventions](#)'. Interventions that addressed a low or high work-break frequency were considered different; interventions that addressed a long, short or micro work-break duration were considered different; and interventions that addressed a passive, active or cognitive work-break type were considered different.

We considered any method used to record participant-reported complaints (e.g. Borg scale, VAS, questionnaires) and participant-reported workloads (e.g. the TLX questionnaire) to be similar. We considered any standardised questionnaire used for the assessment of work performance and productivity (e.g. Health and Work Performance Questionnaire) to be similar. We considered any objective technique related to workload changes (e.g. force, endurance time, muscle activity) to be similar.

We regarded short-term (up to six weeks), medium-term (from six weeks to up to six months) and long-term (more than six months) follow-up times to be different.

We assessed heterogeneity by the visual inspection of forest plots and by using the I^2 statistic. We then quantified the degree of heterogeneity ([Higgins 2011a](#)), and considered an I^2 value greater than 75% to represent substantial heterogeneity. In the presence of substantial heterogeneity and a sufficient number of studies, we explored possible causes by conducting prespecified subgroup analyses.

Assessment of reporting biases

If we had been able to pool seven or more trials in any single meta-analysis, we planned to assess publication bias by funnel plots and examine funnel plot asymmetry using the Egger's test ([Higgins 2011a](#)). Due to too few studies, we could not examine funnel plot asymmetry for assessing publication bias.

Data synthesis

We pooled data from studies judged to be clinically homogeneous using Review Manager 5 software (Review Manager 2014). If more than one study provided usable data in any single comparison, we performed meta-analyses. We plotted the results of each RCT as point estimates with corresponding 95% confidence intervals. We used a random-effects model to pool the results of studies (Borenstein 2009) for all analyses. When I^2 was higher than 75% we did not pool the results of studies in meta-analysis. We narratively described skewed data and, if possible, reported medians and interquartile ranges in addition. Skewness of data was assessed using the methods and recommendations as described in Section 9.4.5.3 of the *Cochrane Handbook of Systematic Reviews and Interventions* (Deeks 2011).

If multiple trial arms would have been reported in a trial, we planned to include only the relevant arms. If two comparisons would have been combined in the same meta-analysis, we planned to halve the control group to avoid double-counting.

Summary of findings table

We created a 'Summary of findings' table using the following outcomes.

- Participant-reported musculoskeletal pain.
- Participant-reported musculoskeletal discomfort or fatigue.
- Productivity or work performance.
- Workload changes.

Quality of the evidence

We used the five GRADE considerations (study limitations based on risk of bias assessment, consistency of effect, imprecision, indirectness and publication bias) to assess the quality of a body of evidence as it related to the studies that contributed data to the data analyses for the prespecified outcomes. We used the methods and recommendations described in Section 8.5 (Higgins 2011b) and Chapter 12 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Schünemann 2011), the *Handbook for grading quality of evidence and the strength of recommendations using the GRADE approach* (Schünemann 2013), using GRADE profiler software (GRADEpro GDT). We justified all decisions to downgrade or upgrade the quality of studies using footnotes and we made comments to aid readers' understanding of the review, where necessary.

Subgroup analysis and investigation of heterogeneity

When data would have allowed it, we planned to carry out the following subgroup analyses for each outcome.

1. Type of intervention (if possible, we planned to compare studies that changed the frequency of work breaks with studies that changed the duration of work breaks and with studies that changed the type of work breaks).
2. Age (if possible, we planned to compare studies conducted in participants aged 18 to 40 years with studies where all participants were aged 41 years and older).
3. Sex (if possible, we planned to compare males with females).
4. Type of work task (if possible, we planned to compare industrial or factory work, such as assembling, with computer work and social work, such as nursing and garbage collecting).

We would have used the χ^2 test to test for subgroup interactions in Review Manager 5 software (Review Manager 2014). However, we included and pooled too few trials to be able to perform subgroup analyses.

Sensitivity analysis

We combined the outcomes self-reported musculoskeletal pain and self-reported musculoskeletal discomfort or fatigue and merged different scales or results of different body regions together. We performed a sensitivity analysis to determine whether combining these musculoskeletal outcomes was justified and would not change the result of the meta-analysis when each single musculoskeletal outcome was evaluated.

We considered studies to be at high risk of bias if one of the main biases was rated unclear or high risk, i.e. random sequence allocation, allocation concealment, incomplete outcome data, selective outcome reporting, or carry-over. We planned to assess the robustness of our conclusions by excluding studies judged to have a high risk of bias from our meta-analyses. However, we did not find enough studies to perform such analysis, i.e. none of the included studies was judged to have a low risk of bias.

Reaching conclusions

We based our conclusions only on findings from the quantitative or narrative synthesis of included studies for this review. We confined our recommendations for practice to those supported by the evidence, such as values and available resources. Our implications for research suggested priorities for future research and outlined the remaining uncertainties in the area.

RESULTS

Description of studies

See: Figure 1, Characteristics of included studies, Characteristics of excluded studies.

Results of the search

The electronic searches identified a total of 12,445 references (Figure 1), collected from several databases: CENTRAL 213 (Appendix 2, 24 April 2019); MEDLINE 2,011 (Appendix 1, 24 April 2019); Embase 3,097 (Appendix 3, 2 May 2019); CINAHL 3,940 (Appendix 4, 24 April 2019); PsycINFO 1,310 (Appendix 5, 24 April 2019); SCOPUS 871 (Appendix 6, 2 May 2019); Web of Science 637 (Appendix 7, 24 April 2019); ClinicalTrials.gov 37 (Appendix 8, 24 April 2019); WHO ICTRP 29 (Appendix 9, 24 April 2019). References of selected systematic reviews and included studies led to the potential inclusion of an additional two references. The total of 12,447 references was reduced to 9,675 after removing 2,772 duplicates. The titles, keywords and abstracts of the 9,675 potentially relevant references were independently screened by two review authors (TL, BS). We selected 129 references for full-text analysis. Two review authors (TL, BS) independently read and analysed the full texts, and finally selected six studies for inclusion in this review.

Included studies

Study design

All six studies were randomised controlled studies, of which four had a parallel design (De Bloom 2017; Henning 1997; Irmak 2012;

McLean 2001), one a cross-over design (Galinsky 2000), and one a mixture of parallel and cross-over design (Galinsky 2007). See [Characteristics of included studies](#) table for further details.

Participants and location

The included studies analysed a total of 373 employees: De Bloom 2017 analysed 153 Finnish knowledge employees, Galinsky 2000 analysed 42 American data-entry operators, Galinsky 2007 analysed 51 American data-entry operators, Henning 1997 analysed 73 American computer operators, Irmak 2012 analysed 39 Turkish office workers, and McLean 2001 analysed 15 Canadian computer operators. At least 295 of the 373 analysed employees were female, at least 39 male, and for the remaining 39 employees, sex was not specified (Irmak 2012).

Interventions

Five out of six studies evaluated different frequencies of work breaks (Galinsky 2000; Galinsky 2007; Henning 1997; Irmak 2012; McLean 2001), and two out of six studies evaluated different types of work breaks (De Bloom 2017; Henning 1997). No study evaluated different durations of work breaks.

Outcomes

Participant-reported musculoskeletal pain was reported by one study, measured on a visual analogue scale (Irmak 2012). Participant-reported discomfort was reported by four studies, measured on either a numeric rating scale (Galinsky 2000; Galinsky 2007; Henning 1997) or a visual analogue scale (McLean 2001). Participant-reported fatigue was reported by one study, measured on a numeric rating scale (De Bloom 2017). Productivity or work performance was reported by five studies (Galinsky 2000; Galinsky 2007; Henning 1997; Irmak 2012; McLean 2001), measured objectively (Galinsky 2000; Galinsky 2007; Henning 1997; McLean 2001) or using a questionnaire (Irmak 2012). No study evaluated newly diagnosed musculoskeletal disorders or workload changes as outcome measures.

Follow-up period

All studies reported outcomes within the treatment period and/or directly after the treatment period. For most studies, this follow-up period was short-term, i.e. up to six weeks (De Bloom 2017; Galinsky 2000; Galinsky 2007; Henning 1997; McLean 2001). For one study,

the follow-up period of 10 weeks was medium-term, i.e. from six weeks up to six months (Irmak 2012).

Excluded studies

One reference was a registered trial (NCT03559153), of which the data collection phase was completed in April 2019; this reference was assigned to the ongoing studies category ([Characteristics of ongoing studies](#) table). From the remaining 128 references, we excluded a total of 122 references for different reasons. Eight references were excluded because they were not available and the abstract did not provide enough information to decide whether the study could potentially be included or not (Baidya 1988; ISRCTN13222474; Kissel 1994; Peper 2006; Petz 1964; Rosa 1985; Tooley 2004; Yusuf 2006). Twelve references (i.e. nine studies) were excluded because they included the wrong population, e.g. students or symptomatic subjects (Blasche 2018; Chaikumarn 2018; Chakrabarty 2016; Faucett 2007; JPRN-UMIN000033210; Lanhers 2015; NCT03840304; Van den Heuvel 2003; Vijendren 2018). Eleven references were excluded because they incorporated the wrong intervention (ACTRN12618000061235; Battecha 2019; Blasche 2017; Havenstein 2017; Keller 2019; Mihaila 1971; NCT01996176; NCT03375749; NCT03468894; Nijp 2016; Oude Hengel 2013). Twenty-three references were excluded because they reported the wrong outcomes, i.e. outcomes focussing on physical activity, non-work related productivity or performance, or only a secondary outcome (Brown 2014; CTRI/2019/01/017117; Czernieckij 1966; Evans 2012; Frey 2002; Gilson 2009; Krajewski 2010; Largo-Wight 2017; Mailey 2017; McLean 2000; Michishita 2017a; Michishita 2017b; Moreira 2007; NCT02951624; NCT02960750; NCT03163953; NCT03560544; Oriyama 2014; Oude Hengel 2012; Sianoja 2018; Taylor 2016). The remaining sixty-seven references were excluded due to a wrong study design, mostly because randomisation was absent. For further details regarding the study populations and settings of the excluded studies, see [Characteristics of excluded studies](#) table.

Risk of bias in included studies

We judged all included studies to have an overall high risk of bias. The results are summarised in the 'Risk of bias' graph, which is an overview of the review authors' judgements about each 'Risk of bias' item presented as percentages across all included studies (Figure 2). Figure 3 shows the 'Risk of bias' summary of each 'Risk of bias' item for each of the six included studies.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Carry-over effect
De Bloom 2017	?	?	-	-	+	-	+
Galinsky 2000	?	?	-	-	-	-	-
Galinsky 2007	?	?	-	-	-	-	-
Henning 1997	?	?	-	-	-	?	+
Irmak 2012	?	?	-	-	+	?	+
McLean 2001	?	?	-	-	?	?	+

Allocation

None of the studies reported using a random number table or equivalent for generating a random sequence and thus all were judged to have an unclear risk of bias. None of the studies reported using adequate measures for concealing allocation such as using sealed opaque envelopes and thus all were judged to have an unclear risk of bias associated with allocation concealment.

Blinding

Blinding of the intervention was not performed in any of the studied interventions as blinding of the different break schedules is difficult to achieve. Therefore, we judged all six studies to have a high risk of performance bias. All six studies included one or more measures that were self-reported, which made us rate the risk for detection bias of all studies as high.

Incomplete outcome data

Two studies reported the number of dropouts that occurred before study start and during follow-up (De Bloom 2017; Henning 1997). One of these studies had so many dropouts, that we judged the risk of bias as high (Henning 1997). The other study used a statistical method (MICE) to impute the missing data, and we judged the risk of bias as low (De Bloom 2017). One study did not report potential dropouts during their study at all, thus, we rated this study as having an unclear risk of attrition bias (McLean 2001). One study did not report potential dropouts during their study; however, after contact with the authors we were informed that no subjects had dropped out during the study (Irmak 2012). Therefore, we judged this study to have a low risk of attrition bias. In the remaining two studies, the dropout rate during follow-up or due to incomplete outcome data reached over 50%, and the authors decided to report only half of the follow-up period (Galinsky 2000; Galinsky 2007). Therefore, these two studies were rated as having a high risk of attrition bias.

Selective reporting

Three studies reported all outcomes in the results section that were listed in the methods section (Henning 1997; Irmak 2012; McLean 2001). However, since there was no registered trial protocol, we could not verify whether the study plan was realised, so these three studies were judged as having an unclear risk of reporting bias. Two studies were judged as having a high risk of reporting bias, because not all outcomes mentioned in the methods section were reported in the results section (Galinsky 2000; Galinsky 2007). One study reported all outcomes in the results section that were mentioned in the methods section (De Bloom 2017). However, since the published study protocol listed more outcomes than those reported in the published paper, we judged the level of reporting bias for this study to be high.

Other potential sources of bias

Two studies that used a cross-over study design were judged to have a high risk for a potential carry-over effect, because there was no wash-out period in between the experimental conditions (Galinsky 2000; Galinsky 2007). Three studies that followed a parallel study design were considered free from risk of a carry-over effect (De Bloom 2017; Henning 1997; Irmak 2012). One study used a parallel group design and compared within-subject differences with a baseline measurement just before implementation of the experiment. Because the authors explicitly mentioned that they avoided carry-over effects, the risk of carry-over effects was judged as low (McLean 2001).

Effects of interventions

See: [Summary of findings for the main comparison](#) Additional work breaks compared to no additional work breaks for preventing musculoskeletal symptoms and disorders in workers; [Summary of findings 2](#) Additional work breaks compared to work breaks as needed for preventing musculoskeletal symptoms and disorders in workers; [Summary of findings 3](#) Additional higher frequency work breaks compared to additional lower frequency work breaks for preventing musculoskeletal symptoms and disorders in workers; [Summary of findings 4](#) Active work breaks compared to passive work breaks for preventing musculoskeletal symptoms and disorders in workers; [Summary of findings 5](#) Relaxation

work breaks compared to physical work breaks for preventing musculoskeletal symptoms and disorders in workers

See: [Summary of findings for the main comparison](#); [Summary of findings 2](#); [Summary of findings 3](#); [Summary of findings 4](#); [Summary of findings 5](#).

1. Changes in the frequency of work breaks

We identified five RCTs that compared different work-break frequencies (Henning 1997; Galinsky 2000; Galinsky 2007; Irmak 2012; McLean 2001). However, one of these studies was not included in the meta-analyses, because the authors did not report numeric results, which could also not be retrieved after email contact with the authors (Henning 1997).

1.1 Additional work breaks versus no additional work breaks

Four studies compared additional work breaks with no additional work breaks. The additional work breaks included: additional 2-minute exercise breaks (Irmak 2012), additional 5-minute passive breaks (Galinsky 2000; Galinsky 2007), additional 30-second and 3-minute passive and active breaks (Henning 1997).

Outcome: participant-reported musculoskeletal pain, discomfort or fatigue

We found low-quality evidence that additional work breaks may have no considerable effect on participant-reported musculoskeletal pain, discomfort and fatigue compared to no additional work breaks (standardised mean difference (SMD) -0.08; 95% confidence interval (CI) -0.35 to 0.18; [Analysis 1.1](#)). For this analysis, the participant-reported musculoskeletal outcomes of three studies were pooled: participant-reported musculoskeletal pain (Irmak 2012) and participant-reported musculoskeletal discomfort (Galinsky 2000; Galinsky 2007). The participant-reported musculoskeletal discomfort outcomes are suspected of being skewed; however, we did not receive data other than means and standard deviations from the authors.

Sensitivity analysis

We performed a sensitivity analysis, within which the pooled analysis ([Analysis 1.1](#)) was compared to the single analyses ([Analysis 6.1](#)). Based on the sensitivity analyses, we decided that the pooled analysis was representative of the single analyses because it showed similar outcomes. We reported the standardised mean difference (SMD) because the scales of participant-reported musculoskeletal pain, discomfort and fatigue differed between studies, including a numeric rating scale (NRS) ranging from 1 to 5 (worse) (Galinsky 2000; Galinsky 2007) and a visual analogue scale (VAS) ranging from 0 mm to 100 mm (worse) (Irmak 2012).

Outcome: productivity or work performance

There was very low-quality evidence that additional work breaks may have no considerable effect on productivity or work performance compared to no additional work breaks (SMD -0.07; 95% CI -0.33 to 0.19; [Analysis 1.2](#)). We pooled the different work productivity outcomes of three studies: work role functioning questionnaire (Irmak 2012), keystrokes per hour (Galinsky 2000; Galinsky 2007), and entered documents per day (Galinsky 2000; Galinsky 2007). The keystrokes per hour and entered documents per day are suspected of being skewed; however, also here we did not receive data other than means and standard deviations.

Sensitivity analysis

The sensitivity analysis showed that the single productivity outcomes (Analysis 6.2) showed similar effects in the same direction as the pooled analysis (Analysis 1.2). The single productivity outcomes were measured differently, including: a numeric rating scale ranging from 1 (worse) to 5 (Irmak 2012) and a number per hour or per day (Galinsky 2000; Galinsky 2007).

1.2 Additional work breaks versus work breaks as needed

One study compared additional work breaks with work breaks as needed (i.e. microbreaks taken at own discretion) (McLean 2001).

Outcome: participant-reported musculoskeletal pain, discomfort or fatigue

We found very low-quality evidence that additional work breaks may have no considerable effect on musculoskeletal pain, discomfort or fatigue when compared to work breaks as needed (MD 1.80; 95% CI -38.15 to 41.75, Analysis 2.1). The participant-reported musculoskeletal outcomes of one study (McLean 2001) were pooled and provided as mean differences, because each outcome was measured on the same VAS scale ranging from 0 mm to 100 mm (worse).

Sensitivity analysis

We performed a sensitivity analysis, comparing the pooled analysis (Analysis 2.1) with the single analyses of discomfort and fatigue per body region (Analysis 7.1). Because none of the outcomes per body region were statistically significant (i.e. 0 was included in the confidence interval) and neither was the outcome of the pooled analysis, we considered the pooled analysis (Analysis 2.1) to be representative of the outcomes of the single body regions (Analysis 7.1).

Outcome: productivity or work performance

There was very low-quality evidence that additional work breaks may have improved work productivity or performance (words typed per three hours) when compared to work breaks as needed (MD 542.50; 95% CI 177.22 to 907.78; Analysis 2.2).

1.3 Additional higher frequency work breaks versus additional lower frequency work breaks

One study compared additional high frequency work breaks with additional low frequency work breaks (McLean 2001).

Outcome: participant-reported musculoskeletal pain, discomfort or fatigue

There was very low-quality evidence that additional higher frequency work breaks may have no considerable effect on musculoskeletal pain, discomfort or fatigue compared to additional lower frequency work breaks (MD 11.65; 95% CI -41.07 to 64.37; Analysis 3.1). The participant-reported musculoskeletal discomfort ratings coming from one study (McLean 2001) were pooled and provided as mean differences because outcomes of each single body region were reported on the same VAS scale ranging from 0 mm to 100 mm (worse).

Sensitivity analysis

A sensitivity analysis was performed, comparing the pooled analysis across body parts (Analysis 3.1) with the single analyses per body region (Analysis 8.1). Because none of the outcomes per

body region showed a statistically significant difference between additional higher and lower frequency work breaks (Analysis 8.1), we considered the pooled analysis (Analysis 3.1), which also showed a statistically non-significant difference between additional higher and lower frequency work breaks, to be representative of the outcomes of the single body regions (Analysis 8.1).

Outcome: productivity or work performance

We found very low-quality evidence that additional higher frequency work breaks may not be associated with an increase in work productivity or performance (number of words typed per three hours) compared with additional low frequency work breaks (MD -83.00; 95% CI -305.27 to 139.27; Analysis 3.2).

2. Changes in the type of work break

We identified two RCTs that compared changes in the type of work breaks (De Bloom 2017; Henning 1997). However, one of the studies was not included in the meta-analyses, because the authors did not report numeric results, which could also not be retrieved after email contact with the authors (Henning 1997).

2.1 Active work breaks versus passive work breaks

Two studies compared active work breaks with passive work breaks (De Bloom 2017; Henning 1997). The active work breaks included: park walk (De Bloom 2017) and muscle relaxation (De Bloom 2017).

Outcome: participant-reported musculoskeletal discomfort or fatigue

We found low-quality evidence that active work breaks may not have a considerable effect on participant-reported musculoskeletal fatigue when compared to passive work breaks (MD -0.17; 95% CI -0.71 to 0.37; Analysis 4.1), as measured on a seven-point NRS (range from 1 to 7 (worse)).

2.2 Relaxation work breaks versus physical work breaks

One study compared relaxation work breaks with physical work breaks (De Bloom 2017).

Outcome: participant-reported musculoskeletal pain, discomfort or fatigue

There was low-quality evidence that active relaxation work breaks may not have a considerable effect on musculoskeletal pain, discomfort or fatigue when compared with physical work breaks (MD 0.20; 95% CI -0.43 to 0.82; Analysis 5.1). This outcome was measured on a seven-point NRS, ranging from 1 to 7 (worse).

DISCUSSION

Summary of main results

This systematic review evaluated the effectiveness of different work-break interventions for preventing work-related musculoskeletal symptoms and disorders in healthy workers, when compared to conventional or alternate work-break schedules. We included six randomised controlled trials and 373 participants, of which four used a parallel RCT (De Bloom 2017; Henning 1997; Irmak 2012; McLean 2001) and two a cross-over RCT design (Galinsky 2000; Galinsky 2007). The studies were all performed in real work places but addressed office workers only. All studies were at overall high risk of bias. We included three types of interventions: work-break frequency, work-break duration and work-break type.

From the included studies, we deduced five comparisons of which three belonged to work-break frequency ([Summary of findings for the main comparison](#); [Summary of findings 2](#); [Summary of findings 3](#)), none to work-break duration, and two to work-break type ([Summary of findings 4](#); [Summary of findings 5](#)).

For the interventions related to frequency of work breaks, three comparisons were included: (1) additional work breaks versus no additional work breaks; (2) additional work breaks versus work breaks as needed (i.e. microbreaks taken at own discretion); (3) additional higher frequency work breaks versus additional lower frequency work breaks. For the first comparison, there was low to very low-quality evidence, based on three studies, that additional work breaks have no considerable effect on self-reported musculoskeletal pain, discomfort or fatigue or on productivity or work performance compared to no additional work breaks ([Summary of findings for the main comparison](#)). For the second comparison, there was low-quality evidence, based on one study, that additional work breaks have no beneficial effect on self-reported musculoskeletal pain, discomfort or fatigue and very low-quality evidence that additional work breaks may have a positive effect on productivity or work performance compared to work breaks as needed ([Summary of findings 2](#)). For the third comparison, there was very low-quality evidence, based on one study, that additional higher frequency work breaks have no beneficial effect on self-reported musculoskeletal pain, discomfort or fatigue or on productivity or work performance compared to additional lower frequency work breaks ([Summary of findings 3](#)). For all three comparisons, musculoskeletal outcomes were pooled and productivity and work performance outcomes were pooled. The sensitivity analyses showed that the pooling did not influence the results of the meta-analyses.

For the interventions related to type of work breaks, two comparisons were included: (4) active work breaks versus passive work breaks; (5) relaxation work breaks versus physical work breaks. For the fourth comparison, there was low-quality evidence, based on one study, that active work breaks have no considerable effect on self-reported musculoskeletal pain, discomfort or fatigue compared to no passive work breaks ([Summary of findings 4](#)). For the fifth comparison, there was low-quality evidence, based on one study, that relaxation work breaks have no considerable effect on self-reported musculoskeletal pain, discomfort or fatigue compared to no physical work breaks ([Summary of findings 5](#)).

Taken together, the five studies that were included in the comparisons did not show a considerable effect of different frequencies and types of work-break schedules on our primary outcomes, i.e. self-reported musculoskeletal pain, discomfort or fatigue and productivity or work performance. None of the included studies reported newly diagnosed musculoskeletal disorders, secondary outcome measures or any adverse events resulting from the added or alternate work breaks.

Overall completeness and applicability of evidence

The aim of this review was to compare the effectiveness of different work-break schedules for preventing work-related musculoskeletal symptoms and disorders in healthy workers. The review included a broad search strategy that aimed to find all RCTs including healthy workers in real work places. The large number of potentially relevant references resulting from the search (i.e. 9,675; see: [Figure 1](#)) was checked by two reviewers. Only six studies were eligible

for inclusion, of which one study could not be used due to poor data reporting and studies could be pooled only for the main comparison (total of three studies). Of the three categories of work-break interventions, only two could be addressed, i.e. frequency and type of work breaks, meaning that duration of work breaks has not been investigated in randomised controlled studies so far.

The evidence resulting from the five comparisons dealing with different work-break frequencies and types, was of low to very low-quality. Furthermore, none of the comparisons yielded a statistically significant beneficial or detrimental effect of the intervention (corresponding risk) compared to the control (assumed risk). In addition, the studies included office workers only, which could be due to the locations where the studies took place, which were in high-income countries (Europe and Northern America). Thus, office work was not being characterised by strict, predetermined work-break schedules, as can be found in the production industry, but was rather characterised by low physical demands. The small, statistically non-significant findings that were reported by the included studies may be the result of the marginal effect the different work-break interventions have among office workers on the selected outcomes. Work breaks may be more effective in occupations requiring higher physical load, such as in assembly work or in nursing. Consequently, work-break interventions should be reconsidered, by including an examination whether the work-break intervention is sufficient to improve musculoskeletal outcomes and might be more effective when combined with another type of intervention, such as targeting worker's fitness so that employees are better able to tolerate the workload or providing ergonomic counselling so that employees are better informed about the risks of their work.

The population of 373 workers included in this review included mainly women (at least 295; i.e. $\geq 79\%$) and relatively few men (at least 39; i.e. $\geq 11\%$). This ratio may not be representative of the population of office workers.

The outcomes included in the studies all belonged to our predefined primary outcomes: self-reported musculoskeletal pain, discomfort or fatigue, and work productivity or performance. None of the studies reported newly diagnosed musculoskeletal disorders or workload changes. We did not consider this as a disadvantage, because the primary outcomes are much more relevant than the secondary outcomes for evaluating work-break interventions. The primary outcomes should give insight into the potential of the intervention regarding improvements of the musculoskeletal system and stability of productivity and performance.

Quality of the evidence

For each outcome of the five comparisons, we assessed the quality of the evidence using the GRADE profiler software ([GRADEpro GDT](#)) based on the five considerations, i.e. study limitations, consistency of effect, imprecision, indirectness and publication bias. Downgrading for potential study limitations was done using the outcomes of the 'Risk of bias' assessment. Since all studies had an overall high potential risk of bias, the certainty of the evidence of all outcomes was downgraded one level. The main reasons for the high risk of overall bias were high risk of performance, detection, attrition and reporting bias (see: [Figure 2](#); [Figure 3](#)). Consistency of the effect was judged based on the heterogeneity or I^2 statistic provided in [Data and analyses](#). None of the outcomes was downgraded, because consistency of the effect was considered

not serious because none of the outcomes had an I^2 statistic over 75%. Indirectness of the results was judged as serious for the primary outcome productivity and work performance, because this outcome was not directly important for workers. All objective outcomes were therefore downgraded one level for certainty of the evidence. The certainty of the evidence of the subjective outcomes was not downgraded for indirectness, because the subjective outcomes were considered directly relevant for the worker. Imprecision of the results may influence the certainty of the evidence when sample sizes are very small (rule of thumb is > 400 subjects) and when the precision of the effect estimate is low, i.e. when the standardised mean difference (SMD) crosses 0.5 in the 95% confidence interval (CI). In case of either low sample size or low precision of the effect estimate, we downgraded the certainty of evidence for the outcome one level. In cases of both low sample size and low precision of the effect estimate, we downgraded the certainty of evidence for the outcome two levels. We were not able to judge whether there was publication bias and judged this GRADE consideration as undetected.

All in all, the overall quality of the body of evidence was assessed based on the judgements of the five considerations (see Chapter 12 of the *Cochrane Handbook for Systematic Reviews of Interventions*; Schünemann 2011). Consequently, the evidence of all subjective outcomes under each comparison was judged to be of low quality, meaning that our confidence in the effect estimate is limited, and the true effect may be substantially different from the estimate of effect. Furthermore, the evidence of all objective outcomes under each comparison was judged to be of very low quality, meaning that we have very little confidence in the effect estimate and the true effect is likely to be substantially different from the estimate of effect. The consequence of this very low- to low-quality evidence makes further research highly necessary for developing recommendations about the effect of work-break interventions based on the reported outcomes in this review.

Potential biases in the review process

We conducted a comprehensive and transparent review process, where two review authors independently performed the selection of studies, data extraction, and 'Risk of bias' assessment. We attempted to minimise selection bias in the search by not restricting by date of publication or language. We furthermore screened the reference lists of included studies and selected literature reviews (Hoe 2018; Shrestha 2018; Stock 2018), after which we added another two references for potential inclusion. During the full-text assessment, both potential references had to be excluded due to wrong outcomes (Evans 2012; Gilson 2009). Disagreements in the selection process were resolved through consensus, meaning that a third assessor was not necessary. Due to the very small number of studies included in the current review, we were not able to create funnel plots and assess publication bias. In case more studies can be included in an update of this review, we aim to assess publication bias.

We avoided duplicate publication bias by using study data only once. This strategy was applied only in the case of De Bloom 2017, where we selected both the registered trial and article publication for potential inclusion. We contacted authors in case data reporting in the identified study was marginal or in case other relevant information was unclear or missing, which was the case for all six included studies. When contacting the authors, all of them replied. The authors of the study of Henning 1997 informed us that they

did not have the data any more because the study was performed too long ago. The authors of the study of Irmak 2012 shared their detailed results with us and answered additional questions about the study protocol and population. The authors of the studies of De Bloom 2017, Galinsky 2000, Galinsky 2007 and McLean 2001 shared additional information about their study protocol and population.

Three randomised controlled trials that incorporated a work-break intervention had to be excluded because the intervention was part of a bigger program and could not be assessed separately (Oude Hengel 2013), because the study population contained symptomatic workers (Faucett 2007) and because the outcomes did not fit with our primary outcome measures (Brown 2014). The authors of two studies (Faucett 2007; Oude Hengel 2013) were contacted to gather this information and make the decision for exclusion.

We performed the data analyses, during which we decided to pool the primary outcomes musculoskeletal pain, discomfort and fatigue. This applied to the data analyses as part of three comparisons (Analysis 1.1; Analysis 1.2; Analysis 2.1; Analysis 3.1). To make sure that these pooled analyses were representative of each single data analysis, we performed sensitivity analyses to compare the pooled analyses with each single analysis (Analysis 6.1; Analysis 6.2; Analysis 7.1; Analysis 8.1). We concluded that the pooled analyses were representative, since their results (Analysis 1.1; Analysis 1.2; Analysis 2.1; Analysis 3.1) did not differ that much from the single analyses (Analysis 6.1; Analysis 6.2; Analysis 7.1; Analysis 8.1). Because the pooled musculoskeletal and productivity/work performance outcomes were both assessed on different scales, we had to report the standardised mean differences (SMD) for the pooled analyses.

In this review, we did not incorporate adverse events as a potential secondary outcome. However, adverse events resulting from additional or alternate work breaks could lead to an increase of harmful effects to be prevented, in this case more instead of less musculoskeletal pain, discomfort or fatigue as a surrogate for disorders. We have screened post hoc the included studies and can report that, of the six trials included in the current review, no trials noted that they measured adverse events and no trials reported adverse event rates in both the control and experimental groups. Additionally, this review primarily focussed on musculoskeletal outcomes, which means that we could not make any conclusions about the effectiveness of work breaks on other health aspects, such as cardiovascular health and mental well-being.

Agreements and disagreements with other studies or reviews

Several literature reviews have been published that focussed on work breaks or on workplace interventions in general to prevent or decrease musculoskeletal-related outcomes. When comparing our results with the other literature reviews, most of the findings were not comparable for different reasons. Our review focussed on RCTs within which participants had to be symptom-free during study enrolment. Some other reviews had no restrictions on whether the study population was symptomatic or non-symptomatic and included other designs than RCTs as well, such as non-RCTs (Boocock 2007; Hoe 2018; Kennedy 2010; Van Eerd 2016; Verbeek 2019; Waongenngarm 2018). Due to these criteria, the one review that focussed on work breaks only included 11 studies (Waongenngarm 2018). Four other reviews focussed

on workplace or occupational health and safety interventions in general, of which one review included 31 studies (Boocock 2007), one included 36 studies (Kennedy 2010), one included 61 studies (Van Eerd 2016), and one included 28 studies Verbeek 2019. Another review that was somewhat comparable to the current review, included workplace interventions in general among office workers only, and included 15 studies (Hoe 2018).

The review of Waongenngarm 2018 aimed to evaluate the effect of breaks on low back pain, discomfort and work productivity in office workers. The study included studies that were published in English, investigated office workers only, and did not set strict restrictions on the study design resulting in included studies being both RCTs and non-RCTs. Since they used relatively few key words to search through the databases, they may have failed to include studies that we included in the current review. The authors concluded that there was low-quality evidence supporting the effectiveness of breaks on discomfort prevention and moderate-quality evidence that breaks had no adverse effect on work productivity. The four studies that were included in the current review under different work-break frequencies, were also among the eleven studies included in the review of Waongenngarm 2018. However, due to the additional seven studies, which were mainly laboratory studies or field RCTs also including symptomatic workers, the results of their meta-analyses, that there was low-quality evidence that breaks were effective in preventing discomfort, were different from those of the current review.

In Boocock 2007, the aim was to evaluate the effect of primary, secondary and tertiary interventions on upper extremity musculoskeletal disorders. Studies were included when they were published in English, were published between 1999 and 2004 and included follow-up periods of two months or longer. The latter criterion is the main reason that Boocock 2007 included a completely different pool of RCTs and non-RCTs. Therefore, it is difficult to compare the conclusions of Boocock 2007 with the current review, since they did not include a category of work breaks based on their 31 included studies.

In the review of Kennedy 2010, the primary aim was to evaluate whether occupational health and safety interventions had an effect on upper extremity musculoskeletal symptoms, signs, disorders, injuries, claims and lost time. Their secondary aim was to evaluate which types of occupational health and safety interventions were effective. The authors used a broad search strategy, as was used in the current review. One of the intervention categories evaluated in the review of Kennedy 2010 was 'rest breaks', which included four studies. Three of the studies were similar to the ones we included (Galinsky 2000; Galinsky 2007; McLean 2001). However, the fourth RCT that was included by Kennedy 2010 was excluded by us during our full-text screening phase, because the investigated study population contained symptomatic workers, which we used as an exclusion criterion (Van den Heuvel 2003). The conclusion of the review of Kennedy 2010 was that limited evidence supported a positive effect of work breaks on upper extremity musculoskeletal outcomes. They furthermore concluded that there was insufficient evidence to support the possibility that active breaks may have a positive effect on upper extremity outcomes. Although they restricted their intervention effect to the upper extremity instead of the whole body, the conclusions are comparable and support the need for high-quality studies about work-break interventions for preventing musculoskeletal symptoms and disorders. In line

with our review, the work populations studied in the included RCTs and non-RCTs of Kennedy 2010 consisted mainly of office workers. Given this limitation, we propose that the effectiveness of different work-break interventions in other work settings be investigated as well, possibly as a combined intervention to increase its effectiveness.

The aim of the review of Verbeek 2019 was to provide an overview of a wide range of interventions for improving recovery from cognitive and physical work, for which the authors used an exhaustive study inclusion process. Seven categories of interventions were formed and grouped into person-directed and work-directed interventions. Work breaks were considered a work-directed intervention, to which four of the 28 included studies were assigned. None of these four studies were included in the current review, because they either used a study design other than an RCT (Beynon 2000; Mathiassen 1996), included the wrong outcomes (Oude Hengel 2012) or the wrong patient population (Lim 2016). From the four work-break studies, the review authors reported that longer breaks are suggested as being beneficial for increasing work recovery based on the work physiology theory. Although this scoping review could not comment on the effectiveness of workplace interventions, it provides a nice overview of different types of interventions aimed at increasing recovery from work and it provides encouragement for future studies that are suggested to focus on the development and improvement of the different types of interventions, including work breaks. Due to the different approach used in the scoping review of Verbeek 2019, their conclusions cannot be compared with the interpretations coming from the current review.

The review of Van Eerd 2016 aimed to evaluate the effect of workplace interventions to prevent upper extremity musculoskeletal disorders. They searched for studies eligible for inclusion and set restrictions on the outcome measures, which had to be related to the upper extremity and to the publication language, which had to be English. Both RCT and non-RCT designs were allowed. The one intervention category evaluated in the review of Van Eerd 2016 that may be comparable to the current review, is the stretching exercise program, within which six studies were included. One of those six studies was also included in the current review (Galinsky 2000); the other five studies reported effects of interventions other than break interventions, were non-RCTs, or included symptomatic workers. The different included studies have resulted in the different conclusion developed by Van Eerd 2016, that there is moderate-quality evidence for stretching exercise programmes having a positive effect on preventing upper extremity musculoskeletal disorders.

In Hoe 2018, the goal was to evaluate the effect of interventions on preventing work-related musculoskeletal disorders in office workers. The databases searched were similar to those searched in the current review; however, the search string used by Hoe 2018 was rather narrow compared to the current review. During their study selection process, Hoe 2018 included studies that used a randomised controlled design, assessed office workers only, evaluated interventions performed in the workplace examining a physical, organisational or cognitive ergonomic intervention, and measured outcomes related to the neck and upper extremity or work-related function and productivity. Hoe 2018 included four studies in the category organisational ergonomic interventions, three of which were included also in the current review. The

fourth included study evaluated a biofeedback intervention which interrupted the work flow at the computer but did not provide a work break as based on our criteria, including a moment of non-work (King 2013). The conclusion of Hoe 2018 with respect to organisational ergonomic interventions was that they found low-quality evidence that supplementary breaks may reduce self-reported discomfort. This trend is similar to our review, but the confidence intervals of the single outcomes per study did not show statistical significance, which may have resulted in the different final conclusion.

AUTHORS' CONCLUSIONS

Implications for practice

The current review provides low-quality evidence that different break frequencies may have no effect on musculoskeletal pain, discomfort or fatigue. Furthermore, very low-quality evidence was found that different work breaks may also have no effect on productivity or work performance outcomes. We found low-quality evidence that different types of work breaks may have no effect on musculoskeletal pain, discomfort or fatigue. The findings of this review imply that there is no clear evidence that different work-break schedules may have an effect, let alone a positive effect, on musculoskeletal outcomes and work performance or productivity.

Implications for research

This review demonstrates that we currently lack reliable evidence to judge whether supplementary breaks or different types of breaks prevent work-related musculoskeletal symptoms or disorders in workers. There is very low-quality evidence that supplementary 30-second passive breaks at intervals of 20 and 40 minutes increase work productivity in office workers. The level of evidence of studies can be improved by including a larger sample size (minimising imprecision of the results), publishing study protocols (minimising reporting bias), defining methods of random sequence generation and allocation concealment (minimising selection bias), and considering adhering to blinding of participants and personnel (minimising performance and detection bias).

Precision of the results may be increased by predetermining the relevant estimated effect of the intervention on the primary outcome based on previously published studies. With this information, a calculation for an appropriate sample size would indicate how many subjects would be necessary to make a sound interpretation of the study's outcomes (Nayak 2010; Patino 2016). Both the estimated effect sizes as well as the related sample size calculations were missing in the RCTs that were included in the current review.

Reducing publication and reporting bias can be achieved by publishing study protocols, which has already been recommended by several medical and biomedical journals. Moreover, published study protocols inform the (scientific) community what studies will be or are being conducted, avoid duplication of studies (Ohtake 2014) and may allow replication of the trial in case the intervention is not too complex (Basu 2017). The advantages and disadvantages of publishing study protocols should be considered, and potential disadvantages (such as blinding) may have to be taken for granted, because in many cases the advantages outweigh the disadvantages. In the current review, only one study published

a study protocol prior to evaluating their work-break intervention (De Bloom 2017).

None of the studies that were included in the current review reported any details about random sequence generation and allocation concealment. Future studies should include a clear description of both procedures in their methods to allow more transparent research and a more accurate assessment of the risk of selection bias.

In light of the nature of the interventions as part of the current review, performance bias was difficult to avoid because employees were able to recognise that they were undergoing an intervention. Detection bias may be easier to tackle by deploying independent assessors who are blinded to the intervention. A disadvantage of applying and investigating interventions in RCTs at the workplace is that workers may become aware that colleagues are part of another intervention or control group. This may lead to treatment group contamination. A cluster-randomised design may be useful in avoiding treatment group contamination with employees from one department assigned to the control or intervention (Hemming 2017). Such a cluster-randomised design may furthermore enhance participant compliance because employees of the complete department are part of the control or intervention group, which may result in fewer dropouts and indirectly in an increased sample size.

We have noticed that the six included trials were undertaken in the USA ($n = 3$), Canada ($n = 1$), Turkey ($n = 1$) and Finland ($n = 1$). We recommend conducting studies also in low- and middle-income countries, because there are differences in culture and politics, and therefore, also in work practices that should be considered in the evaluation of work-break interventions. Additionally, the efficacy or effectiveness of work-break interventions on workers in general should be assessed, which was not possible in the current review because only office workers were assessed. We recommend conducting studies among either one heterogeneous sample across different occupational sectors or several homogeneous samples from different occupational sectors.

Finally, in the current review, we could not perform any subgroup analyses due to the low number of studies. This asks for more randomised controlled (cross-over) trials and cluster-randomised trials, which may increase the chance of gathering more evidence about the differences in the effectiveness of work-break interventions in different age groups, professions, and sexes, in addition to the evidence about the effectiveness of work-break interventions in general. In this respect, it is important to reconsider the work-break intervention in view of the type of work, as two aspects can be of great importance in designing the work-break intervention: the physical load of the occupation as well as the possibly typical (tight) work schedules characteristic of the occupation.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

De Bloom 2017

Methods	Study design: parallel RCT, multicentre (7 companies) Study duration: 7 weeks Follow-up period: 5 weeks Dropout rate: 45% (126 of 279 subjects dropped out) Country: Finland	
Participants	Population: 153 knowledge workers (spring and fall RCT together) Control group: 56 subjects Intervention park walk group: 51 subjects Intervention muscle relaxation group: 46 subjects Randomisation method: not reported Demographics: the mean age of the subjects in spring was 48.9 years old and in fall was 45.5 years old. Of the 153 subjects, 137 were female and 16 were male. All subjects were healthy, because the additional work breaks were not intended to treat pain or discomfort.	
Interventions	Intervention park walk: 15-minute park walk break, which took place during the regular lunch break. This intervention included a guided park walk on a predetermined route, during which participants had to avoid discussions with each other. Intervention muscle relaxation: 20-minute muscle relaxation break, which took place during the regular lunch break. This intervention included guided progressive muscle relaxation, deep breathing and acceptance exercises. Control: regular 30-min lunch break, during which only small talk was permitted.	
Outcomes	Primary outcome: <ul style="list-style-type: none">Participant-reported fatigue (NRS; scale ranging from 1 <i>totally disagree with feeling fatigue</i> to 7 <i>totally agree with feeling fatigue</i>) <p>Outcomes were collected before (T1), during (T2) and after (T3) the intervention during lunch (~12:00), in the afternoon (30-60 min before the end of the working day; ~15:15) and in the evening (~21:00). We included the outcomes collected in the afternoon after the intervention.</p>	
Notes	<p>The study was performed in spring and in fall.</p> <p>Funding: This study was supported by the Academy of Finland (grant no. 257682) as part of a larger research project entitled: “Recovery from job stress: Integrating perspectives of work and environmental psychology”.</p>	
Risk of bias		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	It was unclear how randomisation took place.

De Bloom 2017 (Continued)

Quote from the reference: "Participants were randomised into one of three groups."

Allocation concealment (selection bias)	Unclear risk	The authors did not report whether they used allocation concealment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants knew which of the two interventions they received, because they were all invited to a joint introduction session learning about both interventions. Therefore, the risk of performance bias was judged as high.
Blinding of outcome assessment (detection bias) All outcomes	High risk	Participants assessed their own outcomes with paper-and-pencil questionnaires and one-item questionnaires sent as SMS to their cellphone, which made the risk for detection bias high.
Incomplete outcome data (attrition bias) All outcomes	Low risk	<p>The authors explained that there were incomplete outcome data. They used a statistical method to impute missing data ('MICE'), which made the risk of attrition bias low.</p> <p>Quote from the reference: "We needed at least six participants from each company to be included in the study, because we organized time intensive group training sessions. This precondition reduced the number of potential participants from 279 to 225 and the number of participating companies to seven. Of the initial sample, 48 people dropped out before the study started and five during the study (e.g. due to sickness, travel plans during intervention weeks, change of employer). After data collection 19 people had to be excluded from the data set because either they did not engage in park walking/relaxation (13 people) or their data were largely missing (6 people). The final sample of 153 people represented 56% of the initial sample. ... As missing data drastically reduced the sample size in repeated measures analyses due to listwise deletion, we imputed the missing data using the R package 'Mice'. Mice generates multiple imputations by chained equations in which each variable is imputed based on its own specific model."</p>
Selective reporting (reporting bias)	High risk	This study published a study protocol, within which outcomes were listed that were not reported in the final study reference (including saliva, blood pressure, and well-being). Therefore, the risk of reporting bias was judged as high.
Carry-over effect	Low risk	Not applicable because it was a parallel RCT

Galinsky 2000

Methods	<p>Study design: cross-over RCT, single centre</p> <p>Study duration: 16 weeks</p> <p>Follow-up period: 4 weeks</p> <p>Dropout rate: 58% (59 of initially 101 subjects dropped out)</p> <p>Country: USA</p>
Participants	<p>Total study population: 42 data-entry operators</p> <p>Intervention group: 42 subjects</p> <p>Control group: 42 subjects</p> <p>Randomisation method: not reported</p>

Galinsky 2000 (Continued)

Demographics: the age of the subjects ranged from 19 to 50 years old (mean age was 30 years old). Of the 42 subjects, 31 were female and 11 were male. All subjects were healthy, because the additional work breaks were not intended to treat pain or discomfort.

Interventions	<p>Duration of intervention: 4 weeks</p> <p>Intervention: supplementary rest-break schedule, i.e. conventional rest-break schedule with additional 5-min breaks during each hour that otherwise did not contain a break, i.e. 20-min extra break time, during which participants were encouraged to get up and take at least a short walk away from their workstation.</p> <p>Control: conventional rest-break schedule, i.e. 15-min morning break, 30-min lunch break, 15-min afternoon break</p>
Outcomes	<p>Primary outcomes:</p> <ul style="list-style-type: none"> Participant-reported discomfort (NRS ranging from 1 <i>no discomfort at all</i> to 5 <i>extreme discomfort</i>) Productivity: keystrokes (keystrokes/hour averaged across tax forms) Productivity: work output (total number of documents entered/day) Productivity: error rate (number of errors made/day) Productivity: accuracy (number of documents entered correctly/day) <p>Outcomes of discomfort were collected daily immediately prior to work shift, immediately prior to lunch, immediately following lunch, immediately after work shift. We included the outcomes averaged over the four time points. Outcomes of productivity were collected daily, obtained from agency records.</p>
Notes	<p>Only the mean values of the outcomes were available from the results.</p> <p>Funding: The authors reported no funding resources and no conflicts of interest.</p>

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	<p>It was unclear how randomisation took place.</p> <p>Quote from the reference: "<i>Half of the volunteers from each shift (day and night) were assigned at random to experience the C-S-C-S order of rest break schedules, and the other half were assigned at random to experience the opposite (S-C-S-C) order. As a result of attrition (due mostly to work releases), data from just the first two phases of the study were sufficient for analyses.</i>"</p>
Allocation concealment (selection bias)	Unclear risk	The authors did not report whether they used allocation concealment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants knew in which arm they were during the cross-over trial, which made the risk of performance bias high.
Blinding of outcome assessment (detection bias) All outcomes	High risk	There were some self-reported assessments and participants were aware of which arm they were in at that moment, which made the risk for detection bias high.
Incomplete outcome data (attrition bias) All outcomes	High risk	The authors explained that there were incomplete outcome data; however, no method was used to estimate any missing values/data and undertake a full statistical analysis. Therefore, the risk for attrition bias was judged as high.

Galinsky 2000 (Continued)

Quote from the reference: "Most of the attrition of participants over the course of the study (38 participants) was due to release from employment and resignations from employment. In addition, questionnaire data from 21 of the 101 volunteers were too incomplete for statistical analyses. An individual's data set was designated as insufficient if more than four consecutive days of questionnaires were missing from the first 8 weeks of the study, or if more than a total of 8 days of questionnaires were missing from any 4-week period. Approximately half of these instances were due to absence from work, and the remainder were due to non-compliance in filling out questionnaires."

Selective reporting (reporting bias)	High risk	<p>In the Methods, the POMS questionnaire was mentioned but no findings were presented in the Results. Similarly, not all discomfort ratings were reported in the Results. Finally, not all measured time points were included in the analysis due to incomplete outcome data. Based on these reasons, we judged the risk of reporting bias to be high.</p> <p>Quote 1 from the reference: "As a result of attrition (due mostly to work releases), data from just the first two phases of the study were sufficient for analyses."</p> <p>Quote 2 from the reference: "Records of data-entry accuracy during the first 4 weeks of the study were not available."</p>
Carry-over effect	High risk	<p>This study used a cross-over randomised controlled design, but did not include a wash-out period in between consecutive conditions, which made the risk of a carry-over effect high.</p>

Galinsky 2007

Methods	<p>Study design: parallel & cross-over RCT, single centre</p> <p>Study duration: 8 weeks</p> <p>Follow-up period: 4 weeks</p> <p>Dropout rate: 43% (39 of initially 90 subjects dropped out)</p> <p>Country: USA</p>
Participants	<p>Total study population: 51 data-entry operators</p> <p>Intervention group: 51 subjects (cross-over)</p> <p>Intervention active group: 21 subjects (parallel)</p> <p>Intervention passive group: 30 subjects (parallel)</p> <p>Control group: 51 subjects (cross-over)</p> <p>Randomisation method: not reported</p> <p>Demographics: the age of the subjects ranged from 23 to 60 years old (mean age was 36 years old). Of the 51 subjects, 47 were female and 4 were male. All subjects were healthy, because the additional work breaks were not intended to treat pain or discomfort.</p>
Interventions	<p>Duration of intervention: 4 weeks</p> <p>Intervention active: supplementary rest-break schedule, i.e. conventional rest-break schedule with additional 5-min breaks during each hour that otherwise did not contain a break, i.e. 20-min extra break time, during which participants performed a set of nine brief stretch exercises targeting the neck, shoulders, back, and upper extremities that lasted no longer than 2 min.</p>

Galinsky 2007 (Continued)

Intervention passive: supplementary rest-break schedule, i.e. conventional rest-break schedule with additional 5-min breaks during each hour that otherwise did not contain a break, i.e. 20-min extra break time, during which participants were encouraged to get up and take at least a short walk away from their workstation.

Control: conventional rest-break schedule, i.e. 15-min morning break, 30-min lunch break, 15-min afternoon break

Outcomes	Primary outcomes: <ul style="list-style-type: none">Participant-reported discomfort (NRS ranging from 1 <i>no discomfort at all</i> to 5 <i>extreme discomfort</i>)Productivity: work output (total number of documents entered/day)Productivity: keystrokes (keystrokes/hour)Productivity: total time (duration on terminal/day) <p>Outcomes of discomfort were collected daily immediately prior to work shift, immediately prior to lunch, immediately following lunch, immediately after work shift. We included the outcomes averaged over the four time points. Outcomes of productivity were collected daily, obtained from agency records.</p>	
Notes	<p>For the comparison between stretching and no-stretching, no results are reported because the difference between both conditions was not significant.</p> <p>Funding: The authors report no funding resources and no conflicts of interest.</p>	
Risk of bias		
Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	<p>It was unclear how randomisation took place.</p> <p>Quote from the reference: "<i>Half of the 90 volunteers were assigned at random to the Stretching Exercise condition and half were assigned to the No Stretching Exercise condition. The 8-week study period was divided into two 4-week phases in which all participants alternated between the Conventional and Supplementary rest break schedules. Approximately half (23) of the volunteers in each exercise condition were assigned at random to work for 4 weeks under the Conventional schedule and then switch to the Supplementary schedule for the second 4-week phase. The remaining 22 volunteers in each exercise condition were assigned at random to experience the opposite sequence of rest break conditions.</i>"</p>
Allocation concealment (selection bias)	Unclear risk	The authors did not report whether they used allocation concealment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants knew in which arm they were during the cross-over trial, which made the risk of performance bias high.
Blinding of outcome assessment (detection bias) All outcomes	High risk	There were some self-reported assessments and participants were aware of which arm they were in at that moment, which made the risk for detection bias high.
Incomplete outcome data (attrition bias) All outcomes	High risk	<p>Almost 50% fewer subjects were analysed from the original study population due to incomplete outcome data, which made the risk for attrition bias high.</p> <p>Quote from the reference: "<i>The study sample was recruited from one area of the centre containing workstations for 101 individuals, 90 of whom volunteered to follow the study protocol, which included filling out daily questionnaires for 8 weeks. Twenty seven of those workers were released from employment or re-</i></p>

Galinsky 2007 (Continued)

signed before the study was completed. Questionnaire data from 12 of the remaining participants were too incomplete for statistical analyses. An individual's data set was deemed incomplete if more than 4 consecutive days of questionnaires were missing, or if more than a total of 8 days of questionnaires were missing from either the first or second 4-week period of the study. The resulting sample of data available for analyses included 47 women and 4 men, aged 23–60 years, with a mean age of 36 years. Data-entry experience ranged from 1 month to 24 years, with a mean of 6 years."

Selective reporting (reporting bias)	High risk	All outcomes as listed in the Methods, except for the POMS items and several discomfort ratings, were reported in the Results. Due to missing outcomes in the Results, the risk of reporting bias was judged as high.
Carry-over effect	High risk	This study used a cross-over randomised controlled design, but did not include a wash-out period in between consecutive conditions, which made the risk of a carry-over effect high.

Henning 1997

Methods	<p>Study design: parallel RCT, single centre</p> <p>Study duration: 6 weeks</p> <p>Follow-up period: 3 weeks (smaller work site) or 4 weeks (larger work site)</p> <p>Dropout rate: ranging from 53% to 64% (ranging from 26 to 34 of initially 73 subjects dropped out)</p> <p>Country: USA</p>
Participants	<p>Total study population: 73 computer operators</p> <p>Intervention passive breaks: not specified</p> <p>Intervention active breaks: not specified</p> <p>Control group: not specified</p> <p>Randomisation method: not reported</p> <p>Demographics: the age of the subjects ranged from 19 to 53 years old (mean age was 26.1 years old). Of the 73 subjects, 65 were female and 8 were male. All subjects were healthy, because the additional work breaks were not intended to treat pain or discomfort.</p>
Interventions	<p>Intervention passive breaks: four additional breaks from computer work each hour, i.e. one every 15 minutes. Three of these breaks lasted 30 seconds, during which subjects were asked to sit back and relax; one of these breaks lasted 3 minutes, during which subjects were asked to perform alternative work not involving the computer.</p> <p>Intervention active breaks: four additional breaks from computer work each hour, i.e. one every 15 minutes. During the three 30-second breaks, one 15-second stretch exercise of choice was performed; during the one 3-minute break, two 15-second stretch exercises of choice were performed. A pool of six 15-second stretch exercises was provided, each targeting specific body areas: (1) fingers, hands & forearms, (2) fingers & wrists, (3) chest, shoulders & upper back, (4) shoulders & neck, (5) both sides of the trunk, or (6) lower back.</p> <p>Control: 15-min breaks in the morning and afternoon parts of the shift, and a 30-min lunch break halfway</p>
Outcomes	<p>Primary outcomes:</p>

Henning 1997 (Continued)

- Participant-reported discomfort (NRS ranging from 1 *no discomfort at all* to 5 *extreme discomfort*)
- Productivity: work output (number of claims processed/number of hours available for claims processing)

Outcomes of discomfort were collected daily aft the start of the workday, midday before lunch, and at the end of the workday. Outcomes of productivity were collected daily, obtained from company records.

Notes

No results reported, nor after email contact with the authors.

Funding: Support for this research was provided, in part, by the National Institute for Occupational Safety and Health (NIOSH).

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	It was unclear how randomisation took place. Quote from the reference: "At the larger work site, a between-subjects design was employed. VDU operators were divided into three, nearly equal groups ($n > 20$) consisting of several work teams in close proximity to each other. Each group was then randomly assigned to one of three conditions: (1) control (no breaks nor exercises), (2) breaks only, and (3) breaks and exercise. A 2-week, pre-treatment baseline period was followed by a 4-week treatment period at this work site."
Allocation concealment (selection bias)	Unclear risk	The authors did not report whether they used allocation concealment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants were aware which intervention they received, which made the risk of performance bias high.
Blinding of outcome assessment (detection bias) All outcomes	High risk	Most outcomes were self-reported and participants knew which intervention they received, which made the risk for detection bias high.
Incomplete outcome data (attrition bias) All outcomes	High risk	Due to the large dropout rate (ranging between 53% and 64%, depending on the outcome) and no method to impute missing data, the risk of attrition bias was judged to be high. Quote 1 from reference: "Participant's data were excluded from statistical analysis for any one of four reasons; (1) workplace attrition over the 6-week study period, including transfers to other divisions of the company, (2) $< 10\%$ compliance rate to the added breaks, as reported on the exit survey, (3) failure to complete the mood and musculoskeletal discomfort surveys, or (4) incomplete company records of worker productivity. The number of participants available for analysis of mood states was reduced from 73 cases to 27 cases (control, $n = 10$; breaks only, $n = 9$; breaks and exercises, $n = 8$). For musculoskeletal discomfort, the number of participants available for analysis was reduced from 73 cases to 26 cases (control, $n = 10$; breaks only, $n = 8$; breaks and exercise, $n = 8$). For productivity, the number of participants available for analysis was reduced from 73 cases to 34 cases (control, $n = 14$; breaks only, $n = 15$; breaks and exercise, $n = 5$)." Quote 2 from reference: "Eight operators at the larger work site were excluded because of total non-compliance."

Henning 1997 (Continued)

Selective reporting (re-reporting bias)	Unclear risk	No trial has been registered and no study protocol has been published, which means that we could not judge whether the initial study plan has been pursued. Therefore, we have judged the risk of reporting bias to be unclear.
Carry-over effect	Low risk	Not applicable because it was a parallel RCT.

Irmak 2012

Methods	<p>Study design: parallel RCT</p> <p>Study duration: 10 weeks</p> <p>Follow-up period: 10 weeks</p> <p>Dropout rate: 0% (0 of initially 39 subjects dropped out)</p> <p>Country: Turkey</p>
Participants	<p>Total study population: 39 stenographers</p> <p>Intervention group: 20 subjects</p> <p>Control group: 19 subjects</p> <p>Randomisation method: not reported</p> <p>Demographics: no information about age or sex of the subjects was provided. All subjects were healthy, because the additional work breaks were not intended to treat pain or discomfort.</p>
Interventions	<p>Intervention: exercise reminder software that included 53 strengthening, stretching and posture exercises for all body parts, suitable for the office environment, of which participants had to perform two 15-second exercises per 45 minutes of work</p> <p>Control: no additional exercise breaks</p>
Outcomes	<p>Primary outcomes:</p> <ul style="list-style-type: none"> Participant-reported musculoskeletal pain (VAS ranging from 0 mm <i>no pain at all</i> to 100 mm <i>pain as bad as it could be</i>) Productivity: work performance (work role functioning questionnaire using a NRS ranging from 1 <i>difficult all the time</i> to 5 <i>difficult none of the time</i>) <p>Outcomes were collected before and after the intervention. We included the outcomes collected after the intervention.</p>
Notes	<p>The published reference did not report detailed results; after contacting the authors, they provided us with all detailed data tables from which we were able to calculate the means and standard deviations.</p> <p>Funding: The authors reported no funding resources and no conflicts of interest.</p>

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	<p>It was unclear how randomisation took place.</p> <p>Quote from the reference: "Participants were randomly split into two groups, intervention group (n=20) and control group (n=19)."</p>

Irmak 2012 (Continued)

Allocation concealment (selection bias)	Unclear risk	The authors did not report whether they used allocation concealment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants were aware of which intervention they received, which made the risk of performance bias high.
Blinding of outcome assessment (detection bias) All outcomes	High risk	All outcomes were self-reported and participants were aware of which intervention they received, which made the risk for detection bias high.
Incomplete outcome data (attrition bias) All outcomes	Low risk	The authors did not report whether there were incomplete outcome data. After contact with the authors, they informed us that they were able to include all 39 initially recruited subjects. Based on this information, the risk of attrition bias was judged as low.
Selective reporting (reporting bias)	Unclear risk	No trial has been registered and no study protocol has been published, which means that we could not judge whether the initial study plan has been pursued. Therefore, we have judged the risk of reporting bias to be unclear.
Carry-over effect	Low risk	Not applicable because the study was a parallel RCT.

McLean 2001

Methods	Study design: parallel RCT, multicentre Study duration: 4 weeks Follow-up period: 2 weeks Dropout rate: not reported Country: Canada
Participants	Total study population: 15 computer operators Intervention high frequency group: 5 subjects Intervention low frequency group: 5 subjects Control group: 5 subjects Randomisation method: not reported Demographics: the age of the subjects ranged from 23 to 50 years old (median age was 34 years old). All 15 subjects were female. All subjects were healthy, because the additional work breaks were not intended to treat pain or discomfort.
Interventions	Intervention high frequency: Ergobreak software that included 30-second microbreaks at 20-minute intervals during which participants had to get out of their desk chair and walk away from their workstation Intervention low frequency: Ergobreak software that included 30-second microbreaks at 40-minute intervals during which participants had to get out of their desk chair and walk away from their workstation Control: Participants took breaks whenever they felt they needed to.

McLean 2001 (Continued)

Outcomes

Primary outcomes:

- Participant-reported discomfort (VAS ranging from 0 mm *no discomfort* to 100 mm *worst possible discomfort*)
- Productivity: number of words (number of words typed / 3-hour recording session)

Outcomes of discomfort were collected before and after the intervention. Outcomes of productivity were collected daily, obtained from the Ergobreak software. We included the outcomes collected after the intervention.

Notes

Only means of the outcomes were provided in the results.

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Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	It was unclear how randomisation took place. Quote from the reference: "Participants were randomly assigned to one of three experimental groups according to their set time interval between microbreaks: a control group (where participants took breaks whenever they felt they needed to), a 20-min interval group, and a 40-min interval group."
Allocation concealment (selection bias)	Unclear risk	The authors did not report whether they used allocation concealment.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Participants were aware of which intervention they received, which made the risk of performance bias high.
Blinding of outcome assessment (detection bias) All outcomes	High risk	All outcomes were self-reported and participants were aware of which intervention they received, which made the risk for detection bias high.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	The authors did not report whether there were incomplete outcome data.
Selective reporting (reporting bias)	Unclear risk	No trial has been registered and no study protocol has been published, which means that we could not judge whether the initial study plan has been pursued. Therefore, we have judged the risk of reporting bias to be unclear.
Carry-over effect	Low risk	The authors have tried to avoid carry-over, which made the risk of carry-over effects low. Quote from the reference: "A within-subjects design was used to test participants when no breaks were taken as compared to when breaks were taken, without returning to test the "no breaks" baseline level after implementing the "microbreak" protocol. This sequence was used to avoid the carry-over effects that would be expected following the two-week "microbreak" protocol."

MICE: Multivariate Imputation by Chained Equations.

NRS: Numeric Rating Scale.

POMS: Profile of Mood States.

SMS: Short Message Service.

T1, T2, T3: Time points 1, 2 and 3.

VAS: Visual Analogue Scale.

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Abdelrahmen 2017	Wrong study design
ACTRN12618000061235	Wrong intervention
Baidya 1988	Not available
Balci 2004	Wrong study design
Battecha 2019	Wrong intervention
Bautch 1998	Wrong study design
Beynon 2000	Wrong study design
Bhatia 1969	Wrong study design
Blasche 2017	Wrong intervention
Blasche 2018	Wrong patient population
Boucsein 1995	Wrong study design
Boucsein 1996	Wrong study design
Boucsein 1997	Wrong study design
Brown 2014	Wrong outcomes
Butkovskaia 1981	Wrong study design
Cambo 2017	Wrong study design
Carstensen 1998	Wrong study design
Chaikumarn 2018	Wrong patient population
Chakrabarty 2016	Wrong patient population
Coleman Wood 2018	Wrong study design
Conway 1998	Wrong study design
Crenshaw 2006	Wrong study design
CTRI/2019/01/017117	Wrong outcomes
Czernieckij 1966	Wrong outcomes
Cáceres-Muñoz 2017	Wrong study design

Study	Reason for exclusion
Dababneh 1998	Wrong study design
Dababneh 2001	Wrong study design
De Looze 2010	Wrong study design
Engelmann 2011	Wrong study design
Evans 2012	Wrong outcomes
Faucett 2007	Wrong patient population
Finkbeiner 2016	Wrong study design
Frey 2002	Wrong outcomes
Genaidy 1995	Wrong study design
Gilson 2009	Wrong outcomes
Hallbeck 2017a	Wrong study design
Hallbeck 2017b	Wrong study design
Havenstein 2017	Wrong intervention
Hayashi 2004	Wrong study design
Helander 1990	Wrong study design
Henning 1993	Wrong study design
Hoe 2018	Wrong study design
IRCT201202204242N3	Wrong study design
ISRCTN13222474	Not available
JPRN-UMIN000033210	Wrong patient population
Karlsson 1988	Wrong study design
Karwowski 1990	Wrong study design
Keller 2019	Wrong intervention
Kildebro 2014	Wrong study design
Kiseleva 1970	Wrong study design
Kissel 1994	Not available
Kogi 1982	Wrong study design
Krajewski 1979	Wrong study design

Study	Reason for exclusion
Krajewski 2010	Wrong outcomes
Lacaze 2010	Wrong study design
Lancry 1995	Wrong study design
Lanhers 2015	Wrong patient population
Laporte 1966	Wrong study design
Largo-Wight 2017	Wrong outcomes
Lim 2016	Wrong study design
Luger 2018	Wrong study design
Mailey 2017	Wrong outcomes
Martin-Gill 2018	Wrong study design
McLean 2000	Wrong outcomes
Michishita 2017a	Wrong outcomes
Michishita 2017b	Wrong outcomes
Middaugh 2002	Wrong study design
Mihaila 1971	Wrong intervention
Mihaila 1973	Wrong study design
Mitra 2008	Wrong study design
Mohan 1969	Wrong study design
Moreira 2007	Wrong outcomes
NCT01996176	Wrong intervention
NCT02951624	Wrong outcomes
NCT02960750	Wrong outcomes
NCT03163953	Wrong outcomes
NCT03375749	Wrong intervention
NCT03468894	Wrong intervention; withdrawn study due to insufficient resources
NCT03560544	Wrong outcomes
NCT03715816	Wrong study design
NCT03840304	Wrong patient population

Study	Reason for exclusion
NCT03863340	Wrong study design
Neri 2002	Wrong study design
Nijp 2016	Wrong intervention
Oriyama 2014	Wrong outcomes
Oude Hengel 2012	Wrong intervention
Oude Hengel 2013	Wrong intervention
Park 2017	Wrong study design
Peper 2006	Not available
Petz 1964	Not available
Purnell 2002	Wrong study design
Rahman 2018	Wrong study design
Rosa 1985	Not available
Scammell 2018	Wrong study design
Scholz 2018	Wrong study design
Schrempf 2017	Wrong study design
Scott 2018	Wrong study design
Sheahan 2016	Wrong study design
Shrestha 2018	Wrong study design
Sianoja 2018	Wrong outcomes
Stock 2018	Wrong study design
Sundelin 1989	Wrong study design
Takahashi 2004	Wrong study design
Taylor 2016	Wrong outcomes
Tempesta 2013	Wrong study design
Tiwari 2006	Wrong study design
Tooley 2004	Not available
Van den Heuvel 2003	Wrong patient population
Van Dieën 1998	Wrong study design

Study	Reason for exclusion
Verhaegen 1960	Wrong study design
Vijendren 2018	Wrong patient population
Yusuf 2006	Not available
Zhu 2019	Wrong study design
Zolina 1963	Wrong study design

Characteristics of ongoing studies [ordered by study ID]

NCT03559153

Trial name or title	Effect of passive and active rest break in musculoskeletal complains
Methods	Cluster-randomised controlled trial (parallel design)
Participants	<p>Population: 286 office workers (based on a sample size calculation)</p> <p>Inclusion criteria: employees of 18 years and older who work at least 6 hours a day in a sitting position</p> <p>Exclusion criteria: disabled employees</p>
Interventions	<p>Passive intervention group: the office workers will receive a 10-min shiatsu massage two times a week during their rest break.</p> <p>Active intervention group: the office workers will receive a 15- to 20-min physical exercise program two times a week during their rest break.</p> <p>Active control group: the office workers will not receive an intervention, but they will receive ergonomics instructions about rest breaks.</p>
Outcomes	<p>Primary outcomes:</p> <ul style="list-style-type: none"> Change in musculoskeletal complaints between baseline and 4, 8, 12 and 16 weeks using the Nordic Questionnaire for Musculoskeletal Symptoms Change in musculoskeletal pain intensity between baseline and 4, 8, 12 and 16 weeks using an 0 to 10 NRS (range from 0 "no pain" to 10 "worst possible pain") <p>Secondary outcome:</p> <ul style="list-style-type: none"> Change in work ability between baseline and 16 weeks using the Work Ability Index
Starting date	June 20, 2017 (study completion for primary outcome measure was March 3, 2019)
Contact information	Principal investigator: Rosimeire Simprini Padula (https://clinicaltrials.gov/ct2/show/nct03559153)
Notes	The study was sponsored by the City University of São Paulo, Brasil.

DATA AND ANALYSES

Comparison 1. Additional work breaks versus no additional work breaks

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 4 or 10 weeks)	3	225	Std. Mean Difference (IV, Random, 95% CI)	-0.08 [-0.35, 0.18]
2 Productivity or work performance (follow-up 4 or 10 weeks)	3	225	Std. Mean Difference (IV, Random, 95% CI)	-0.07 [-0.33, 0.19]

Analysis 1.1. Comparison 1 Additional work breaks versus no additional work breaks, Outcome 1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 4 or 10 weeks).

Analysis 1.2. Comparison 1 Additional work breaks versus no additional work breaks, Outcome 2 Productivity or work performance (follow-up 4 or 10 weeks).

Comparison 2. Additional work breaks versus work breaks as needed

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 4 weeks)	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
2 Productivity or work performance (follow-up 4 weeks)	1		Mean Difference (IV, Random, 95% CI)	Totals not selected

Analysis 2.1. Comparison 2 Additional work breaks versus work breaks as needed, Outcome 1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 4 weeks).

Study or subgroup	Additional breaks		Breaks as needed		Mean Difference Random, 95% CI	Mean Difference Random, 95% CI
	N	Mean(SD)	N	Mean(SD)		
McLean 2001	10	26.9 (38.5)	5	25.1 (36.5)		1.8[-38.15,41.75]

Analysis 2.2. Comparison 2 Additional work breaks versus work breaks as needed, Outcome 2 Productivity or work performance (follow-up 4 weeks).

Study or subgroup	Additional breaks		Breaks as needed		Mean Difference Random, 95% CI	Mean Difference Random, 95% CI
	N	Mean(SD)	N	Mean(SD)		
McLean 2001	10	225.5 (174.6)	5	-317 (398)		542.5[177.22,907.78]

Comparison 3. Additional higher frequency work breaks versus additional lower frequency work breaks

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 4 weeks)	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
2 Productivity or work performance (follow-up 4 weeks)	1		Mean Difference (IV, Random, 95% CI)	Totals not selected

Analysis 3.1. Comparison 3 Additional higher frequency work breaks versus additional lower frequency work breaks, Outcome 1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 4 weeks).

Study or subgroup	Additional high frequency		Additional low frequency		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Random, 95% CI	Random, 95% CI
McLean 2001	5	32.7 (54.9)	5	21.1 (24.6)		11.65[-41.07,64.37]
					Favours high frequency	Favours low frequency

Analysis 3.2. Comparison 3 Additional higher frequency work breaks versus additional lower frequency work breaks, Outcome 2 Productivity or work performance (follow-up 4 weeks).

Study or subgroup	Additional high frequency		Additional low frequency		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Random, 95% CI	Random, 95% CI
McLean 2001	5	184 (154.3)	5	267 (201.3)		-83[-305.28,139.28]
					Favours low frequency	Favours high frequency

Comparison 4. Active work breaks versus passive work breaks

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 5 weeks)	1		Mean Difference (IV, Random, 95% CI)	Totals not selected

Analysis 4.1. Comparison 4 Active work breaks versus passive work breaks, Outcome 1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 5 weeks).

Study or subgroup	Active breaks		Passive breaks		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	Random, 95% CI	Random, 95% CI
De Bloom 2017	97	4 (1.6)	56	4.2 (1.7)		-0.18[-0.72,0.36]
					Favours active breaks	Favours passive breaks

Comparison 5. Relaxation work breaks versus physical work breaks

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 5 weeks)	1		Mean Difference (IV, Random, 95% CI)	Totals not selected

Analysis 5.1. Comparison 5 Relaxation work breaks versus physical work breaks, Outcome 1 Participant-reported musculoskeletal pain, discomfort or fatigue (follow-up 5 weeks).

Study or subgroup	Relaxation breaks		Physical breaks		Mean Difference Random, 95% CI	Mean Difference Random, 95% CI
	N	Mean(SD)	N	Mean(SD)		
De Bloom 2017	46	4.1 (1.4)	51	3.9 (1.8)		0.2[-0.42,0.82]
					Favours relaxation -5 -2.5 0 2.5 5	Favours physical

Comparison 6. Additional work breaks versus no additional work breaks (sensitivity analysis)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Participant-reported musculoskeletal outcomes (pain, discomfort or fatigue)	3		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only
1.1 Participant-reported musculoskeletal pain (follow-up 10 weeks)	1	39	Std. Mean Difference (IV, Random, 95% CI)	-0.34 [-0.97, 0.29]
1.2 Participant-reported musculoskeletal discomfort (neck; follow-up 4 weeks)	2	186	Std. Mean Difference (IV, Random, 95% CI)	-0.01 [-0.30, 0.27]
1.3 Participant-reported musculoskeletal discomfort (back; follow-up 4 weeks)	2	186	Std. Mean Difference (IV, Random, 95% CI)	-0.05 [-0.33, 0.24]
1.4 Participant-reported musculoskeletal discomfort (right shoulder & upper arm; follow-up 4 weeks)	2	186	Std. Mean Difference (IV, Random, 95% CI)	-0.04 [-0.32, 0.25]
1.5 Participant-reported musculoskeletal discomfort (left shoulder & upper arm; follow-up 4 weeks)	2	186	Std. Mean Difference (IV, Random, 95% CI)	-0.03 [-0.32, 0.25]
1.6 Participant-reported musculoskeletal discomfort (right elbow; follow-up 4 weeks)	1	84	Std. Mean Difference (IV, Random, 95% CI)	-0.03 [-0.46, 0.40]
1.7 Participant-reported musculoskeletal discomfort (left elbow; follow-up 4 weeks)	1	84	Std. Mean Difference (IV, Random, 95% CI)	-0.02 [-0.45, 0.41]
1.8 Participant-reported musculoskeletal discomfort (right forearm, wrist & hand; follow-up 4 weeks)	2	186	Std. Mean Difference (IV, Random, 95% CI)	-0.03 [-0.32, 0.26]
1.9 Participant-reported musculoskeletal discomfort (left forearm, wrist & hand; follow-up 4 weeks)	1	102	Std. Mean Difference (IV, Random, 95% CI)	-0.02 [-0.41, 0.37]
1.10 Participant-reported musculoskeletal discomfort (buttocks; follow-up 4 weeks)	2	186	Std. Mean Difference (IV, Random, 95% CI)	-0.04 [-0.32, 0.25]
1.11 Participant-reported musculoskeletal discomfort (legs, follow-up 4 weeks)	1	102	Std. Mean Difference (IV, Random, 95% CI)	-0.04 [-0.43, 0.35]
2 Productivity or work performance	3		Std. Mean Difference (IV, Random, 95% CI)	Subtotals only

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
2.1 Productivity or work performance (WR-FQ, follow-up 10 weeks)	1	39	Std. Mean Difference (IV, Random, 95% CI)	0.39 [-0.24, 1.03]
2.2 Productivity or work performance (key-strokes per hour; follow-up 4 weeks)	2	186	Std. Mean Difference (IV, Random, 95% CI)	0.01 [-0.27, 0.30]
2.3 Productivity or work performance (entered documents per day; follow-up 4 weeks)	2	186	Std. Mean Difference (IV, Random, 95% CI)	-0.01 [-0.29, 0.28]

Analysis 6.1. Comparison 6 Additional work breaks versus no additional work breaks (sensitivity analysis), Outcome 1 Participant-reported musculoskeletal outcomes (pain, discomfort or fatigue).

Analysis 6.2. Comparison 6 Additional work breaks versus no additional work breaks (sensitivity analysis), Outcome 2 Productivity or work performance.

Comparison 7. Additional work breaks versus work breaks as needed (sensitivity analysis)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Participant-reported musculoskeletal pain, discomfort or fatigue	1		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected
1.1 Participant-reported musculoskeletal discomfort (neck; follow-up 4 weeks)	1		Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.2 Participant-reported musculoskeletal discomfort (back; follow-up 4 weeks)	1		Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.3 Participant-reported musculoskeletal discomfort (shoulder; follow-up 4 weeks)	1		Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.4 Participant-reported musculoskeletal discomfort (forearm & wrist; follow-up 4 weeks)	1		Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]

Analysis 7.1. Comparison 7 Additional work breaks versus work breaks as needed (sensitivity analysis), Outcome 1 Participant-reported musculoskeletal pain, discomfort or fatigue.

Comparison 8. Additional higher frequency work breaks versus additional lower frequency work breaks (sensitivity analysis)

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Participant-reported musculoskeletal pain, discomfort or fatigue	1		Std. Mean Difference (IV, Random, 95% CI)	Totals not selected
1.1 Participant-reported musculoskeletal discomfort (neck; follow-up 4 weeks)	1		Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.2 Participant-reported musculoskeletal discomfort (back; follow-up 4 weeks)	1		Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.3 Participant-reported musculoskeletal discomfort (shoulder; follow-up 4 weeks)	1		Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]
1.4 Participant-reported musculoskeletal discomfort (forearm & wrist; follow-up 4 weeks)	1		Std. Mean Difference (IV, Random, 95% CI)	0.0 [0.0, 0.0]

Analysis 8.1. Comparison 8 Additional higher frequency work breaks versus additional lower frequency work breaks (sensitivity analysis), Outcome 1 Participant-reported musculoskeletal pain, discomfort or fatigue.

APPENDICES

Appendix 1. MEDLINE (PubMed) search strategy

#1 "rest"[MeSH]

#2 "rest period"[tw] OR "rest periods"[tw] OR "resting period"[tw] OR "resting periods"[tw] OR "work pause"[tw] OR "work pauses"[tw] OR "work interruption"[tw] OR "work interruptions"[tw] OR "work break"[tw] OR "work breaks"[tw] OR "work-break*"[tw] OR "micro break"[tw] OR "micro breaks"[tw] OR "micro-break*"[tw] OR microbreak*[tw] OR "rest break"[tw] OR "rest breaks"[tw] OR "rest-break*"[tw] OR "break pattern"[tw] OR "break patterns"[tw] OR "break frequency"[tw] OR "break frequencies"[tw] OR "break duration"[tw] OR "short break"[tw] OR "short breaks"[tw] OR "coffee break"[tw] OR "coffee breaks"[tw] OR "lunch break"[tw] OR "lunch breaks"[tw] OR "break type"[tw] OR "break types"[tw] OR "active break"[tw] OR "active breaks"[tw] OR "passive break"[tw] OR "passive breaks"[tw] OR "cognitive break"[tw] OR "cognitive breaks"[tw] OR "frequent break"[tw] OR "frequent breaks"[tw] OR "regular break"[tw] OR "regular breaks"[tw] OR "taking break"[tw] OR "taking breaks"[tw] OR "break activity"[tw] OR "break activities"[tw] OR "break schedule"[tw] OR "break schedules"[tw] OR "scheduling break"[tw] OR "scheduling breaks"[tw] OR "scheduled break"[tw] OR "scheduled breaks"[tw] OR "employee break"[tw] OR "employee breaks"[tw]

#3 #1 OR #2

#4 workplace[MeSH] OR work[MeSH] OR "work schedule tolerance"[MeSH]

#5 work*[tw] OR occupation*[tw] OR job[tw] OR jobs[tw] OR employee*[tw]

#6 #4 OR #5

#7 "musculoskeletal diseases"[MeSH] OR "musculoskeletal pain"[MeSH] OR "occupational diseases"[MeSH] OR "occupational injuries"[MeSH] OR "occupational health"[MeSH] OR "cumulative trauma disorders"[MeSH] OR "carpal tunnel syndrome"[MeSH] OR "shoulder pain"[MeSH] OR "neck pain"[MeSH] OR "back pain"[MeSH] OR "leg injuries"[MeSH] OR "back injuries"[MeSH] OR "neck injuries"[MeSH] OR "arm injuries"[MeSH] OR "hand injuries"[MeSH] OR "upper extremity"[MeSH] OR "lower extremity"[MeSH] OR "muscle fatigue"[MeSH] OR posture[MeSH] OR movement[MeSH] OR fatigue[MeSH] OR "physical exertion"[MeSH]

#8 "occupational overuse"[tw] OR "tension neck"[tw] OR "cumulative trauma"[tw] OR musculoskeletal*[tw] OR skeletal*[tw] OR pain[tw] OR disorder*[tw] OR "carpal tunnel"[tw] OR discomfort[tw] OR well-being[tw] OR wellbeing[tw] OR myalgia[tw] OR muscle*[tw] OR muscular*[tw] OR postur*[tw] OR position*[tw]

#9 (repetiti*[tw] OR monoton*[tw]) AND (strain[tw] OR stress[tw] OR motion[tw] OR movement[tw] OR workload*[tw] OR task[tw] OR tasks[tw]) AND (injur*[tw] OR disorder*[tw] OR disease*[tw] OR decreas*[tw] OR reduc*[tw])

#10 #7 OR #8 OR #9

#11 #3 AND #6 AND #10

#12 (animals[MeSH] OR animal*[tw]) NOT (humans[MeSH] OR human*[tw])

#13 #11 NOT #12

Appendix 2. Cochrane Central Register of Controlled Trials (CENTRAL; Wiley Online Library) search strategy

#1 [mh rest]

#2 "rest period":ti,ab,kw OR "rest periods":ti,ab,kw OR "resting period":ti,ab,kw OR "resting periods":ti,ab,kw OR "work pause":ti,ab,kw OR "work pauses":ti,ab,kw OR "work interruption":ti,ab,kw OR "work interruptions":ti,ab,kw OR "work break":ti,ab,kw OR "work breaks":ti,ab,kw OR "work-break*":ti,ab,kw OR "micro break":ti,ab,kw OR "micro breaks":ti,ab,kw OR "micro-break*":ti,ab,kw OR "microbreak*":ti,ab,kw OR "rest break":ti,ab,kw OR "rest-break":ti,ab,kw OR "break pattern":ti,ab,kw OR "break patterns":ti,ab,kw OR "break frequency":ti,ab,kw OR "break frequencies":ti,ab,kw OR "break duration":ti,ab,kw OR "short break":ti,ab,kw OR "short breaks":ti,ab,kw OR "coffee break":ti,ab,kw OR "coffee breaks":ti,ab,kw OR "lunch break":ti,ab,kw OR "lunch breaks":ti,ab,kw OR "break type":ti,ab,kw OR "break types":ti,ab,kw OR "active break":ti,ab,kw OR "active breaks":ti,ab,kw OR "passive break":ti,ab,kw OR "passive breaks":ti,ab,kw OR "rest break":ti,ab,kw OR "rest breaks":ti,ab,kw OR "cognitive break":ti,ab,kw OR "cognitive breaks":ti,ab,kw OR "frequent break":ti,ab,kw OR "frequent breaks":ti,ab,kw OR "regular break":ti,ab,kw OR "regular breaks":ti,ab,kw OR "taking break":ti,ab,kw OR "taking breaks":ti,ab,kw OR "break activity":ti,ab,kw OR "break activities":ti,ab,kw OR "break schedule":ti,ab,kw OR "break schedules":ti,ab,kw OR "scheduling break":ti,ab,kw OR "scheduling breaks":ti,ab,kw OR "scheduled break":ti,ab,kw OR "scheduled breaks":ti,ab,kw OR "employee break":ti,ab,kw OR "employee breaks":ti,ab,kw

#3 #1 OR #2

#4 [mh workplace] OR [mh work] OR [mh "work schedule tolerance"]

#5 "work*":ti,ab,kw OR "occupation*":ti,ab,kw OR "job":ti,ab,kw OR "jobs":ti,ab,kw OR "employee*":ti,ab,kw

#6 #4 OR #5

#7 [mh "musculoskeletal diseases"] OR [mh "musculoskeletal pain"] OR [mh "occupational diseases"] OR [mh "occupational injuries"] OR [mh "occupational health"] OR [mh "cumulative trauma disorders"] OR [mh "carpal tunnel syndrome"] OR [mh "shoulder pain"] OR [mh "neck pain"] OR [mh "back pain"] OR [mh "leg injuries"] OR [mh "back injuries"] OR [mh "neck injuries"] OR [mh "arm injuries"] OR [mh "hand injuries"] OR [mh "upper extremity"] OR [mh "lower extremity"] OR [mh "muscle fatigue"] OR [mh posture] OR [mh movement] OR [mh fatigue] OR [mh "physical exertion"]

#8 "occupational overuse":ti,ab,kw OR "tension neck":ti,ab,kw OR "cumulative trauma":ti,ab,kw OR "musculoskeletal*":ti,ab,kw OR "skeletal*":ti,ab,kw OR "pain":ti,ab,kw OR "disorder*":ti,ab,kw OR "carpal tunnel":ti,ab,kw OR "discomfort":ti,ab,kw OR "well-being":ti,ab,kw OR "wellbeing":ti,ab,kw OR "myalgia":ti,ab,kw OR "muscle*":ti,ab,kw OR "muscular*":ti,ab,kw OR "postur*":ti,ab,kw OR "position*":ti,ab,kw

#9 ("repetiti*":ti,ab,kw OR "monoton*":ti,ab,kw) AND ("strain":ti,ab,kw OR "stress":ti,ab,kw OR "motion":ti,ab,kw OR "movement":ti,ab,kw OR "workload*":ti,ab,kw OR "task":ti,ab,kw OR "tasks":ti,ab,kw) AND ("injur*":ti,ab,kw OR "disorder*":ti,ab,kw OR "disease*":ti,ab,kw OR "decreas*":ti,ab,kw OR "reduc*":ti,ab,kw)

#10 #7 OR #8 OR #9

#11 #3 AND #6 AND #10

#12 ([mh animals] OR "animal*":ti,ab,kw) NOT ([mh humans] OR "human*":ti,ab,kw)

#13 #11 NOT #12

#14 #13 "in Trials"

Appendix 3. Embase (embase.com; OVID) search strategy

#1 "rest":de

#2 "rest period":ti,ab OR "rest periods":ti,ab OR "resting period":ti,ab OR "resting periods":ti,ab OR "work pause":ti,ab OR "work pauses":ti,ab OR "work interruption":ti,ab OR "work interruptions":ti,ab OR "work break":ti,ab OR "work breaks":ti,ab OR "work break*":ti,ab OR "micro break":ti,ab OR "micro breaks":ti,ab OR "micro break*":ti,ab OR "microbreak*":ti,ab OR "rest break":ti,ab OR "rest breaks":ti,ab OR "rest break*":ti,ab OR "break pattern":ti,ab OR "break patterns":ti,ab OR "break frequency":ti,ab OR "break frequencies":ti,ab OR "break duration":ti,ab OR "short break":ti,ab OR "short breaks":ti,ab OR "coffee break":ti,ab OR "coffee breaks":ti,ab OR "lunch break":ti,ab OR "lunch breaks":ti,ab OR "break type":ti,ab OR "break types":ti,ab OR "active break":ti,ab OR "active breaks":ti,ab OR "passive break":ti,ab OR "passive breaks":ti,ab OR "cognitive break":ti,ab OR "cognitive breaks":ti,ab OR "frequent break":ti,ab OR "frequent breaks":ti,ab OR "regular break":ti,ab OR "regular breaks":ti,ab OR "taking break":ti,ab OR "taking breaks":ti,ab OR "break activity":ti,ab OR "break activities":ti,ab OR "break schedule":ti,ab OR "break schedules":ti,ab OR "scheduling break":ti,ab OR "scheduling breaks":ti,ab OR "scheduled break":ti,ab OR "scheduled breaks":ti,ab OR "employee break":ti,ab OR "employee breaks":ti,ab

#3 #1 OR #2

#4 "workplace":de OR "work":de OR "work schedule":de

#5 "work*":ti,ab OR "occupation*":ti,ab OR "job":ti,ab OR "jobs":ti,ab OR "employee*":ti,ab

#6 #4 OR #5

#7 "musculoskeletal disease":de OR "musculoskeletal pain":de OR "occupational disease":de OR "occupational health":de OR "cumulative trauma disorder":de OR "carpal tunnel syndrome":de OR "shoulder pain":de OR "neck pain":de OR "back pain":de OR "backache":de OR "leg injury":de OR "neck injury":de OR "arm injury":de OR "hand injury":de OR "arm":de OR "body posture":de OR "movement (physiology)":de OR "fatigue":de

#8 "occupational injur*":ti,ab OR "back injur*":ti,ab OR "lower extremity*":ti,ab OR "occupational overuse":ti,ab OR "tension neck":ti,ab OR "cumulative trauma":ti,ab OR "musculoskeletal*":ti,ab OR "skeletal*":ti,ab OR "pain":ti,ab OR "disorder*":ti,ab OR "carpal tunnel":ti,ab OR "discomfort":ti,ab OR "well-being":ti,ab OR "wellbeing":ti,ab OR "myalgia":ti,ab OR "muscle*":ti,ab OR "muscular*":ti,ab OR "postur*":ti,ab OR "position*":ti,ab OR "physical exertion":ti,ab

#9 ("repetiti*":ti,ab OR "monoton*":ti,ab) AND ("strain":ti,ab OR "stress":ti,ab OR "motion":ti,ab OR "movement":ti,ab OR "workload*":ti,ab OR "task":ti,ab OR "tasks":ti,ab) AND ("injur*":ti,ab OR "disorder*":ti,ab OR "disease*":ti,ab OR "decreas*":ti,ab OR "reduc*":ti,ab)

#10 #7 OR #8 OR #9

#11 #3 AND #6 AND #10

#12 ("animal":de OR "animal*":ti,ab) NOT ("human":de OR "human*":ti,ab)

#13 #11 NOT #12

Appendix 4. CINAHL (EBSCO) search strategy

S1 TX rest NOT MW "bed rest"

S2 TX "rest period" OR TX "rest periods" OR TX "resting period" OR TX "resting periods" OR TX "work pause" OR TX "work pauses" OR TX "work interruption" OR TX "work interruptions" OR TX "work break" OR TX "work breaks" OR TX "work-break*" OR TX "micro break" OR TX "micro breaks" OR TX "micro-break*" OR TX microbreak* OR TX "rest break" OR TX "rest breaks" OR TX "rest-break*" OR TX "break pattern" OR TX "break patterns" OR TX "break frequency" OR TX "break frequencies" OR TX "break duration" OR TX "short break" OR TX "short breaks" OR TX "coffee break" OR TX "coffee breaks" OR TX "lunch break" OR TX "lunch breaks" OR TX "break type" OR TX "break types" OR TX "active break" OR TX "active breaks" OR TX "passive break" OR TX "passive breaks" OR TX "cognitive break" OR TX "cognitive breaks" OR TX "frequent break" OR TX "frequent breaks" OR TX "regular break" OR TX "regular breaks" OR TX "taking break" OR TX "taking breaks" OR TX "break activity" OR TX "break activities" OR TX "break schedule" OR TX "break schedules" OR TX "scheduling break" OR TX "scheduling breaks" OR TX "scheduled break" OR TX "scheduled breaks" OR TX "employee break" OR TX "employee breaks"

S3 S1 OR S2

S4 SU "work environment" OR MW "work environment" OR SU work OR MW work

S5 TX work* OR TX occupation* OR TX job OR TX jobs OR TX employee*

S6 S4 OR S5

S7 SU "musculoskeletal diseases" OR SU "muscle pain" OR SU "occupational diseases" OR SU "occupational-related injuries" OR SU "occupational health" OR SU "cumulative trauma disorders" OR SU "carpal tunnel syndrome" OR SU "shoulder pain" OR SU "neck pain" OR SU "back pain" OR SU "leg injuries" OR SU "back injuries" OR SU "neck injuries" OR SU "arm injuries" OR SU "hand injuries" OR SU "upper extremity" OR SU "lower extremity" OR SU "muscle fatigue" OR SU posture OR SU movement OR SU fatigue OR SU exertion

S8 TX "occupational overuse" OR TX "tension neck" OR TX "cumulative trauma" OR TX musculoskeletal* OR TX skeletal* OR TX pain OR TX disorder* OR TX "carpal tunnel" OR TX discomfort OR TX well-being OR TX wellbeing OR TX myalgia OR TX muscle* OR TX muscular* OR TX postur* OR TX position*

S9 (TX repetiti* OR TX monoton*) AND (TX strain OR TX stress OR TX motion OR TX movement OR TX workload* OR TX task OR TX tasks) AND (TX injur* OR TX disorder* OR TX disease* OR TX decreas* OR TX reduc*)

S10 S7 OR S8 OR S9

S11 S3 AND S6 AND S10

S12 (SU animals OR TX animal*) NOT (SU human OR TX human*)

Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers (Review)

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S13 S11 NOT S12

Appendix 5. PsycINFO (ProQuest; OVID) search strategy

S1 DE("work scheduling") OR DE("workday shifts") OR DE("work rest cycles")

S2 TI("rest period") OR TI("rest periods") OR TI("resting period") OR TI("resting periods") OR TI("work pause") OR TI("work pauses") OR TI("work interruption") OR TI("work interruptions") OR TI("work break") OR TI("work breaks") OR TI("work-break*") OR TI("micro break") OR TI("micro breaks") OR TI("micro-break*") OR TI("microbreak*") OR TI("rest break") OR TI("rest breaks") OR TI("rest-break*") OR TI("break pattern") OR TI("break patterns") OR TI("break frequency") OR TI("break frequencies") OR TI("break duration") OR TI("short break") OR TI("short breaks") OR TI("coffee break") OR TI("coffee breaks") OR TI("lunch break") OR TI("lunch breaks") OR TI("break type") OR TI("break types") OR TI("active break") OR TI("active breaks") OR TI("passive break") OR TI("passive breaks") OR TI("cognitive break") OR TI("cognitive breaks") OR TI("frequent break") OR TI("frequent breaks") OR TI("regular break") OR TI("regular breaks") OR TI("taking break") OR TI("taking breaks") OR TI("break activity") OR TI("break activities") OR TI("break schedule") OR TI("break schedules") OR TI("scheduling break") OR TI("scheduling breaks") OR TI("scheduled break") OR TI("scheduled breaks") OR TI("employee break") OR TI("employee breaks")

S3 AB("rest period") OR AB("rest periods") OR AB("resting period") OR AB("resting periods") OR AB("work pause") OR AB("work pauses") OR AB("work interruption") OR AB("work interruptions") OR AB("work break") OR AB("work breaks") OR AB("work-break*") OR AB("micro break") OR AB("micro breaks") OR AB("micro-break*") OR AB("microbreak*") OR AB("rest break") OR AB("rest breaks") OR AB("rest-break*") OR AB("break pattern") OR AB("break patterns") OR AB("break frequency") OR AB("break frequencies") OR AB("break duration") OR AB("short break") OR AB("short breaks") OR AB("coffee break") OR AB("coffee breaks") OR AB("lunch break") OR AB("lunch breaks") OR AB("break type") OR AB("break types") OR AB("active break") OR AB("active breaks") OR AB("passive break") OR AB("passive breaks") OR AB("cognitive break") OR AB("cognitive breaks") OR AB("frequent break") OR AB("frequent breaks") OR AB("regular break") OR AB("regular breaks") OR AB("taking break") OR AB("taking breaks") OR AB("break activity") OR AB("break activities") OR AB("break schedule") OR AB("break schedules") OR AB("scheduling break") OR AB("scheduling breaks") OR AB("scheduled break") OR AB("scheduled breaks") OR AB("employee break") OR AB("employee breaks")

S4 KW("rest period") OR KW("rest periods") OR KW("resting period") OR KW("resting periods") OR KW("work pause") OR KW("work pauses") OR KW("work interruption") OR KW("work interruptions") OR KW("work break") OR KW("work breaks") OR KW("work-break*") OR KW("micro break") OR KW("micro breaks") OR KW("micro-break*") OR KW("microbreak*") OR KW("rest break") OR KW("rest breaks") OR KW("rest-break*") OR KW("break pattern") OR KW("break patterns") OR KW("break frequency") OR KW("break frequencies") OR KW("break duration") OR KW("short break") OR KW("short breaks") OR KW("coffee break") OR KW("coffee breaks") OR KW("lunch break") OR KW("lunch breaks") OR KW("break type") OR KW("break types") OR KW("active break") OR KW("active breaks") OR KW("passive break") OR KW("passive breaks") OR KW("cognitive break") OR KW("cognitive breaks") OR KW("frequent break") OR KW("frequent breaks") OR KW("regular break") OR KW("regular breaks") OR KW("taking break") OR KW("taking breaks") OR KW("break activity") OR KW("break activities") OR KW("break schedule") OR KW("break schedules") OR KW("scheduling break") OR KW("scheduling breaks") OR KW("scheduled break") OR KW("scheduled breaks") OR KW("employee break") OR KW("employee breaks")

S5 S1 OR S2 OR S3 OR S4

S6 DE("workplace intervention") OR DE("working conditions")

S7 TI(work*) OR TI(occupation*) OR TI(job) OR TI(jobs) OR TI(employee*)

S8 AB(work*) OR AB(occupation*) OR AB(job) OR AB(jobs) OR AB(employee*)

S9 KW(work*) OR KW(occupation*) OR KW(job) OR KW(jobs) OR KW(employee*)

S10 S6 OR S7 OR S8 OR S9

S11 DE("musculoskeletal disorders") OR DE("muscular disorders") OR DE("occupational health") OR DE("work related illnesses") OR DE("back pain") OR DE("posture") OR DE("musculoskeletal system") OR DE("fatigue") OR DE("occupational stress")

S12 TI("occupational overuse") OR TI("tension neck") OR TI("cumulative trauma") OR TI(musculoskeletal*) OR TI(skeletal*) OR TI(pain) OR TI(disorder*) OR TI("carpal tunnel") OR TI(discomfort) OR TI(well-being) OR TI(wellbeing) OR TI(myalgia) OR TI(muscle*) OR TI(muscular*) OR TI(postur*) OR TI(position*)

S13 AB ("occupational overuse") OR AB("tension neck") OR AB("cumulative trauma") OR AB(musculoskeletal*) OR AB(skeletal*) OR AB(pain) OR AB(disorder*) OR AB("carpal tunnel") OR AB(discomfort) OR AB(well-being) OR AB(wellbeing) OR AB(myalgia) OR AB(muscle*) OR AB(muscular*) OR AB(postur*) OR AB(position*)

S14 KW("occupational overuse") OR KW("tension neck") OR KW("cumulative trauma") OR KW(musculoskeletal*) OR KW(skeletal*) OR KW(pain) OR KW(disorder*) OR KW("carpal tunnel") OR KW(discomfort) OR KW(well-being) OR KW(wellbeing) OR KW(myalgia) OR KW(muscle*) OR KW(muscular*) OR KW(postur*) OR KW(position*)

Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers (Review)

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S15 (TI(repetiti*) OR TI(monoton*) OR AB(repetiti*) OR AB(monoton*) OR KW(repetiti*) OR KW(monoton*)) AND (TI (strain) OR TI(stress) OR TI(motion) OR TI(movement) OR TI(workload*) OR TI(task) OR TI(tasks) OR AB(strain) OR AB(stress) OR AB(motion) OR AB(movement) OR AB(workload*) OR AB(task) OR AB(tasks) OR KW(strain) OR KW(stress) OR KW(motion) OR KW(movement) OR KW(workload*) OR KW(task) OR KW(tasks)) AND (TI (injur*) OR TI(disorder*) OR TI(disease*) OR TI(decreas*) OR TI(reduc*) OR AB(injur*) OR AB(disorder*) OR AB(disease*) OR AB(decreas*) OR AB(reduc*) OR KW(injur*) OR KW(disorder*) OR KW(disease*) OR KW(decreas*) OR KW(reduc*))

S16 S11 OR S12 OR S13 OR S14 OR S15

S17 S5 AND S10 AND S16

S18 (PO(animal) OR DE(animals) OR TI(anim*) OR AB(anim*) OR KW(anim*)) NOT (PO(human) OR DE("human males") OR DE("human females") OR TI(human*) OR AB(human*) OR KW(human*))

S19 S17 NOT S18

Appendix 6. SCOPUS (Elsevier) search strategy

#1 TITLE-ABS-KEY("rest period") OR TITLE-ABS-KEY("rest periods") OR TITLE-ABS-KEY("resting period") OR TITLE-ABS-KEY("resting periods") OR TITLE-ABS-KEY("work pause") OR TITLE-ABS-KEY("work pauses") OR TITLE-ABS-KEY("work interruption") OR TITLE-ABS-KEY("work interruptions") OR TITLE-ABS-KEY("work break") OR TITLE-ABS-KEY("work breaks") OR TITLE-ABS-KEY("work-break*") OR TITLE-ABS-KEY("micro break") OR TITLE-ABS-KEY("micro breaks") OR TITLE-ABS-KEY("micro-break*") OR TITLE-ABS-KEY("microbreak*") OR TITLE-ABS-KEY("rest break") OR TITLE-ABS-KEY("rest breaks") OR TITLE-ABS-KEY("rest-break*") OR TITLE-ABS-KEY("break pattern") OR TITLE-ABS-KEY("break patterns") OR TITLE-ABS-KEY("break frequency") OR TITLE-ABS-KEY("break frequencies") OR TITLE-ABS-KEY("break duration") OR TITLE-ABS-KEY("short break") OR TITLE-ABS-KEY("short breaks") OR TITLE-ABS-KEY("coffee break") OR TITLE-ABS-KEY("coffee breaks") OR TITLE-ABS-KEY("lunch break") OR TITLE-ABS-KEY("lunch breaks") OR TITLE-ABS-KEY("break type") OR TITLE-ABS-KEY("break types") OR TITLE-ABS-KEY("active break") OR TITLE-ABS-KEY("active breaks") OR TITLE-ABS-KEY("passive break") OR TITLE-ABS-KEY("passive breaks") OR TITLE-ABS-KEY("cognitive break") OR TITLE-ABS-KEY("cognitive breaks") OR TITLE-ABS-KEY("frequent break") OR TITLE-ABS-KEY("frequent breaks") OR TITLE-ABS-KEY("regular break") OR TITLE-ABS-KEY("regular breaks") OR TITLE-ABS-KEY("taking break") OR TITLE-ABS-KEY("taking breaks") OR TITLE-ABS-KEY("break activity") OR TITLE-ABS-KEY("break activities") OR TITLE-ABS-KEY("break schedule") OR TITLE-ABS-KEY("break schedules") OR TITLE-ABS-KEY("scheduling break") OR TITLE-ABS-KEY("scheduling breaks") OR TITLE-ABS-KEY("scheduled break") OR TITLE-ABS-KEY("scheduled breaks") OR TITLE-ABS-KEY("employee break") OR TITLE-ABS-KEY("employee breaks")

#2 TITLE-ABS-KEY(work*) OR TITLE-ABS-KEY(occupation*) OR TITLE-ABS-KEY(job) OR TITLE-ABS-KEY(jobs) OR TITLE-ABS-KEY(employee*)

#3 TITLE-ABS-KEY("occupational overuse") OR TITLE-ABS-KEY("tension neck") OR TITLE-ABS-KEY("cumulative trauma") OR TITLE-ABS-KEY(musculoskeletal*) OR TITLE-ABS-KEY(skeletal*) OR TITLE-ABS-KEY(pain) OR TITLE-ABS-KEY(disorder*) OR TITLE-ABS-KEY("carpal tunnel") OR TITLE-ABS-KEY(discomfort) OR TITLE-ABS-KEY(well-being) OR TITLE-ABS-KEY(wellbeing) OR TITLE-ABS-KEY(myalgia) OR TITLE-ABS-KEY(muscle*) OR TITLE-ABS-KEY(muscular*) OR TITLE-ABS-KEY(postur*) OR TITLE-ABS-KEY(position*)

#4 (TITLE-ABS-KEY(repetiti*) OR TITLE-ABS-KEY(monoton*)) AND (TITLE-ABS-KEY(strain) OR TITLE-ABS-KEY(stress) OR TITLE-ABS-KEY(motion) OR TITLE-ABS-KEY(movement) OR TITLE-ABS-KEY(workload*) OR TITLE-ABS-KEY(task) OR TITLE-ABS-KEY(tasks)) AND (TITLE-ABS-KEY(injur*) OR TITLE-ABS-KEY(disorder*) OR TITLE-ABS-KEY(disease*) OR TITLE-ABS-KEY(decreas*) OR TITLE-ABS-KEY(reduc*))

#5 #3 OR #4

#6 #1 AND #2 AND #5

#7 TITLE-ABS-KEY(anim*) AND NOT TITLE-ABS-KEY(human*)

#8 #6 AND NOT #7

Appendix 7. Web of Science (Thomson Reuters) search strategy

#1 TS="rest period" OR TS="rest periods" OR TS="resting period" OR TS="resting periods" OR TS="work pause" OR TS="work pauses" OR TS="work interruption" OR TS="work interruptions" OR TS="work break" OR TS="work breaks" OR TS="work-break*" OR TS="micro break" OR TS="micro breaks" OR TS="micro-break*" OR TS="microbreak*" OR TS="rest break" OR TS="rest breaks" OR TS="rest-break*" OR TS="break pattern" OR TS="break patterns" OR TS="break frequency" OR TS="break duration" OR TS="short break" OR TS="short breaks" OR TS="coffee break" OR TS="coffee breaks" OR TS="break type" OR TS="break types" OR TS="active break" OR TS="active breaks" OR TS="passive break" OR TS="passive breaks" OR TS="cognitive break" OR TS="cognitive breaks" OR TS="frequent break" OR TS="frequent breaks" OR TS="regular break" OR TS="regular breaks" OR TS="taking break" OR TS="taking breaks" OR TS="break activity" OR TS="break activities" OR TS="break schedule" OR TS="break schedules" OR TS="scheduling break" OR TS="scheduling breaks" OR TS="scheduled break" OR TS="scheduled breaks" OR TS="employee break" OR TS="employee breaks"

#2 TS=work* OR TS=occupation* OR TS=job OR TS=jobs OR TS=employee*

#3 TS="occupational overuse" OR TS="tension neck" OR TS="cumulative trauma" OR TS="musculoskeletal*" OR TS="skeletal*" OR TS="pain" OR TS="disorder*" OR TS="carpal tunnel" OR TS="discomfort" OR TS="well-being" OR TS="wellbeing" OR TS="myalgia" OR TS="muscle*" OR TS="muscular*" OR TS="postur*" OR TS="position*" OR TS="cumulative trauma disorder*" OR TS="injury" OR TS="injuries" OR TS="extremity" OR TS="extremities" OR TS="muscle fatigue" OR TS="physical exertion"

#4 (TS="repetiti*" OR TS="monoton*") AND (TS="strain" OR TS="stress" OR TS="motion" OR TS="movement" OR TS="workload*" OR TS="task" OR TS="tasks") AND (TS="injur*" OR TS="disorder*" OR TS="disease*" OR TS="decreas*" OR TS="reduc*")

#5 #3 OR #4

#6 #1 AND #2 AND #5

#7 TS="animal*" NOT TS="human"

#8 #6 NOT #7

Appendix 8. ClinicalTrials.gov (clinicaltrials.gov) search strategy

#1 work OR occupation OR job OR employee

#2 "rest break" OR break OR pause

#3 #1 AND #2

Appendix 9. World Health Organization (WHO) International Clinical Trials Registry Platform (ICTRP; who.int/ictRP/en/) search strategy

#1 work OR occupation OR job OR employee

#2 "rest break" OR break OR pause

#3 #1 AND #2

CONTRIBUTIONS OF AUTHORS

Conceiving the protocol: TL

Designing the protocol: TL, CM, MR, BS

Coordinating the protocol: TL, CM, BS

Designing search strategies: TL, BS

Writing the protocol: TL, CM, MR, BS

Providing general advice on the protocol: CM

Selection of studies: TL, BS

Data extraction: TL, BS

Data analysis: TL

Writing the review: TL, CM, MR, BS

DECLARATIONS OF INTEREST

Tessy Luger: None known

Christopher Maher: I have received competitive grants from government agencies and industry to support my research. As an invited speaker at conferences, I have had my expenses covered and also received small gifts such as a box of chocolates or a bottle of wine. I have received honoraria for marking theses, reviewing grants and preparing talks.

Monika A. Rieger: Our Institute receives an unrestricted grant by Südwestmetall (employers' association of the metal and electric industry Baden-Württemberg) which covered about half of the costs of the Institute for several years. The cooperation treaty between Südwestmetall, University of Tübingen, Medical Faculty of the University of Tübingen, University Hospital of Tübingen rules all aspects which are necessary to secure the 'unrestrictedness', and a board of independent trustees monitors this regulation.

Benjamin Steinhilber: None known

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- Australia's National Health and Medical Research Council, Australia.

Funding for the fellowship of CM.

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

The objective and title were modified, including also symptoms besides disorders, since symptoms are recognised as a precursor of developing disorders, including self-reported musculoskeletal pain, discomfort and fatigue.

The title and objectives were modified, so that it is clear that only healthy workers were considered, since the aim is primary prevention. In addition, we provided a definition of a healthy worker in the section on types of participants.

The work-break intervention had to happen at work, meaning that our definition of a work break did not include a free evening after work, a weekend or a holiday. In the section on types of interventions, we added that the work-break intervention had to happen at work and during working hours.

In the section on types of outcome measures, we modified the first two primary outcome categories. Originally, they were called participant-reported musculoskeletal pain and participant-reported musculoskeletal discomfort or fatigue. They have been modified into newly diagnosed musculoskeletal disorders and participant-reported musculoskeletal symptoms, including pain, discomfort and fatigue. This categorisation is better, since we are focussed on primary prevention. Although none of the included studies lasted long enough to report on diagnosed disorders, all of them reported either pain, discomfort or fatigue as a symptom which is recognised as preceding the actual development of disorders.

We performed sensitivity analyses to check whether combining the outcomes participant-reported musculoskeletal pain, participant-reported musculoskeletal discomfort, and participant-reported musculoskeletal fatigue was justified. Similarly, we performed sensitivity analyses to check whether combining the different outcome measures of productivity and work performance was justified. We added this information in the section on sensitivity analyses and reported the results in the sections where the effects of interventions were described. In addition, the sensitivity analyses are discussed in the section on potential biases in the review process.

The planned number of comparison categories in the protocol was three; however, after collecting the studies, we decided to create five comparisons in the review, which belonged to one of the three main categories of comparisons: frequency, duration or type of work breaks.

INDEX TERMS

Medical Subject Headings (MeSH)

*Health Personnel; *Personnel Staffing and Scheduling; Ergonomics; Health Workforce; Musculoskeletal Diseases [*prevention & control]; Occupational Diseases [*prevention & control]; Randomized Controlled Trials as Topic; Workplace

MeSH check words

Adult; Humans