

Heavy physical work and its association with sickness absence and disability pension

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Foreword

A cornerstone of Sweden's current work environment strategy is that everyone should be willing and able and that working life should be healthy. However, prolonged or persistent heavy physical strain occurs frequently in Swedish workplaces and research indicates that this can lead to serious health risks, which can result in sickness absence, exit from working life or the need to change jobs. Research shows that high mechanical load on joints and muscles, and work that causes high strain on the respiratory and circulatory systems, physically demanding can have various types of negative health effects.

At present, there is a lack of compiled knowledge from a Swedish perspective on the extent to which, and in what way, long-term or persistent physically demanding work affects the risks of sickness absence, disability pension, early retirement and the need to change jobs. For this reason, we have chosen to conduct a review on the subject in which we focus on Swedish research, which is more relevant from a social insurance system point of view and provides a simpler interpretation of the results.

The authors of the systematic review are Associate Professor Daniel Falkstedt, PhD Melody Almroth, PhD Kuan-Yu Pan, Professor Maria Albin and Associate Professor Katarina Kjellberg, all at the Institute of Environmental Medicine at Karolinska Institutet. PhD Alicia Nevriana and doctoral student Karin Berglund provided assistance in the development of this systematic review. Mid Sweden University has contributed with literature and information searches and Professor David Hallman at the University of Gävle has, on behalf of the Agency, contributed with quality assessment and valuable viewpoints to the benefit of the systematic review. The responsible process manager at the Swedish Work Environment Authority has been Thomas Nessen, PhD. The Agency's communicator has been Lasse Nivér. The authors of the systematic reviews have chosen their own theoretical and methodological starting points and are responsible for the results and conclusions presented in the review. I would like to thank both our external researchers and quality reviewers as well as employees at the authority who have contributed to producing this valuable systematic review, and a special thank you to Carl Lind at the Swedish Work Environment Authority for his contribution and support.

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Summary

Background and aim

Research indicates that heavy physical load at work can lead to serious health risks and possibly premature death. The statistics show that sickness absence is often higher in occupations with heavy physical loads. However, there has been a lack of aggregated knowledge about the extent to which and in what way heavy physical workload affects sickness absence, disability pension, labour market exit, and the need to change jobs. Heavy physical workload includes both work that causes high mechanical strain on muscles and joints and work that causes high strain on the respiratory and circulatory systems.

The aim of this systematic review is to increase knowledge about the consequences of heavy physical workload for individuals' health and specifically to highlight its connection with work-related sickness absence, disability pension, labour market exit and the need to change jobs from a Swedish research perspective. Because the Nordic countries differ in terms of their social security systems, this review focuses on studies from Sweden to simplify the description and interpretation of the results.

An ambition is that the results of this literature review, and the preventive measures to reduce the risks in heavy physical work that are proposed in it, will be of practical use, both in workplaces where such work occurs and for policymakers.

Review questions

This review is based on two main questions. Within this framework, we hope to increase knowledge on the topic and identify knowledge gaps and necessary directions for future research. The main questions are as follows:

- What does the concept of heavy physical workload include and what measures have been used to study the relationship with sickness absence, disability pension, change of job or labour market exit?
- What is the relationship between heavy physical workload and sickness absence, disability pension, change of job, or labour market exit? What differences exist based on education level, gender, and occupation?

Method

This systematic literature review is limited to studies from Sweden, published between 2003 and February 2024. It includes 30 articles that have investigated the relationship between heavy physical workload and the outcomes included in the review questions.

Results

Overall, the last 20 years of research in Sweden showed a clear link between heavy physical workload and long-term sickness absence and disability pension, for both men and women. The medical reason for disability pension was included in some studies, which in those cases showed the strongest and clearest association with disability pension due to musculoskeletal diagnoses (where back, neck and shoulder pain is common).

Many of the included studies used composite or general measures of heavy physical workload. This was often done using average exposure levels in occupations, or other use of occupations as indicators of heavy physical work. Several of the included studies examined different aspects of physical workload in relation to sickness absence and disability pension. The researchers could then potentially distinguish between, for example, high physical activity, heavy lifting and uncomfortable working postures at work. These studies were most often based on data from the Swedish Work Environment Authority's work environment surveys.

Sickness absence and disability pension were the most common focus

The most common outcome in relation to heavy physical workload turned out to be disability pension, where all 16 studies with this focus retrieved data on disability pension from the Swedish Social Insurance register. The second most common study outcome was sickness absence (8 studies), where information about sickness absence in almost all studies also came from the social insurance register and thus meant at least 14 days of sickness absence (the first 14 days are paid by the employer and not registered in the social insurance register). Few studies were found in which other labour market exit was analysed as a potential consequence of heavy physical workload, and no studies were found regarding changing jobs.

Heavy physical workload showed consistently increased risks

Consistently increased risks were found in studies that analysed the relationship between heavy physical workload and sickness absence or disability pension using occupational exposure levels or specific occupations for indications of physical workload. An example of an occupation with heavy physical workload was rock workers, who had a doubled risk of sickness absence compared to lower exposed occupations in the construction industry. Studies where medical diagnoses were available found that disability pension due to musculoskeletal disorders showed the strongest associations. Almost no studies included other diagnoses for sickness absence and disability pension, for example cardiovascular disease.

A higher risk among those with heavy physical workload was also found in studies that analysed the relationship between heavy physical workload and sickness absence or disability pension using individual questionnaire responses regarding different types of physical workload. These studies, however, did not find clear difference in results regarding these different types of physical exposures, such as work involving high physical exertion and work in uncomfortable working positions.

Studies that analysed women and men separately found few meaningful differences

Studies that analysed women and men separately rarely found significant sex differences. The only study comparing workers with lower and higher levels of education also did not find significant differences between groups. Some studies investigated hypotheses about factors that could strengthen or protect against negative consequences of heavy physical workload, including either factors at the individual level (BMI, physical capacity) or occupational level (opportunities for influence, time pressure, etcetera.), but most often did not find evidence for these hypotheses.

Discussion

A likely explanation for the associations that the studies identified between heavy physical workload and sickness absence and disability pension is that high mechanical load causes damage to various structures in the muscles and joints. There is extensive evidence that heavy physical workload increases the risk of musculoskeletal disorders, such as problems with the lower back, neck and shoulders, as well as osteoarthritis in the knees and hips. Such injuries and disorders can lead to functional impairment and reduced work ability.

An additional, probable explanation for the association between heavy physical workload and sickness absence and disability pension is that it is difficult to continue working in heavy physical work when health has deteriorated for other reasons. Musculoskeletal disorders caused by factors outside of work are one such example. It is likely that diseases that are not caused by high occupational physical workload itself, can also make heavy physical work difficult to cope with. One example of this is lung disease.

Heavy physical work is often characterised by limited opportunities for influence, which can, for example, prevent people with back problems from adapting their work themselves. In more qualified jobs, there is often greater flexibility in terms of when and how different tasks are to be performed, which means that impaired health is less often an obstacle. This explanation is partially accounted for and supported in some studies included in this review which have accounted for the covariation between heavy physical workload and limited opportunities for influence over work tasks.

Conclusions

This systematic review shows that the studies often found an association between heavy physical workload and an increased risk of sickness absence or disability pension, and that the associations were strongest when the outcomes were linked to musculoskeletal disorders. However, the studies did not clearly show which specific physical workload exposures gave rise to these associations.

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1. Introduction

Background

Many research studies indicate that heavy physical workloads can pose serious health risks (1, 2). More detailed knowledge on these factors is needed to develop preventive measures and create healthy workplaces. For the same reason, knowledge about the impact of physical workloads on sickness absence, early exit from working life and the need to change jobs is important to further understand potential consequences of the physical work environment.

Today, there is no comprehensive national overview of the extent to which and how physically heavy or strenuous work affects the risks of sickness absence, disability pension, early retirement and the need to change jobs, with a discussion of practical and preventive measures.

Physically heavy workload

In this review, heavy physical workload refers to work that causes high mechanical strain on muscles and joints, as well as work that causes strain on the respiratory and circulatory systems (so-called physically strenuous work). Mechanical stress refers to forces acting on and in muscles and joints when moving, handling objects such as lifting and carrying, or holding a position such as squatting.

There is strong evidence indicating that high mechanical load on muscles and joints increases the risk of musculoskeletal disorders, such as pain in the lower back, neck, shoulders, wrists/hands, knees and hips (3, 4). High musculoskeletal strain occurs during work that requires large muscle forces, such as heavy lifting or otherwise handling heavy loads. Examples of such tasks include carrying, pushing and pulling heavy objects, for example on a construction site and in agriculture, as well as moving and handling patients within health care. High physical load can also occur in work performed in uncomfortable working positions, where joints are loaded close to the limits of their range of motion. Examples include working with a bent and/or twisted back on a construction site or in a preschool when helping children to get dressed. Harmful mechanical load can also occur during repetitive work, which involves working with hands/arms with repeated, often rapid, work movements of a similar nature, for example during assembly work in the manufacturing industry.

Heavy physical work that is mainly characterised by high energy expenditure, and that places high demands on the body's ability to absorb oxygen, is referred to as whole-body load. Such work occurs in prolonged dynamic work, such as cycling, walking and stair climbing by a postman or a bicycle messenger, and in prolonged heavy muscular work, such as prolonged manual handling on a

construction site. It can also be referred to as pulse-raising work or work that put strain on the respiratory and circulatory systems.

The two types of heavy physical work; work causing high mechanical load and high strain on the respiratory and circulatory systems, often co-occur, though this is not always the case. There is no evidence that whole-body load without simultaneous mechanical loading entails a risk of musculoskeletal problems. However, associations have been shown between heavy physical workload in general and cardiovascular disease and premature death (1, 2, 5, 6), although the causality is still debated. In these studies, mechanical and whole-body load are rarely separated, and the overall literature shows no consensus on the state of the evidence.

In this review, these two types of physically demanding work are discussed in terms of 'mechanical load' and 'pulse-raising work'. The measures of physical load investigated in the included studies will also be divided in the review into "general" and "specific". General measures mean that the researchers either asked general questions about physically demanding work or summarized measurements of several different specific exposures into one measure. Examples of specific measures of physical load are heavy lifting and uncomfortable work postures. The latter include forward bending and/or twisting work postures. A specific measure of pulse-raising work is 'pure physical work'. Alternative labels for these occupational exposures appear in the studies, but the aim has been to use the above terminology in the review.

Decisions on social insurance compensation such as disability pension are based on the individual's *work ability*. This is partly a function of the individual's health and capacity, and partly of the demands and conditions of the individual's work. The degree of physical strain is an example of the latter. The link between physically demanding work and, for example, sickness absence, and disability pension, may be due to injuries to the muscles and joints caused by the work, or possibly because long-term whole-body load has caused cardiovascular disease.

Sickness absence, disability pension, early pension and changing jobs

Swedish research on working conditions and risks of sickness absence and disability pension often uses data on cases registered with the Swedish Social Insurance Agency, which administers payments. Sickness absence follows a reduction in work ability due to illness or injury for a limited period of time - it can be days, weeks or months, and the reduction in work ability can be total or partial. However, it is the employer who pays benefits for the first 14 days, and therefore short-term sickness absence is not usually recorded. A permanent reduction in work ability due to illness or injury can lead to a transition from sickness absence with sickness benefit to disability pension. The terminology has changed in Sweden about 20 years ago and the direct translation is *sickness compensation*, though for clarity in English we still refer to this as disability

pension. Disability pension can be applied for by people aged 30-64. For it to be granted, the person must have a verified and permanent reduction in working capacity of at least 25% of full-time work.

It is possible to show how physical workload affects specific illnesses and problems. However, the impact of heavy physical workloads on labour market outcomes such as incidence of sickness absence, necessary job changes, disability pension and early retirement is likely to be a more complex issue. Those with medical conditions may be on long-term sickness absence, but the extent and duration of sickness absence may also be influenced by the adaptability of the workplace. Similarly, disability pension may result from medical problems of a permanent nature, but not if the individual is able to work in other types of jobs. Early withdrawal of old-age pension is also likely to be due to, for example, musculoskeletal problems among individuals who are not granted disability pension (7-9).

At the same time, the incidence of sickness absence, disability pension and job changes is influenced by many other factors, both at the individual and societal level. Various physical problems, but also psychological problems, underlie sickness absence and disability pension even when they are not due to working conditions (9). Variations in systems for providing for workers with reduced or lost work ability are also important, and there is reason to see early retirement, long-term sickness absence and long-term unemployment as partly overlapping functions (10). Disability pension used to be more common in Sweden and Norway than in Finland and Denmark but is now least common in Sweden among these countries (11). Long-term sickness absence is more common in Norway than in Sweden, Finland and Denmark, as disability pensions. Until recently, long-term unemployment was by far the most common in Finland and unusual in Sweden, but this has changed in recent years. Denmark also has had 'efterløn', an alternative to disability pension (12).

Purpose

The overall aim of this review is to increase knowledge about the consequences of heavy physical work for individuals' health and labour market outcomes in the Swedish context, with regard to sickness absence, disability pension exit from working life and the need to change jobs. Within the framework of this aim, we hope that knowledge gaps and research needs can be identified. The focus on studies from Sweden was chosen to simplify descriptions and interpretation of results, as the Nordic countries may differ in the provision to long-term absent workers.

The discussion section of the review attempts to answer what practical, preventive measures can be taken to counteract the demonstrated consequences of heavy physical work. One aim of the review is that it can be of practical use: both for work environment management in environments where heavy physical work occurs, and for politicians.

Review questions

The review is based on two main questions. Within the framework of these questions, the ambition is to increase knowledge in the field and to identify knowledge gaps and research needs. The review questions are as follows:

- What is the concept of heavy physical workload and what measurements of it have been used to study the relationship with sickness absence, disability pension, labour market exit and job changes?
- What are the links between physically demanding work and sickness absence, disability pension, labour market exit and job changes? What are the differences by education level, gender and occupation?

2. Method

Criteria for inclusion and exclusion

This is a systematic review (13), which combines a systematic literature search with a critical review of the included literature. The review includes studies that, in a Swedish context, have examined associations between physical workloads and outcomes in terms of sickness absence, job change (or unemployment), and early retirement for medical or other reasons, especially disability pension. It excludes corresponding studies from other countries, with different social insurance systems of providing for individuals with lost work ability. However, such studies are referenced in the discussion section of this review. Included studies should be designed so that exposure (physical workload) temporally precedes outcome (e.g. sickness absence) and that data are analysed using quantitative methods; cohort studies are most common, but case-control studies are also included. Pure cross-sectional studies are excluded, as are qualitative studies. In addition, publication period is a criterion for inclusion/exclusion: only studies published in 2003 and later are included. It should be noted, however, that data from earlier years may be present in these studies.

Search strategy

The systematic literature searches were conducted using the following criteria, in accordance with PEO (population, exposure and outcome), a framework for searching research studies; the publication period 2003-2024 (February) was used as an additional criterion. The specific search terms are shown in Table 1 below and the specific search string in Appendix 3. The literature searches were conducted by search specialists at the Mid Sweden University Library, in the databases Web of science, Pub med (NCBI), Scopus, Sociological abstracts and Econlit. The final searches were done in the second half of February, 2024.

Table 1: Search terms presented in accordance with the PEO framework

PEO criteria	Search terms
Population	(sweden OR swedish)
Exposure	(heavy OR strenuous* OR physical* OR manual OR ergonomic* OR biomechanical* OR mechanical* OR "blue collar") AND (work OR "work-load" OR workload OR "work-place" OR workplace OR job OR labor OR occupation)
Outcome	("sickness absence" OR "longterm sickness" OR "long-term sickness" OR "sick leave" OR "disability pension" OR "disability benefit*" OR "disability allowance" OR "early retirement" OR "exit" OR "pension" OR "retirement" OR "unemployment" OR "labor market" OR "job change" OR "job mobility")
(Period)	PY=2003-2024 (February)

Selection process

Thirty studies were identified and included in this review, and the selection of these studies is described below.

- The final search yielded a total of 505 articles, after removing two duplicates from the library file. Each of these articles was screened for title and abstract by two project staff members, independently of each other. Of these, 448 were deemed not to meet the inclusion criteria for the review.
- The remaining 57 articles were read in full text, after which a further 23 articles were excluded on the basis of the same criteria: cross-sectional study (3), measure of physical workload not useful (10), no relevant estimate of statistical associations (3), not the right outcome variable (two studies with SA without specified duration, and one study with WAI score) and lack of separate data for Sweden (2 studies).
- The number of articles retained for data extraction was thus 34, but after extraction and tabulation of these articles, 4 were also found not to sufficiently meet the inclusion criteria and were also excluded.

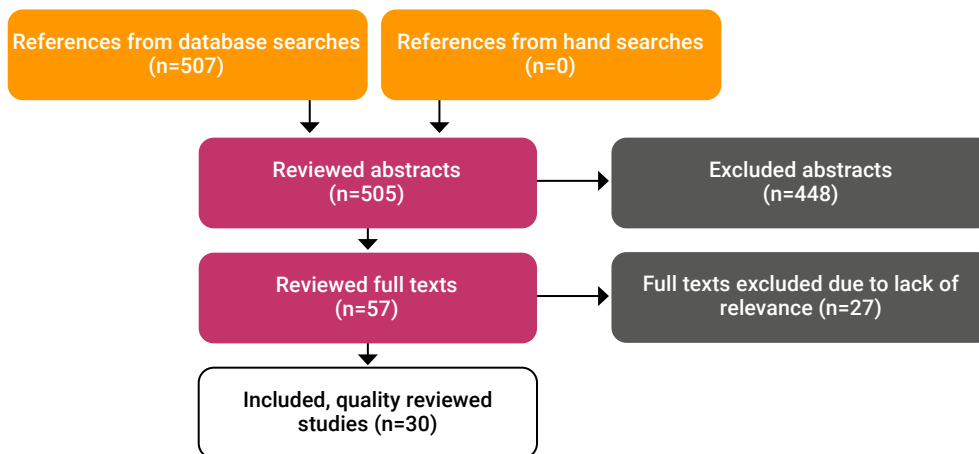


Figure 1. Process for selection of studies

Quality assessment

Two project staff members independently assessed the quality of each study; that is, they assessed the risk of bias in the studies. In cases where a study was assessed as having a high risk of bias by only one of the assessors, a third, independent quality assessment was carried out by an additional project worker. In this way, each study could be assessed as having either a relatively low/moderate risk of bias or a relatively high risk of bias.

The quality assessments used a modified, quantitative version of the Robins-E review template (14); the Swedish Agency for Health Technology Assessment and Assessment of Social Services (SBU) recommended review template for exposure studies (15) is also a version of this. A copy of the review template,

which was a Google Form, is provided in Appendix 4. Various risks of bias were scored and summed up to a total score on a scale of 0-29, where a lower score means a lower risk of bias. The representativeness of the sample could be classified as 0 or 1, while other risks of bias were scored on a scale of 0-3. These risks were: exposure variables, outcome variables, confounders, adjustments for these confounders or data on pre-exposure (baseline) outcome status, follow-up time, and non-response at follow-up. In addition, the adequacy of statistical methods was assessed, and any risks beyond the above were scored (additional weaknesses could be added with a comment and scored). The risk of bias was assessed as relatively low at 5 or fewer total points, moderate at 6-9 total points, and relatively high at 10 or more total points.

Analysis and synthesis

Information on the methods and results from the 30 studies was extracted, analysed and synthesised in accordance with the review questions. The results of the quality assessment have been used so that studies assessed as having a relatively low or moderate risk of bias (21 studies) are dealt with first and most extensively in the results summary. Studies with a higher risk of bias (9 articles) are then treated in a more concise manner.

3. Results

This section provides a detailed account of the results of the studies that were assessed as having a relatively low or moderate risk of bias. The starting point for the review is the question on the meaning and measurement of heavy physical workload at work and its relationship with outcomes such as sickness absence and disability pension in the included studies. How these outcomes are measured is also reported under a separate heading. At the end of the section, there is also a brief, summarised account of the results from the studies that were deemed to have a higher risk of bias.

Measures of physical workload at work

Many of the included studies use composite or generalised measurements of physical workload. Examples include the use of an overall survey question on physically demanding work (16) or calculating a summary index based on several survey questions on specific exposures (17-19). Many of the studies of general workload that have been included have used occupational average exposure levels ('job exposure matrices'), measuring average exposure levels by occupation. Another way of studying general workload is to use occupations with known differences in the prevalence of physical workload and study outcomes among people working in these occupations. The results of this type of study cannot provide information on associations for specific physical exposures, such as heavy lifting, uncomfortable working postures and pulse-raising work.

The above-mentioned "job exposure matrices" consist of average levels of physical (or other) exposures in occupations calculated from questionnaire data from individuals in Sweden using the Swedish Work Environment Authority's work environment surveys. Using these average exposures and a registered occupation, individuals in large studies can be given "exposure values" which is the average exposure level for their particular occupation. This method makes it possible to study populations that include large numbers of workers, thus achieving high statistical precision. The disadvantage is that individual variation in exposure within occupations is not measured.

However, several of the included studies have examined different specific types of physical strain in relation to sickness absence and disability benefits (see for example (20-22)). The researchers have sought to distinguish between the potential effects of, for example, heavy lifting, uncomfortable working positions and pulse-raising work. These studies are also often based on data from the Swedish Work Environment Authority's work environment surveys, that is, questionnaire data based on individuals' own estimates of workloads.

Measures of sickness absence, disability pension and other outcomes

Studies were searched for based on potential relevance to the question of the associations with sickness absence, disability pension, labour market exit, or having to change jobs. More specifically, a variety of terms used to describe sickness absence, disability pension, labour market exit, and job change/occupational mobility were used (see Table 1, above).

Disability pension was found to be most commonly studied in relation to physical workload. All of these studies obtained data on disability pension from registers (17-21, 23-33). Sickness absence was the next most commonly studied (22, 34-41), where sickness absence in almost all studies was defined by registered sickness absence (by the Swedish Social Insurance Agency), that is, for at least 14 days. One single study (22) used a different definition of long-term sickness absence, namely 104 days or more (that is, 3 months or more of registered sickness absence, with 14 days of unregistered sickness absence added to the definition). The same study used 28 days (14 recorded and 14 unrecorded) or less as the definition of short-term sickness absence, but in the literature in general, there does not seem to be a consistent definitions of short-term and long-term sickness absence. Two studies included early retirement as an outcome (25, 32), while a few studies examined return to work after sickness absence, leaving the industry (health care) (42) and remaining in employment at age 66 or later (43). No studies were identified that analysed job change or unemployment as a potential consequence of physical workload.

Design of the studies

Among the criteria chosen for inclusion of studies in this review was 'prospective study design'. This means that the included studies are based on quantitative data and have data on physical workload that precedes outcomes such as long-term sickness absence, which is usually retrieved from official registers in Sweden. However, a few studies have a case-control design, where previous workloads are estimated retrospectively by the study participants. A small number (4) of these studies collected all data through questionnaires. A larger number (18) of the studies collected data from questionnaires (physical workload) and from registers (long-term sickness absence, etcetera.). Some studies (8) also collected data for physical workload externally (using job exposure matrices) and linked these to individuals via occupations.

Associations in studies with general measures of physical workload

The following is a review of the included studies that examined the relationship between general measures of heavy physical workload (see the previous section "Measures of physical workload") and sickness absence, disability

pension, labour market exit, job change and so on. Table 2 summarises the estimated associations from these studies, usually in the form of relative risks or odds ratios. This table also shows what the estimates represent, that is, what relationships they refer to. Figure 2 shows the importance of statistical adjustment, that is, the differences between estimates in models with and without control variables; only some of the studies provided these figures.

Table 2 Results and characteristics of studies with general measures of exposure

General exposure measures	OR/RR (95% CI)	What does the estimate represent?
Lindberg and others (16)		Physically non-strenuous work; odds of return to work after sickness absence
Women	1.6 (1.3-1.9)	
Men	2.1 (1.5-2.8)	
Stattin and others (31)		Highest quartile of physical workload compared to lowest; risk of disability pension
Men	2.91 (2.57-3.29)	
Johansson and others (28)	2.36 (2.06-2.69)	Highest quartile of physical workload compared to lowest; risk of disability pension among men
Järholm and others (44)	2.16 (1.96-2.69)	Rock workers compared to electricians: risk of sickness benefits
Kjellberg and others (19)		Highest lowest quartile of physical workload compared to; risk of disability pension
Women	1.64 (1.26-2.14)	
Men	1.13 (0.84-1.51)	
Women, M diagnoses	2.19 (1.48-3.23)	
Men, M diagnoses	2.25 (1.28-3.94)	
Robroek and others (30)		Highest physical workload compared to lowest, three ranked categories; risk of disability pension among men
Men	2.28 (2.21-2.34)	
Men, M diagnoses	3.02 (2.90-3.15)	
Falkstedt and others (18)		Highest quintile of physical workload compared to lowest; risk of disability pension
Women	1.31 (1.26-1.36)	
Men	1.56 (1.48-1.64)	
Women, M diagnoses	2.45 (2.29-2.62)	
Men, M diagnoses	3.96 (3.50-4.47)	
Badarin and others (23)		People who changed from heavy to light physical work; risk of sickness benefits
Women	0.63 (0.52-0.76)	
Men	0.59 (0.46-0.77)	
Berglund and others (17)		Highest lowest tertile of physical workload compared to; risk of disability pension among men
Men	1.48 (1.39-1.57)	
Men, M diagnoses	2.03 (1.75-2.37)	
Söderberg and others (33)		

Table 2 continued

General exposure measures	OR/RR (95% CI)	What does the estimate represent?
Men, 50 years	0.74 (0.58-0.94)	Concrete workers who left compared to those who did not leave construction industry, by age; risk of disability pension
Men, 55 years	0.63 (0.51-0.77)	
Men, 50 years	0.66 (0.51-0.87)	Electricians who left compared to those who did not leave construction industry, by age; risk of disability pension
Men, 55 years	0.61 (0.47-0.77)	
Men, 50 years	0.87 (0.69-1.10)	Foremen who left the construction industry compared to those who did not leave the industry, by age; risk of disability pension
Men, 55 years	0.78 (0.63-0.96)	
Väisänen and others (41)	1.46 (1.44-1.47)	Construction workers compared to office workers; risk of disability pension
OR/RR: Odds ratio/risk ratio; 95% CI: 95% confidence interval		
M diagnoses: musculoskeletal diagnoses		

Occupations with different workloads in the construction industry

Several of the studies (30, 31, 33, 44) have analysed heavy physical workload and disability pension in the so-called Construction Workers Cohort in Sweden; the cohort consists of data collected in connection with health examinations between 1971 and 1993 among more than 350,000 individuals aged 15-65 years, working in the construction industry. These data are then linked to registers with data on sickness absence, disability pension and so on. Of these studies, one (31) showed a comparatively high incidence of sickness benefits among rock workers, concrete workers, insulators and roofers. Age-specific analyses were also carried out, showing that the steepest increase in disability pension in these occupations was in the 52-57 age group. Another study, published later (44), confirmed that these occupations, which represented heavily physically demanding working conditions, were at the top: rock workers, concrete workers, insulators and roofers had clearly elevated risks of disability pension compared to electricians, used as a reference group. Rock workers showed a more than doubled risk, after statistical adjustment (age, smoking, BMI), with a 37 percent incidence of disability pension.

Another study by the Construction Workers Cohort (33) examined whether switching from heavy work in the construction industry to other, presumably less physically strenuous work (at the age of 45, 50 or 55) is followed by a lower risk of disability pension later (age 60-64). For example, workers who stayed in their occupations as concrete workers, electricians and foremen in the construction industry were compared to those who left these occupations. The analyses showed that switching to another industry was followed by a lower risk of disability pension. However, the analyses showed that this seemingly favourable effect was present among electricians and foremen as well as concrete workers - the former being presumably less physically strenuous occupations.

This was particularly evident when switching after the age of 50. Because of this unexpected result, selection effects were discussed as a possible explanation, that is that the workers who left the construction industry may have had some common denominator (other than heavy physical workload) that also meant a lower risk of disability pension later in working life. However, it cannot be ruled out that the electrician profession may be perceived as physically strenuous due to uncomfortable working positions.

Differences in physical workload applied to the whole working population

Another group of studies were based on cohort data with the entire working population in Sweden (18, 23-25). The prerequisite for studies of physical workload on the working population as a whole is that job exposure matrices are used. This is because a questionnaire can, of course, not be sent to all workers in Sweden. The advantage is the size of the studies, which allows, among other things, gender-specific analyses of sickness absence and disability pension specific to several types of disease, and also dose-response relationships.

One of these studies (18) examined the relationship between a summary measure of physical workload, which included eight different aspects, and the risk of disability pension due to different types of illness up to retirement age. This study showed a clear increase in the risk of disability pension with a musculoskeletal diagnosis with progressively higher levels of physical workload, among both women and men. Women with the highest physical workload had almost two and a half times the risk, compared with the lowest, and men with the highest physical workload had four times the risk. The study also showed an association with disability pension based on respiratory disease.

Another study (23) examined whether changing from an occupation with a higher physical workload to one with a lower physical workload could reduce the risk of early exit from working life through disability pension. Men and women who permanently switched occupations were compared with men and women who remained in their higher physical workload occupation. The results showed a roughly halved risk of disability pension among workers who changed occupation, for both middle-aged and older workers. An even lower risk was confirmed for disability pension with a musculoskeletal diagnosis.

Differences in physical workload applied to specific populations

Three other studies that used job exposure matrices are Kjellberg et al (19), Berglund et al (17) and Johansson et al (28). The first study included men and women born around 1950, with occupations registered in both 1985 and 1990, which were used to link data on physical workload taken from a job exposure matrix, and data from registers of disability pension with different types of illness that could be followed until around the age of 60. The results showed a gradual increase in the risk of disability pension with higher levels of physical workload, where the association after statistical adjustments was most evident for disability

pension due to musculoskeletal diagnosis. At the same time, the study showed that there were other explanations for people with higher workload occupations having a higher risk of disability pension, such as a generally lower level of education.

The second study (17) included only men (just under 280,000), due to the use of physical fitness data from compulsory military service assessments. Physical workload was measured using a job exposure matrix, as in the studies by Falkstedt et al. (18) and Badarin et al. (23). The analyses in this study showed that excess risks for disability pension during follow-up remained clear after statistical adjustments, with the strongest associations in relation to disability pensions due to a musculoskeletal diagnosis and less associations with disability pensions due to cardiovascular disease .

The third study (28), based on men born around 1950, actually aimed to study differences in working conditions as an explanation for the higher risk of disability pension for the lower educated. It showed the same pattern as Kjellberg and Berglund: men with more physically demanding occupations were more likely to leave work prematurely on disability pension.

Other studies with general measurements

Other relevant studies have also used occupations or job exposure matrices. One of these studies (41) is based on the Health Profile Institute (HPI) database with data from health profile surveys conducted since the late 1980s, in companies linked to occupational or other health care. In this study, using various validations, a set of occupations was developed that represented variation in physical workload (actually variation in the probability of high physical workload). HPI participants in these occupations were then followed up for the presence of recorded sickness absence, also by disease types. The survey results showed that occupations estimated as having high physical were associated with a higher risk of sickness absence with musculoskeletal and cardiovascular diagnoses.

One study (16) used data on various self-reported exposures at work from questionnaires in a random sample of about 6,300 men and women. It examined various work factors in relation to the likelihood of later full work ability (measured by zero days of recorded sickness absence). One of these work factors was physically non-strenuous work, compared to more physically strenuous work. The results of the analysis showed an association between physically non-strenuous work and a higher probability of full work ability during follow-up in registers. The association was consistent after statistical adjustments and was seen among both men and women in the study.

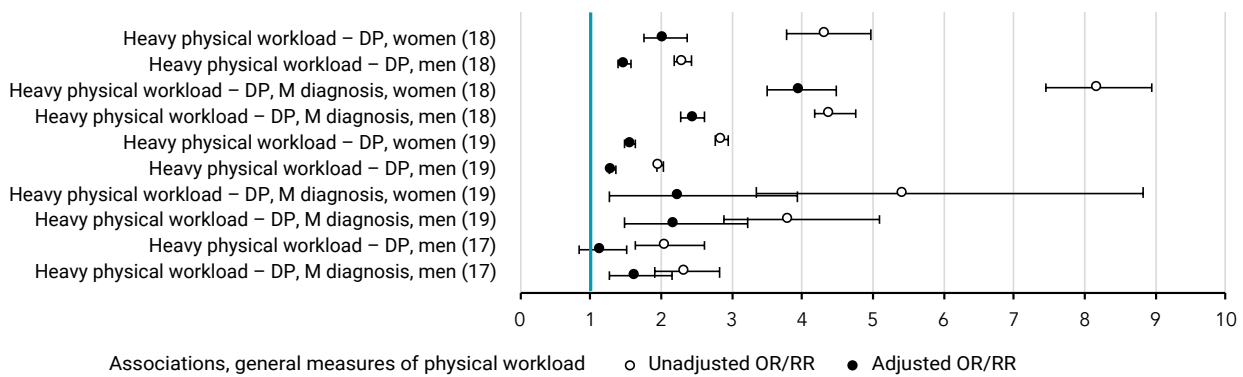


Figure 2. Estimated associations (from regression models), unadjusted and adjusted for control variables, respectively. For comparability, only studies (17–19) that estimated associations between heavy physical workload and disability pension (DP) are included. “M diagnosis” means musculoskeletal diagnoses.

Associations in studies with specific measures of physical workload

A small number of studies have been able to examine specific types of physical workload (see the section “Measures of physical workload” below) in relation to sickness absence and disability pension. Several of these are based on data from the Swedish Work Environment Authority’s work environment surveys. The estimated associations from the studies, usually in the form of relative risks or odds ratios, are presented in Table 3. The table also shows what the estimates represent, that is, which associations are referred to. Figure 3 shows the significance of statistical adjustment (not all studies provided these figures).

Table 3 Results and characteristics of studies with specific exposure measurements

Specific exposure measurements	OR/RR (95% CI)	What does the estimate represent?
Dellve and others (20)		Odds of physical workload five years earlier among individuals on disability pension (“cases”) compared to control individuals
Lifting in uncomfortable working postures	2.0 (1.2-3.4)	
Frequent heavy lifting	1.7 (1.2-2.4)	
Heavy lifting alone	1.9 (1.5-2.6)	
Gustafsson and others (21)		
Physically heavy work		Higher physical loads compared to lighter ones (excluding health care workers); risk of disability pension
Heavy lifting	1.47 (1.34-1.62)	
Pure physical work (>1/2 time)	1.56 (1.44-1.69)	
Effort leading to rapid breathing	1.64 (1.50-1.79)	
comfortable working postures		More strenuous work positions compared to less strenuous (excl. health care workers); risk of disability pension

Forts. tabell 2

Specific exposure measurements	OR/RR (95% CI)	What does the estimate represent?
Repeated bending/twisting	1.53 (1.42-1.64)	
Work that involves bending forward	1.62 (1.50-1.74)	
Working in a twisted working position	1.49 (1.38-1.60)	
Leineweber and others (29)		Exposure every day compared not every day; risk of disability pension
Repeated bending/twisting	1.58 (1.49-1.68)	
Leineweber and others (22)		
Physically heavy work		Higher physical loads compared to lighter ones (among health care workers); risk of sickness absence (<1 month)
Heavy lifting	1.20 (1.10-1.32)	
Pure physical work (>1/2 time)	1.23 (1.12-1.35)	
Effort leading to rapid breathing	1.32 (1.18-1.47)	
Uncomfortable working postures		More strenuous work positions compared to less strenuous (excl. health care workers); risk of disability pension
Repeated bending/twisting	1.25 (1.14-1.37)	
Work that involves bending forward	1.30 (1.19-1.42)	
Working in a twisted posture	1.30 (1.19-1.43)	
Physically heavy work		Higher physical loads compared to lighter ones (among health care workers); risk of sickness absence (< 3.5 months)
Heavy lifting	1.15 (1.00-1.34)	
Pure physical work (>1/2 time)	1.36 (1.17-1.58)	
Effort leading to rapid breathing	1.34 (1.13-1.60)	
Uncomfortable working postures		More strenuous work positions compared to less strenuous (excl. health care workers); risk of disability pension
Repeated bending/twisting	1.28 (1.11-1.49)	
Work that involves bending forward	1.41 (1.22-1.63)	
Working in a twisted posture	1.37 (1.19-1.59)	
Marklund and others (38)		Higher physical loads compared to lighter ones, 1993-2013 (among health care workers); risk of sickness absence
Physically heavy work	1.4-1.9 (1.2-2.8)	
Uncomfortable working posture	1.4-1.9 (1.2-2.8)	
OR/RR: Odds ratio/risk ratio; 95% CI: 95% confidence interval		

Among other things, Marklund et al (38) investigated associations between uncomfortable (specifically "twisted" and "bent") work postures and purely physical (pulse-raising) work and registered sickness absence (14 days or more), in each of the work environment surveys 1991-2014. The analyses of this combination of data from questionnaires and registers indicated associations of the same magnitude for both factors that were stable across all survey years: between one and a half and two times higher risk of sickness absence among people exposed to work in twisted work postures and purely physical work.

In another study, Leineweber (22) reported associations between a number of different aspects of physical workload and longer periods of sickness absence, ranging from 28 or fewer days of sickness absence to 105 or more days of sickness absence. The analyses showed similar associations with sickness absence according to heavy lifting, purely physical work, exertion leading to faster breathing, daily work in repeatedly bent or twisted work postures and work in forward-bent or twisted work postures for at least 25 percent of working time. Further analyses showed that both purely physical work (at least 50 percent of the time) and work in forward-bent or twisted work postures (at least 25 percent of the time) showed particularly strong associations with relatively short periods of sickness absence (28 days or less) with musculoskeletal diagnoses.

Two other studies (21, 29) examined the associations with disability pension, focusing on health and social care workers and using data from the Work Environment Surveys. In these studies, psychosocial factors at work, measured by demands and control, could also be included in the statistical adjustments. The results of these studies showed that heavy lifting, purely physical work, exertion leading to faster breathing and work in uncomfortable working postures daily or at least 25 percent of working hours were associated with an increased risk of disability pension. This was true both for the entire Swedish working population and for health and social care workers, and it was most evident for disability pension with a musculoskeletal diagnosis.

Dellve et al (20) based a study on various risk factors at work and the risk of disability pension on approximately 450 home care workers on disability pension and 580 not on disability pension. The risk factors analysed included lifting in awkward work postures, frequent heavy lifting, and heavy lifting by hand. The results of that study showed that participants on disability pension were more likely to report all these exposures. However, no statistical adjustments were made to the associations, creating uncertainty about the exact meaning of the associations.

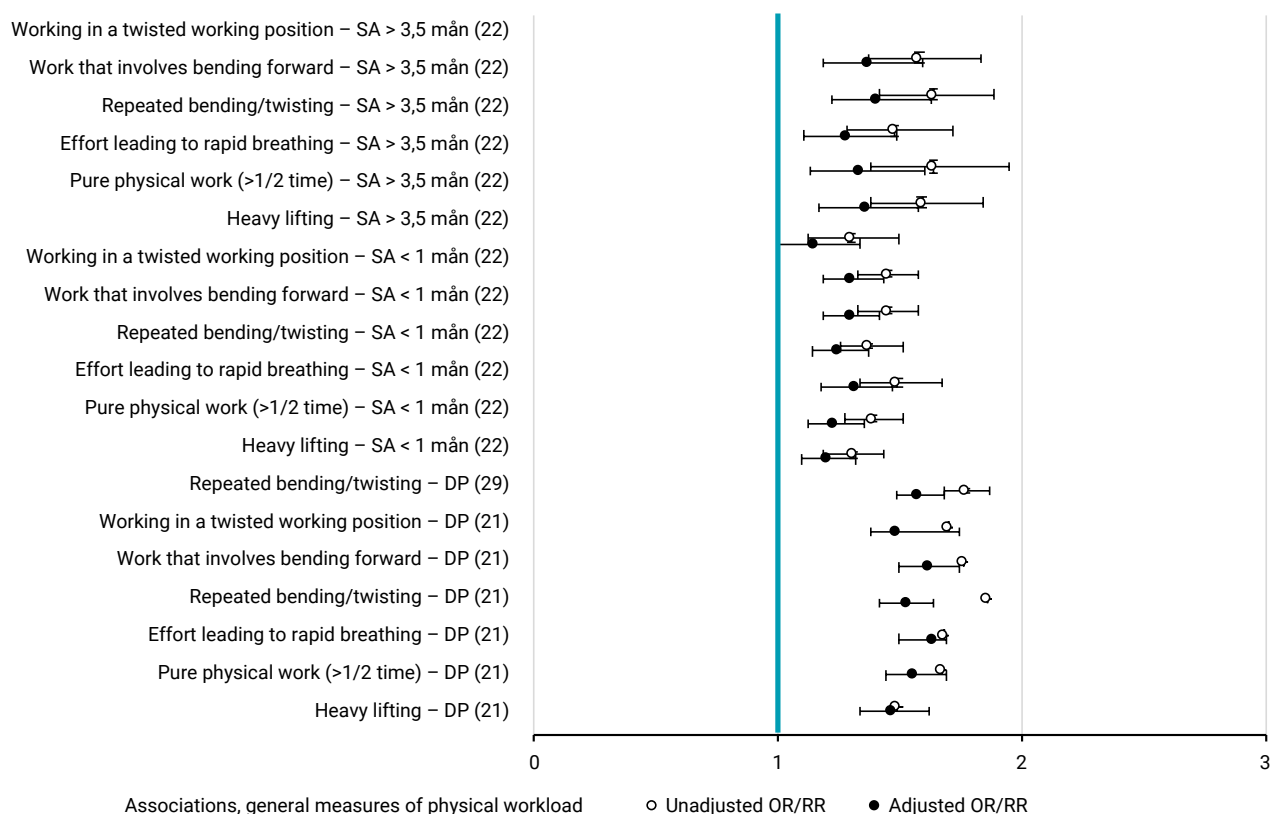


Figure 3. Estimated associations (from regression models), unadjusted and adjusted for control variables, respectively. For comparability, only studies (21, 22, 29) that estimated associations between general physical workload and disability pension (DP) or sickness absence (SA) are included.

Possible influence of other factors on the associations

Stratified relationships

It is common for studies to stratify the analyses between women and men, if the size of the study allows it. The reason for this division is rarely an explicit hypothesis about gender differences in the relationships studied but seems to be an openness to the possibility of differences in results between women and men. Of the studies included in this review, eight articles (16, 19, 23-25, 31, 45) reported analyses split in this way, almost all of which confirmed associations in the same direction for both groups. One large study (18) did show a statistically stronger association between high physical workload and disability pension with a musculoskeletal diagnosis for men compared to women. However, it showed similar associations for both sexes for other disease types. Another study (19), on the other hand, found similar associations for disability pension with a musculoskeletal diagnosis, but stronger associations for disability pension in general for women compared to men. A few studies with analyses divided into women and men found indications of differences in results, but the studies were statistically uncertain (16, 45).

Only one study conducted analyses separating low- and high-educated workers (18). The results of this study confirmed the association between physical workload and disability pension for both higher and lower educated workers.

Interacting factors

A study based on the Swedish Construction Workers Cohort (30) investigated the hypothesised interaction between obesity (BMI 30 or more) and heavy physical workload on the risk of leaving work early on disability pension. More specifically, the hypothesis concerned a high risk of lower back pain among obese workers with heavy physical workloads. Heavy physical workload for the workers was measured using a job exposure matrix based on two questions about frequency of heavy lifting and forward bending/twisting posture at work. The analyses showed a higher risk of disability pension at higher physical workload levels and higher BMI respectively, and also seemed to confirm the hypothesis of a synergistic effect of high physical workload and high BMI on the risk of disability pension to some extent. The study also included analyses of the types of illness causing the disability pension. These analyses showed the clearest link between physical workload and disability pension with a musculoskeletal diagnosis.

Similar results were shown in the previously mentioned study by Berglund et al (17), but it was low physical fitness rather than high BMI that was analysed in combination with physical workload at work. For men who had poorer results on the fitness test before military service, and who had later had heavy physical work, a possible "synergy effect" on the risk of disability pension was seen. This mainly applied to disability pension due to musculoskeletal disorders. Väisänen et al (41) also investigated the combination of fitness level and physical workload in different occupations, in this case, in relation to days on sickness absence. Fitness had been measured during visits to the occupational health service or similar. The analyses in that study showed a potentially counteracting effect of good fitness on an increased number of sickness absence days in heavily physically demanding jobs.

Another of these studies (25) examined the question of a stronger effect of heavy physical workload on the risk of disability pension among individuals with existing back problems, compared to healthy individuals. In parallel with disability pension, the risk of early old-age retirement was also analysed. The hypothesis was not confirmed by the results, which instead showed similar increases in the relative risk of disability pension at higher physical workloads among individuals with and without back problems, both for women and men. The analyses did not show a stronger increased risk of early old-age retirement among individuals with a combination of higher physical workload and existing back problems. However, among women, there was a weak but statistically significant association between physical workload and early old-age retirement.

An additional study using register data including the entire working population examined a hypothetical exacerbating effect of low job control on the association between high physical workload and risk of disability pension (24). Although both low job control and high physical workload were found to be associated with increased risk of disability pension among both women and men, an exacerbating

effect of low job control could not be statistically confirmed; the researchers saw similar associations with high physical workload, regardless of how much or little job control people had in their work. Job control means that individuals have the possibility to decide for themselves when to perform tasks, how to perform them, etcetera.

Gustafsson et al (27) used data from the work environment surveys for health and social care workers to investigate the hypothesised interactive effects of unfavourable combinations of physical workloads and lack of time for breaks and little influence over the pace of work on the risk of disability pension. The results of the analysis supported a couple of hypotheses, namely an unfavourable interaction between lack of time/time pressure and uncomfortable working postures and heavy physical work and low control at work on the risk of disability pension. A parallel study (35) showed that both heavy physical work and uncomfortable work postures in combination with low control at work were associated with significant excess risks of sickness absence. This study was largely identical to the previous one but with sickness absence as the outcome variable. However, the analyses did not support the interaction effects of uncomfortable work postures, heavy physical work and high time pressure. It should be mentioned that the exposure variables in both of these studies were analysed in a simplified form (with only two categories for each variable). This creates uncertainty about the levels of physical workloads to which individuals in these categories were actually exposed.

Stengård et al (45) conducted a study on the so-called SLOSH cohort (*Swedish Longitudinal Occupational Survey of Health*). They used questionnaire data for people just below retirement age in blue-collar occupations to investigate factors at work that could affect retirement age together. The self-reported factors examined were physically demanding work, heavy lifting and uncomfortable working postures, and their association with time left before retirement as well as people's job control and social support at work. The analyses showed that people with higher physical workloads were less likely to still be working. At the same time, they also showed that this association was weaker for people with greater social support as well as greater influence at work, though the latter was less clear.

Results from studies assessed as having a higher risk of bias

In addition to the 21 studies reported above, 9 studies met the inclusion criteria and were thus also considered to contain results of relevance to this review. It may therefore be of value to see overall whether or not these results confirm what has been shown above. It is also relevant to point out some typical limitations of the studies in general. These studies were assessed as having a higher risk of bias and are therefore not given as much weight. At the same time, the assessment does not mean that these studies in all, or even most, respects have greater limitations than others. The assessment should therefore be viewed in relation to the questions of the review, not as an evaluation of each study in itself.

The results in seven (26, 32, 34, 36, 37, 39, 43) of these nine studies are consistent with the overview. Overall result above of evidence for associations between higher physical workloads and risk of sickness absence, disability pension and earlier retirement:

- four of these studies (34, 36, 37, 39) have sickness absence as an outcome
- one study has disability pension as an outcome (26)
- two have different retirement age outcomes (32, 43)
- four of the seven studies contained results split between women and men (32, 34, 37, 39), and those results are also consistent with the results of the studies with lower assessed risk of bias
- One of the studies (32) also split analyses between blue-collar (manual) workers and white-collar workers and showed an association between physically demanding work and an increased likelihood of retirement among blue-collar workers, but a lower likelihood of retirement among white-collar workers with high physical demands at work.

However, the results of two of the studies are not consistent with the overall result of associations between higher physical workloads and risk of sickness absence, disability pension, and labour market exit. One of these studies (40) was based on data collected in public regional workplaces in Sweden. It used an index based on several questions as a measure of physical workload but also included a measure indicating physical workload relative to perceived work capacity in the analysis. The results showed an association between the latter measure and risk of long-term sickness absence, but not an association between higher physical workload per se and risk of sickness absence. The second study (42), with just under 1,100 respondents, examined factors behind increased likelihood of leaving the nursing profession, with a particular focus on physical workload and musculoskeletal problems. The analyses in the study found few statistically significant associations: while patient transfers without tools appeared to be linked to increased likelihood of leaving the profession, perceived physical exertion at work, the number of patient transfers per shift and the presence of heavy patient transfers did not.

The assessment of risk of bias performed on the 30 included studies concerned the study population, exposure measurement, outcome measurement, statistical control of other factors that may affect the outcome ("confounding") and the statistical method used. In general, the 9 studies with a relatively higher assessed risk of bias had smaller study populations than the other studies, resulting in lower precision in the association estimates. In general, these studies also had less statistical control over other factors that may affect the outcome and thus a higher risk of spurious associations. In other words, they may have overestimated the associations. However, this is not the case in every study, and it may also occur in some studies with a lower assessed risk of bias.

4. Discussion

Many of the included studies used composite or generalised measures of physical workload. This was usually based on the use of average exposure levels in occupations (from 'job exposure matrices'), or other use of occupations as exposure measures. However, the use of general survey questions on physically demanding work was also common. Several of the included studies also examined specific types of physical workload in relation to sickness absence and disability pension. The researchers wanted to distinguish between, for example, high physical activity, heavy lifting and stressful work postures at work. Most often, these studies were based on data from the Swedish Work Environment Authority's work environment surveys.

Studies that analysed the association between heavy physical workload and sickness absence or disability pension, and used exposure information linked to individuals via their occupations or made comparisons between occupations with different levels of physical workload, consistently show clearly elevated risks in work with heavy physical workload. Studies where diagnoses of medical conditions were available found that sickness absence or disability pension due to musculoskeletal disorders showed the clearest and strongest associations.

Increased risks were also found at higher physical workloads in studies that have analysed the association between heavy physical workloads and sickness absence or disability pension using individuals' questionnaire responses to questions on different aspects of physical workload. These studies sometimes used self-reported information on specific physical workload exposures, but there was no clear difference in results regarding, for example, work with high physical exertion and work with strenuous/uncomfortable working postures. Thus, there is no aspect of physical workload that consistently showed a stronger association with the outcomes compared to other aspects.

Studies that analysed women and men separately rarely found significant differences in outcomes. The only study that separates workers with lower and higher levels of education also did not find significant differences in outcomes. Studies that examined hypothetical reinforcing (or counteracting) factors, either at the individual (BMI, physical fitness) or workplace level (opportunities for influence, time pressure, etcetera.) showed inconsistent results in support of such an impact on the relationship between heavy physical work and the risk of sickness absence or disability pension. In other words, the studies did not identify any factor that clearly appears to strengthen or weaken the effects of heavy physical workload on these outcomes.

Comparison with other Nordic countries

Denmark

Over a number of years, a series of studies from Denmark have analysed survey data from a large number of respondents and linked their responses to registered long-term sickness absence, disability pension and in some cases also other early retirement. One study (46), which used survey data on employees' workloads showed that uncomfortable working postures, heavy lifting/carrying, and pushing and pulling loads were associated with an increased risk of long-term sickness absence among both men and women. A later study, from 2016 (47), again showed increased risks of long-term sickness absence. There, the same data had been expanded with more respondents. In addition, it was shown that the various factors to some extent added risks to each other, which is a way of indicating that different factors at work have unique effects and do not represent one and the same underlying risk factor. A 2018 study (48) used additional data and examined the associations between different levels of physical workload and risk of long-term sickness absence. In addition, it showed the risk of disability pension and what is known in Denmark as 'efterløn', which is a form of early retirement (see introductory section). For long-term sickness absence, this study showed associations in line with previous studies. It also showed that the relationship had a dose-response pattern that is, a gradual increase in risk from the group with no physical workload to the group with very heavy physical work. A similar dose-response relationship was also found for disability pension. Incidentally, other early retirement was also more common among those with a higher physical workload. Another study (49), published in 2021, showed that the associations with long-term sickness absence were similar for women and men. The study also showed that the associations seemed to increase in strength with increasing age of the workers; there was no association among 20-year-olds and the strongest association was found among 60-year-olds.

In the later published Danish studies, the statistical models took into account potential covariation with psychosocial risk factors in the work environment (47-49). However, the specific physical workloads were not included in the same statistical model, which prevents conclusions about their independent effects.

Finland

A series of studies from Finland have analysed the same type of extensive survey data and linked respondents' answers to recorded long-term sickness absence and disability pension. A 2010 study by Laaksonen et al. (50) found that heavy physical workload was associated with a higher relative risk of sickness absence compared to other types of workloads. The study was based on survey data from employees (both white-collar and blue-collar, with varying occupations) in the City of Helsinki and on sickness absence data from registers. The results seemed to apply to both short-term and long-term sickness absence episodes. Another

study, published slightly earlier (51), showed an association between heavy physical work and disability pension. The study was based on questionnaire data on physical workload and other factors from middle-aged male workers, linked to pension data. The association was seen for disability pension due to musculoskeletal disease, but not as clearly for disability pension due to cardiovascular disease and not at all for psychiatric diagnosis as a reason for disability pension. In the study, particularly high risks seemed to be associated with manual handling, static muscle strain, uncomfortable working postures and heavy physical strain at work; the associations showed a dose-response pattern, with highest risks at high self-reported exposure. A study published in 2012 (52) also showed that physical workload could be linked to an increased risk of disability pension with musculoskeletal disease. Like the above-mentioned study by Laaksonen, it was based on data from employees of the City of Helsinki. A more recent study of the same data, published in 2019 (53), instead measured physical workload using a job exposure matrix and also showed a clear and distinct relationship between higher levels of physical workload in the occupation and disability pension due to musculoskeletal disorders.

In these Finnish studies, the statistical models usually took into account potential covariation with other risk factors in the work environment. However, in one of the studies (51) this was not done; this limits the possibility of drawing conclusions about the pure effect of physical workload, and in particular about separate effects of different aspects of physical workload. Only one of the above-mentioned studies reported results split between women and men (52). That study found similar associations between the genders regarding physical workload and risk of disability pension.

The results in the Nordic countries seem to be consistent

The studies from Sweden included in this review thus appear to be consistent with findings from Denmark and Finland published during the same period. Work with high physical workload is associated with an increased risk of long-term sickness absence, and the association with the risk of disability pension due to musculoskeletal problems appears to be stronger than other associations when this has been studied. Specific measures of physical workload are included in some of the studies, but no one aspect of physical workload showed consistently stronger associations.

However, it should be noted that the exact relationship between high physical workload and variables indicating exit from the labour force can be expected to vary between Nordic countries, as different countries have different ways of responding to problems of employment difficulties in the labour force (11, 54). People can support themselves with the help of unemployment insurance, sickness absence insurance, disability pension or the possibility of early retirement (for example, 'efterløn' in Denmark). In addition, unemployment is often perceived as stigmatising. Systems such as early retirement, which may be more socially acceptable, play a role as a result of this (7).

Heavy physical work and shorter working lives

In this context, it is worth mentioning studies of expected years in working life (so-called working life expectancy). These studies seem to confirm that work in heavy, manual jobs contributes to fewer years of working life for the working population, and that sickness absence and disability pension contribute to these lost years (8, 55). In a study based on data from Denmark, Pedersen et al. (8) have compared working life expectancies calculated from different ages as well as specific states of non-work between people with high and low physical workloads. The method of analysis is to map and summarise workers' transitions between different states: employment, unemployment, sickness absence, other non-activity (in the labour market), disability pension, early retirement and death. The comparison shows that Danish 30-year-olds in jobs with high physical workload can expect fewer years in active work (about 3 years for women and about 2 years for men) compared to 30-year-olds in jobs with low physical workload. The study shows that more time on sickness absence and disability pension helps to explain these 'lost years' for workers with higher workloads, which is expected based on the results of the present review. It also shows that unemployment contributes to the differences in working life expectancy. However, as the study is purely descriptive, it does not isolate high physical workload from co-varying factors, such as low educational level.

Schram et al (55) have also calculated working life expectancies in relation to the amount of physical strain at work, which was estimated using a job exposure matrix. The calculations were made on data on the majority of men and women aged 50-63 years from the working population in Finland. The method of analysis is similar to the study above (8), but the working lives of groups with different amounts of physical workload were also compared by type of occupation (manual work, lower white-collar, higher white-collar and self-employed). The results show that shorter working lives among men and women with more physical workloads are explained by an increased incidence of disability pension, while time in unemployment does not differ between the exposure groups. Instead, differences in the incidence of unemployment are seen between different types of work: highest incidence in manual work, lower incidence in white-collar groups and lowest incidence among the self-employed.

Possible explanations for the associations

The results of the studies included in this review are interpreted as that heavy physical workload at work leads to an increased incidence of long-term sickness absence and disability pension among workers, and that this is mainly due to musculoskeletal disorders. A plausible explanation for these associations is that high mechanical load causes injuries to various structures in muscles and joints. There is extensive evidence that heavy physical work increases the risk of musculoskeletal disorders, such as low back, neck and shoulder pain, as well as knee and hip osteoarthritis (3, 4). Such injuries and disorders can lead to functional impairment and decreased work ability, which is what the Swedish Social Insurance Agency bases its decisions on entitlement to sickness absence benefits and disability pension on.

There is a debate about how to assess the evidence on causal associations between work-related physical strain and musculoskeletal problems - despite the very extensive research showing associations between a range of specific exposures to physical workload and disorders in various parts of the musculoskeletal system (3). Punnett (4) discusses the problem that the mechanisms of onset of musculoskeletal disorders are complex, with some risk factors unrelated to work, such as age, gender, genetics and lifestyle. Another problem is that differences in levels of physical workload at work are so closely related to socio-economic position, measured, for example, as educational attainment, that the effects on ill health are difficult to disentangle. However, Punnett points out that the links between physical workload and musculoskeletal problems seem to be demonstrated in most studies, despite these methodological difficulties. Punnett concludes that much of the research evidence on musculoskeletal disorders points to the importance of high physical workload as a cause of disease.

A further likely explanation for the associations between heavy physical workload and sickness absence is that it is difficult to remain in heavy manual work compared to in white-collar jobs that are more qualified, when health has deteriorated for some reason. Musculoskeletal disorders caused by factors outside work are one such example. Even diseases not caused by high physical workloads per se can make heavy physical work difficult to manage. One example is lung diseases such as COPD. Heavy manual work is often characterised by limited opportunities for influence over work, which may, for example, prevent people with back problems from adapting their work themselves. In more skilled jobs, there is often greater flexibility in terms of when and how different tasks are performed, which means that health problems are less likely to be an obstacle (56).

An individual's physical capacity affects the risk of injury from heavy physical work

An individual's ability to perform manual tasks is covered by the concept of physical capacity. It includes muscle strength, balance, mobility, coordination, fitness and aerobic capacity; that is maximum oxygen uptake. The level of physical capacity is influenced by a variety of factors, such as age, gender, health, genetics and how physically active the person is. The physical capacity of an individual affects the ability to perform heavy physical work and the relative load on, for example, muscles, joints, heart and blood vessels. This, in turn, affects the risk of being injured by the heavy physical work and developing a reduced work ability. As an example, women on average have lower muscle strength, which means that lifting a 15 kg load will require a higher proportion of a woman's capacity and a higher risk of back injury. Having to use a high proportion of the maximum capacity, for example in terms of muscle strength, endurance and aerobic capacity, can lead to insufficient recovery during a working day and lead to fatigue and risk of injury. Matching the workload with the worker's capacity is therefore of utmost importance to prevent injuries and reduced work ability. Studies have found that the negative effects of physically heavy work on health and work ability are greater in those with low fitness levels. This has been shown, for example, by Väisänen et al (41).

Physical capacity naturally declines with age. For example, muscle strength, mobility, and maximum oxygen uptake decrease as age increases. This can lead to an imbalance between the physical demands of work and the physical capacity of the individual. This in turn means that the 'reserve capacity' of the older worker decreases and the older worker is more often exposed to loads that are too great in relation to his or her capacity, and more often has insufficient recovery (57, 58). Daily overload, lack of recovery and previously developed musculoskeletal disorders are probably the main reasons why work-related musculoskeletal disorders increase with age. The decline in age-related capacity rarely seems to be counteracted by any so called 'exercise effects', which might be expected in the context of prolonged heavy physical work (58, 59). On the contrary, an accelerating negative effect on muscles, joints and circulatory organs has often been observed (60). Moreover, although the physical capacity varies between younger and older groups of workers in different occupations, the physical demands on these individuals rarely differ (57, 61). A large number of studies show that there are major difficulties in remaining in work until normal retirement age in physically demanding jobs and in groups with low levels of education (62-65). This poses a major challenge as retirement ages are gradually raised in Sweden.

Possible consequences of research methods

The literature review shows that the included studies' measures of physical workload vary and are not standardised. Punnett (4) has previously pointed out that research on physical workload at work and musculoskeletal problems lack standardised measures, in terms of both exposure outcome variables. Differences in results between different studies may then be related to differences in the choice of measures of exposure and/or outcome. In addition, measurements may vary in precision and thus lead to different strengths of association.

The measures of physical workload in many of the studies are general. These studies do not show whether it is heavy lifting or high exertion or uncomfortable working postures that are most important for the associations between heavy physical workload and sickness absence or disability pension. While some studies have measured specific physical exposures, not all of these studies isolate the specific factors from each other in the statistical analyses and therefore do not estimate their individual effects. The resulting uncertainty limits the possibility of developing concrete recommendations and proposals for actions in the work environment.

Measures of physical workload are also affected to some extent by the fact that studies are based on populations with different prevalence or distribution of exposures; a study of workers restricted to one industry is likely to have less exposure variation than a study of all workers in Sweden. Many researchers rank exposure levels, thereby examining them as relative, which affects the estimates of associations.

Some of the studies do not adjust for the correlation between physical workload and psychosocial risk factors at work. This probably means that some of the reported associations have a different explanation than heavy physical workload. There are also other risk factors at work that may lie behind sickness absence and disability pension, such as other physical exposures. However, measures of these are rarely included in the studies. In addition, detailed measures of workers' health behaviours over time are often lacking. In studies of the entire working population, demographic and socioeconomic indicators have been used instead to statistically control for other factors that may affect the outcome.

The impact of the phenomenon "healthy worker effect", that is, that individuals in work tend to have better health than individuals not in work, is not explicitly addressed in the studies included in the review. If people whose health is less affected by physical workloads are overrepresented in physically demanding occupations, the effects on more average people may be larger than indicated by the association estimates (57). However, studies that take into account such comparability problems to a greater extent would require repeated measurement of exposure, which have not been used in the included studies.

Practical implications

The results show a clear link between heavy physical workload and long-term sickness absence and disability pension. This points to a great need for clear recommendations and initiatives in occupations with heavy physical work. The Swedish Work Environment Authority's work environment surveys show that many people are employed in jobs that are highly physically demanding: about 2 in 10 workers (66). Agriculture, forestry and fishing, construction and hotels and restaurants are industries where such jobs are particularly common. Around four out of ten workers in these sectors have physically demanding jobs.

To the greatest extent possible, work should be designed so that it can be carried out throughout an entire working life, without leading to overload. The Work Environment Act is clear that all work must be designed so that the employee is not exposed to physical or mental strain that may lead to ill health or accidents, and that the employer must take all necessary measures to prevent this (Work Environment Act, AML 1977:1160, chapters 2, 3). In addition, well-established principles in ergonomics state that

- physically demanding work should be organised in a way that minimises the heavy work tasks
- breaks can be taken when needed
- a variation in physical workload is provided by alternating between different types of tasks (67).

One way to achieve a more favourable workload is to increase the worker's influence over the work arrangement in such jobs. This can enable him or her to adapt the physical workload to his or her own abilities and to decide when it is time to take a break or to change tasks as a way to increase variation in workload and promote recovery.

Adapting the physical demands of the work to the physical capacity of the individual is of utmost importance to prevent injuries and reduced work ability. According to the Work Environment Act, the employer has a clear responsibility to adapt the demands of the work to the employee's ability (AML 1977:1160, chapter 2, AFS 2023:2, chapter 3). The relationship between the physical demands of work and the physical capacity of the individual, and a good match between these, is a growing and important challenge in working life. Sweden is changing demographically, with an increasing proportion of older people and longer life expectancy. To counteract the societal consequences, working life is now being extended, including by gradually raising retirement ages. In addition, the possibilities for receiving social insurance benefits have been tightened considerably since 2008. Research suggests that remaining in work until normal retirement age in physically demanding jobs is a particular challenge (64).

Another worrying trend concerns the physical capacity of younger people in the workforce. Studies show that the fitness of the Swedish workforce has deteriorated over the past two decades. The decline in fitness is most pronounced among younger people, men, people with low education and those living in rural areas (68). The same research group has shown that people with physically demanding jobs often have poorer fitness than sedentary office workers, and that fitness has deteriorated most over time in such occupational groups (41).

The physical capacity of workers naturally decreases with age. Therefore, the physical demands of different jobs cannot be assessed solely on the basis of what younger workers are able to. This assessment may also need to take into account that physical capacity seems to have declined over generations and is now lower among younger workers. These aspects are important to include when designing new production systems and changes to work. Furthermore, workplaces need to be more prepared to adapt work tasks to the individual's capabilities, due to an increasing proportion of older people in the workforce and therefore more people in work with chronic diseases. To avoid early exit from the labour market, it is essential that work is adapted at an early stage, before, for example, musculoskeletal disorders develop to the extent that the person is no longer able to continue working. Important measures to enable work in older age can be to give older workers the opportunity to receive adaptations such as less heavy tasks and increased opportunities to control their work, for example in terms of how the work is organised, breaks and pace.

Physical exercise during working hours in workplaces with physically demanding work can be an intervention to prevent sickness absence and exit from working life. It can be a way to give more people a physical capacity that meets the demands of the job. Employer support for exercise outside working hours, for example through wellness allowances, can also be such an intervention. This can be particularly important for older workers.

Other measures at the workplace level are improved opportunities for professional development that can increase individuals' chances of switching to less physically demanding jobs and work tasks to enable them to work into old age. This requires efforts to raise the issue and discuss with the employee already during mid-life

on how to complement his or her skills in the workplace or through external training, so that he or she can shift to less demanding work tasks.

Systematic work environment management with risk assessment and measures, and which are documented, is of course of utmost importance in industries and occupational groups where heavy physical work is involved. Here, occupational health services can be called upon to provide support. Access to occupational health services can be particularly important for groups with physically demanding tasks. This is because of the need for expert support in work environment prevention efforts to reduce physically demanding work, and the increased need for support in adapting work to the individual's ability. In Norway, industries such as manufacturing and construction are covered by mandatory occupational health services (69).

5. Conclusions

Over the past 20 years in Sweden, a large number of studies have been conducted in which, among other things, measures of high physical workload at work have been considered in relation to either registered sickness absence or registered disability pension. There are very few studies of other outcomes, such as changing jobs or early retirement. Some of the studies use composite or general measures of physical workload. One of the reasons for this is the use of exposure information on occupations (from so-called job exposure matrices). The results of these studies do not provide information on the relative importance of specific physical exposures, such as heavy lifting, uncomfortable postures and pulse-raising work. Other studies have examined survey data on different types of physical load in relation to sickness absence and disability pension. In these studies, researchers have sought to distinguish between the effects of, for example, heavy lifting, uncomfortable postures and pulse-raising work. These studies are often based on the Swedish Work Environment Authority's work environment surveys.

Studies that have analysed the relationship between heavy physical workload and sickness absence or disability pension, and that have used job exposure matrices or compared occupations with different physical workloads, consistently find increased risks in work with heavy physical workload. The clearest and strongest associations are seen for sickness absence and disability pension due to musculoskeletal disorders. Studies that have analysed individuals' survey responses to questions about various aspects of physical workload in relation to sickness absence or disability pension also find increased risks with higher physical workload. These studies sometimes used self-reported information on specific workloads, but no clear difference in estimated effects between different types of physical exposures are apparent.

The estimated effects of physical workload on sickness absence or disability pension do not appear to differ significantly between women and men. Nor do they appear to be significantly strengthened or weakened by other factors, such as the individual's physical characteristics (BMI, physical fitness) or factors at work (opportunities for influence, time pressure, etcetera.). At the same time, the evidence base is uncertain, and therefore further studies using other research methods may be warranted.

An important explanation for the links between physical workloads and sickness absence or disability pension appears to be musculoskeletal disorders, where pain in the back, neck and shoulder, for example, is common. One part of this explanation may be that high physical workloads lead to an increased risk of sickness absence or disability pension through the development or worsening of musculoskeletal disorders, another part that physical workloads prevent people with such disorders from working.

6. Knowledge gaps

In compiling this review, several areas have been identified where knowledge is limited and where further research would be valuable. These knowledge gaps are briefly described below.

Studies based on longitudinal data are needed

There is a strong need for research using longitudinal data. In this context, longitudinal data refers to repeated measurements of physical workloads and the co-varying factors inside and outside work that may give rise to over- or underestimated associations with sickness absence, disability pension, early retirement, etcetera. Comparability problems due to the fact that individuals in work tend to have better health than individuals who are not in work could also be better managed with longitudinal data. Repeated measurements would also make it possible to classify physical workload based on duration and accumulation, the significance of which is not really known in the research field.

There is also a need for studies based on technical measurements of physical workload that can identify threshold values for high workloads. At present, however, it is difficult and expensive to carry out workplace measurements in sufficiently large populations. All studies included in the review have, directly or indirectly, used self-rated and simplified exposure data in the analyses. These data may be misleading in terms of individuals' actual exposures, which may have a negative impact on the reliability of the association estimates. There are also knowledge gaps regarding whether the type of physical workload affects risk. In many of the studies, the measures of heavy physical workload are general, and the studies therefore did not show which specific physical exposures had the greatest impact on the outcomes. All of this knowledge is needed as a basis for more effective workplace interventions and regulation of heavy physical work.

Knowledge is needed on whether heavy physical workload at work prevents older people from remaining in work. Studies are needed to determine whether the risk of sickness absence and disability pension arises as a direct result of the health consequences of heavy physical workload or whether physical workload primarily makes work more difficult for workers (especially older workers) with reduced health and capacity, for example musculoskeletal problems. Linked to this is the question of whether other illnesses also prevent people in occupations with heavy physical workload from continuing to work.

There is limited knowledge to be gleaned from the included studies about the extent to which physical workload at work and the negative health consequences put an end to workers' careers, and whether older workers retire earlier than they would otherwise have done because of difficulties with physically heavy work. It is also noted that comparisons between older and younger workers are lacking in studies in Sweden over the last 20 years. With a larger proportion of older people in the labour force, this would be valuable knowledge.

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8. Appendix

Appendix 1. Table of included studies

Publikation/ artikel	Studiepopulation och -design	Exponeringsvariabler	Variabler för justering eller interaktion	Utfallsvariabler	Resultat
Tabell	Text				
Badarin, 2022, Does a change to an occupation with a lower physical work- load reduce the risk of disability pension? A cohort study of employed men and women in Sweden	National; Swedish Work, Illness, and labor-market Participation (SWIP) cohort; Register; Cohort; Baseline year: 2010; Age range at baseline: 44-63 years; N=359,453; Follow-up years: 2011-2016	Change to a stable lower exposure to physical workload (from the top quartile of physical workload to any of the lower quartiles in 2008 and remaining in the lower quartiles in 2009 and 2010). Physical workload was estimated using job exposure matrix (JEM). JEM was constructed using the responses to eight questions inclu- ded in the Swedish Work Environ- ment Surveys 1997-2013 (heavy lifting (≥ 15 kg), physically strenuous work, fast breathing due to physical work, forward bent position, twisted position, working with hands above shoulder level, repetitive work and frequent bending and twisting). Over- all exposure to physical workload was estimated using an index score created by summing the scores of the responses to the eight questions on physical workload and calcula- ting an overall mean value, linked to occupation, and stratified by sex.	Education, civil status, country of birth, unemployment history, sick leave history, history of psychiatric hospitalization Sex, age	Disability pension, all cause and due to musculoske- letal	Change from high to low physical workload was associated with lower risk for disability pension HR all age, all cause Women 0.63 (0.52-0.76) Men 0.59 (0.46-0.77) HR middle-aged (44-53), all cause Women 0.61 (0.51-0.73) Men 0.52 (0.39-0.68) HR older (54-63) Women 0.58 (0.42-0.79) Men 0.63 (0.43-0.92)
Badarin, 2023, Combined exposure to heavy physical workload and low job control and the risk of disability pension: A cohort study of employed men and women in Sweden	National; Swedish Work, Illness, and labor-market Participation (SWIP) cohort; Register; Cohort; Baseline year: 2009; Age range at baseline: 44-63 years; N=1,804,242; Follow-up years: 2010-2019	Average index of physical workload in 2007-2009, divided into tertiles. Physical workload was estimated using job exposure matrix (JEM). JEM was constructed using the responses to eight questions inclu- ded in the Swedish Work Environ- ment Surveys 1997-2013 (heavy lifting (≥ 15 kg), physically strenuous work, fast breathing due to physical work, forward bent position, twisted position, working with hands above shoulder level, repetitive work and frequent bending and twisting). Over- all exposure to physical workload was estimated using an index score created by summing the scores of the responses to the eight questions on physical workload and calcula- ting an overall mean value, linked to occupation, and stratified by sex.	Education, civil status, country of birth, unemployment history, sick leave history, history of psychiatric hospitalization Sex, age, job control	Disability pension, all cause and due to musculo- skeletal	Medium and high physical workload was associated with higher risk for disability pension HR women Medium PWL 1.36 (1.31-1.41) High PWL 1.83 (1.76-1.90) HR men Medium PWL 1.49(1.43-1.56) High PWL 1.77 (1.69-1.85)
Berglund, 2023, The impact of cardiorespiratory fitness and phy- sical workload on disability pen- sion—a cohort study of Swedish men	National; Swedish Work, Illness, and labor-market Participation (SWIP) cohort; Register; Cohort; Baseline year: 2005; Age range at baseline: 44-54 years; N=279,353 (men only); Follow-up years: 2006-2020	Mean values of physical workload in 2005, divided into tertiles. Physical workload was classified using a Swedish JEM based on responses to five questions on physical workload, from the Swedish Work Environment Surveys between 1997 and 2013 (heavy lifting (\geq 15 kg), physically strenuous work, working in a forward bent position, working in a twisted posture, and working with hands above shoul- ders). An index mean-value was computed by summing the scores for these questions and calculating the mean value.	Cognitive ability, body mass index, parental socioeconomic position, education, previous unemployment Cardiorespiratory fitness	Disability pension, all cause and due to musculos- keletal and cardiovascular	Medium and high physical workload was associated with higher risk for disability pension among men HR medium 1.46 (1.39-1.55) HR high 1.48 (1.39-1.57)

Publikation/ artikel	Studiepopulation och -design	Exponeringsvariabler	Variabler för justering eller interaktion	Utfallsvariabler	Resultat
Bildt, 2006, Work and health in Gnosjö: A longitudinal study	Regional; Leva och bo i Gnosjö, ("Life and living in Gnosjö"); Questionnaire linked with register; Cohort; Baseline year: 1998-1999; Age range at baseline: 45-64; N=473; Follow-up years: 1998-2001	Physical workload is assessed through questionnaire on the following domains: - Level of physical stress at work using Ratings of Perceived Exertion (score range 6-20, dichotomised into low 6-13, high 14-20) - working with hands above shoulders (dichotomized into almost never/never vs others) - working with hands below knee levels (dichotomized into almost never/never vs others) - bending and twisting movements of the body (dichotomized into 1 day/week or more seldom vs others) - same hand or finger movements (dichotomized into almost never/ never vs others) - lifting 5-15 kg (dichotomized into 1 day/week or more seldom vs others) - lifting ≥ 15 kg (dichotomized into 1 day/week or more seldom vs others)		Sickness absence during 4th quarter 1998 -3rd quarter 2001 dichotomised	The majority of high physical workload domains were asso- ciated with sickness absence, except lifting ≥ 15 kg. However, there is uncertainty in the estimates. OR - high physical stress 1.5 (0.7-2.9) - working with hands above shoulders 1.9 (0.9-3.9) - working with hands below knee levels 2.0 (0.8-4.6) - bending and twisting movements of the body 1.2 (0.7-2.3) - same hand or finger movements 1.3 (0.7-2.4) - lifting 5-15 kg 1.7 (0.9-3.1) - lifting ≥ 15 kg 0.7 (0.3-1.6)
Bjuhr, 2023, Health and work-related factors as predictors of still being active in working life at age 66 and 72 in a Swedish population: A longitudinal study	National; Swedish National Study on Ageing and Care project (SNAC); Questionnaire linked with register; Cohort; Baseline year: Cohort 1 (2001-2003), Cohort 2 (2007-2009); Age range at baseline: 60; N Cohort 1=479, N Cohort 2=751; Follow-up years: Cohort 1 (2007- 2009, 2013-2015), Cohort 2 (2013- 2015)	Physical workload is assessed through questionnaire on the following domains: - Physical activity required in work (light, medium, heavy)	Gender, education	Active in working life (working at least 1 hour/ week) at age 66 and 72, assessed through questionnaire	Light physical activity required in work is associated with active in working life at later age, although the estimates are uncertain Age 66 Cohort 1 OR medium 0.51 (0.24-1.06) OR light 1.30 (0.73-2.32) Cohort 2 OR medium 1.34 (0.78-2.29) OR light 1.40 (0.89-2.23) Age 72 Cohort 1 OR medium 0.74 (0.25-2.25) OR light 1.62 (0.67-3.92)
'Errico et al. 2022. 'Long- term sick leave for back pain, exposure to physical work- load and psycho- social factors at work, and risk of disability and early-age reti- rement among aged Swedish workers'.	National; SWIP- cohort (Swedish, work, illness and labour market participation), consisting of linked national registers. Baseline year 2009, follow-up 2010- 2016; aged 53-64. N= 835,956 (outcome 1) N= 329,415 (outcome 2)	Heavy physical workload assessed by a Swedish Job Exposure Matrix (JEM). An index was created based on the items: heavy lifting, forward bent position, twisted trunk posture, frequent bending or twisting of the trunk, and physically strenuous work.	Stratified for gender. Age, marital status, education, and previous unemployment.	Premature retirement through two outcomes: Outcome 1 = First episode of disability pension (DP) (full or partial), due to any health-related condition. Outcome 2 = Receiving an early age pension (EAP), from the age of 61-65.	High physical work- load was associated with an increased risk of receiving av DP (adjusted HR 1.75 for both men and women). High physical workload was also associated with an increased risk of receiving an EAP, for women (adjusted HR 1.07), but not for men (adjusted HR 0.82).

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Dellve et al. 2003. 'Work-system risk factors for permanent work disability among home-care workers: a case-control study'.	National, covering the occupational group home-care workers. Women only. Questionnaire and register data. Case-control design. Cases selected 1997-1998. Age 32-65. N= 454 cases and 580 controls.	Questionnaire on various items. Physical workload included: lifting in awkward positions, frequent heavy lifting and heavy lifting on one's own. Retrospective exposure assessment 5 and 15 years prior to baseline.	Only crude associations (case-control study).	Disability pension (to a degree of 50-100%), due to any cause, collected from registers.	High physical workload was one of the strongest indicators for receiving a DP, for all included items: lifting in awkward positions (crude OR 2.0-2.2), frequent heavy lifting (crude OR 1.7-2.4) and heavy lifting on one's own (crude OR 1.7-1.9).
Edén et al. 2006. 'Return to work still possible after several years as a disability pensioner due to musculoskeletal disorders: a population-based study after new legislation in Sweden permitting "resting disability pension".'	National. All individuals granted a resting disability pension (RDP) in Sweden in 2000. Questionnaire and register data. Case-control design. Controls where those granted a regular DP, without resting DP. N= 299 cases, 242 controls	Questionnaire on various items. Physical workload before DP was self-reported and categorized as having physical workload "never/seldom", "sometimes", "often" or "always". Retrospective exposure assessment.	Only crude associations (case-control study).	Resting disability pension due to musculoskeletal disorders, collected from registers.	Those who reported less physical workload where more likely to return to work by means of a RDP, compared to those who reported to "always" have physical workload. Results reported in positive OR; "often" physical workload compared to "always" (OR 2.21), "sometimes" physical workload compared to "always" (OR 2.47), "seldom/never" physical workload compared to "always" (OR 1.53).
Falkstedt et al, 2021, 'Disability pensions related to heavy physical workload: a cohort study of middle-aged and older workers in Sweden'	National; Swedish Work, Illness, and labor-market Participation (SWIP) cohort; register-based cohort; baseline year 2005; follow up 2006-2016, until ages 55-65 years; aged 44-63; N= ca 1.8 million.	A gender-specific JEM for overall PWL based on data from the Swedish Work Environment Surveys 1997–2013, including eight questions regarding physical loads that involve heavy lifting, uncomfortable working postures, repetitive work, and physically demanding work	education, marital status, history of unemployment, and job control Stratified by sex	DP, any as well as specific diagnoses: musculoskeletal diagnoses; psychiatric diagnoses; circulatory system diagnoses; and respiratory diagnoses	Dose-response associations between PWL and DP with a musculoskeletal diagnosis (adj HR for the heaviest exposure: 2.58 in women and 3.34 in men). Also dose-response associations with a cardiovascular or a respiratory diagnosis, with smaller adj HRs. No association with a psychiatric diagnosis after adjustment for job control.
Fochsen et al, 2006, 'Predictors of leaving nursing care: a longitudinal study among Swedish nursing personnel'	Nursing personnel; survey; sampled from two pre-existing research projects; baseline years 1992–95; follow-up in January 2003; 31% aged <30 years and 69% aged 30+ years at baseline (mean 47 years and all aged <65 in 2003); N=1095	Four self-reported independent measures: 1) perceived physical exertion at work; 2) number of patient transfers during a working shift; 3) heavy patient transfer on one's own, and 4) use of transfer devices	Sex, age, years in nursing care, position in nursing, hospital location, musculoskeletal symptoms	Self-reported not employed in nursing care at follow up	Limited use of transfer devices was associated with a higher risk of leaving (adj OR 1.5). Heavy patient transfer on one's own was associated with the outcome in crude model (OR 1.6), but not after adjusting for use of transfer device. The other two PWL measures were not associated with the outcome.

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Gustafsson et al, 2019, 'Physical work environment factors affecting risk for disability pension due to mental or musculoskeletal diagnoses among nursing professionals, care assistants and other occupations: a prospective, population-based cohort study'	National; Swedish work environment surveys (SWES); survey data 1993-2013 (representative samples) linked to social insurance and administrative register data; cohort study; baseline years: 1993-2013; age range at baseline: 16-64; N:79004; follow-up years: 1994-2014.	Three self-reported indicators with each of them containing three items: heavy physical work (heavy lifting, work only physical, and exertion until breathing fast), strenuous work postures (bent or twist repeatedly, working bent forward, and working in a twisted position) and exposure to substances (detergent/disinfections, water in contact with skin, and human secretions). Each item was used as an independent exposure.	Age, year of interview, sex, education, country of birth, number of years in current occupation, sector of employment, and demand-control index Stratified by occupation: 1) nursing professionals (n=2576); 2) care assistants (n=10175); all other occupations (n=66253)	All DP, DP with mental diagnoses, and DP with musculoskeletal diagnoses	Heavy physical work (heavy lifting, purely physical work, exertion to the point of breathing fast) and strenuous work postures (bent or twist repeatedly, working bent forward, and working in a twisted position) were significantly associated with risks of future DP among care assistants (adj HRs 1.17-1.66) and all other occupations (adj HRs 1.47-1.64), but not among nursing professionals. Physical work indicators were mainly associated with musculoskeletal DP diagnoses among care assistants, but two indicators (exertion until breathing fast and working in a twisted position) were significant also for mental diagnoses. An increased risk of DP was found among nursing professionals exposed to detergents or disinfectants (adj HR 1.48), but not among care assistants.
Gustafsson et al, 2020, 'Interaction effects of physical and psychosocial working conditions on the risk of disability pension among nursing professionals and care assistants in Sweden: A prospective study'	National; Swedish work environment surveys (SWES); survey data 1993-2013 (representative samples) linked to social insurance and administrative register data; cohort study; baseline years: 1993-2013; age range at baseline: 16-64; N:79004; follow-up years: 1994-2014.	Two dimensions of physical workload were studied: <i>Heavy physical work</i> , which was the extent to which the work was purely physical (from nearly all the time to not at all); and <i>Physically strenuous work postures</i> , which was the extent to which the work meant working bent forward without supporting with hands or arms (from nearly all the time to not at all).	Age, year of interview, sex, education, country of birth, sector of employment, and country of birth Stratified by occupation: 1) nursing professionals (n=2576); 2) care assistants (n=10175); all other occupations (n=66253)	Disability pension (all-cause, full or part-time), 1994-2014	Heavy PWL comb. with high job demands associated with DP in all three occupations (around HR 2.0), but only in care assistants and other care occupations if comb. with low job demands (HRs 1.33 and 1.63, respectively). Almost identical findings/HRs with strenuous postures instead of heavy work!
Helgesson et al, 2020, 'Interaction effects of physical and psychosocial working conditions on the risk for sickness absence: a prospective study of nurses and care assistants in Sweden'	National; Swedish work environment surveys (SWES); survey data 1993-2013 (representative samples) linked to social insurance and administrative register data; cohort study; baseline years: 1993-2013; age range at baseline: 16-64; N:79004; follow-up years: 1994-2016.	Two dimensions of physical workload were studied: <i>Heavy physical work</i> , which was the extent to which the work was purely physical (from nearly all the time to not at all); and <i>Physically strenuous work postures</i> , which was the extent to which the work meant working bent forward without supporting with hands or arms (from nearly all the time to not at all).	Age, year of interview, sex, education, country of birth, sector of employment, and country of birth Stratified by occupation: 1) nursing professionals (n=2576); 2) care assistants (n=10175); all other occupations (n=66253)	Sickness absence, 1994-2016	Heavy PWL comb. with high job demands associated with SA in both occupations (nurses, care assistants) (around HR 1.5), but only in care assistants if comb. with low job demands (HRs 1.2). Almost identical findings/HRs with strenuous postures instead of heavy work! Physical PWLs associated with SA at both high and low job control in care workers

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Johansson et al, 2012, 'Educational differences in disability pension among Swedish middle-aged men: role of factors in late adolescence and work characteristics in adulthood'	National; Swedish men conscripted for military service in 1969-1970 (conscripted cohort) linked to social insurance and administrative register data; cohort study; baseline years: 1990; age range at baseline: 39-41; N:49321; follow-up years: 1991-2002.	JEM based on the Swedish Annual Level-of-Living Surveys (1979-1981) – an index integrating eight physical risk factors: heavy lifts daily, repetitive and one-sided work movements, awkward work postures, heavy shaking or vibrations, daily perspiration from physical exertion, contact with dirt, deafening noise, and risk for exposure to accidents.		Income from DP	Compared to low PWL, medium-low, medium-high, and high PWL were associated with a higher risk of DP (HRs 1.36, 2.79, and 2.36, respectively).
Kjellberg et al. 2016 'Long-term physical workload in middle age and disability pension in men and women: a follow-up study of Swedish cohorts'	National; Evaluation through Follow-up (UGU) survey of schoolchildren, 1961 and 1966 linked to population census and social insurance register; cohort study; occupation measured 1985 and 1990; (age range 32-42); N: 21,809 (11,925 in final analysis); follow-up years 1991-2009.	A sex-specific index (mean) of 8 physical risk factors: heavy lifts daily, repetitive and one-sided work movements, awkward work postures, heavy shaking or vibrations, daily perspiration from physical exertion, contact with dirt, deafening noise, and risk for exposure to accidents. Measured with a JEM based on the Swedish Annual Survey of Living Conditions (1977-1981), categorized into quartiles and linked to registered occupation in 1985 and 1990. Only those with stable exposure at both time points eventually included.	Birthyear, cognitive ability and parental education in childhood, job control, and education. Stratified by sex.	First episode of disability pension in social insurance register (full or partial). All cause Musculoskeletal (ICD-9 710-739, ICD-10 M01-M99) Psychiatric (ICD-9 290-311, ICD-10 F00-F99) Other (all other codes)	Long term exposure to heavy physical workload was associated with DP due to musculoskeletal disorders among both men (adj HR 2.25, CI 1.28-3.94) and women (adj HR 2.19, CI 1.48-3.23). For women there was also an association with all cause DP (adj HR 1.64, CI 1.26-2.14).
Landberg & Thern, 2023 'Is the association between alcohol use and sickness absence modified by socioeconomic position? findings from the Stockholm public health cohort'	Stockholm; Stockholm Public Health Cohort linked to social insurance registers; Baseline in 2006; population age 25 to 64 at baseline; Follow-up years 2006-2008.	Self-reported physical working conditions categorized as: sedentary, light, moderately heavy, and heavy.	Age and sex	SA of at least 14 days.	Moderate and heavy PWL were associated with an increased risk of sickness absence (adj IRR 1.12, CI 1.67-2.68 and IRR 3.36, CI 2.20-5.15 respectively)
Leineweber et al. 2019: 'Work-related psychosocial risk factors and risk of disability pension among employees in health and personal care: A prospective cohort study'	National; Swedish work environment surveys (SWES); survey data 1993-2013 (representative samples) linked to social insurance and administrative register data; cohort study; baseline years: 1993-2013; age range at baseline: 16-64; N:79004; follow-up years: 1994-2014	Strenuous work posture (bent or twist repeatedly)	Age, year of interview, sex, educational level, work sector, country of birth, sector of employment	Disability pension (at least partial) in social insurance register, MIDAS, 1994-2014	Working (often) in strenuous positions related to increased risk for disability pension; adj. HR 1.58

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Leineweber et al; 2020. Work environment risk factors for the duration of all cause and diagnose-specific sickness absence among healthcare workers in Sweden: a prospective study	National; Swedish work environment surveys (SWES); survey data 1993-2013 (representative samples) linked to social insurance and administrative register data; cohort study; baseline years: 1993-2013; age range at baseline: 16-63; N:12452; follow-up years: 1994-2016	Physical work exposure: frequencies of exposures to kinds of heavy physical work (three items) and strenuous work postures (three items). "... for heavy physical work, information on two items were missing for 2003 and for strenuous work postures one item was missing for the same year in certain iterations of the survey."	Age, year of interview, sex, educational level, work sector, country of birth, and SA during year of interview	Short-term (≤ 28 days) or long-term (> 104 days) sickness absence, 1994-2016; both these also divided into musculoskeletal diagnoses (ICD-10, chapter M) and psychiatric diagnoses (ICD-10, chapter F)	Heavy physical work (heavy lifting, physical work most of the time, exertion until breathing fast) associated with both short and long SA (adj. HRs 1.15-1.36). Strenuous work postures (bent or twist repeatedly, work bent forward, work in a twisted position) associated with both short and long SA (adj. HRs 1.25-1.41). Heavy physical work and strenuous work postures (see above) associated with short SA with MSD (adj. HRs 1.30-1.91); only strenuous work postures associated with long SA with MSD. Work in a twisted position associated with short SA with psychiatric dis.
Lindberg, et al. 2005 'Retaining the ability to work—associated factors at work'	National; random sample recruited for questionnaire with one year follow up in social insurance register; Baseline year 2000, follow up in 2001; aged 35, 45, or 55. N=6,337.	Physically non-strenuous work assessed with Borg's Perceived Physical Exertion score (13 as the cutoff point).	Stratified for gender. Age, education, income, family situation, employment sector, previous sickness absence. Co-adjusted for psychosocial work organization factors, recuperation	Retained work ability defined as not having any sickness absences of at least 14 days during follow up.	Physically non-strenuous work was associated with a greater likelihood of not being on sickness absence (adj OR 1.6, CI 1.3-1.9 for women and OR 2.1, CI 1.5-2.8 for men)
Löve et al, 2013, 'Explaining the social gradient in sickness absence: a study of a general working population in Sweden'	Regional (Västra Götaland); randomly sampled from new sick listings (cases) and general population (controls); selected Feb-April 2008, baseline (questionnaire) April-June 2008; age 19-64; N=7337	Heavy lifting (1 item), uncomfortable postures (1 item), self-reported on a four-point scale based on frequency.	Occupational class, age. Stratified by sex.	Odds of being in the newly sick listed sample compared to the general sample. Sick-listed population defined as those registered with SA (14 days).	Heavy lifting associated with an increased odds of SA for men (adj OR 1.15, CI 1.04-1.27) and women (adj OR 1.16, CI 1.00-1.32). Awkward postures also associated with an increased odds of SA for men (OR 1.20, CI 1.09-1.39) and women (OR 1.28, CI 1.12-1.47)
Marklund et al 2019. Working conditions and compensated sickness absence among nurses and care assistants in Sweden during two decades: a cross-sectional biennial survey study	Swedish work-environment surveys 1991-2013. Survey with register-based follow up; baseline: biennial survey; N=98249 (16179 nurses and care assistants, and 82070 ref population).	Two survey items: Heavy physical work (Yes, every day/a couple of days per week/1 day per week/a couple of days per month (or No); Strenuous working postures (Yes, nearly all the time/about $\frac{3}{4}$ of the time/half the time/about $\frac{1}{4}$ of the time/1/10th of the time (or No)	Sex, educational level, employment sector	Sickness absence compensated by Social Insurance Agency in any of three years after survey	RR per survey year/ follow up were estimated, showing significant RRs of 1.4 to 1.9 for both heavy physical work and strenuous working postures

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Oliv, 2019. Important work demands for reducing sickness absence among workers with neck or upper back pain: a prospective cohort study	National; Swedish Work Env surveys 2009, 2011, 2013. Survey data linked with register data (LISA); prospective cohort study; baseline year(s): 2009, 2011, 2013; age range at baseline(s): 16-64 years; N=4567 individuals (with neck or upper back pain); follow-up was the year after respective survey.	Physical work demands measured through self-report; questions regarding lifting 15kg or more, frequent trunk rotations, twisted work posture, hand-held vibrating tools, leaning forward without support, hands at shoulder level or higher, whole-body vibrations, repetitive movements, seated work.	No control variables, but stratification by gender and age groups (and work ability index).	Registered sickness absence (income), meaning <14 days.	Mean n-days of SA were more in those with high physical demands in terms of lifting, trunk rotations, twisted work posture, leaning forward w/o support, and seated work; in men also whole-body vibrations and hands high. No clear differences according gender and age.
Robroek, 2017. Influence of obesity and physical workload on disability benefits among construction workers followed up for 37 years	National (Sweden), construction worker cohort; data: health examination data 1971-1993 plus registered disability benefits; cohort design; baseline years 1980-1993; age range: 15-64; 328743 men (too few women); follow-up years 1980-2008	Job-exposure matrix based on 77803 male construction workers responding during 1989-1992, indicating on a five-point scale, ranging from rarely (1) to often (5) how often they worked with heavy lifting and worked in bent forward/twisted working postures. Mean scores were divided into three exposure categories.	Age, smoking, BMI,	Date of first full disability pension, registered; MSD diagnoses, mental diagnoses, and other d.	Intermediate and high (respectively) associated with significantly increased hazard of DP with CVD, MSD, mental, and other diagnoses. MSD strongest: HR=2.13 for intermed, and HR=3.02 for high.
Stattin, 2005. Occupation, work environment, and disability pension	Construction workers, Sweden; Construction worker cohort; health examination/survey data 1985- linked to social insurance register; cohort study; baseline: regular health examinations 1985-(response rate ~80%); age range approx. 20-64 (not clear, but indicated in Figure 1); N=389000 in analysis of occupations & N=87000 in analysis of work environment; follow-up years: from year of health exam until 1997, Dec 31.	Occupations: 21 major occupational groups with construction industry; Physical workload: Summation index based on questions concerning frequency of heavy lifting, twisted positions, hand of shoulders, kneeling position; reliability of index: 0,87.	Age	Disability pension date and diagnosis (MSD, psychiatric, CVD, respiratory)	Occupations: highest incidence of DP in rock workers, concrete workers, insulators, roofers foundation laying work (and lowest in salaried and electricians); clearly highest incidence for DP w MSD diagnosis. Among work env factors, physical workload showed the strongest association with DP.
Stengård, 2022. The implication of physically demanding and hazardous work on retirement timing	dNationwide/national; Swedish; SLOSH, years 2008-2018; survey data linked with register data; design: two waves (baseline, follow up); baseline: 2008-2016; age range at baseline: 59-64; N=5201 individuals/8791 obs; follow up: 2010-2018, i.e., next wave (2 years later);	1) Physically demanding work tasks related to body movements; 2) physically hazardous work environment related to worker's immediate work surroundings; 1 was measured by physical labor, heavy lifting, and awkward working positions; 2 was measured by noise, bright light, heat/cold etc., vibrations, toxins or irritants, or tangible risk of injury; response scale was dichotomized.	Age, wave, education, marital status, parental status, working time, and caring for a relative	Retiring: in second wave answering full-time retired on old-age or disability pension in the questionnaire for non-working	In blue-collar workers, increasing odds of retiring with increasing level of physically demanding work tasks; both in women and men. In white-collar workers, lower odds of retiring in those with high physical demands (!) – both genders.

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Stengård, 2023. Prolonging working life among blue-collar workers: the buffering effect of psychosocial job resources on the association between physically demanding and hazardous work and retirement timing	Nationwide/national; Swedish; SLOSH, years 2008-2018; survey data linked with register data; design: two waves (baseline, follow up); baseline: 2008-2016; age range at baseline: 59-64; N=1741 individuals/2792 obs; follow up: 2010-2018, i.e., next wave (2 years later);	1) Physically demanding work tasks related to body movements; 2) physically hazardous work environment related to worker's immediate work surroundings; 1 was measured by physical labor, heavy lifting, and awkward working positions; 2 was measured by noise, bright light, heat/cold etc., vibrations, toxins or irritants, or tangible risk of injury; response scale was dichotomized.	Age, wave, education, marital status, parental status, working time, and caring for a relative Moderator variables: decision authority (what, how), social support (support among co-workers and also managers), work-time control (days, breaks, vacation, etc.), rewards (salary/promotion, esteem, job security)	Working longer: in second wave answering still working vs. retired on old-age or disability pension in the questionnaire for non-working	Physical demands assoc. with reduced odds of working longer (OR=0.79, CI: 0.64-0.98). High social support and (less certain) decision authority appeared to weaken this association; most clear for women.
Söderberg, 2021. Industry mobility and disability benefits in heavy manual jobs: a cohort study of Swedish construction workers	National; The Construction Worker Cohort; survey data linked with register data; cohort design (?); baseline: 1971-1993; age range at baseline (?): those aged 60-64 anytime during 1990-2015 (LISA). N=approx. 55000 men; follow up: 1990-2015 (LISA register).	Occupations, namely the largest occupations with either heavy or lighter physical workload; heaviness was a classification based on a JEM of heart rate measurements (physical long-term cardiovascular load). Shifting out from construction industry vs. not in occupations with different levels of physical heaviness.	Age, smoking (cigarettes per day, categ.), BMI (standard categ.)	Registered disability benefit age 60-64.	Men who shifted out of the construction industry had reduced risk of DB during age 60-64 relative to those who stayed. The diff's/assoc. were similar in shape in concrete workers, electricians, and foremen, though foremen showed weaker risk reduction (RR).
Vingård, 2005. Long-term sick-listing among women in the public sector and its associations with age, social situation, lifestyle, and work factors: a three-year follow-up study	Multiple regions and municipalities; HAKuL ("Work and health in the public sector in Sweden"); employee survey and employer survey 3 years after; cohort study (i.e., two surveys); baseline: 1999-2000; age range: 61 years or younger; N=5,224; follow up: 3 years after baseline.	Physical workload measured by factor analysed items on (MUSIC study): (1) proportion of the day spent sitting; (2) hands above shoulder level exceeding 30 min per day; (3) hands below knee level exceeding 30 min per day; (4) bent or twisted body postures several times per hour; (5) lifting/carrying loads between 5 and 15 kilograms; (6) Lifting/carrying loads exceeding 15 kilograms.	None	Employer-reported sicklisting longer than 27 days (in follow-up survey)	Physically demanding work showed an association (RR 1.2 [1.1-1.4] with sicklisting. However, no aRR was presented. Also, see comment.
Väisänen, 2023. Moderating effect of cardiorespiratory fitness on sickness absence in occupational groups with different physical workloads	National; Health Profile Institute (HPI) database, i.e., voluntary health assessments for employees; questionnaire and measurement data linked with registry data, e.g., MIDAS; cohort study; baseline: 1988-2020 (HPI); age range: 18-75 years; follow-up years: from individual health assessment to unspecified end of MIDAS data (2020?)	Occupational groups with different physical workload (ranked on the basis of HPI self-report data on own physical work situation being occupationally physically demanding or very demanding (vs. not so); occupation= SSYK96 or SSYK12; major occupational groups (3 or 4 digits) not requiring high educational qualifications;	Age, sex, calendar time, SA before assessment, BMI, length of education, self-reported smoking habits, stress at work, and exercise habits Moderator variable: cardiorespiratory fitness (CRF) measured through submaximal cycle ergometer test and VO2max calculations	Sickness absence as registered in MIDAS, i.e., 15 days or more; SA with psychiatric (F in ICD-10), musculoskeletal (M) or cardiorespiratory (I, J) diagnoses	Association between occupational physical workload and sickness absence with M-diagnosis, though no clear dose-response pattern and weaker association with counted SA days than incident SA as outcome variable. No association with psychiatric SA, and weak/no association with cardiorespiratory SA. High CRF was associated with lower SA in some groups, but interaction not clearly tested.

Appendix 2. Summary of excluded full texts and reason

Artikel/referens/publikation	Skäl för exkludering
Al-Windi A, Theobald H, Johansson SE. Relation between sickness absence and socio-demographic characteristics, well-being, and health care utilisation - A primary care based study. <i>J Chin Clin Med</i> . 2009;4(4):186-96.	Exponering ej enligt kriterierna
Amin R, Mittendorfer-Rutz E, Björkenstam E, Virtanen M, Helgesson M, Gustafsson N, et al. Time period effects in work disability due to common mental disorders among young employees in Sweden - a register-based cohort study across occupational classes and employment sectors. <i>European Journal of Public Health</i> . 2023;33(2):272-8.	Exponering ej enligt kriterierna
Berglund T, Seldén D, Halleröd B. Factors affecting prolonged working life for the older workforce: The Swedish case. <i>Nord J of Work Life Stud</i> . 2017;7(1):19-36.	Exponering ej enligt kriterierna
Björkenstam E, Helgesson M, Mittendorfer-Rutz E. Childhood adversity and risk of later labor market marginalization in young employees in Sweden. <i>European Journal of Public Health</i> . 2023;33(2):264-71.	Exponering ej enligt kriterierna
Enthoven P, Skargren E, Carstensen J, Oberg B. Predictive factors for 1-year and 5-year outcome for disability in a working population of patients with low back pain treated in primary care. <i>Pain</i> . 2006;122(1-2):137-44.	Exponering ej enligt kriterierna
Eyjólfssdóttir HS, Agahi N, Fritzell J, Lennartsson C. Physical functioning as a predictor of retirement: Has its importance changed over a thirty-year period in Sweden? <i>Eur J Ageing</i> . 2022;19(4):1417-28.	Inget relevant sambandsestimater
Falkstedt D, Backhans M, Lundin A, Allebeck P, Hemmingsson T. Do working conditions explain the increased risks of disability pension among men and women with low education? A follow-up of Swedish cohorts. <i>Scand J Work Environ Health</i> . 2014;40(5):483-92.	Överflödig (bättre estimering i Kjellberg et al, 2016)
Gjöstad A, Zimmerman M, Anker I, Dahlin E, Dahlin LB, Nyman E. Factors influencing return to work after surgery for ulnar nerve compression at the elbow. <i>Sci Rep</i> . 2022;12(1):22229-.	Exponering ej enligt kriterierna
Holland P, Burström B, Möller I, Whitehead M. Gender and socio-economic variations in employment among patients with a diagnosed musculoskeletal disorder: A longitudinal record linkage study in Sweden. <i>Rheumatology (UK)</i> . 2006;45(8):1016-22.	Exponering ej enligt kriterierna
Holmberg SAC, Thelin AG. Predictors of sick leave owing to neck or low back pain: a 12-year longitudinal cohort study in a rural male population. <i>Ann Agric Environ Med</i> . 2010;17(2):251-7.	Utfall ej enligt kriterierna
Horneij EL, Jensen IB, Holmström EB, Ekdahl C. Sick leave among home-care personnel: a longitudinal study of risk factors. <i>BMC Musculoskelet Disord</i> . 2004;5(1):38-.	Utfall ej enligt kriterierna
Jackson JA, Liv P, Sayed-Noor AS, Punnett L, Wahlström J. Risk factors for surgically treated cervical spondylosis in male construction workers: a 20-year prospective study. <i>Spine J</i> . 2023;23(1):136-45.	Inget relevant sambandsestimater
Lund T, Labriola M, Christensen KB, Bültmann U, Villadsen E. Physical work environment risk factors for long term sickness absence: prospective findings among a cohort of 5357 employees in Denmark. <i>BMJ-BRITISH MEDICAL JOURNAL</i> . 2006;332(7539):449-51.	Ej Sverige
Lundin A, Wallin AS, Falkstedt D, Allebeck P, Hemmingsson T. Intelligence and Disability Pension in Swedish Men and Women Followed from Childhood to Late Middle Age. <i>PLoS ONE</i> . 2015;10(6):e0128834-e.	Överflödig (bättre estimering i Kjellberg et al, 2016)
Marklund S, Bolin M, von Essen J. Can individual health differences be explained by workplace characteristics? – A multilevel analysis. <i>Soc Sci Med</i> . 2008;66(3):650-62.	Inget relevant sambandsestimater
Reinholdt S, Upmark M, Alexanderson K. Health-selection mechanisms in the pathway towards a disability pension. <i>WORK-A JOURNAL OF PREVENTION ASSESSMENT & REHABILITATION</i> . 2010;37(1):41-51.	Inget relevant sambandsestimater
Robroek SJW, Schuring M, Croezen S, Stattin M, Burdorf A. Poor health, unhealthy behaviors, and unfavorable work characteristics influence pathways of exit from paid employment among older workers in Europe: A four year follow-up study. <i>Scand J Work Environ Health</i> . 2013;39(2):125-33.	Ej Sverige (separat)
Ropponen A, Samuelsson A, Alexanderson K, Svedberg P. Register-based data of psychosocial working conditions and occupational groups as predictors of disability pension due to musculoskeletal diagnoses: A prospective cohort study of 24 543 Swedish twins. <i>BMC Musculoskelet Disord</i> . 2013;14.	Exponering ej enligt kriterierna

Artikel/referens/publikation	Skäl för exkludering
Sandmark H. Work and family: associations with long-term sick-listing in Swedish women - a case-control study. BMC Public Health. 2007;7:287-.	Exponering ej enligt kriterierna
Schell E, Theorell T, Nilsson B, Saraste H. Work health determinants in employees without sickness absence. Occup Med. 2013;63(1):17-22.	Tvärsnittsstudie
Soidre T. Who Wants to Work until 65? Perspectives on Work and Private Life in the Elderly Workforce. Sociologisk Forskning. 2005(3):59-79.	Exponering ej enligt kriterierna
Solovieva S, Udem K, Falkstedt D, Johansson G, Kristensen P, Pedersen J, et al. Utilizing a Nordic Crosswalk for Occupational Coding in an Analysis on Occupation-Specific Prolonged Sickness Absence among 7 Million Employees in Denmark, Finland, Norway and Sweden. Int J Environ Res Public Health. 2022;19(23).	Exponering ej enligt kriterierna
Stjernbrandt A, Wahlström J. The impact of Raynaud's phenomenon on work ability - a longitudinal study. J Occup Med Toxicol. 2022;17(1):12-.	Utfall ej enligt kriterierna
Sydsjö A, Claesson IM, Ekholm Selling K, Josefsson A, Brynhildsen J, Sydsjö G. Influence of obesity on the use of sickness absence and social benefits among pregnant working women. Public Health. 2007;121(9):656-62.	Exponering ej enligt kriterierna
Von Thiele U, Lindfors P, Lundberg U. Evaluating different measures of sickness absence with respect to work characteristics. Scand J Public Health. 2006;34(3):247-53.	Tvärsnittsstudie
Voss M, Floderus B, Diderichsen F. How do job characteristics, family situation, domestic work, and lifestyle factors relate to sickness absence? A study based on Sweden Post. J Occup Environ Med. 2004;46(11):1134-43.	Tvärsnittsstudie
Österman C, Hult C, Praetorius G. Occupational safety and health for service crew on passenger ships. Saf Sci. 2020;121:403-13.	Inget relevant sambandsestimat

Appendix 3. List of search strings

Sökprotokoll för kunskapssammanställning

Bilaga till projektet *Tungt fysiskt arbete och koppling till sjukskrivning, sjukersättning samt att behöva byta eller sluta jobb*

Enligt myndighetens processmodell bör redovisning av sökstrategi ske i detta sökprotokoll. Sökprotokollet fylls i med stöd av bibliotekarie/informationsspecialist och sakkunniga och används som underlag för beslut om sökstrategi. Inför sökning ska projektplan bifogas till protokollet.

1. Övergripande information

1.1. Projektdetaljer

Datum:	2023-11-27
Projekt:	Tungt fysiskt arbete och dess samband med sjukskrivning och sjukersättning
Typ av kunskapssammanställning:	Systematisk översikt (etiologi, riskfaktor); narrativ
Ansvarig processledare	Thomas Nessen
Ansvarig expert (ange kontaktuppgifter):	Daniel Falkstedt
Ansvarig bibliotekarie/informationsspecialist	Lars Våge
Övriga projektdeltagare:	Katarina Kjellberg, Melody Almroth, Kuan-Yu Pan, Maria Albin

1.2. Syfte

Syftet med projektet är att öka kunskapen om effekter och samband av långvarigt eller ihållande tungt fysiskt arbete för individers arbetshälsa, samt belysa dess samband med arbetsrelaterade sjukskrivningar, utträde ur arbetslivet och behov av att byta arbete ur ett svenskt och nordiskt perspektiv.

Målet med projektet är ta fram en kunskapssammanställning som kan komma till praktisk nytta för arbetsmiljöarbete i de miljöer tungt fysiskt arbete förekommer. Kunskapssammanställningen ska även kunna bidra till Arbetsmiljöverkets arbete med föreskrifter genom att belysa några riskkällor i arbetslivet som kan orsaka sjukskrivning, utträde ur arbetslivet och behov av att byta arbete.

1.3. Frågeställning/ar för kunskapsöversikten (t.ex PEO)

1. Vad innefattar begreppet långvarigt eller ihållande fysiskt tungt/ansträngande arbete?
2. Vilka samband finns det mellan långvarigt eller ihållande fysiskt tungt eller ansträngande arbete och sjukskrivning, sjukersättning samt behöva byta eller sluta jobb? Vilka skillnader finns utifrån utbildningsnivå, kön och yrke?
3. Vilka konkreta högriskförhållanden har befintlig forskning identifierat som riskfaktorer om ett arbete innehåller långvarigt eller ihållande fysiskt tungt eller ansträngande arbete som kan öka risken för sjukskrivning, sjukersättning samt behöva byta eller sluta jobb?
4. Vilka praktiska åtgärder har diskuterats som effektiva för att förebygga ihållande fysiskt tungt eller ansträngande arbete som kan orsaka ökad risk för sjukskrivning, sjukersättning samt behöva byta eller sluta jobb?

1.4. Nyckelartiklar (golden articles)

Identifiera ett antal (2-5) vetenskapliga nyckelartiklar ("golden articles") inför testsökning. Ange om möjligt var/hur artiklarna hittades.

1. Andersen LL, Fallentin N, Thorsen SV, Holtermann A. Physical workload and risk of long-term sickness absence in the general working population and among blue-collar workers: prospective cohort study with register follow-up. *Occup Environ Med.* 2016;73(4):246-53.
2. Andersen LL, Pedersen J, Sundstrup E, Thorsen SV, Rugulies R. High physical work demands have worse consequences for older workers: prospective study of long-term sickness absence among 69 117 employees. *Occup Environ Med.* 2021;78(11):829-34.
3. Järholm B, Stattin M, Robroek SJW, Janlert U, Karlsson B, Burdorf A. Heavy work and disability pension - a long term follow-up of Swedish construction workers. *Scand J Work Environ Health.* 2014;40(4):335-42.
4. Kjellberg K, Lundin A, Falkstedt D, Allebeck P, Hemmingsson T. Long-term physical workload in middle age and disability pension in men and women: a follow-up study of Swedish cohorts. *Int Arch Occup Environ Health.* 2016;89(8):1239-50.
5. Lund T, Labriola M, Christensen KB, Bultmann U, Villadsen E. Physical work environment risk factors for long term sickness absence: prospective findings among a cohort of 5357 employees in Denmark. *BMJ.* 2006;332(7539):449-52.

1.5. Tidplan för litteratursökning

(Ange när varje del beräknas vara färdigställd)

Aktivitet	Tidpunkt
Uppstartsmöte	2024-01-22
Testsökning	2024-01-29
Uppföljningsmöte	2024-02-20 (mejl)
Huvudsökning	2024-02-28
Återkopplingsmöte	2024-04-03 (mejl)
Uppdaterad sökning (vid behov)	-
Återkoppling efter avslutad litteratursökning	-

2. Sökstrategi/metoder

Sökstrategin utformas för att fånga in publicerat material och kan innehålla fyra komponenter: databassökning, manuell sökning, konsultation av expert, samt referens- och citeringssökningar.

2.1. Databassökning

Sökning efter relevant litteratur kommer att genomföras i de bibliografiska databaser som listas i tabellen nedan. Sökningarna genomförs med en i förväg beslutad sökstrategi (se Appendix A). Sökstrategin anpassas efter behov beroende på projektspecifika frågeställningar och sökresultatets relevans.

Databas (ange i relevansordning)	Kommentar: ämne/disciplin etc.?
Web of Science	
PubMed (Medline)	
Scopus	
Sociological abstracts	
ECONLIT	

2.2. Manuell sökning

Om så bedöms nödvändigt kan manuell sökning genomföras i tidskrifter och på webbplatser. De ska listas i tabellen nedan. Syftet är att hitta litteratur som inte kan identifieras genom sökning i bibliotekgrafiska databaser.

Tidskrift/webbplats	Ämne/disciplin
-	

2.3. Expertkonsultation

Om det bedöms viktigt kan expertkonsultationer utöver sakkunniga i projektet genomföras för att identifiera grå litteratur eller forskning som inte har återfunnits genom tidigare nämnda processer (Övervägande delen av svensk grå litteratur går att finna i LIBRIS. Internationell grå litteratur återfinns ofta via Google Scholar, Lens och Dimension). Om expertkonsultationer bedöms som relevanta att genomföra, lista de experter eller nätverk som ska kontaktas i tabellen nedan.

Expert/nätverk	Ämne/disciplin
-	

2.4. Referens/Citeringssökning

Ange om referens/citeringssökning är aktuell.

Nej	Datum: -
-----	----------

Litteraturförteckningarna i den litteratur som, baserat på inklusionskriterierna, kommer att ingå i översikten kommer att granskas för att identifiera ytterligare relevant litteratur som inte fångats in genom någon av ovanstående metoder.

Citeringssökningar genomförs för de referenser som enligt inklusionskriterierna bedömts som relevanta för att ingå i kvalitetsgranskningen.

Litteratur som identifieras som relevant baserat på referens- och citeringssökningar ska genomgå samma granskning och urvalsprocess som de som identifierats genom databassökningar.

3. Metod/er för granskning

Inledande relevansbedömning på titel- och abstract nivå (screening)	Sakkunniga experter bedömer hur inledande relevansbedömning ska genomföras
Relevansbedömning av artiklar i fulltext	Ange vilket bedömningsinstrument som ska användas – se bilaga!
Kvalitetsbedömning	Ange vilket/vilka bedömningsinstrument som ska användas – se bilaga!
Referenshanteringssystem	EndNote

Appendix A: Sökstrategier

Datum för sökningen: 2024-02-28 Antal träffar: totalt 507 träffar Kommentar: Den slutgiltiga söksträngen (nedan) användes för sökningar i samtliga databaser: Web of Science, PubMed/Medline, Scopus, Sociological abstracts, ECONLIT	
TS=((heavy OR strenuous* OR physical* OR manual OR ergonomic* OR biomechanic* OR mechanical* OR "blue collar") AND (work OR "work-load" OR workload OR "work-place" OR workplace OR job OR labor OR occupation) AND ("sickness absence" OR "longterm sickness" OR "long-term sickness" OR "sick leave" OR "disability pension" OR "disability benefit*" OR "disability allowance" OR "early retirement" OR "exit" OR "pension" OR "retirement" OR "unemployment" OR "labor market" OR "job change" OR "job mobility") AND (sweden OR swedish)) AND PY=(2003-2024)	

Fältagg/ar:

* = Trunkering; " " = Citattecken, söker en exakt fras

Appendix B

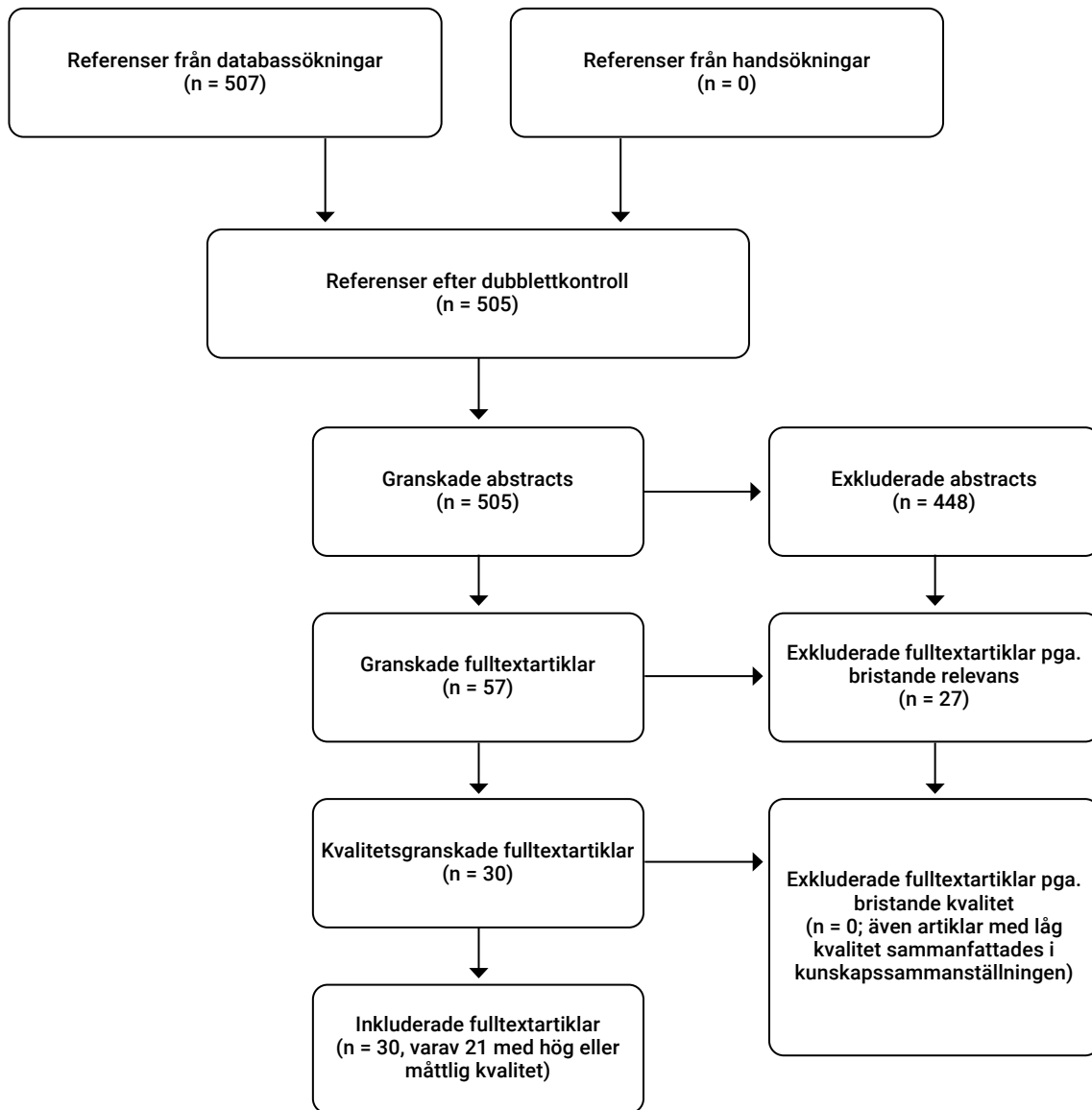
Söktermer presenterade i enlighet med ramverket PEO	
Population	(sweden OR swedish)
Exponering	(heavy OR strenuous* OR physical* OR manual OR ergonomic* OR biomechanic* OR mechanical* OR "blue collar") AND (work OR "work-load" OR workload OR "work-place" OR workplace OR job OR labor OR occupation)
Utfall (Outcome)	("sickness absence" OR "longterm sickness" OR "long-term sickness" OR "sick leave" OR "disability pension" OR "disability benefit*" OR "disability allowance" OR "early retirement" OR "exit" OR "pension" OR "retirement" OR "unemployment" OR "labor market" OR "job change" OR "job mobility")
(Period)	PY=2003-2024 (februari)

Appendix C: PRISMA

PRISMA Checklist

<http://www.prisma-statement.org/PRISMAStatement/Checklist>

PRISMA Flödesschema



Appendix 4. Instrument for assessing risk of bias


Quality assessment tool

Hi, Daniel. When you submit this form, the owner will see your name and email address.


Information about publications



Fill in the last name of first author, year, title of publications

1. First author (last name) * 

Enter your answer

2. Year * 

Enter your answer

3. Title 

Enter your answer



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Quality assessment tool

* Required

Risk of bias



4. Was the sample representative of the study population? *

- 0 Yes, very much
- 1 No, only partially

5. Can we be confident... *

	0 Definitely yes (low risk of bias)	1 Probably yes	2 Probably no	3 Definitely no (high risk of bias)
5.1 in the exposure assessment?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5.2 that the outcome was not present at the start of the study OR that outcome status was accounted for appropriately?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5.3 that all relevant confounders were taken into consideration in the analyses?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5.4 in the assessment of confounders?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5.5 in the outcome assessment?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5.6 that follow-up was adequate?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5.7 that loss of follow-up did not induce bias?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



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