Pre-employment examinations for preventing injury, disease and sick leave in workers

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[Intervention Review]

Pre-employment examinations for preventing injury, disease and sick leave in workers

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ABSTRACT

Background

Many employers and other stakeholders believe that health examinations of job applicants prevent occupational diseases and sickness absence. This is an update of the original Cochrane review (Mahmud 2010).

Objectives

To evaluate the effectiveness of pre-employment examinations of job applicants in preventing occupational injury, disease and sick leave compared to no intervention or alternative interventions.

Search methods

We searched CENTRAL (the Cochrane Library), MEDLINE, EMBASE, CINAHL, PsycINFO and PEDro (up to 31 March 2015). We did not impose any restrictions on date, language or publication type.

Selection criteria

We included randomised controlled trials (RCTs), controlled before-after (CBA) studies, and interrupted time-series (ITS) studies of health examinations to prevent occupational diseases and injuries in job applicants in comparison to no intervention or alternative interventions.

Data collection and analysis

All five review authors independently selected studies from the updated search for inclusion. We retrieved two new studies with the updated search from 1 April 2008 to 31 March 2015, resulting in a total of eleven studies.

Main results

We included two RCTs, seven CBA studies and two ITS studies. Nine studies with 7820 participants evaluated the screening process of pre-employment examinations as a whole, and two studies with 2164 participants evaluated the measures to mitigate the risks found following the screening process. The studies were too heterogeneous for statistical pooling of results. We rated the quality of the evidence for all outcomes as very low quality. The two new CBA studies both used historical controls and both had a high risk of bias.

Of those studies that evaluated the screening process, there is very low quality evidence based on one RCT that a general examination for light duty work may not reduce the risk for sick leave (mean difference (MD) -0.09, 95% confidence interval (CI) -0.47 to 0.29). For army recruits, there is very low quality evidence based on one CBA study that there is a positive effect on fitness for duty after 12 months follow-up (odds ratio (OR) 0.40, 95% CI 0.19 to 0.85).

We found inconsistent evidence of an effect of job-focused pre-employment examinations on the risk of musculoskeletal injuries in comparison with general or no pre-employment examination based on one RCT with high risk of bias, and four CBA studies. There is very low quality evidence based on one ITS study that incorporation of a bronchial challenge test may decrease occupational asthma (trend change -2.6, 95% CI -3.6 to -1.5) compared to a general pre-employment examination with lung function tests.

Pre-employment examinations may also result in a rejection of the applicant for the new job. In six studies, the rates of rejecting job applicants increased because of the studied examinations , on average, from 2% to 35%, but not in one study.

There is very low quality evidence based on two CBA studies that risk mitigation among applicants considered not fit for work at the pre-employment examination may result in a similar risk of work-related musculoskeletal injury during follow-up compared to workers considered fit for work at the health examination.

Authors' conclusions

There is very low quality evidence that a general examination for light duty work may not reduce the risk for sick leave, but may have a positive effect on fitness for duty for army recruits after 12 months follow-up.

There is inconsistent evidence of an effect of job-focused pre-employment examinations on the risk of musculoskeletal injuries in comparison with general or no pre-employment examination. There is very low quality evidence that incorporation of a bronchial challenge test may decrease occupational asthma compared to a general pre-employment examination with lung function tests. Pre-employment examinations may result in an increase of rejecting job applicants in six out of seven studies.

Risk mitigation based on the result of pre-employment examinations may be effective in reducing an increased risk for occupational injuries based on very low quality evidence. This evidence supports the current policy to restrict pre-employment examinations to only job-specific examinations. Better quality evaluation studies on pre-employment examinations are necessary, including the evaluation of the benefits of risk mitigation, given the effect on health and on the financial situation for those employees who do not pass the pre-employment examination.

PLAIN LANGUAGE SUMMARY

Health examination of people before they start work at a new job to prevent injuries, disease and sick leave

What is the purpose of health examinations before people start work at a new job?

The aim of pre-employment examinations is to find people who may have a higher risk for occupational disease, injury or sick leave if they are given the job. By not employing job applicants with higher health risks, it may be possible to prevent disease or injury. These possible health benefits come at the cost of the applicants not having a job. Other prevention strategies are to fix the problems found at the examination by changing work tasks or by physical fitness training.

How has this been studied?

We conducted a systematic search for studies that had been published up to 31 March 2015. We found eleven studies, including 7820 people that evaluated the whole process of health examinations, including rejection of applicants with higher risks of occupational disease, injury or sick leave.

What did the research find out?

One of the included studies found that a general examination did not reduce sick leave among light duty workers compared to no intervention. However, another study found that army recruits were more fit for duty 12 months after a health examination. Results were inconsistent in five studies that compared job-focused pre-employment examinations with no health examination or with a general health examination. Pre-employment examinations may also result in the rejection of a job applicant. In six studies the rates of rejecting job applicants because of health examinations increased, on average, from 2% to 35%, but not in one study. Two of the included 11 studies (including 2164 people) compared job applicants that were considered fit during the health examination to those who received particular recommendations to address health-related issues based on the health examination. Both studies reported no difference in musculoskeletal injury rates between groups during follow-up. This means that job applicants were able to take care of the health problems identified during their health examinations.

Quality of the evidence

We rated all studied comparisons providing very low quality evidence.

Conclusions

Health examinations that focus on health risks of particular jobs may be effective. Adequately dealing with potential health risks by changing work tasks or physical fitness training may also be effective. We need more and better quality evaluation studies. Not allowing people to work in certain jobs may have effects on their health. It also costs them money. Future research should assess both.

BACKGROUND

Many employers and other stakeholders believe that health examinations of job applicants can prevent occupational diseases and sick leave (Pachman 2009). Even though concrete figures are lacking, it is our impression that pre-employment examinations are widely applied in most countries of the world, and that many health professionals perform pre-employment examinations.

Description of the intervention

In this review, we use the widely accepted definition of pre-employment examinations: "the assessment of a job applicant's capacity to work without risk to their own or others' health and safety" (Cox 2000; Serra 2007). Pre-employment examinations can be carried out before or after a job offer. In the latter case they are called pre-placement examinations. Pre-employment examinations can supposedly prevent injury or disease in the workplace by either rejecting job applicants considered at risk, so that they are not exposed to working conditions that are hazardous particularly to them, or by mitigating the risk through work accommodations or training. Despite great variations in purpose and procedures described in the literature, pre-employment examination usually results in one of the following three conclusions.

1. Low risk of injury or disease; no accommodation needed.
2. At risk of injury or disease; can be mitigated through offer of accommodation (e.g. job modification, job restriction and/or training).
3. At high risk of injury or disease; no possible accommodation (Serra 2007; Nachreiner 1999).

Ethical aspects of pre-employment examinations, such as possible discrimination of people with disabilities, have evoked public debate internationally which has led to the introduction of regulation of pre-employment medical examinations aimed at protecting workers with disabilities (Pachman 2009). In the USA, according to the Americans with Disabilities Act, pre-employment medical examinations may only focus on job-related aspects (ADA 2009). This is also the case in other countries such as Australia, Canada and the Netherlands, in accordance with their respective Occupational Safety and Health Acts. Most pre-employment legislation mandates that employers provide reasonable accommodation for workers with disabilities, leaving it up to employers to decide what may or may not be reasonable. However, it remains unclear what the effectiveness is of pre-employment examinations aiming at reducing the burden of injury or disease in the workplace, whilst remaining non-discriminatory (Serra 2007).

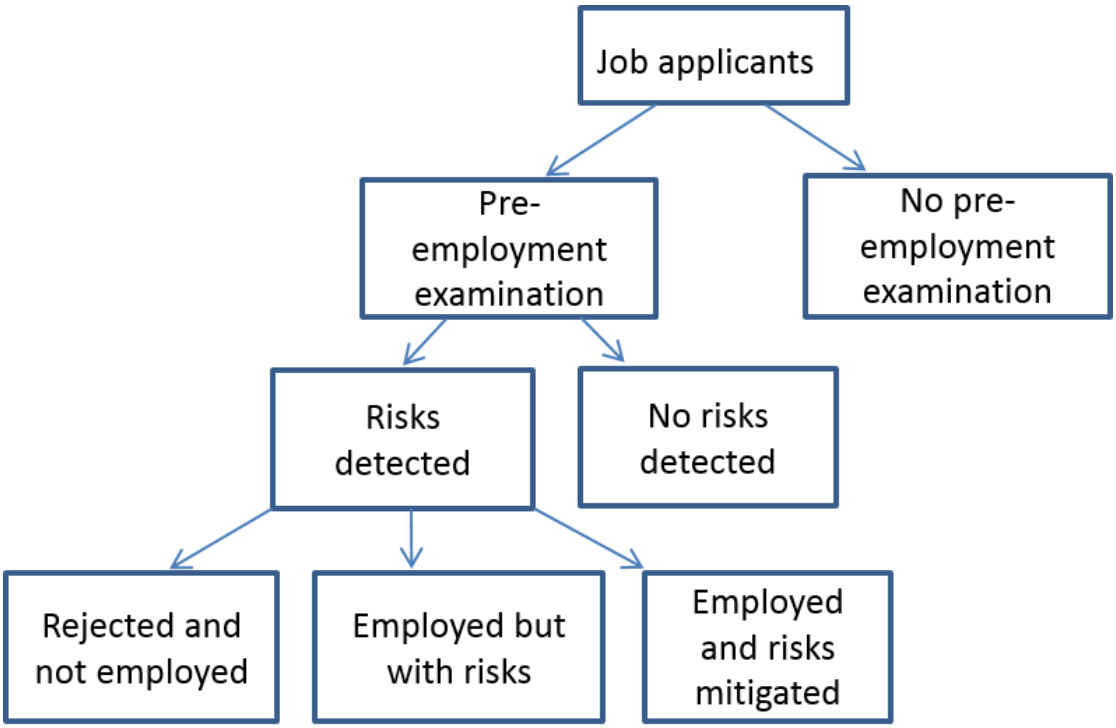
How the intervention might work

Pre-employment examinations are similar to medical screening and face similar complex issues regarding their validity. As with screening, the validity of pre-employment examination goes beyond the accuracy of the test for early diagnosis. Sound evidence is needed that job applicants are better off in the long-run when assessed as being at risk in the prospective job (Straus 2006). As with early diagnosis in screening, job applicants with false positive

screening tests will experience only harm. In the case of pre-employment screening, these workers will be either denied employment or will receive unnecessary work accommodations. The main difference between medical screening and pre-employment examinations is the environment in which the screening takes place. The realisation of the recommendations resulting from the pre-employment examination depends not only on the medical fitness of the job applicant, but also on the willingness or capacity of the employer to offer work accommodations. For job applicants who do not pass the pre-employment screening test there may be an additional harm because they are denied the job they want, which in itself may have an effect on their health or financial situation.

There are two ways to evaluate pre-employment procedures. One way is to evaluate the screening procedure as a whole and to assign participants either to a screening procedure including the resultant recommendations or to no screening procedure (Figure 1). The other option is to include only participants who screen positive for a health problem, and to assign them to either treatment for the problem at issue or not (Barrat 2002). The evaluation of pre-employment examinations is complicated further by the fact that those job-applicants who are rejected are usually lost to follow-up because they are not employed by the employer from whose point of view the research is carried out.

Figure 1. Organisation of pre-employment evaluation studies included in the review



Why it is important to do this review

This is an update of the original Cochrane review by Mahmud 2010b in which the search strategy was executed in 2008. One other systematic review evaluated the effectiveness of pre-employment examinations (Hulshof 1999). They included a wide range of study designs but only one study that evaluated the outcome of pre-employment examinations. Based also on modelling studies, the authors concluded that the lack of effectiveness and efficiency of the pre-employment examination should lead to its abandonment as a means of selection of personnel by occupational health services. Another systematic review examined criteria and methods used for the assessment of fitness for work and reports that there is no evidence to support the cost-effectiveness of examining all candidates and excluding those who are considered unfit to perform

a job (Serra 2007). Given the time since the search of the previous version of this review, and the lack of other recent systematic reviews there is a need for updating this review on the effectiveness of health examinations within the framework of Cochrane.

OBJECTIVES

To evaluate the effectiveness of pre-employment examinations of job applicants in preventing occupational injury, disease and sick leave compared to no intervention or alternative interventions.

METHODS

Criteria for considering studies for this review

Types of studies

We included both randomised controlled trials (RCTs) and non-randomised studies (NRS) in our review. It can be difficult to implement a RCT design in field studies in which occupationally focused health examinations are carried out (Schonstein 2006). For this reason we considered also the following NRS designs for inclusion.

- Controlled before-after (CBA) studies. In these studies, observations are made before and after the implementation of an intervention, both in a group that receives the intervention and in a control group that does not. Studies may use concurrent or historical control groups.

- Interrupted time-series (ITS) studies. In these studies, observations are used at multiple time points before and after an intervention (the 'interruption'). The design attempts to detect whether the intervention has had an effect significantly greater than any underlying trend over time. We included studies that had at least three data points before and three data points after the interrupting intervention (EPOC 2006; Ramsay 2003).

Types of participants

Study participants were job applicants who received a pre-employment health examination. We included studies conducted in all organisational sectors.

Types of interventions

We included: 1) studies that evaluated the pre-employment process as a whole and screening and implementation of recommendations; and 2) studies that only evaluated the addressing of issues found at the pre-employment examination for those that screened positive for being at higher risk for a work-related health injury (see Figure 1).

We included all pre-employment health examinations carried out by a health professional (for example, physician, physiotherapist, nurse) used to evaluate the health status or physical capacity, or both, of job applicants. The results of a pre-employment examination should be used to make recommendations about individuals' capabilities, or ways of improving these to perform a job safely, without increased risk of ill health or injury to themselves or others. The recommendations can be:

1. hire the worker as he/she is considered fit for duties;
2. offer training and/or workplace accommodation to mitigate injury risk; or
3. reject the worker because of significant health or safety risks which cannot be accommodate

Types of outcome measures

We included the following outcome measures.

- Occupational diseases and (musculoskeletal) injuries
- Sick leave
- Fitness for duties
- Medical visits as proxies for occupational diseases and injury outcome measures

As an outcome of the screening procedure, we also included the job applicants' rejection rates. This is considered an adverse outcome when a job applicant is incorrectly denied the job based on the screening ('false positive'). This is considered a desired outcome when a job applicant is correctly denied the job based on the screening ('true positive'). Both true and false positives, however, cannot be distinguished based on the studies included. This is why we reported plain rejection rates.

Search methods for identification of studies

Electronic searches

For the update of this Cochrane review, we searched the following databases: CENTRAL, MEDLINE, EMBASE, Pedro, CINAHL and PsycINFO from 2008 to 31 March 2015 with help from the clinical librarian of the research institute of the primary author (FS) of the review. We used the same search strategy as in the original review in 2008. We did not restrict the searches by date, language or place of publication. The search strategy is outlined in Appendix 1.

Searching other resources

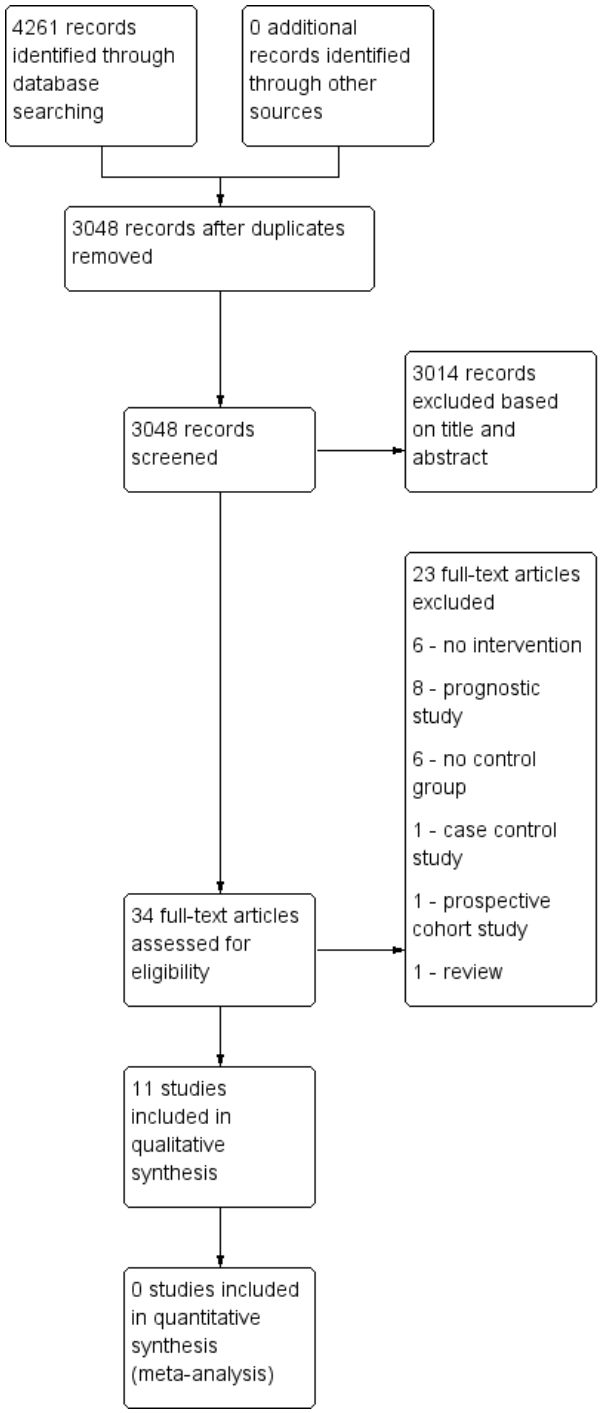
We scanned reference lists of identified studies for further papers.

Data collection and analysis

Selection of studies

All review authors screened titles and abstracts of the potentially relevant studies found in the electronic databases, independently working in pairs. We used the same standardised form of inclusion criteria as in the original review to assist in the selection of studies. The inclusion criteria included type of study, type of intervention, and outcomes measures (Appendix 2) . We documented the reasons for exclusion in the table of Characteristics of excluded studies and recorded the selection process in sufficient detail to complete a PRISMA flow diagram (Figure 2; Moher 2009). When disagreements occurred we discussed the matter until we reached consensus. Following this process, we obtained the full text of all articles that potentially qualified for inclusion. Two review authors (FS, FJ) read the full text of the articles and independently decided whether or not to include any new studies. A third review author (JBF) resolved disagreements.

Figure 2. PRISMA Study flow diagram.



Data extraction and management

Three review authors (FS, JBF, FJ) independently extracted data based on the methods, participants, interventions, outcomes and main results of a study. We used the same standardised data extraction form as in the original review. When disagreements occurred we discussed the matter until we reached consensus. We contacted study authors for more information when there was insufficient information in the study reports.

Assessment of risk of bias in included studies

Including NRS designs increases the likelihood of potential biases. Susceptibility to selection bias is regarded as the principal difference between RCT and NRS designs. Because of this, we chose to use the checklist developed by Downs 1998 to measure risk of bias. This checklist is considered valid and reliable especially for the following features: appropriateness for assessing both randomised studies and NRS; provision of both an overall score for a study and a profile of scores for reporting, internal validity (bias and confounding), power and external validity (MacLean 2006; Oliver 2007).

The criteria for risk of bias consisted of seven items for bias and six items for confounding that are reported in the Characteristics of included studies table. In addition, we measured external validity (three items) and reporting quality (10 items); this is presented in Table 1. We scored the items 'YES', 'NO' or 'UNABLE TO DETERMINE' (Appendix 3).

The Cochrane Effective Practice and Organisation of Care group has developed a quality assessment tool for interrupted time-series studies (EPOC 2006). We used this tool to measure the methodological quality for those studies with an interrupted time series design (Appendix 4). The quality criteria for risk of bias consisted of protection against secular changes (three items), detection bias (two items), completeness of data set (one item) and reliable primary outcome measures (one item). We scored items 'DONE', 'NOT CLEAR' or 'NOT DONE' (Table 2).

Three review authors (FS, JBF, FJ) independently assessed risk of bias. We resolved disagreements by discussion.

Grading the strength of evidence

We assessed the strength of evidence for each outcome using the GRADE approach (GRADE working group 2004) (Appendix 5). The included RCTs had severe study limitations and so we downgraded the quality of evidence by two levels. As we had only single studies addressing each comparison, we further downgraded the quality of the evidence to very low quality. Comparisons that included NRS study designs were either inconsistent or the comparisons were based on single studies with severe study limitations; we therefore considered such comparisons to also yield very low quality evidence.

Measures of treatment effect

For RCT and CBA studies with dichotomous outcomes, the results were plotted as odds ratios (ORs) with 95% confidence intervals (CIs). In case the basic data were not available we used the log odds ratios in the tables to plot the study results (Knapik 2006). For studies with continuous outcomes, we used mean differences (MDs) with 95% CIs. For studies with rates as outcomes we plotted the outcome as the log rate-ratio (Keyserling 1980).

For interrupted time-series (ITS) studies, we extracted data from the original papers and re-analysed them according to recommended methods for analysis of ITS designs for inclusion in systematic reviews (Ramsay 2003). These methods use a segmented time-series regression analysis to estimate the effect of an intervention, while taking into account secular time trends and any autocorrelation between individual observations. We plotted the results of the ITS studies as a change in level immediately following the intervention as the difference between the point in time just before the intervention and the point in time after the intervention (had the pre-intervention trend continued). In addition, we plotted the MD of the trend in time before the intervention with the trend in time after the intervention.

When necessary, we recalculated outcomes so that an effect measure, smaller than one for dichotomous outcomes, and smaller than zero for continuous outcomes, indicates a beneficial effect of the intervention or the most intensive intervention.

The percentage of job applicants rejected was defined as the number of applicants declared unfit divided by the total number of applicants examined.

Unit of analysis issues

There were no cluster-randomised trials for which we had to assess a unit of analysis error.

Dealing with missing data

If the standard deviations (SDs) (continuous data) or numbers of outcomes for each group (dichotomous data) were not presented in the publication, we contacted the authors with a request to provide these data. Whenever authors were unable or unwilling to provide this information, we calculated SDs from P values and CIs following the instructions in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011).

We sought additional information regarding study details or statistical data, or both, from the authors of 20 studies and received

information from 15 authors. Ten of the authors provided statistical data that had not been published in their articles. We included this information in the description of results. In the case of two studies, the correspondence led to the exclusion of the study because the authors could not provide essential information on the primary outcome measure (Simon 2000; Stant 2009). Whenever essential information concerning the risk of bias could not be obtained within four weeks of contacting the authors, we listed the corresponding details as 'unclear'.

Assessment of heterogeneity

We did not conduct meta-analysis in this Cochrane review due to the high clinical heterogeneity and small number of included studies.

Assessment of reporting biases

Due to the small number of studies in each comparison we did not further assess reporting bias.

Data synthesis

We were unable to pool studies due to lack of homogeneity in terms of interventions, participants and outcomes.

Subgroup analysis and investigation of heterogeneity

Due to the small number of studies we did not perform a subgroup analysis.

Sensitivity analysis

Due to the small number of studies we did not perform a sensitivity analysis.

RESULTS

Description of studies

Results of the search

The updated search resulted in 697 new references (after removing duplicates), since the previous search in 2008. After screening the titles and abstracts, we identified seven potentially suitable articles for which we obtained the full text. The screening of each full text article resulted in two new studies that fulfilled our inclusion criteria (Faris 2008; Harbin 2011). In combination with the included studies from the previous search, this resulted in 11 studies for this Cochrane review. Please see Figure 2.

Included studies

Type of study

Nine studies evaluated the pre-employment process as a whole, including screening and recommendations and two studies evaluated only the effectiveness of addressing the problems in workers that screened positive for a higher risk (Knapik 2006; Nachreiner 1999).

We classified two studies as randomised controlled trials (RCTs) (Alexander 1977; de Raad 2004), seven as controlled before-after (CBA) studies (Faris 2008; Hama 2001; Harbin 2011; Keyserling 1980; Knapik 2006; Nachreiner 1999; Rosenblum 2006), with two studies using a historical control group (Faris 2008; Harbin 2011) and two studies as interrupted time series studies (de Looff 1992; Nassau 1999). The two RCTs did not have an adequate randomisation procedure, both alternated the intervention and control conditions.

The two studies (Knapik 2006; Nachreiner 1999) that evaluated addressing the identified issues as a result of the pre-employment screening, compared the effect on injury for workers whose issues were addressed by training or workplace accommodation, to those workers that passed the employment examination without any issues. Both study designs could be called equivalence studies because the intention is to show that the injury outcome of risk mitigation is equal to the injury outcome of workers deemed at low risk as a result of the pre-employment examination.

Location and settings

Eight studies were conducted in the USA (Alexander 1977; Faris 2008; Harbin 2011; Keyserling 1980; Knapik 2006; Nachreiner 1999; Nassau 1999; Rosenblum 2006), two in the Netherlands (de Looff 1992; de Raad 2004) and one study in Japan (Hama 2001).

Three studies were conducted in the military sector (Hama 2001; de Raad 2004; Knapik 2006), four in manufacturing companies (Alexander 1977; de Looff 1992; Keyserling 1980; Rosenblum 2006), two studies in a hospital or outpatient clinic (Faris 2008; Nassau 1999), one study in a school setting (Harbin 2011) and one study in several sectors (manufacturing, healthcare providers and a local government agency) (Nachreiner 1999).

Participants

All participants were job applicants or new army recruits.

Interventions

Please see Table 3 for an overview of included studies and the different types of interventions used.

Studies that evaluated the screening process

Two studies evaluated the effect of a general pre-employment examination with no examination or to an examination of which results were not revealed to the employer (Alexander 1977; Hama 2001). The content of examination was only described in general terms as 'a health evaluation was performed by a nurse, and if any risks were detected the applicant was medically examined by a doctor to categorise into three options: 1) no risk; 2) work restriction imposed but no risk within appropriate job placement; 3) or risk identified' (Alexander 1977). Or the content of the examination was described in much detail such as 'a physical examination, chest circumference, visual examination, colour vision, auditory acuity, vital capacity, height, weight, urinary studies (proteinuria, hematuria, glycosuria), blood pressure, occult blood stool analysis, body mass index, chest radiograph and pulmonary function test (spirometer). In addition, job applicants who were older than 35 years received serum chemistry assay and electrocardiography tests'. Also in this study applicants were categorised into risk groups: 1) A (no abnormalities) and B1 (some abnormalities, no treatment); or 2) B2 (some abnormalities, treatment), C1 (regular follow-up, work restrictions), C2 (treatment, work restrictions) AND D (not able to work due to disease) (Hama 2001).

Five studies evaluated a job-focused or task-specific pre-employment examination to prevent musculoskeletal injuries compared with a general pre-employment examination (de Raad 2004; Harbin 2011; Keyserling 1980; Nassau 1999; Rosenblum 2006) and one study compared such a pre-employment examination to no examination for job applicants (Faris 2008). The content of these job-focused pre-employment examinations were based on various forms of functional capacity evaluations to measure the workers' physical work capacity such as the measurement of muscle strength or lifting capacity in relation to the job-specific biomechanical job analysis (Soer 2008).

One study evaluated bronchial challenge testing to prevent occupational asthma (de Looff 1992). In this study, a histamine provocation test was added to an existing more general pre-employment examination including a medical history, clinical examination and respiratory function tests (FVC, FEV_1) and the urinary fluoride test. The occurrence of occupational asthma was measured in an interrupted time series analysis. In the same period, however, a number of other preventive measures were taken such as decreasing fluoride exposure.

Studies that evaluated the effectiveness of measures to mitigate risks

One study evaluated the effect of extra training offered to army recruits who failed a fitness test (Knapik 2006). In this study, army recruits had to pass a fitness test to be allowed to go into basic combat training. Recruits who failed this fitness test were offered a three-week fitness training programme. The effectiveness of this fitness training programme was evaluated by comparing injury rates to those who had passed the fitness test and did not need the additional training.

In another study, a group of workers deemed at risk of injury as a result of the pre-employment examination were accommodated with work adjustments, and the effect on injuries was compared to a group of workers that were considered fit for work (Nachreiner 1999). The objective of this study was to evaluate the effectiveness of work accommodation.

Follow-up

One study had a short-term follow-up of nine weeks (Knapik 2006). Five studies had long and very long-term follow-up periods ranging from one year (Alexander 1977; Hama 2001; Keyserling 1980; Nachreiner 1999; Rosenblum 2006) to two years (de Raad 2004). For two studies the follow-up period was unclear (Faris 2008; Harbin 2011). Two interrupted time series studies (ITS) were conducted during a period of 10.5 years (Nassau 1999) and 20 years (de Looff 1992).

Outcomes

Injury rates were measured as outcomes in six studies (Faris 2008; Harbin 2011; Knapik 2006; Nachreiner 1999; Nassau 1999; Rosenblum 2006). Two studies measured sick leave (Alexander 1977; de Raad 2004). One study measured fitness for duty and health-related problems of army personnel (hypertension, hyperuricaemia, hyperlipidaemia, severe obesity, dental problems, asthma, musculoskeletal problems, urinary tract problems) (Hama 2001). One study measured the incidence of occupational asthma (de Looff 1992) and another study measured medical visits because of musculoskeletal injuries (Keyserling 1980).

Rejection rates defined as the number of applicants that were deemed unfit for work as a result of the pre-employment examination were available for seven studies (Alexander 1977; de Looff 1992; de Raad 2004; Faris 2008; Harbin 2011; Keyserling 1980; Nassau 1999). The rates varied from 2% for the control group in Nassau 1999 to as high as 31% in the control group in de Raad 2004. After being assessed as unfit, some job applicants were still hired in Alexander 1977 in spite of the results of the pre-employment examination.

Excluded studies

For this updated review we excluded another seven studies. For one study, we contacted the authors of the study because of serious doubts as to whether or not to include the study (Legge 2013). In the end we decided not to include the study as the intervention included a pre-employment examination without any reported advice towards the applicant or employer.

In total, we excluded 16 studies because of inadequate study designs (Ali 2002; Anderson 2008; Barnard 2004; Bigos 1992a; Bigos 1992b; Chaffin 1978; Dale 2014; de Raad 2005; Evans 2005;

Franzblau 2004; Gassoway 2000; La Rocca 1969; Lucey 2008; Madan 2012; Normand 1989; Ryan 2010), six studies because they did not have any recommendations about work accommodations or work restrictions to safely perform the job (Adeyekun 2010; Arndt 2002; Bigos 1987; Bingham 1996; Legge 2013; Lowenthal 1986), and one ITS study because it reported two data points only, before and after the intervention (Harbin 2005).

Risk of bias in included studies

We contacted some study authors for additional information related to the scores 'unable to determine'. Three study authors responded to our request (de Looff 1992; de Raad 2004; Keyserling 1980): we changed three items to 'yes', two items remained as 'no' and we changed two items from 'not clear' to 'not done' (see Appendix 3 and Table 2).

Internal validity: bias and confounding

The results of internal validity for RCT and CBA studies are presented in the 'Risk of bias tables' within the table Characteristics of included studies. The results for internal validity for the two ITS studies are presented in Table 2.

Randomised controlled trials (RCTs)

The internal validity quality ratings for the two RCTs included were 7/13 (Alexander 1977) and 8/13 (de Raad 2004). One RCT used blinded outcome assessors (Alexander 1977). Neither study reported on the adequacy of concealment of participants and healthcare providers during the intervention. The method of randomisation used in Alexander 1977 was not adequate, and it was not reported in de Raad 2004.

Controlled before-after (CBA) studies

The internal validity quality ratings for CBA studies were 2/13 (Faris 2008), 5/13 (Harbin 2011), 6/13 (Hama 2001), 7/13 (Knapik 2006) and 8/13 (Keyserling 1980; Nachreiner 1999; Rosenblum 2006). Outcome assessment was done blind in two studies (Hama 2001; Rosenblum 2006).

Interrupted time series study designs (ITS)

The internal validity quality ratings for the two ITS studies were 4/7 (de Looff 1992) and 5/7 (Nassau 1999). See details in Table 2. It was not clear if the intervention administered was independent of other changes in both studies. In both studies, the primary outcome variables were assessed blindly and data were gathered objectively according to the number of workers who had occupational asthma (de Looff 1992) and musculoskeletal injuries (Nassau 1999). The interventions conducted in de Looff 1992 and Nassau 1999 were unlikely to affect data collection because they were conducted as part of organisational policy to prevent occupational asthma or work-related injuries.

Reporting

We report the results of reporting and external validity for RCT and CBA studies in Table 1.

The reporting quality rating score for the two RCTs was 3/10 (Alexander 1977)and 9/10 (de Raad 2004). The reporting quality rating score for the seven CBA studies was 2/10 (Faris 2008), 4/10 (Harbin 2011), 5/10 (Keyserling 1980; Knapik 2006), 7/10 (Hama 2001; Rosenblum 2006) and 8/10 (Nachreiner 1999).

External validity

The external validity quality rating score for nine studies (Alexander 1977; de Looff 1992; de Raad 2004; Hama 2001; Keyserling 1980; Knapik 2006; Nachreiner 1999; Nassau 1999; Rosenblum 2006) was 3/3, 2/3 for (Harbin 2011), and 1/3 for (Faris 2008).

Effects of interventions

A. Studies that evaluated the pre-employment process as a whole

1: General pre-employment examination versus no pre-employment examination

Outcome: Days of sick leave

One RCT with high risk of bias measured the difference in days of sick leave between employees with non-hazardous light duty work whose pre-employment examination results were reported (control group), and for those whose results were not (intervention group) reported to the employer (Alexander 1977, 6125 participants). The hiring rates between the control (69%, n = 2090) and intervention group (71%, n = 2200) differed significantly (Chi^2 4.1328, P = 0.042) mainly as a result of hiring less applicants in the higher risk categories in the control group (73% A category, 54% B category, 40% R category) compared to (72% A category, 69% B category, 64% R category). This study showed very low quality evidence that there is no significant difference in sick leave during 12 months follow-up, comparing workers whose test results were or were not reported to the employer, with a mean difference of -0.09 (95% CI -0.47 to 0.29; Analysis 1.1).

Outcome: Fitness for work, health-related problems

One CBA study with high risk of bias measured health-related problems of army personnel 12 months after they underwent a pre-employment examination (Hama 2001, 240 participants). This study showed very low quality evidence that army personnel who undergo a pre-employment examination are more likely to be fit for work compared to workers who do not undergo a pre-employment examination, with an OR of 0.40 (95% CI 0.19 to 0.85; Analysis 1.2). Fitness for work was defined in this study as workers without abnormalities and who did not require treatment for illness or disability during 12 months of follow-up.

In addition, army personnel who did undergo a pre-employment examination were less likely to be severely obese, with an OR of 0.11 (95% CI 0.01 to 1.22; Analysis 1.3), less likely to be diagnosed with hyperlipidaemia, with an OR of 0.17 (95% CI 0.05 to 0.52; Analysis 1.4) and less likely to have hypertension, with an OR of 0.33 (95% CI 0.10 to 1.07; Analysis 1.5). However, the reason for not undergoing a pre-employment examination was not known and it is possible that those who avoided the examination did so because of known health problems. Rejection rates in this study were not reported.

2: Job-specific pre-employment examination versus no pre-employment examination

Outcome: Musculoskeletal injury

One CBA study with high risk of bias showed very low quality evidence that a job-specific pre-employment examination for the physical work tasks of nursing personnel significantly reduced the number of musculoskeletal injuries compared to no pre-employment examination during an unclear period of follow-up (Faris 2008, 789 participants), with an OR of 0.16 (95% CI 0.06 up to 0.40; Analysis 2.1). The rejection rate was 18 out of 275 tests, resulting in a pass rate of 94%.

3: Job-specific pre-employment examination versus general pre-employment examination

Outcome: Days of sick leave

One RCT with high risk of bias showed very low quality evidence that a job-specific pre-employment examination for the physical work tasks of army personnel reduced the number of days of sick leave (de Raad 2004, 352 participants), with a mean difference of 36 days (95% CI -68.24 to -3.76) compared to a more general pre-employment examination with a follow-up of two years (Analysis 3.1). The rejection rates were significantly lower in the job-specific pre-employment examination with an OR of 0.58 (95% CI 0.42 to 0.79).

Outcome: Musculoskeletal injury

There is inconsistent evidence for the effect on lowering musculoskeletal injuries of a job-specific pre-employment examination compared to a general pre-employment examination.

One CBA study with high risk of bias reported that employees who received a job-specific pre-employment examination for physical work tasks of custodial staff in a public school were less likely to report shoulder injuries during an unclear period of follow up compared to those who received a general pre-employment examination (Harbin 2011, 1159 participants), with an OR of 0.04 (95% CI 0.00 to 0.64; Analysis 3.3). The rejection rate was slightly higher in the group with job-specific examinations with an OR of 1.17 (CI 95% 0.91 to 1.51; Analysis 3.2).

One CBA study reported that employees who received a job-specific pre-employment examination for the physical work tasks of drivers and helpers in a warehouse were less likely to report musculoskeletal injuries after 7.4 months follow-up compared to those who received a general pre-employment examination (Rosenblum 2006, 1926 participants), with an OR of 0.37 (95% CI 0.26 to 0.53; Analysis 3.3). The rejection rate in this study was not known.

In contrast, one ITS study over the course of 10.5years showed neither evidence of an immediate effect nor of a long-term effect on musculoskeletal injuries after the inclusion of a job-specific pre-employment examination for the physical work tasks of hospital workers compared to a general pre-employment examination or compared to an examination with a general physical assessment of workers (Nassau 1999, 1457 participants). The immediate change in level of the injury rate was -0.69 injuries/100 person years (95% CI -2.98 to 1.60; Analysis 3.4) and change in slope was -0.12 injuries/100 person years/year (95% CI -0.63 to 0.39; Analysis 3.5). The rejection rate in this study doubled after the introduction of the job-specific pre-employment examination, with an OR of 2.11 (95% CI 0.96 to 4.64; Analysis 3.2).

In addition, another CBA study did not find a significant difference in the number of medical visits because of musculoskeletal injuries after one year follow-up between those workers who underwent a job-specific pre-employment examination for the physical work tasks in a tyre and rubber plant, and those who underwent a general pre-employment examination (Keyserling 1980, 71 participants), with an OR of 0.30 (95% CI 0.07 to 1.22; Analysis 3.6). The rejection rate was much higher in the group that underwent the job-specific pre-employment examination, with an OR of 3.83 (95% CI 0.98 to 15.00; Analysis 3.2).

Outcome: Incidence of occupational asthma

One ITS study showed very low quality evidence that the inclusion of a bronchial challenge test with histamine in the pre-employment examination for workers in an aluminium plant may have a significant immediate and long-term effect on the incidence of occupational asthma (de Looff 1992, 174 participants) (change

in level -14.37 cases/year, 95% CI -20.09 to -8.65; Analysis 3.7); change in slope of -2.59 cases/year (95% CI -3.63 to -1.55). The rejection rate rose from 20% before, to 35% after the introduction of the histamine test in 1982.

B. Studies that evaluated the effectiveness of recommendations following pre-employment examinations

1: Fitness training for unfit applicants versus fit applicants

Outcome: Musculoskeletal injury

One CBA study showed very low quality evidence that there was no difference in musculoskeletal injury rates for army recruits between those who passed a pre-employment examination, and those who did not pass, but participated in a fitness training programme before entering basic combat training (Knapik 2006, 2072 participants). This was the case for both male and female army recruits with a hazard ratio for males of 1.48 (95% CI 0.97 to 2.26; Analysis 4.1) and a hazard ratio for females of 1.19 (95% CI 0.89 to 1.59; Analysis 4.2).

2: Work accommodations versus no need for work accommodations

Outcome: Workplace injury or illness

One CBA study showed very low quality evidence that workers employed in manufacturing agencies, health service agencies and a local government agency who receive work restrictions or workplace adjustments following results of a pre-employment examination had similar injury rates during a three-year follow-up as those workers who did not need those work accommodations (Nachreiner 1999, 197 participants) (OR 0.90, 95% CI 0.37 to 2.21; Analysis 5.1).

DISCUSSION

Summary of main results

In this updated Cochrane review we found eleven studies, all with high risk of bias that evaluated the effect of pre-employment examinations as a whole on lowering injury, disease or sick leave, and two studies with high risk of bias that evaluated the effect of mitigation of the risks found at the examination.

There is very low quality evidence that general pre-employment examinations do not reduce sick leave for workers in light duty work.

There is inconsistent evidence, based on five studies with high risk of bias, on whether job-focused pre-employment examinations focusing on the physical demands of particular work tasks lower the risk of musculoskeletal injuries compared to no examination or a more general pre-employment examination. However, the majority of these job-focused examinations increased the number of rejected applicants substantially, except for one study. There is very low quality evidence based on one interrupted time-series (ITS) study that a job-focused pre-employment examination focusing on the risk of developing asthma may lower the risk.

There is very low quality evidence that mitigation of risks found at the pre-employment examination may have positive effects in the sense that they could result in similar injury rates as for fit job applicants.

Overall completeness and applicability of evidence

Despite an extensive search for literature in all the relevant medical databases, including both randomised controlled trials (RCTs) and non-RCTs since 2008, we could include only two new studies with high risk of bias, resulting in a total of eleven studies in this updated Cochrane review. There were many other studies on pre-employment examinations but most of them were prognostic and not evaluation studies (e.g. Adeyekun 2010; Bigos 1992a; Chaffin 1978; Harbin 2005).

Two studies evaluated pre-employment examinations, but did not specify what kind of recommendations were given and how many of the people examined were excluded (Legge 2013; Lowenthal 1986). We did not include modelling studies that did not use their own observations of pre-employment examinations (de Kort 1997; Sorgdrager 2004).

One study was performed more than 30 years ago and the screening procedure described would not comply with current international legislation aimed at protecting job applicants (Alexander 1977). Three studies were carried out in the military and their results would probably not be applicable to other occupations. The results of those studies that included job task-specific tests focusing on functional capacity or bronchial challenge testing in their pre-employment examination can be applied more widely beyond the occupations included in these studies.

We believe that the studies included in this review form the best available evidence despite their low quality, and despite being a small proportion of all the studies on pre-employment examinations.

A dilemma with pre-employment examinations is that rejection of job applicants may prevent an occupational disease or injury, but this also means that the worker is denied employment. The question as to whether screening does more good than harm, thus

cannot be answered. For diseases like occupational asthma, the benefits of preventing it in some workers may outweigh the harms of rejecting job applicants. On the other hand, the benefit of a small reduction in sick leave may not outweigh the harms of denying employment to many job applicants. This supports current regulations in place in many countries that restrict the use of unfocussed general health examinations. There is a paucity of information in current studies on the job applicants that are denied employment following pre-employment examinations and this is somewhat understandable when employers fund research studies. Studies that take a societal perspective are needed. They should have the capacity to follow-up all job applicants regardless of their employment status following health examinations. These studies should also include an economic evaluation of all costs and benefits for all stakeholders.

Quality of the evidence

Overall, the quality of evidence was very low due to both a lack of RCTs and the low quality of both randomised studies and non-randomised studies (NRS). Both included ITS studies were affected by co interventions. Even though the included RCTs had serious defects, they provide a valid model for the study of the effectiveness of pre-employment examination. The two studies that we included in this updated review were both controlled before-after (CBA) studies, with a very high risk of bias, and did not improve the evidence base for pre-employment examinations.

Better and clearer reporting of the intervention in pre-employment examinations is needed, such as cut-off scores of strength tests used for physical assessment. Another concern is related to the information provided on unfit workers who were rejected after screening. The reasons for rejection of employment should be made clear, that is, whether applicants are not fit to perform the tasks either with work restrictions or because they are highly susceptible to risks (Sorgdrager 2004).

Potential biases in the review process

A potential bias may have been caused by excluding the two studies on pre-employment examinations that did not provide clear advice to the employee and employer (Legge 2013; Lowenthal 1986). Other potential biases in this review have been minimised by the fact that we conducted a thorough systematic search in all the major relevant electronic databases and also screened their lists of references for potential studies. Therefore, we are confident that we did not miss studies that would have met the inclusion criteria. We did not impose any language restrictions on the search strategy, and translated all non-English abstracts to determine suitability for inclusion.

We included outcome measures such as sick leave, fitness for duties and number of medical visits as proxies of occupational diseases and injuries. We included these outcomes because they were considered appropriate for measuring the effectiveness of interventions in relation to occupational injuries and diseases (for example, sick leave for army personnel).

Agreements and disagreements with other studies or reviews

The results of this updated Cochrane review are in line with the original review (Mahmud 2010b), and partly with the conclusions by Hulshof 1999 who reported that pre-employment examinations could be useful in specific job conditions, for example, in jobs that have specific health risks, such as occupational asthma for workers working in an aluminium factory. This notion was supported by studies conducted by Braddick 1992 and Whitaker 1995 on medical audit of pre-employment examinations at the National Health Service in the United Kingdom. Both authors concluded that pre-employment examinations should be targeted at specific occupational groups to increase their effectiveness. de Kort 1997 reported low effectiveness of pre-employment examinations to predict risks based on calculations of epidemiological data on risk factors and validity characteristics of the tests used. Furthermore, de Kort 1991 reported that pre-employment examinations might not be effective to prevent work absenteeism or work disability in a non-hazardous job. Also a systematic review conducted by Serra 2007 supports our conclusions, as it reported there was no evidence to support the idea that the activity of screening all job applicants and not hiring those who were not fit for work, was (cost)effective.

AUTHORS' CONCLUSIONS

Implications for practice

Pre-employment examinations that are specific to certain job tasks or health risks may, in theory, be effective in reducing occupational disease, injury or sick leave, by either denying the job, or by adequately mitigating the job risk on the health of the worker. The evidence is however, inconsistent for reducing the risk of musculoskeletal injuries using a job-specific pre-employment examination based on biomechanical job analyses. There is very low quality evidence that supports the general notion that unfocussed medical examinations do not decrease sick leave, but come at a considerable cost of denying employment to a high proportion of job applicants.

Implications for research

In view of the ongoing widespread use of pre-employment examinations, randomised controlled trials (RCTs) are needed to study

the effectiveness of the screening process and of related interventions for workers who screened positive for health risks. These studies should provide information on human and financial harms and benefits of pre-employment examinations of all workers concerned, and should therefore take a societal point of view.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

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

Alexander 1977

Methods	Randomised controlled trial, applicants were alternated between the pre-employment condition and the pre-employment condition with hidden recommendations
Participants	6125 applicants for light duty telephone company work of which n = 4290 were hired. Pacific Telephone Company, USA
Interventions	**Control group**: pre-employment examination performed by physician or a nurse. From the result of the examination, applicants were classified into 3 categories of which the results were transmitted to the employment office. Categories: A: no evident risk for work performance or attendance B: work restrictions imposed, but no risk within appropriate job placement R: risk identified **Intervention group**: Pre-employment examination where all applicants were actually examined but no details about the test result were discussed with the employer. All applicants were reported as if they were in category 'A'
Outcomes	- Hiring rates Follow-up of workers after 3 and 12 months using questionnaires sent to supervisors - Workforce loss - sick leave measured by the supervisor as the number of days and occurrences of all sickness and other absences (e.g. accidents) divided by the total number of working days of all individuals in the group times 100 - Overall job performance rated by the supervisor as 'recommendation as a hire today and how well matched to the job'
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Blinding of study subjects?	High risk	Control group received the actual medical results based on the pre-employment examination
Blinding of outcome assessor?	Low risk	Employment office including supervisors were blinded in the study
Results based on "data dredging"?	Low risk	No retrospective unplanned subgroup analyses reported
Analyses adjust for different lengths of follow-up of workers?	Low risk	Analyses were conducted at 3 and 12-months follow-up for both groups

Alexander 1977 (*Continued*)

Appropriate statistical test use?	Low risk	A ratio was computed equal to the total number of absence days divided by the total number of working days of all individuals in the group x 100
Compliance with recommendation reliable?	Unclear risk	There was no mention of the compliance with the recommendations
Outcome measures used valid and reliable?	Low risk	The outcome measure was clearly described on page 688: ".... relates to the exact number of days and occurrences of all sickness and other absence as well as an assessment of work performance....." (Alexander 1977)
Recruitment of participants from the same population?	Low risk	"Participants were recruited from all applicants for the full time, permanent position in non-hazardous assignments who were successfully passed job placement...." (Alexander 1977)
Recruitment of participants over the same time period?	Low risk	Job applicants were recruited between 15 May, 1973 and 15 November, 1974
Subjects randomised to intervention groups?	High risk	"Applicants are alternately assigned and coded with a serial number into an intervention and control group according to the order of arrival in the medical department" (Alexander 1977). The method used was not sufficient to be considered randomly assigned
Adequate adjustment for confounding in the analyses?	High risk	Since applicants were not randomly assigned, there was a high possibility of differences between two groups that can affect the result of intervention
Losses to follow-up taken into account?	High risk	25% loss to follow-up was reported
Randomised intervention assignment concealed?	High risk	Not reported

de Looff 1992

Methods	Interrupted time series
Participants	174 aluminium smelter workers who had typical work-related respiratory problems between the period of 1970-1990 in the Netherlands
Interventions	**Intervention group**: - Pre-employment examination consisted of medical history, clinical examination and respiratory function tests (FVC, FEV_1) including histamine provocation test (HPT) (1982-1990) If FEV_1 > 10% decrease at 32 mg/mL or less histamine, applicants were not hired for the job Relevant medical data were compared between the groups at the pre-employment examination. In addition, data on dust measurements and urinary fluoride levels were included to gain more information about the course of exposure to dust and fluorides **Control group**: - Pre-employment examination consisted of medical history, clinical examination and respiratory function tests (FVC, FEV_1). There was limited medical support and health information and protective measures were not actively promoted (1970-1975) - Pre-employment examination consisted of medical history, clinical examination and respiratory function tests (FVC, FEV_1) and the urinary fluoride test was introduced (1976-1981)
Outcomes	Rejection rates, number of workers diagnosed with occupational (potroom) asthma every year
Notes	Active efforts to lower concentrations of dust and fluorides in potrooms and use of personal protective equipment during the period 1970-1990 FVC = functional vital capacity FEV_1 = forced expiratory volume

Risk of bias

Bias	Authors' judgement	Support for judgement
Blinding of study subjects?	Unclear risk	Please see Table 2 for all risk of bias judgements for interrupted time-series studies

de Raad 2004

Methods	Randomised controlled trial in which the total pre-employment examination schedule was alternated per week
Participants	352 army recruits (186 intervention and 166 control) in the Netherlands; all male; mean age 20.8 years
Interventions	**Intervention group**: Basic medical requirements (BMEKL in Dutch) based on the workload capability test consisting of 43 main tasks of behavioural components and specific military skills such as sitting, standing, walking, bending, neck movement, vision, speaking skill, etc **Control group**: General pre-employment medical assessment consisting of physical capacity, upper limbs, locomotion, hearing, eyesight, and emotional and mental state (PULHEEMS)

de Raad 2004 (*Continued*)

Outcomes	Fitness for duty in number of (calendar) days; determined by subtracting the number of days absence because of illness (95%) or other medical reasons Rejection rates calculated as the number of applicants rejected divided by the total number of applicants that were examined
Notes	BMEKL = Dutch test of basic medical requirements based on workload capability test consisting of 43 main tasks PULHEEMS= test of Physical capacity, Upper limbs, Locomotion, Hearing, Eyesight, and Emotional and Mental State

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Blinding of study subjects?	High risk	Not reported
Blinding of outcome assessor?	High risk	Not reported
Results based on "data dredging"?	Low risk	No retrospective unplanned subgroup analyses were reported
Analyses adjust for different lengths of follow-up of workers?	Low risk	Analyses were conducted for 2-year follow-up
Appropriate statistical test use?	Low risk	Mann-Whitney U test , Kruskal-Wallis H test , Pearson X^2 and multiple linear regression were used for data analyses
Compliance with recommendation reliable?	Low risk	Intervention group was examined by BMEKL and control group examined by PULHEEMS
Outcome measures used valid and reliable?	Low risk	"Fitness for duty for each candidate was measured by the number of (calendar) days of fitness from duty during the study period was determined by subtracting the number of days of absence because of illness (95%) or other medical reasons" (de Raad 2004)
Recruitment of participants from the same population?	Low risk	Participants for the intervention group (BMEKL) and control group (PULHEEMS) were recruited from the Royal Netherlands Army
Recruitment of participants over the same time period?	Low risk	Army personnel from both groups were recruited between 22 September and 16 October, 1998

de Raad 2004 (*Continued*)

Subjects randomised to intervention groups?	High risk	Not reported
Adequate adjustment for confounding in the analyses?	Low risk	In the analysis the following three items were taken into account: the examination system, the military training location and arm or branch of service (i.e. army, navy, etc.)
Losses to follow-up taken into account?	High risk	No information about loss to follow-up
Randomised intervention assignment concealed?	High risk	Not reported

Faris 2008

Methods	Historically controlled study
Participants	789 nursing applicants (p.41) of which 275 in the intervention group, and 514 in the control group; no mention of the setting
Interventions	**Intervention group**: (hired after 15/10/2006) Pre-employment examination including a brief medical history, blood pressure, heart rate and a functional employment test (FET) according to the WorkSTEPS protocol which is a job-specific test focusing on the physical demands of nursing (such as transfers and pull up of a 150 lb dummy in a bed) **Control group**: (hired before 15/10/2006) No pre-employment examination
Outcomes	Primary outcome measure: "reported injuries" (p.41/42) with their reported mechanisms (pushing/pulling, lifting or falling of an item)
Notes	- The different time intervals between the intervention group and the control group makes it difficult to compare these groups despite the efforts taken to specify the groups and job exposures

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Blinding of study subjects?	High risk	Subjects in the 'post offer' physical test group signed a consent form, p.41
Blinding of outcome assessor?	Unclear risk	Not reported
Results based on "data dredging"?	Low risk	No suggestion found

Faris 2008 (*Continued*)

Analyses adjust for different lengths of follow-up of workers?	Unclear risk	Not reported
Appropriate statistical test use?	Unclear risk	Not reported
Compliance with recommendation reliable?	Low risk	Applicants in the intervention group could either pass or fail the test
Outcome measures used valid and reliable?	Unclear risk	Not reported how injury was measured
Recruitment of participants from the same population?	Unclear risk	All nursing applicants; but not reported from what source
Recruitment of participants over the same time period?	High risk	Historical controlled study
Subjects randomised to intervention groups?	High risk	No randomisation procedure
Adequate adjustment for confounding in the analyses?	Unclear risk	Not reported
Losses to follow-up taken into account?	Unclear risk	Not reported
Randomised intervention assignment concealed?	High risk	No randomisation procedure

Hama 2001

Methods	Controlled before-after study
Participants	240 male personnel (196 intervention, 44 control) of the Japan Maritime Self-Defense Force; mean age 38.4 years
Interventions	**Intervention group**: Pre-employment examination included a physical examination, chest circumference, visual examination, colour vision, auditory acuity, vital capacity, height, weight, urinary studies (proteinuria, hematuria, glycosuria), blood pressure, occult blood stool analysis, body mass index, chest radiograph and pulmonary function test (spirometer). In addition, job applicants who were older than 35 years received serum chemistry assay and electrocardiography tests Army personnel were divided into 2 categories based on the clinical assessment: Category 1 : A (no abnormalities) and B1 (some abnormalities, no treatment) Category 2 : B2 (some abnormalities, treatment), C1 (regular follow-up, work restrictions), C2 (treatment, work restrictions) and D (not able to work due to disease) **Control group**: No pre-employment examination

Hama 2001 (*Continued*)

Outcomes	Results of the annual medical examination: - Fitness for duty: Category 1 (A, B1) or Category 2 (B2, C1, C2, D) - Health outcomes such as hypolipidaemia, hypertension, severe obesity, asthma, dental problems, gastrointestinal tract ulcers, musculoskeletal problems, urinary track problems, cardiac arrhythmias and neurologic problems
Notes	The number of army personnel who were rejected for employment (unfit, category D) were not reported in this study

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Blinding of study subjects?	High risk	Not possible
Blinding of outcome assessor?	Low risk	Health professional was blinded in the study
Results based on "data dredging"?	High risk	Whole study was conducted retrospectively
Analyses adjust for different lengths of follow-up of workers?	Low risk	Analyses were conducted after 12-months follow-up for both groups
Appropriate statistical test use?	Low risk	Logistic regression was used to analyse data
Compliance with recommendation reliable?	Unclear risk	No information provided
Outcome measures used valid and reliable?	Low risk	Clear description of measurements and cut-off points provided
Recruitment of participants from the same population?	Low risk	Participants from intervention and control group were recruited from personnel who worked on Iwo Jima, Japan Maritime Self-Defense Force
Recruitment of participants over the same time period?	Low risk	Participants were recruited from 1st to 31st December, 1999
Subjects randomised to intervention groups?	High risk	" We divided all of the participants into two groups based on whether pre-assignment medical examination was carried out (Group Y) or not (Group N)" Hama 2001
Adequate adjustment for confounding in the analyses?	High risk	The characteristics of army personnel at baseline were not reported
Losses to follow-up taken into account?	High risk	No information about the group that was not hired; the study was done retrospectively

Hama 2001 (*Continued*)

Randomised intervention assignment concealed?	High risk	Not reported

Harbin 2011

Methods	Historically controlled study (using both a concurrent and historical control group)
Participants	1159 job applicants for custodial staff in a metropolitan public school district (USA); n = 402 intervention group and n = 757 control group; mean age 39.3
Interventions	**Intervention group**: (from January 2002 through December 2005) Job applicants received a pre-employment examination including a medical exam and drug screening, and a post-offer physical capacity evaluation utilising the concepts of functional capacity testing. Twenty-two different anthropometric, fitness, strength, and lifting tests were utilised in the protocol. The protocol was used to determine an employee's maximum physical capacity, and this was then related to the lifting requirements of the specific job. These requirements were divided into 5 categories on ascending order of effort as defined by the US Department of Labor **Control group**: (from January 1999 through December 2001) Job applicants received a pre-employment examination including a medical exam and drug screening
Outcomes	Number of shoulder injuries during 36 up to 40 months of follow-up
Notes	- Rejection rate 153/402 (38%) intervention group, and 260/757 (35%) control group - The historical control group has a previous exposure of 8 years to occupational risk factors of shoulder disorders in the same job (table 6 p120); even though 5 out of 19 events occurred in the first year, this is a major bias likely to explain the difference in injury rates between the intervention/control group

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Blinding of study subjects?	High risk	Not possible
Blinding of outcome assessor?	Unclear risk	Not reported
Results based on "data dredging"?	Low risk	No retrospective unplanned subgroup analyses reported
Analyses adjust for different lengths of follow-up of workers?	Low risk	Evaluation of shoulder injury incidence between 36 and 40 months of follow-up
Appropriate statistical test use?	Low risk	Fisher's exact test and the Chi^2 test for equality of distribution p.118

Harbin 2011 (*Continued*)

Compliance with recommendation reliable?	Low risk	Applicants could either fail or pass the pre-employment examination in the intervention group
Outcome measures used valid and reliable?	Low risk	Based on claims for shoulder injuries
Recruitment of participants from the same population?	High risk	In the intervention group all applicants were followed in their first 3 years of working; however in the historical control group the applicants were followed sometimes after 8 years of working (p.118)
Recruitment of participants over the same time period?	High risk	Historically controlled study
Subjects randomised to intervention groups?	High risk	No randomisation procedure
Adequate adjustment for confounding in the analyses?	Unclear risk	Not reported
Losses to follow-up taken into account?	Unclear risk	Not reported
Randomised intervention assignment concealed?	High risk	Not applicable

Keyserling 1980

Methods	Controlled before-after study
Participants	71 applicants for a manual material handling job (n = 26 intervention, n = 55 control) in a tyre and rubber plant
Interventions	**Intervention group**: Pre-employment examination included a medical examination and an isometric strength test based on job-specific biomechanical analysis. Strength test consisted of isometric exertion of four work postures i.e. arm lift, back lift, push out, and pull in for 5 seconds. The performance was scored by measuring the final three seconds of the exertion, and an average of this period was calculated. The cut-off point for intervention was that job applicants had to exceed the strength standards before being hired **Control group**: Applicants in the control group were hired based on the result of a general medical examination only
Outcomes	Number of medical visits for musculoskeletal injuries calculated as number of injuries per 100 person years

Keyserling 1980 (*Continued*)

Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Blinding of study subjects?	High risk	Not feasible
Blinding of outcome assessor?	Low risk	Visits to the medical department were recorded as outcome measures and physicians were unaware of the study
Results based on "data dredging"?	Low risk	No retrospective unplanned subgroup analyses reported
Analyses adjust for different lengths of follow-up of workers?	Low risk	Analyses were conducted for a 1-year follow-up for both groups
Appropriate statistical test use?	Low risk	Chi^2 test was used to analyse data
Compliance with recommendation reliable?	Unclear risk	It was not clear whether hired job applicants were given a proper position in the company
Outcome measures used valid and reliable?	Low risk	Medical visits to physicians were measured
Recruitment of participants from the same population?	Low risk	Participants for both groups were recruited from job applicants in a tyre and rubber plant
Recruitment of participants over the same time period?	Low risk	"Prior to pre-employment examination, all new applicants were assigned to either control or the experimental group" Keyserling 1980
Subjects randomised to intervention groups?	High risk	Not reported
Adequate adjustment for confounding in the analyses?	High risk	Not reported
Losses to follow-up taken into account?	Low risk	Authors reported the number of job applicants who were not hired in the intervention group (n = 6) and control group (n = 4) because of medical reasons or poor performance of strength tests
Randomised intervention assignment concealed?	High risk	Not reported

Knapik 2006

Methods	Controlled before-after study
Participants	2072 military recruits who took a physical fitness test in 2003 to be allowed into basic combat training at Fort Jackson (South Carolina). 1174 male and 898 female, mean age 23 years
Interventions	Fitness assessment in the pre-employment examination included > 13 push-ups and > 17 sit-ups-for men and > 3 push-ups and > 17 sit-ups for women plus one mile run in 8.5 min (men) and 10.5 min (women) **Intervention group**: recruits failed fitness test and received a fitness training program n = 158 Fitness Assessment Program consisted of specific physical activity training such as weight training, push-ups and sit-ups improvement, road marching and stretching. Recruits also participated in military training such as customs, courtesies, drill and ceremony, wearing of the uniform, Uniform Code of Military Justice and Army values. Recruits were discharged from service if they could not meet the standard criteria within 3-4 weeks **Control group 1**: recruits failed fitness test and did not get fitness training n = 105 **Control group 2**: recruits passed fitness test n = 1809
Outcomes	Difference in time to first injury during the 9 weeks of basic combat training using Injury data obtained from the Standard Ambulatory Data Record
Notes	Initial rejection rates defined as the number of persons failing the fitness test divided by the total number of persons taking the test: for male applicants (96/1174) 8% and for female applicants (167/898) 19%

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Blinding of study subjects?	High risk	Not reported
Blinding of outcome assessor?	High risk	Not reported
Results based on "data dredging"?	Low risk	No retrospective unplanned subgroup analyses reported
Analyses adjust for different lengths of follow-up of workers?	Low risk	All analyses were conducted for 9-week follow-up
Appropriate statistical test use?	Low risk	ANOVA, ANCOVA, and Cox regression analyses were used to analyse data
Compliance with recommendation reliable?	Low risk	If recruits were considered unfit for the combat training they needed to do more fitness training and pass the test
Outcome measures used valid and reliable?	Low risk	Injury data were obtained from the Standard Ambulatory Data Record

Knapik 2006 (*Continued*)

Recruitment of participants from the same population?	Low risk	Participants from intervention and control groups were recruited from recruits arriving for basic combat training in Fort Jackson
Recruitment of participants over the same time period?	Low risk	Army recruits were recruited between October 1999 through May 2004
Subjects randomised to intervention groups?	High risk	Not reported
Adequate adjustment for confounding in the analyses?	High risk	Not reported
Losses to follow-up taken into account?	High risk	Not reported
Randomised intervention assignment concealed?	High risk	Not reported

Nachreiner 1999

Methods	Controlled before-after study
Participants	197 job applicants (67 intervention and 130 control) seen by an occupational health service for production, clerical, or healthcare provider positions, USA (Minneapolis)
Interventions	Both groups received a pre-employment examination based on medical record review, and a physical examination including a back and upper extremity screening in relation to their job needs **Intervention group**: Work restrictions or workplace accommodations were recommended by occupational nurse to applicants to ensure safety at work. Examples of work restrictions were restricted to lifting no more than 40 Ibs or to limit repetitive wrist flexion to less than 4 hours per shift **Control group**: No advice on work restriction or accommodations
Outcomes	Follow-up 3 years. Musculoskeletal injuries rate refers to the reported OSHA recorded workplace injuries. Thirty-eight musculoskeletal injuries such as back strains, tendonitis and cumulative trauma disorders were included in the study
Notes	No rejection rates were reported OSHA = occupational safety and health administration

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**

Nachreiner 1999 (*Continued*)

Blinding of study subjects?	High risk	Not reported
Blinding of outcome assessor?	High risk	Not reported
Results based on "data dredging"?	Low risk	No retrospective unplanned subgroup analyses reported
Analyses adjust for different lengths of follow-up of workers?	Low risk	All analyses were conducted for 3-year follow-up
Appropriate statistical test use?	Low risk	Chi^2 test was used to analyse data
Compliance with recommendation reliable?	Unclear risk	It was not mentioned whether intervention group (at work) complied with the work restrictions
Outcome measures used valid and reliable?	Low risk	Recorded workplace injuries
Recruitment of participants from the same population?	Low risk	Participants from intervention and control group were recruited from all job applicants screened by occupational health clinic in the Upper Midwest
Recruitment of participants over the same time period?	Low risk	Participants were recruited between 1 January, 1993 through 31 December, 1995
Subjects randomised to intervention groups?	High risk	"Non random sample selection process"
Adequate adjustment for confounding in the analyses?	Low risk	Potential interaction of employees' duration of employment, their status as case or control, and injury incidence were taken into account in the analysis
Losses to follow-up taken into account?	Low risk	No loss to follow-up
Randomised intervention assignment concealed?	High risk	Not reported

Nassau 1999

Methods	Interrupted time series
Participants	1457 new hires at hospital and medical centre in Baltimore, Maryland (USA) underwent pre-employment examinations, from 1986 to 1996
Interventions	**Intervention group**: Stage III (July 1992 to June 1996): Pre-work FCE examination was used to assess job applicants' physical capacity to match essential work demands in different work tasks (Stage III: July 1992 to June 1996). The pre-work FCE examination matched the essential demands of 16 high risk (for musculoskeletal disorders) departments in the medical

	centre. In addition, job applicants also received educational training in safe body mechanics. Applicants were not hired if they did not have the ability to perform the essential demands of their job safely. Those who were not hired were encouraged to re-apply in 3 months after improving their failed physical abilities during the screening. The number of failed applicants in Stage III were 30 out of 938 screened **Control group**: - Stage I (January 1986 to December 1987): Pre-employment examination includes rubella and serologic test for syphilis titres, complete blood count, urinalysis and purified protein derivative measured and a health history. The examination was conducted by a physician - Stage II (January 1988 to June 1992): Pre-employment examination includes rubella and hepatitis titres, drugs screen, a health history, blood pressure, height and weight. In addition, an assessment of posture, flexibility, strength and range of motion. Applicants were given instruction in correct body mechanics during lifting. In the second year, the screen was applied to applicants from 10 different departments that were identified as having a high risk of back strain or strain injuries. The screen was however not related to their job descriptions. The number of failed applicants in Stage II was 8 out of 519 screened
Outcomes	The rate of injury per 100 full-time employees was measured as: (injuries per year/total employees screened and unscreened × total hours worked) × equivalent hours of 100 FTEs working 40 hours a week The injuries refer to work-related back sprains or strains
Notes	FCE = functional capacity evaluation FTE = full time equivalent

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Blinding of study subjects?	Unclear risk	Please see Table 2 for all risk of bias judgements for interrupted time-series studies
Results based on "data dredging"?	Low risk	
Analyses adjust for different lengths of follow-up of workers?	Low risk	
Appropriate statistical test use?	Low risk	
Outcome measures used valid and reliable?	Low risk	
Recruitment of participants from the same population?	Low risk	
Recruitment of participants over the same time period?	Low risk	

Nassau 1999 (*Continued*)

Adequate adjustment for confounding in the analyses?	Low risk	

Rosenblum 2006

Methods	Controlled before-after study
Participants	1926 newly hired employees (503 intervention, 1423 control) for a building materials supplier (warehouse) in the USA; mean age 29.5 years
Interventions	**Intervention group**: Job applicants received a pre-employment examination including an isokinetic screening for physical capability in relation to specific job demand based on independent ergonomic job analyses of the three positions (driver, helper and combination of driver/helper). The screening consisted of the assessments of shoulders (bi-laterally), knees (bilaterally), back (torso), the full range of motion (flexion and extension) for five repetitions each at 60, 120 and 360 degrees per second. The tests were based on various models of Cybex isokinetic testing and rehabilitation systems Applicants were not hired if their test scores were below the US Department of Labor "very heavy" (push, pull, lift or carry of > 60 pounds frequently or > 100 pounds occasionally) Since applicants were hired in relation to their strength capability, no work recommendation was given **Control group**: Job applicants received no pre-employment examination
Outcomes	Rate of musculoskeletal injury per person-year obtained from the insurance companies during 33 months of follow-up
Notes	The rejection rate was not reported

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Blinding of study subjects?	High risk	Not reported
Blinding of outcome assessor?	Low risk	Musculoskeletal injuries data were gathered from 3 insurance companies that were blind for the group assignment
Results based on "data dredging"?	Low risk	No retrospective unplanned subgroup analyses reported
Analyses adjust for different lengths of follow-up of workers?	Low risk	All analyses were conducted for 33-months follow-up

Rosenblum 2006 (*Continued*)

Appropriate statistical test use?	Low risk	Poisson regression model, Wilcoxon test and Kruskal-Wallis analyses were used to analyse data
Compliance with recommendation reliable?	High risk	It was not reported whether all hired job applicants were given a job according to their physical demands capability
Outcome measures used valid and reliable?	Low risk	Musculoskeletal injuries gathered from compensation data from three insurance carriers
Recruitment of participants from the same population?	Low risk	Participants from intervention and control group were recruited from job applicants from a large US employer's 105 industrial yards
Recruitment of participants over the same time period?	High risk	"As the study progressed, 24 additional sites over the following 33 months were added to the experimental cohort....."
Subjects randomised to intervention groups?	High risk	"Subjects, ... not randomly enrolled in their respective cohorts... "
Adequate adjustment for confounding in the analyses?	Low risk	Race, age, pay type and job descriptions were taken into account
Losses to follow-up taken into account?	Low risk	No loss to follow-up
Randomised intervention assignment concealed?	High risk	Not reported

BMEKL = Dutch test of basic medical requirements based on workload capability test consisting of 43 main tasks
FEV_1 = forced expiratory volume
FTE= full time equivalent
FVC = functional vital capacity
OSHA = occupational safety and health administration
PULHEEMS = test of Physical capacity, Upper limbs, Locomotion, Hearing, Eyesight, and Emotional and Mental State

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

Study	Reason for exclusion
Adeyekun 2010	No intervention i.e. recommendation about work accommodations, only follow-up
Ali 2002	No control group, only follow-up

(*Continued*)

Anderson 2008	Prognostic study design
Arndt 2002	No intervention i.e. recommendation about work accommodations, only follow-up
Barnard 2004	Case-control study design
Bigos 1987	No intervention i.e. recommendation about work accommodations
Bigos 1992a	Prognostic study design
Bigos 1992b	Prognostic study design
Bingham 1996	No intervention i.e. recommendation about work accommodations
Chaffin 1978	Prognostic study design
Dale 2014	Prognostic study design
de Raad 2005	Prognostic study design
Evans 2005	Prospective cohort study design
Franzblau 2004	Study design is before-after
Gassoway 2000	Study design is before-after
Harbin 2005	Interrupted time series only reported two data-points before and after intervention
La Rocca 1969	Prognostic study design
Legge 2013	No intervention i.e. recommendation about work accommodations
Lowenthal 1986	No intervention i.e. recommendation about work accommodations
Lucey 2008	No control group, retrospective cohort study
Madan 2012	Review study
Normand 1989	Prognostic study design
Ryan 2010	No control group, retrospective cohort study

DATA AND ANALYSES

Comparison 1. General pre-employment examination versus no pre-employment examination

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Days of sick leave	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
2 Number of participants unfit for duties	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected
3 Severe obesity	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected
4 Hyperlipidaemia	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected
5 Hypertension	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected
6 Rejection rate	1		Risk Ratio (M-H, Fixed, 95% CI)	Totals not selected

Comparison 2. Job-specific pre-employment examination versus no pre-employment examination

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Musculoskeletal injury	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected

Comparison 3. Job-specific pre-employment examination versus general pre-employment examination

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Days of sick leave	1		Mean Difference (IV, Random, 95% CI)	Totals not selected
2 Rejection rate	4		Odds Ratio (IV, Random, 95% CI)	Totals not selected
3 Musculoskeletal injury	2		Odds Ratio (M-H, Random, 95% CI)	Totals not selected
4 Musculoskeletal injury (change in level)	1		Cases/Year (Fixed, 95% CI)	Totals not selected
5 Musculoskeletal injury (change in slope)	1		Cases/Year (Fixed, 95% CI)	Totals not selected
6 Number of medical visits for musculoskeletal injury	1		Odds Ratio (Fixed, 95% CI)	Totals not selected
7 Incidence of occupational asthma (change in level)	1		Cases/year (Random, 95% CI)	Totals not selected
8 Incidence of occupational asthma (change in slope)	1		Cases/Year (Random, 95% CI)	Totals not selected

Comparison 4. Fitness training for unfit applicants versus fit applicants

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Risk of Injury (men)	1		Hazard Ratio (Random, 95% CI)	Totals not selected
2 Risk of injury (women)	1		Hazard Ratio (Random, 95% CI)	Totals not selected

Comparison 5. Work accommodations versus no need for work accommodations

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Musculoskeletal injury	1		Odds Ratio (M-H, Fixed, 95% CI)	Totals not selected

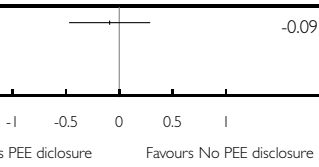
Analysis 1.1. Comparison 1 General pre-employment examination versus no pre-employment examination, Outcome 1 Days of sick leave.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 1 General pre-employment examination versus no pre-employment examination

Outcome: 1 Days of sick leave

Study or subgroup	PEE results disclosed		No PEE results disclosed		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	IV,Random,95% CI	IV,Random,95% CI
Alexander 1977	1087	1.65 (4.0379)	1117	1.74 (4.9572)		-0.09 [-0.47, 0.29]



Analysis 1.2. Comparison 1 General pre-employment examination versus no pre-employment examination, Outcome 2 Number of participants unfit for duties.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 1 General pre-employment examination versus no pre-employment examination

Outcome: 2 Number of participants unfit for duties

Study or subgroup	PEE n/N	No PEE n/N	Odds Ratio M-H,Fixed,95% CI	Odds Ratio M-H,Fixed,95% CI
Hama 2001	28/196	13/44		0.40 [0.19, 0.85]

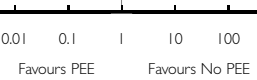
Analysis 1.3. Comparison 1 General pre-employment examination versus no pre-employment examination, Outcome 3 Severe obesity.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 1 General pre-employment examination versus no pre-employment examination

Outcome: 3 Severe obesity

Study or subgroup	PEE n/N	No PEE n/N	Odds Ratio M-H,Fixed,95% CI	Odds Ratio M-H,Fixed,95% CI
Hama 2001	1/196	2/44		0.11 [0.01, 1.22]



Analysis 1.4. Comparison 1 General pre-employment examination versus no pre-employment examination, Outcome 4 Hyperlipidaemia.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 1 General pre-employment examination versus no pre-employment examination

Outcome: 4 Hyperlipidaemia

Study or subgroup	PEE n/N	No PEE n/N	Odds Ratio M-H,Fixed,95% CI	Odds Ratio M-H,Fixed,95% CI
Hama 2001	6/196	7/44		0.17 [0.05, 0.52]

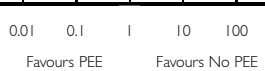
Analysis 1.5. Comparison 1 General pre-employment examination versus no pre-employment examination, Outcome 5 Hypertension.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 1 General pre-employment examination versus no pre-employment examination

Outcome: 5 Hypertension

Study or subgroup	PEE n/N	No PEE n/N	Odds Ratio M-H,Fixed,95% CI	Odds Ratio M-H,Fixed,95% CI
Hama 2001	8/196	5/44		0.33 [0.10, 1.07]



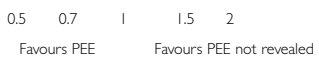
Analysis 1.6. Comparison 1 General pre-employment examination versus no pre-employment examination, Outcome 6 Rejection rate.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 1 General pre-employment examination versus no pre-employment examination

Outcome: 6 Rejection rate

Study or subgroup	PEE n/N	PEE not revealed n/N	Risk Ratio M-H,Fixed,95% CI	Risk Ratio M-H,Fixed,95% CI
Alexander 1977	252/3026	296/3089		0.87 [0.74, 1.02]



Analysis 2.1. Comparison 2 Job-specific pre-employment examination versus no pre-employment examination, Outcome 1 Musculoskeletal injury.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 2 Job-specific pre-employment examination versus no pre-employment examination

Outcome: 1 Musculoskeletal injury

Study or subgroup	Job specific PEE n/N	No PEE n/N	Odds Ratio M-H,Fixed,95% CI	Odds Ratio M-H,Fixed,95% CI
Faris 2008	5/275	54/514		0.16 [0.06, 0.40]

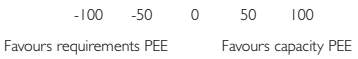
Analysis 3.1. Comparison 3 Job-specific pre-employment examination versus general pre-employment examination, Outcome 1 Days of sick leave.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 3 Job-specific pre-employment examination versus general pre-employment examination

Outcome: 1 Days of sick leave

Study or subgroup	Job specific based PEE		General PEE		Mean Difference	Mean Difference
	N	Mean(SD)	N	Mean(SD)	IV,Random,95% CI	IV,Random,95% CI
de Raad 2004	186	83 (134)	166	119 (170)		-36.00 [-68.24, -3.76]



Analysis 3.2. Comparison 3 Job-specific pre-employment examination versus general pre-employment examination, Outcome 2 Rejection rate.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 3 Job-specific pre-employment examination versus general pre-employment examination

Outcome: 2 Rejection rate

Study or subgroup	Job specific based PEE	General PEE	Odds Ratio	Odds Ratio
	n/N	n/N	IV,Random,95% CI	IV,Random,95% CI
de Raad 2004	95/464	123/399		0.58 [0.42, 0.79]
Harbin 2011	153/402	260/757		1.17 [0.91, 1.51]
Keyserling 1980	6/26	4/55		3.83 [0.98, 15.00]
Nassau 1999	30/938	8/519		2.11 [0.96, 4.64]

Analysis 3.3. Comparison 3 Job-specific pre-employment examination versus general pre-employment examination, Outcome 3 Musculoskeletal injury.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 3 Job-specific pre-employment examination versus general pre-employment examination

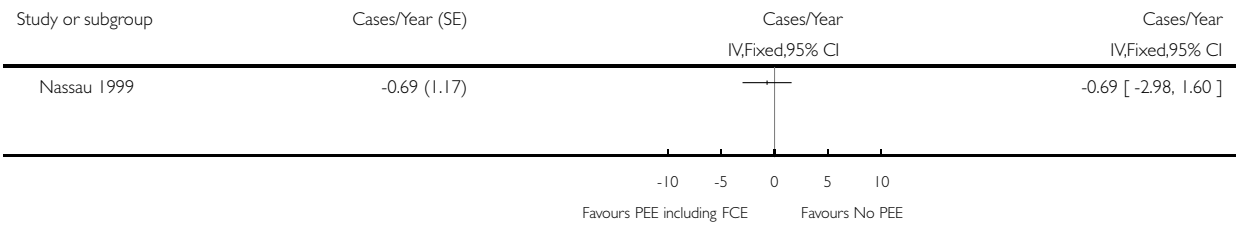
Outcome: 3 Musculoskeletal injury

Analysis 3.4. Comparison 3 Job-specific pre-employment examination versus general pre-employment examination, Outcome 4 Musculoskeletal injury (change in level).

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 3 Job-specific pre-employment examination versus general pre-employment examination

Outcome: 4 Musculoskeletal injury (change in level)

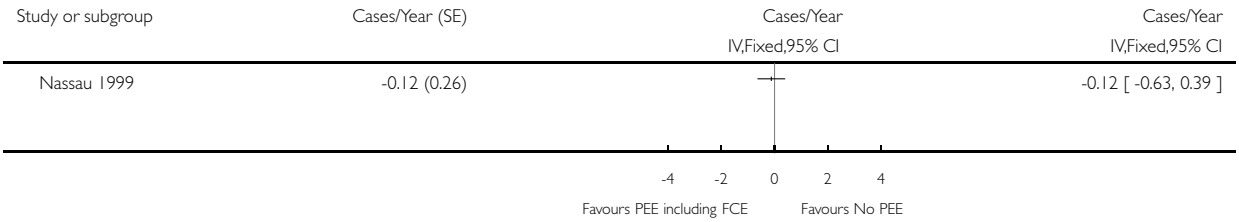


Analysis 3.5. Comparison 3 Job-specific pre-employment examination versus general pre-employment examination, Outcome 5 Musculoskeletal injury (change in slope).

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 3 Job-specific pre-employment examination versus general pre-employment examination

Outcome: 5 Musculoskeletal injury (change in slope)

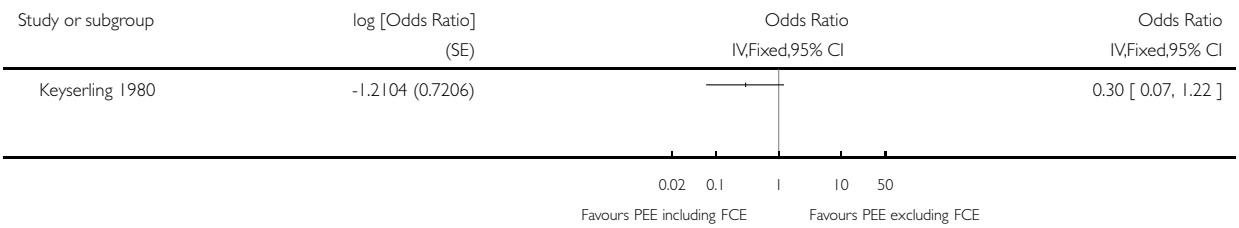


Analysis 3.6. Comparison 3 Job-specific pre-employment examination versus general pre-employment examination, Outcome 6 Number of medical visits for musculoskeletal injury.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 3 Job-specific pre-employment examination versus general pre-employment examination

Outcome: 6 Number of medical visits for musculoskeletal injury

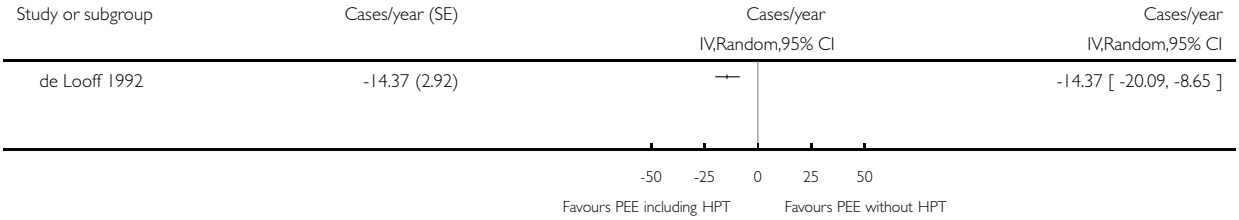


Analysis 3.7. Comparison 3 Job-specific pre-employment examination versus general pre-employment examination, Outcome 7 Incidence of occupational asthma (change in level).

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 3 Job-specific pre-employment examination versus general pre-employment examination

Outcome: 7 Incidence of occupational asthma (change in level)

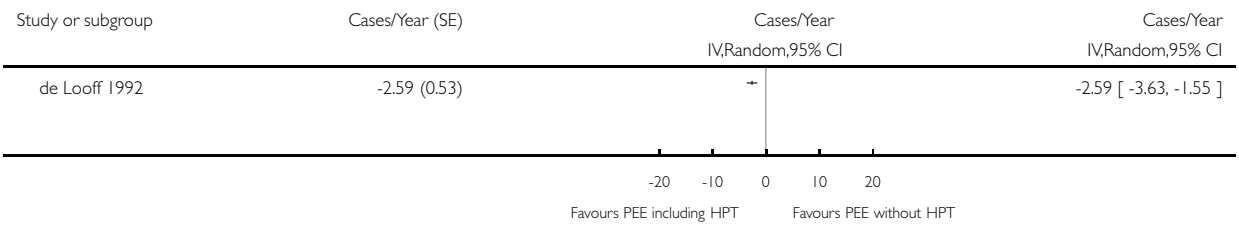


Analysis 3.8. Comparison 3 Job-specific pre-employment examination versus general pre-employment examination, Outcome 8 Incidence of occupational asthma (change in slope).

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 3 Job-specific pre-employment examination versus general pre-employment examination

Outcome: 8 Incidence of occupational asthma (change in slope)



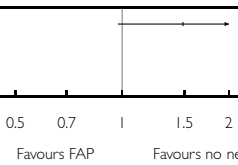
Analysis 4.1. Comparison 4 Fitness training for unfit applicants versus fit applicants, Outcome 1 Risk of Injury (men).

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 4 Fitness training for unfit applicants versus fit applicants

Outcome: 1 Risk of Injury (men)

Study or subgroup	FAP N	No need for FAP N	log [Hazard Ratio] (SE)	Hazard Ratio IV,Random,95% CI	Hazard Ratio IV,Random,95% CI
Knapik 2006	64	1078	0.392 (0.21567)		1.48 [0.97, 2.26]



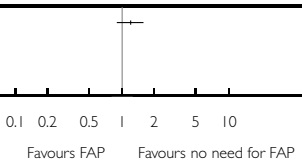
Analysis 4.2. Comparison 4 Fitness training for unfit applicants versus fit applicants, Outcome 2 Risk of injury (women).

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 4 Fitness training for unfit applicants versus fit applicants

Outcome: 2 Risk of injury (women)

Study or subgroup	FAP N	No need for FAP N	log [Hazard Ratio] (SE)	Hazard Ratio IV,Random,95% CI	Hazard Ratio IV,Random,95% CI
Knapik 2006	94	731	0.1739 (0.14801)		1.19 [0.89, 1.59]

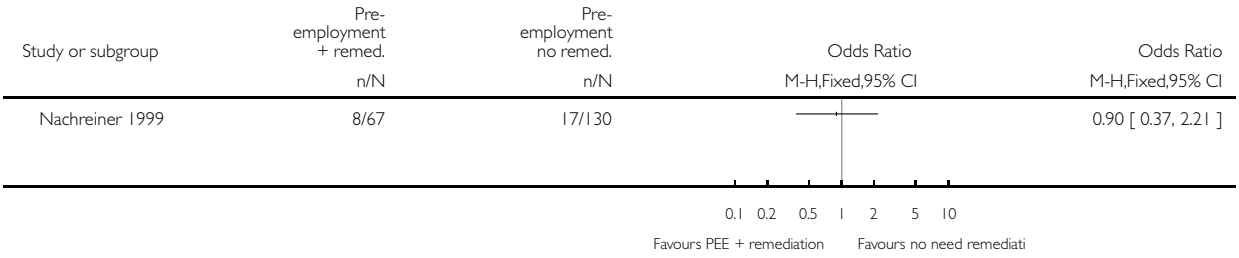


Analysis 5.1. Comparison 5 Work accommodations versus no need for work accommodations, Outcome 1 Musculoskeletal injury.

Review: Pre-employment examinations for preventing injury, disease and sick leave in workers

Comparison: 5 Work accommodations versus no need for work accommodations

Outcome: 1 Musculoskeletal injury



ADDITIONAL TABLES

Table 1. Reporting and external validity for RCTs and non-RCTs (controlled before-after studies)

Study design		RCT	RCT	RCT	CBA	CBA	CBA	CBA	CBA	CBA
Study ID		**Alexander (1977)**	**Keyserling (1980)**	**de Raad (2004)**	**Nachreiner (1999)**	**Hama (2001)**	**Knapik (2006)**	**Rosenblum (2006)**	**Faris (2008)**	**Harbin (2011)**
Reporting										
1	Is the hypothesis/aim/objective of the study clearly described?	1	1	1	1	1	1	1	1	1
2	Are the main outcomes to be measured clearly de-	0	1	1	1	1	1	1	0	0

Table 1. Reporting and external validity for RCTs and non-RCTs (controlled before-after studies) (*Continued*)

	scribed in the Introduction or the Methods section?									
3	Are the characteristics of the participants included in the study clearly described?	0	0	1	1	1	0	1	0	0
4	Are the interventions of interest clearly described? (aims, content, ...)	0	1	1	1	0	1	0	0	1
5	Is the distribution of confounders in each group of subjects to be compared clearly described (working condition, health status...)	0	0	1	1	0	0	1	0	0

Table 1. Reporting and external validity for RCTs and non-RCTs (controlled before-after studies) (*Continued*)

6	Are the main findings of the study clearly described?	0	1	1	1	1	0	1	1	1
7	Does the study provide estimates of the random variability in the data for the main outcomes?	0	0	1	1	1	1	1	0	0
8	Have any adverse events that may be a consequence of the intervention been reported?	0	0	0	0	0	0	0	0	0
9	Have the characteristics of participants lost to follow-up been described?	1	0	1	0	1	0	0	0	0
10	Have actual probability values been reported for	1	1	1	1	1	1	1	0	1

Table 1. Reporting and external validity for RCTs and non-RCTs (controlled before-after studies) (*Continued*)

	main outcomes instead of discreet values (e.g. 0.035 instead of < 0.05), except when less than 0.001?									
External validity										
11	Were the subjects asked to participate in the study representative of the entire population from which they were recruited?	1	1	1	1	1	1	1	0	1
12	Were those subjects who were prepared to participate, representative of the entire population from which they were recruited?	1	1	1	1	1	1	1	1	1
13	Were the staff, places	1	1	1	1	1	1	1	0	0

Table 1. Reporting and external validity for RCTs and non-RCTs (controlled before-after studies) (*Continued*)

	and facilities where the participants were treated, representative of the treatment the majority of workers would receive?									
	TOTAL	**6/13**	**8/13**	**12/13**	**11/13**	**10/13**	**8/13**	**10/13**	**3/13**	**6/13**

CBA: controlled before-after
RCT: randomised controlled trial

Table 2. Risk of bias for interrupted time-series studies

Study ID		**Nassau (1999)**			**de Looff (1992)**		
Quality criteria		**Done**	**Not clear**	**Not done**	**Done**	**Not clear**	**Not done**
A.	**Protection against secular changes**						
i)	The intervention is independent of other changes		1				1
ii)	There are sufficient data points to enable reliable statistical inference	1				1	
iii)	Formal test for trend reported (complete this section if authors have used ANOVA modelling)			1			1

Table 2. Risk of bias for interrupted time-series studies *(Continued)*

B	**Protection against detection bias**						
i)	Intervention unlikely to affect data collection	1			1		
ii)	Blinded assessment of primary outcome variable(s)	1			1		
C	**Completeness of data set**	1			1		
D	**Reliable primary outcome measure(s)**	1			1		
	TOTAL	**5**			**4**		

Table 3. Overview of studies

Name study	Design	Type of job for applicants	Intervention	Comparison	Outcome	Result
Alexander 1977	RCT	Non-hazardous light duty work (n = 6125)	**A1**. General PEE	No PEE	No. of days of sick leave	No significant difference
Hama 2001	CBA	Army personnel (n = 240)	**A1**. General PEE	No PEE	No. of health-related problems	Significant difference in favour of general PEE
Faris 2008	CBA	Nursing personnel (n = 789)	**A2**. Job-specific PEE for physical work tasks	No PEE	No. of musculoskeletal injuries	Significant difference in favour of job-specific PEE
de Raad 2004	RCT	Army personnel (n = 352)	**A3**. Job-specific PEE for physical work tasks	General PEE	No. of days of sick leave	Significant difference in favour of job-specific PEE
Harbin 2011	CBA	Custodial staff within a public school district (n = 1159)	**A3**. Job-specific PEE for physical work tasks	General PEE	No. of shoulder injuries	No significant difference

Table 3. Overview of studies (*Continued*)

Keyserling 1980	CBA	Jobs in tire and rubber plant (n = 81)	**A3**. Job-specific PEE for physical work tasks	General PEE	No. of medical visits due to musculoskeletal injuries	No significant difference
Nassau 1999	ITS	Hospital workers (n = 1457)	**A3**. Job-specific PEE for physical work tasks	General PEE	No. of musculoskeletal injuries	No significant difference
Rosenblum 2006	CBA	Driver or helper in warehouse (n = 1926)	**A3**. Job-specific PEE for physical work tasks	General PEE	No. of musculoskeletal injuries	Significant difference in favour of job-specific PEE
de Looff 1992	ITS	Workers in aluminium plant (n = 174)	**A3**. Job-specific PEE including bronchial challenge test	General PEE	No. of cases of occupational asthma	Significant difference in favour of job-specific PEE
Knapik 2006	CBA	Army personnel (n = 2072)	**B1**. PEE + fitness training (for those who failed the test)	PEE (for those who passed the test)	No. of musculoskeletal injuries	No significant difference indicating an effective fitness training programme
Nachreiner 1999	CBA	Jobs in manufacturing, health service and local government agencies (n = 197)	**B2**. PEE + work accommodations (for those who failed the test)	PEE (for those who passed the test)	No. of workplace injuries	No significant difference indicating effective work accommodations

CBA = controlled before-after
ITS = interrupted time-series
PEE = pre-employment examination
RCT = randomised controlled trial

APPENDICES

Appendix 1. Search strategies

MEDLINE/PUBMED (update 31 March 2015)

#1 Search fitness for work[tw] OR fitness for duty[tw] OR fitness to work[tw] OR occupational fitness[tw] OR fitness for employment[tw] OR job fitness[tw] OR pre-employ*[tw] OR preemploy*[tw] OR pre-place*[tw] OR preplace*[tw] OR ((pre-work[tw] OR prework[tw]) AND screen*[tw]) OR employment screen*[tw] OR employment test*[tw] OR employee screen*[tw] OR employee test*[tw] OR (post-offer[tw] AND (screen*[tw] OR test[tw] OR tests[tw] OR testing[tw]))

#2 Search "Randomized Controlled Trial" [Publication Type] OR "Controlled Clinical Trial" [Publication Type] OR "Randomized Controlled Trials as Topic"[Mesh] OR "Random Allocation"[Mesh] OR "Double-Blind Method"[Mesh] OR "Single-Blind Method"[Mesh]

#3 Search "Clinical Trial" [Publication Type] OR "Clinical Trials as Topic"[Mesh] OR "Placebos"[Mesh] OR "Research Design"[Mesh] OR "Epidemiologic Research Design"[Mesh] OR (clinical*[tw] AND trial*[tw]) OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw]) AND (blind*[tw] OR mask*[tw])) OR (placebo*[tw] OR random*[tw])

#4 Search "Comparative Study" [Publication Type] OR "Evaluation Studies" [Publication Type] OR "Evaluation Studies as Topic"[Mesh] OR "Follow-Up Studies"[Mesh] OR "Prospective Studies"[Mesh] OR control*[tw] OR perspectiv*[tw] OR volunteer*[tw]

#5 Search #1 AND (#2 OR #3 OR #4)

#6 Search #5 NOT ("Animals"[Mesh] NOT "Humans"[Mesh])

#7 Search (#6) AND ("2008/03/01"[Date - Create] : "3000"[Date - Create])

#8 Search (#6) AND ("2008/03/01"[Date - Completion] : "3000"[Date - Completion])

#9 Search (#6) AND ("2008/03/01"[Date - Entrez] : "3000"[Date - Entrez])

#10 Search (#6) AND ("2008/03/01"[Date - MeSH] : "3000"[Date - MeSH])

#11 Search #7 OR #8 OR #9 OR #10

EMBASE (update 31 March 2015)

No.	Query	Results
#5	#4 AND [1-3-2008]/sd	164
#4	#3 NOT ([animals]/lim NOT [humans]/lim)	613
#3	#1 AND #2	647
#2	'controlled study'/exp OR 'controlled study':de,mn,tn,df,ab,dn,ti OR 'statistical analysis'/exp OR 'statistical analysis':de,mn,tn,df,ab,dn,ti OR 'major clinical study'/exp OR 'major clinical study':de,mn,tn,df,ab,dn,ti OR 'randomized controlled trial'/exp OR 'randomized controlled study':de,mn,tn,df,ab,dn,ti OR random$:de,mn,tn,df,ab,dn,ti OR 'double blind procedure'/exp OR 'double blind procedure':de,mn,tn,df,ab,dn,ti OR 'single blind procedure'/exp OR 'single blind procedure':de,mn,tn,df,ab,dn,ti OR 'multicenter study'/exp OR 'multicenter study':de,mn,tn,df,ab,dn,ti	7084212
#1	'fitness for work':de,ab,ti OR 'fitness for duty':de,ab,ti OR 'fitness to work':de,ab,ti OR 'occupational fitness':de,ab,ti OR 'fitness for employment':de,ab,ti OR 'job fitness':de,ab,ti OR 'preemployment medical examination'/exp OR (pre NEXT/1 employ*):de,ab,ti OR preemploy*:de,ab,ti OR (pre NEXT/1 place*):de,ab,ti OR preplace*:de,ab,ti OR ('pre work':de,ab,ti	2592

(*Continued*)

	OR prework:de,ab,ti AND screen*:de,ab,ti) OR (employment NEXT/1 screen*):de,ab,ti OR (employment NEXT/1 test*) :de,ab,ti OR (employee NEXT/1 screen*):de,ab,ti OR (employee NEXT/1 test*):de,ab,ti OR ('post offer':de,ab,ti AND (screen*:de,ab,ti OR test:de,ab,ti OR tests:de,ab,ti OR testing: de,ab,ti))	

CENTRAL (*the Cochrane Library 31 March 2015)*

"fitness for work":ab,ti,kw OR "fitness for duty":ab,ti,kw OR "fitness to work":ab,ti,kw OR "occupational fitness":ab,ti,kw OR "fitness for employment":ab,ti,kw OR "job fitness":ab,ti,kw OR "pre-employ*":ab,ti,kw OR "preemploy*":ab,ti,kw OR "pre-place*":ab,ti,kw OR "preplace*":ab,ti,kw OR (("pre-work":ab,ti,kw OR prework:ab,ti,kw) AND screen*:ab,ti,kw) OR "employment screen*":ab,ti,kw OR "employment test*":ab,ti,kw OR "employee screen*":ab,ti,kw OR "employee test*":ab,ti,kw OR (post-offer:ab,ti,kw AND (screen*: ab,ti,kw OR test:ab,ti,kw OR tests:ab,ti,kw OR testing:ab,ti,kw))

CINAHL (31 March 2015)

#	Query	Results
S11	S10 AND EM 20080301-20151231	44
S10	S9 NOT (MH "Animals+" NOT MH "Human")	101
S9	S1 AND S8	101
S8	S2 OR S3 OR S4 OR S5 OR S6 OR S7	843,039
S7	TX ((allocat* or allot* or assign* or divid*) N3 (condition* or experiment* or intervention* or treatment* or therap* or control* or group*))	21,270
S6	TX ((singl* or doubl* or trebl* or tripl*) N7 (blind* or mask*))	635,307
S5	TX (Random* N7 (allocat* or allot* or assign* or basis* or divid* or order*))	47,786
S4	TX ((clinical or controlled or comparative or placebo or prospective or randomi#ed) N3 (trial or study))	146,228
S3	PT clinical trial	51,982
S2	MH "Clinical Trials+") OR (MH "Evaluation Research+") OR (MH "Comparative Studies")	209,083
S1	TX ("fitness for work" OR "fitness for duty" OR "fitness to work" OR "occupational fitness" OR "fitness for employment" OR "job fitness" OR "pre-employ*" OR "preemploy*" OR "pre-place*" OR "preplace*" OR (("pre-work" OR prework)	452

(*Continued*)

	AND screen*) OR "employment screen*" OR "employment test*" OR "employee screen*" OR "employee test*" OR (post-offer AND (screen* OR test OR tests OR testing)))	

PsycINFO (31 March 2015)

#	Query	Results
S15	S14 AND RD 20080301-20151231	1,324
S14	S5 AND S13	2,228
S13	S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12	280,224
S12	TX ((allocat* or allot* or assign* or divid*) N3 (condition* or experiment* or intervention* or treatment* or therap* or control* or group*))	39,830
S11	TX ((singl* or doubl* or trebl* or tripl*) N7 (blind* or mask*))	21,054
S10	TX (Random* N7 (allocat* or allot* or assign* or basis* or divid* or order*))	38,414
S9	TX ((clinical or controlled or comparative or placebo or prospective or randomi#ed) N3 (trial or study))	221,005
S8	TX randomi#ed N7 trial	32,773
S7	MR TREATMENT OUTCOME/CLINICAL TRIAL	29,300
S6	DE "Clinical Trials"	8,462
S5	S1 OR S2 OR S3 OR S4	30,659
S4	DE "Screening" OR DE "Drug Usage Screening" OR DE "Health Screening" OR DE "Job Applicant Screening"	11,346
S3	DE "Health Screening" OR DE "Cancer Screening" OR DE "Genetic Testing" OR DE "HIV Testing" OR DE "Physical Examination"	8,743
S2	DE "Personnel Selection" OR DE "Job Applicant Interviews" OR DE "Job Applicant Screening"	7,491
S1	TX ("fitness for work" OR "fitness for duty" OR "fitness to work" OR "occupational fitness" OR "fitness for employment"	7,810

(*Continued*)

	OR "job fitness" OR "pre-employ*" OR "preemploy*" OR "pre-place*" OR "preplace*" OR (("pre-work" OR prework) AND screen*) OR "employment screen*" OR "employment test*" OR "employee screen*" OR "employee test*" OR (post-offer AND (screen* OR test OR tests OR testing)))	

PEDro search strategy (up to March 2015)
Searched with "match all search terms (AND)" en "new records added since 01/03/2008"

	Ergonomics and occupational health	musculoskeletal
fitness work	13	8
fitness duty	0	2
occupational fitness	3	2
fitness employment	0	0
job fitness	5	0
pre-employ*	13	13
preemploy*	0	0
pre-place*	4	27
preplace*	0	0
pre-work screen*	1	0
prework screen*	0	0
employment screen*	1	0
employment test*	2	1
employee screen*	1	0
employee test*	2	1
post-offer screen*	0	1
post-offer test*	0	1

(*Continued*)

total	78	

Appendix 2. Inclusion criteria

Article: **Reviewer:**		
Type of studies	**Yes**	**No**
1) Randomised controlled trial (any type of control group accepted)		
2) Clinical controlled trial (any type of control group accepted)		
3) Prospective cohort study (controlled before-after) (any type of control group accepted)		
4) Interrupted time series (3 time points before and 3 time points after the intervention)		
Interventions	**Yes**	**No**
5) Pre-employment assessment if all items below are yes: i) there is a health examination carried out ii) participants are job applicants iii) there is an intervention, meaning recommendations/advice about A) work accommodations or B) being able/not being able to safely carry out the job in question		
Outcomes	**Yes**	**No**
6) Occupational disease as stated by the authors of original article		

(*Continued*)

7) Occupational injuries as stated by authors of original article		
8) Other potential outcomes: Please specify		
Include if : (1 or 2 or 3 or 4) AND (5) AND (6 and/or 7 and/or 8)	**INCLUDE**	**EXCLUDE**

Appendix 3. Quality assessment for RCTs and non-RCTs (controlled before-after studies)

Reporting	
1. Is the hypothesis/aim/objective of the study clearly described?	YES/NO
2. Are the main outcomes to be measured clearly described in the Introduction or the Methods section? If the main outcomes are first mentioned in the Results section, the question should be answered NO	YES/NO
3. Are the characteristics of the participants included in the study clearly described? In cohort studies and trials, inclusion and/or exclusion criteria should be given. In case-control studies, a case-definition and the source for controls should be given	YES/NO
4. Are the interventions of interest clearly described? (aims, content, ...)	YES/NO
5. Is the distribution of confounders in each group of subjects to be compared clearly described? A list of principal confounders is provided (e.g. working condition, health status, etc.)	YES/NO
6. Are the main findings of the study clearly described? If no simple outcome data reported (e.g. 50/100,000 hours), answer NO	YES/NO
7. Does the study provide estimates of the random variability in the data for the main outcomes? Answer YES if reported for normal distribution: SD (standard deviation), SE (standard error) or CI (confidence intervals) OR (Odds Ratio) for non-normal distribution: IQR (interquartile range)	YES/NO

(*Continued*)

8. Have any adverse events that may be a consequence of the intervention been reported? This should be answered YES if the study demonstrates that there was a comprehensive attempt to measure adverse events (a list of possible adverse events is provided)	YES/NO
9. Have the characteristics of participants lost to follow-up been described? Answer NO, if numbers are not reported.	YES/NO
10. Have actual probability values been reported for main outcomes instead of discrete values (e.g. 0.035 instead of < 0.05), except when less than 0.001?	YES/NO
External validity	
11. Were the subjects asked to participate in the study representative of the entire population from which they were recruited? The study must identify the source population for patients and describe how the patients were selected. Patients would be representative if they comprised the entire source population, an unselected sample of consecutive patients, or a random sample. Random sampling is only feasible where a list of all members of the relevant population exists. Where a study does not report the proportion of the source population from which the patients are derived, the question should be answered as UNABLE TO DETERMINE	YES/NO/UNABLE TO DETERMINE
12. Were those subjects who were prepared to participate, representative of the entire population from which they were recruited? The proportion of those asked who agreed should be stated. Validation that the sample was representative would include demonstrating that the distribution of the main confounding factors was the same in the study sample and the source population (If volunteers and more than 25% refuse to participate answer NO)	YES/NO/UNABLE TO DETERMINE
13. Were the staff, places and facilities where the participants were treated, representative of the treatment the majority of workers would receive? For the question to be answered YES the study should demonstrate that the intervention was representative of that in use in the source population and NO if, for example, the intervention was undertaken in a specialist centre unrepresentative of the hospitals most of the source population would attend	YES/NO/UNABLE TO DETERMINE
Internal validity (bias)	

(*Continued*)

14. Was an attempt made to blind study subjects to the intervention they received? For studies where the patients would have no way of knowing which intervention they received, this should be answered YES	YES/NO/UNABLE TO DETERMINE
15. Was an attempt made to blind those measuring the main outcome? (The outcome assessors being blind to which group the participants belong to)	YES/NO/UNCLEAR
16. If any of the results of the study were based on "data dredging", was this made clear? Any analyses that had not been planned at the outset of the study should be clearly indicated. If no retrospective unplanned subgroup analyses were reported, then answer YES	YES/NO/UNABLE TO DETERMINE
17. In trials and cohorts, do the analyses adjust for different lengths of follow-up of workers? Where follow-up was the same for all study patients the answer should be YES. If different lengths of follow-up were adjusted for by, for example, survival analysis the answer should be YES. Studies where differences in follow-up are ignored should be answered NO	YES/NO/UNABLE TO DETERMINE
18. Were the statistical tests used to assess the main outcomes appropriate? The statistical techniques used must be appropriate to the data. For example nonparametric methods should be used for small sample sizes. Where little statistical analysis has been undertaken but where there is no evidence of bias, the question should be answered YES. If the distribution of the data (normal or not) is not described it must be assumed that the estimates used were appropriate and the question should be answered YES	YE /NO/UNABLE TO DETERMINE
19. Was compliance with the intervention reliable? Where there was non-compliance with the allocated treatment or where there was contamination of one group, the question should be answered NO. For studies where the effect of any misclassification was likely to bias any association to the null, the question should be answered YES	YES/NO/UNABLE TO DETERMINE
20. Were the main outcome measures (occupational injury and disease) used accurate (valid and reliable)? For studies where the outcome measures are clearly described, the question should be answered YES. For studies which refer to other work or that demonstrates the outcome measures are accurate, the question should be answered as YES	YES/NO/UNABLE TO DETERMINE

(*Continued*)

Internal validity (confounding, selection bias)	
21. Were the workers in different intervention groups (trials and cohorts) or were the cases and controls (case-controls) recruited from the same population? For example, patients for all comparison groups should be selected from the same hospital. The question should be answered as unable to determine for cohort and case-control studies where there is no information concerning the source of patients included in the study	YES/NO/UNCLEAR
22. Were study subjects in different intervention groups (trials and cohorts) or were the cases and controls (case-controls) recruited over the same time period? For a study which does not specify the time period over which patients were recruited, the question should be answered as unable to determine	YES/NO/UNABLE TO DETERMINE
23. Were subjects randomised to intervention groups? Studies that state that subjects were randomised should be answered YES except where method of randomisation would not ensure random allocation. For example alternate allocation would score NO because it is predictable	YES/NO/UNCLEAR
24. Was the randomised intervention assignment concealed from both the participants and healthcare provider (= those who perform intervention) until recruitment was complete and irrevocable? All non-randomised studies should be answered NO. If assignment was concealed from patients but not from staff, it should be answered NO	YES/NO/UNABLE TO DETERMINE
25. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn? This question should be answered NO for trials if: the main conclusions of the study were based on analyses of treatment rather than intention-to-treat; the distribution of known confounders in the different treatment groups was not described; or the distribution of known confounders differed between the treatment groups but was not taken into account in the analyses. In non-randomised studies if the effect of the main confounders was not investigated or confounding was demonstrated but no adjustment was made in the final analyses the question should be answered NO	YES/NO/UNABLE TO DETERMINE
26. Were losses of workers/companies to follow-up taken into account? If the numbers of patients lost to follow-up are not reported, the question should be answered as UNABLE TO DETERMINE. If	YES/NO/UNABLE TO DETERMINE

(*Continued*)

the proportion lost to follow-up was too small to affect the main findings, the question should be answered YES	
POINTS TOTAL **yes = 1** **no/unable to determine = 0**	**out of 26**

Appendix 4. Quality assessment for interrupted time series studies

Quality criteria	DONE	NOT CLEAR	NOT DONE
A. Protection against secular changes			
i) The intervention is independent of other changes *Answer NOT CLEAR if not specified (will be treated as NOT DONE if information cannot be obtained from the authors)*			
ii) There are sufficient data points to enable reliable statistical inference *Answer DONE* *(a) If at least 20 points are recorded before the intervention* ***AND the authors have done a traditional*** time-series*analysis (ARIMA model)* *OR (b) If at least 3 points are recorded pre- and post-intervention* ***AND the authors have done a repeated measures analysis*** *OR (c) If at least 3 points are recorded pre- and post-intervention* ***AND the authors have used ANOVA or multiple T-tests AND there are at least 30 observations per data point.*** *Answer NOT CLEAR if not specified in paper e.g. number of discrete data points not mentioned*			

(*Continued*)

in text or tables.			
iii) Formal test for trend reported (complete this section if authors have used ANOVA modelling)			
B. Protection against detection bias			
i) Intervention unlikely to affect data collection			
ii) Blinded assessment of primary outcome variable(s)* *Answer DONE if the authors state explicitly that the primary outcome variables were assessed blindly OR the outcome variables are objective e.g. length of hospital stay, drug levels as assessed by a standardised test.* *In the event that some of the primary outcome variables were assessed in a blind fashion and others were not, score each separately			
C. Completeness of data set *Answer DONE if data set covers 80% - 100% of the total number of participants or episodes of care in the study.*			
D. Reliable primary outcome measure(s)* *Answer DONE if two or more raters with at least 90% agreement or kappa greater than or equal to 0.8 OR the outcome is obtained from some automated system e.g. length of hospital stay, drug levels as assessed by a standardised test.*			

(*Continued*)

* In the event that some outcome variables were assessed in a reliable fashion and others were not, score each separately			
POINTS TOTAL		**out of 7 points**	

Appendix 5. Grade criteria

- Limitations of study refer to the lack of allocation concealment and blinding, incomplete accounting of patients and outcome events, selective outcome reporting and other limitations (e.g. stopping early for benefit observed in randomised trials, use of invalidated patient-reported outcomes, carry-over effects etc).
- Inconsistency refers to unexplained heterogeneity of results.
- Indirectness refers to the clarity and explicitness of evidence tables, depending on the target population, intervention and outcomes of interest to help authors of systematic a review answer a healthcare question.
- Imprecision refers to the results of studies which include relatively few patients and few events and consequently have wide confidence intervals around the estimate of the effect.
- Publication bias refers to the systematic underestimate and overestimate of the underlying beneficial and harmful effect due to the selective publication of studies.

WHAT'S NEW

Date	Event	Description
20 November 2015	New citation required but conclusions have not changed	We included two new studies but their results did not warrant a change in conclusions
4 August 2015	New search has been performed	We conducted a new search on 31 March, 2015
21 November 2014	New search has been performed	We conducted a new search on 8 November, 2013

HISTORY

Date	Event	Description
11 July 2008	Amended	Author contact details amended

CONTRIBUTIONS OF AUTHORS

FS conducted the study selection, quality assessment, data extraction, data analysis and wrote the draft for the update.

NM and MR conducted the study selection and reviewed the text for the update.

JBF and FJ conducted the study selection, quality assessment, data extraction and reviewed the text for the update.

DECLARATIONS OF INTEREST

Frederieke Schaafsma: None known.

Norashikin Mahmud: None known.

Michiel Reneman: None known.

Jean-Baptiste Fassier: None known.

Franciscus Jungbauer: None known.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

1. We added: sick leave, unfitness for duty and visits to physicians for musculoskeletal injuries as proxies of occupational injuries and diseases.
2. We also included army recruits as participants.
3. We expanded the search methods to include searching reference lists.
4. We brought in new authors (FS and FJ) to perform study selection and data extraction.
5. We used the EPOC 2006 criteria instead of the quality assessment criteria developed by Ramsay 2003.
6. We assessed the quality of evidence according to GRADE.
7. We changed the title of the review to also include sick leave.

NOTES

This review was split from the review titled: Functional capacity evaluations for the prevention of occupational re-injuries in injured workers by Mahmud 2010a. That is why there was no separate protocol for this particular review. The pre-split protocol was titled: Health examination for preventing occupational injuries and disease in workers by Mahmud 2008.

INDEX TERMS

Medical Subject Headings (MeSH)

*Employment; Accidents, Occupational [*prevention & control]; Controlled Before-After Studies; Interrupted Time Series Analysis; Occupational Diseases [*prevention & control]; Personnel Selection [*methods]; Physical Examination; Randomized Controlled Trials as Topic; Sick Leave [statistics & numerical data]; Wounds and Injuries [*prevention & control]

MeSH check words

Humans