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Association between occupational exposures and chronic low back pain: a reference document

Alexander Jahn,[1] Johan Hviid Andersen,[2,5] David Høyrup Christiansen,[3,4,5] Andreas Seidler,[6] Annett Dalbøge[1,5]

[1] Danish Ramazzini Centre, Department of Occupational Medicine, Aarhus University Hospital, Aarhus, Denmark.
[2] Danish Ramazzini Centre, Department of Occupational Medicine - University Research Clinic, Gødstrup Hospital, Herning, Denmark.
[3] Elective Surgery Centre, Silkeborg Regional Hospital, Silkeborg, Denmark.
[4] Research, Regional Hospital Central Jutland, Viborg, Denmark.
[5] Department of Clinical Medicine, Aarhus University, Aarhus, Denmark.
[6] Institute and Policlinic of Occupational and Social Medicine (IPAS), Faculty of Medicine, Technische Universität Dresden, Fetscherstr. 74, 01307 Dresden, Germany.

Foreword

The Labour Market Insurance and the Occupational Diseases Committee in Denmark has requested a reference document on the causal relation between occupational exposures and the development of chronic low back pain (LBP). Guidelines are currently needed due to inconsistent knowledge on the association between specific occupational exposures, including exposure-response relations and potential thresholds and the risk of chronic LBP. Therefore, a reference document was conducted in form of a systematic review based on the existing epidemiological literature, investigating occupational mechanical and psychosocial exposures as risk factors for developing chronic LBP. The mechanical exposures included lifting/carrying loads, pushing/pulling loads, awkward postures, standing/walking, sitting, kneeling/squatting, whole-body vibrations, and a combination of different mechanical exposures. Psychosocial exposures included job strain, control, support, and stress.

The reference document was conducted by research assistant Alexander Jahn, professor Johan Hviid Andersen, associate professor David Høyrup Christiansen, professor Andreas Seidler, and associate professor Annett Dalbøge. The reference document followed specific guidelines for preparation and quality approval provided by the Danish Work Environment Fund. Kai Bo Veiersted and Jan Hartvigsen independently evaluated the reference document. The Danish Work Environment Fund granted the conduction of the reference document (project number: 44-2020-09, 20205100711).

Contents

1. Introduction

Low back pain (LBP) is a frequent health problem in the general population.[1-3] In 2017, the global point prevalence of activity-limiting LBP was 7.5%, indicating that approximately 577 million people were affected.[4] Although LBP often is temporary, 4-20% of the adult population develops chronic LBP (pain $\geq$3 months) gradually increasing with age.[5 6] LBP affects everyday activity, increases the risk of sick leave and early retirement from the labour market, and is the most significant reason for years lived with a disability.[3 7] This makes the economic effect profound due to increasing expenses for healthcare and rehabilitation. Furthermore, from an individual perspective, LBP decreases income-producing assets in general.[7 8]

LBP is defined as pain or discomfort located to the lumbar region and/or gluteal region, anatomically outlined from the 12th thoracic vertebra to the gluteal sulcus with or without radiating pain. It is well-known that LBP is a complex condition. The structural causes of pain are difficult to determine and even more difficult to characterise.[8] The majority of LBP is therefore categorised as non-specific LBP, while a specific pathoanatomical diagnosis only can be reached in a minority of cases (e.g., radiculopathy and severe pathology affecting the lumbar spine).[7] Despite a fluctuating pattern of recovery in the early course of LBP, about one-third of patients show spontaneous recovery from non-specific LBP in the first 3 months after onset of LBP, but up to 65% of patients will still experience pain after 1 year.[9 10]

In Denmark, chronic LBP is recognised as an occupational disease making it possible to provide financial compensation. To determine whether chronic LBP is caused by occupational risk factors, knowledge of specific exposures, exposure-response relations, and potential thresholds is crucial. Occupational exposures can be divided into mechanical and psychosocial exposures. Mechanical exposures include lifting/carrying loads, pushing/pulling loads, awkward postures, standing/walking, sitting, kneeling/squatting, whole-body vibrations, and the combination of different mechanical exposures. Occupational psychosocial exposures include job strain, control, support, and stress.[11] Additionally, non-occupational risk factors for developing chronic LBP include age, smoking, prior LBP history, and other diseases.[7 12-14]

The scientific literature on the association between occupational exposures and LBP is comprehensive, including several systematic reviews.[15] In 2014, the Swedish Council on Health Technology Assessment (SBU) published a report conducted as a systematic review and meta-analysis of the association between occupational mechanical and psychosocial exposures and back problems defined as "back trouble, sciatica, degenerative disc change, and back disease" (excluding the cervical part of the spine).[16] The SBU report identified almost 8,000 potential relevant articles, performed nearly 1,000 full paper readings, and included a total of 109 moderate or high quality-rated cohort or case-control studies. Moderate evidence of an association was found for manual handling including lifting loads (OR=1.32, 95% CI 1.22 – 1.42), non-neutral work position including spine flexion (OR=1.61, 95% CI 1.42 – 1.83), and whole-body vibrations (OR=1.20, 95% CI 1.04 – 1.38). In a systematic review from 2014 including 8 cohort studies of LBP, the meta-analysis showed an OR of 1.11 (95% CI 1.05 – 1.18) for 10 kg lifted and an OR of 1.09 (95% CI 1.03 – 1.15) for 10 lifts per day.[17] A systematic review from 2015 including 27 epidemiological studies found an association between whole-body vibration and risk of both LBP (OR=2.17, 95% CI 1.61 – 2.91) and sciatica (OR=1.92, 95% CI 1.38 – 2.67).[18] A systematic review from 2018 (24 epidemiological studies) found significant associations between heavy physically demanding work (OR=2.03, 95% CI 1.48–2.79), bending or twisting of the trunk (OR=2.43, 95% CI 1.67–3.55), and lifting and carrying loads in combination with bending or twisting of the trunk (OR 2.84, 95% CI 2.18–3.69) and lumbosacral radiculopathy.[19] However, in 2020 an overview of systematic reviews did not support an association between occupational mechanical exposures and LBP.[15] Conflicting results were found for spine curvatures, prolonged or occupational standing, awkward postures, bending and twisting movements, components of heavy physical work, and whole-body vibrations, while no association was found for prolonged or occupational sitting.[15]

The association between occupational psychosocial exposures and LBP has also been studied in systematic reviews. In 2004, a systematic review including 40 cohort studies found moderate evidence for no association between perception of work, organisational aspects of work, and social support at work and LPB, and insufficient evidence for a positive association between stress at work and LBP.[20] However, in the SBU report from 2014 (109 cohort and case-control studies) moderate evidence of an association was found between job control (OR=1.17, 95% CI 1.02 – 1.34) and work satisfaction (OR=1.29, 95% CI 1.18 – 1.42) and back problems.[16] Also, in a systematic review from 2019 (18 epidemiological studies), workload (OR=1.32, 95% CI 1.20 – 1.46), high job control (OR=0.81, 95% CI 0.71 – 0.94), and high social support (OR=0.77, 95% CI 0.65 – 0.90) were significant related to chronic LBP.[11] Finally, symptoms of depression were found to be associated with the developing of LBP.[21]

To our knowledge, no systematic review has studied the association between occupational exposures and chronic LBP defined as pain ≥3 months. To make informed decisions in processing compensation claims, clarification on causality between occupational exposures and chronic LBP needs to be established. Therefore, the overall aim of the scientific reference document was to conduct a systematic review to summarize the existing epidemiological evidence of the association between occupational exposures and chronic LBP in the working population. An evaluation of which specific occupational mechanical exposures are associated with increased risk of chronic LBP was evaluated along with potential exposure-response relations and exposure thresholds. We also evaluated the effect of occupational psychosocial exposures on chronic LBP.

2. Materials and methods

2.1 Protocol and study registration

This reference document was conducted as a systematic review using the SBU report[16] as a basis to identify studies published before 2014. The reference document followed specific guidelines stated by the PRISMA-P 2015 checklist (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) as well as guidelines for preparation and quality approval provided by the Danish Working Environment Fund. The study protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with registration number CRD42021281996.

2.2 Eligibility study criteria

A systematic literature search was performed based on criteria devised in a PECOS (Population, Exposure, Comparison, Outcome, and Study design) presented in Appendix 1. Study population was restricted to adults in or above working age with no limitations regarding sex, demographics, or ethnicity. Occupational mechanical exposures were divided into 9 different exposure groups i.e., lifting/carrying loads, pushing/pulling loads, awkward postures, standing/walking, sitting, kneeling/squatting, whole-body vibrations, combination of different mechanical exposures, and "other mechanical exposures". Occupational psychosocial exposures were divided into 5 different exposure groups i.e., job strain, control, support, stress, and "other psychosocial exposures". Eligible criteria for exposure assessment included self-report (e.g., questionnaire and interview), observation, expert rating, technical measure, or job exposure matrix (JEM). The outcome comprised non-specific chronic LBP defined as pain in ≥3 months[22] and specific LBP including pain caused by degenerative changes or other pathologies. Eligible criteria for outcome assessment included self-report (e.g., questionnaire and interview), clinically assessment (e.g., International Classification of Diseases (ICD) code), surgery, and assessment using imaging modalities (e.g., x-ray, computed tomography, and magnetic resonance imaging), and compensation claim/insurance. Only studies reporting estimates of the association between occupational exposures and chronic LBP were included. Additionally, due to the expected comprehensive literature, we only included cohort and case-control studies. Cross-sectional studies were excluded due to the lack of temporality.

2.3 Literature search and study selection

Articles published before 10th January 2014 were retrieved from the SBU report, which contained a systematic literature search on articles published back to 1980.[16] To identify eligible articles, full-text reading of 192 potential relevant articles was performed independently by 2 authors (AJ and JHA) and discrepancies were solved by a third author (AD). The selection of relevant articles was based on predefined exclusion criteria presented in Appendix 2. For studies published after the 10th of January 2014, a systematic literature search was conducted in collaboration with a librarian using the following international electronic databases: National Library of Medicine (PubMed), Excerpta Medica Database (EMBASE), PsycInfo, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Library, and Web of Science. The literature search in the respective databases was conducted between the 2nd and the 21st of September, 2021. The search consisted of 4 blocks of keywords, each containing search terms using Boolean operators within and between blocks as presented in Appendix 3. We did not search for grey literature.

The reference management tool EndNote 20[23] was used to remove all article duplicates, before the remaining articles were transferred to the review management software Covidence.[24] Identification of eligible articles were performed using a two-step model; title/abstract screening followed by full-text reading. The selection of relevant articles was based on predefined exclusion criteria (Appendix 2). Both steps were performed independently by 2 authors (AJ, AD, JHA, or DHC) and all discrepancies were solved through discussion with all authors until consensus was reached. Finally, lists of references in all included articles were screened for other relevant articles.

2.4 Data extraction

Using predefined tables, information on study design, population, outcome, outcome assessment, exposure, exposure assessment, and confounder was extracted from each article by one author (AJ) and quality checked by another author (AD, JHA, or DHC). We also extracted information on study results including any measure of association (Relative Risks (RR), Odds Ratios (OR), Hazard Ratios (HR), and Prevalence Ratios (PR)) with its corresponding 95% confidence interval (CI).

2.5 Risk of bias

To critically appraise methodological quality of each included article, we used a modified risk of bias tool used in research on chronic diseases in several systematic reviews.[19 25-28] The tool was adapted for the current scientific research question, tested by all authors considering wording, construction, structure, and was adjusted accordingly to the feedback until consensus was reached (Appendix 4). Adjustments consisted of determining the most important epidemiological domains for risk of bias. The risk of bias tool was divided into 5 major and 3 minor domains. The major domains contained questions regarding "Study design", "Exposure", "Outcome", "Enrolment", and "Analysis method", while the minor domains consisted of "Funding", "Chronology", and "Conflict of Interests". The overall study quality could be rated as "low", "moderate", and "high" risk of bias. For a study to be considered as having "low" risk of bias, all major domains and at least 1 minor domain should be rated as low risk of bias. To be considered as "moderate" risk, 4 out of 5 major domains and at least 1 minor domain should to be rated as "low" risk. All other combinations were considered as high risk of bias. The quality assessment was first performed independently by 2 of the authors (AJ, JHA, AD, and DHC) and then compared. If disagreements occurred, the discrepancies were solved through discussion with all authors until consensus was reached.

2.6 Analysis

In order to obtain an indication of whether an association between occupational exposure and chronic LBP exists, meta-analyses were conducted. We excluded studies which were based on identical source population to avoid double-counting data. If studies were based on the same population, we chose the study with the highest quality rating, and if both studies had the same quality rating, the size of the study population would determine the exclusion. Exposure groups with LBP at baseline were included in the meta-analysis given that this was accounted for in the analysis. In the meta-analysis, we only included measure of association of the highest exposure category vs. the lowest exposure category. Measure of association with risk estimates other than ORs were considered equivalent to ORs when assumed that the incidence proportion of the outcome was <10%.[29] To support this, articles providing other estimates than ORs were tested for either <10% incidence proportion of an outcome or the OR were calculated if number of participants were provided.

Forest plots of studies included in the meta-analysis were constructed exclusively to visualise the association between occupational exposures and chronic LBP for 8 of the mechanical exposures (i.e., lifting/carrying loads, pushing/pulling loads, awkward postures, standing/walking, sitting, kneeling/squatting, whole-body vibration, and the combination of different mechanical exposures) and 4 of the psychosocial exposures (i.e., job strain, control, support, and stress). We disregarded mechanical and psychosocial exposure groups defined as "other exposures" due to heterogeneity. In forest plots, sex-combined measures of association were presented; but if only sex-specific estimates were available, associations for each sex were presented.

In the meta-analysis, a weighted estimate (OR with a 95% confidence interval) was calculated using random-effects models based on the assumption that studies cannot be assumed to provide estimates of a common, true effect.[30] In order to estimate what proportion of the observed variance reflects real differences among studies, I-squared was calculated. I-squared described the percentage of variability due to heterogeneity and was quantified by using the restricted maximum likelihood method (REML).[31] We used Cochrane's thresholds for interpretation of the I-squared statistic:[32]

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

Finally, publication bias was evaluated using funnel plots, and we tested the asymmetry of the funnel plots by Egger's test. If a study provided more than one estimate in the funnel plot (e.g., men and women), the group containing the highest number of participants were included to avoid double counting.

In sensitivity analysis, the meta-analyses were repeated by dividing studies according to the assessment of risk of bias (moderate/low vs. high risk of bias). Furthermore, we assessed differences in weighted estimates according to study design (cohort vs. case-control studies) and information on chronic LBP (non-specific chronic LBP vs. specific chronic LBP). The analyses were performed using STATA 17.0 (Stata Corp, College Station, TX, USA).

2.7 Assessment of overall quality of evidence

Across studies, the quality of evidence of the association between occupational exposures and chronic LBP was assessed according to guidelines provided by The Danish Work Environmental Fund

(Appendix 5). The quality of evidence could be rated "good" (+++), "some" (++), "limited" (+), "insufficient" (0) evidence of an association, or good evidence for no association (-). If “good” or “some” evidence of an association was indicated for a specific occupational exposure, we further evaluated whether exposure-response relations and/or thresholds could be identified.

3. Results

3.1 Literature search and exclusion of studies

Figure 1 presents the flow chart of the literature search and exclusion of articles. Among the 192 articles from the SBU, 11 article were included. The literature search of studies published after the 10th of January 2014 yielded 11,789 articles including 3,301 duplicates. A total of 8,488 articles were screened based on title and abstract which additionally excluding 8,305 articles providing 183 articles eligible for full-text reading. After full-text reading, a total of 162 articles were excluded providing 21 articles to be included. Therefore, a total of 32 articles were included in the systematic review. Appendix 6 lists excluded articles and explanation for their exclusion based on the full-text reading.

Figure 1: Flowchart of the literature search and exclusions of articles

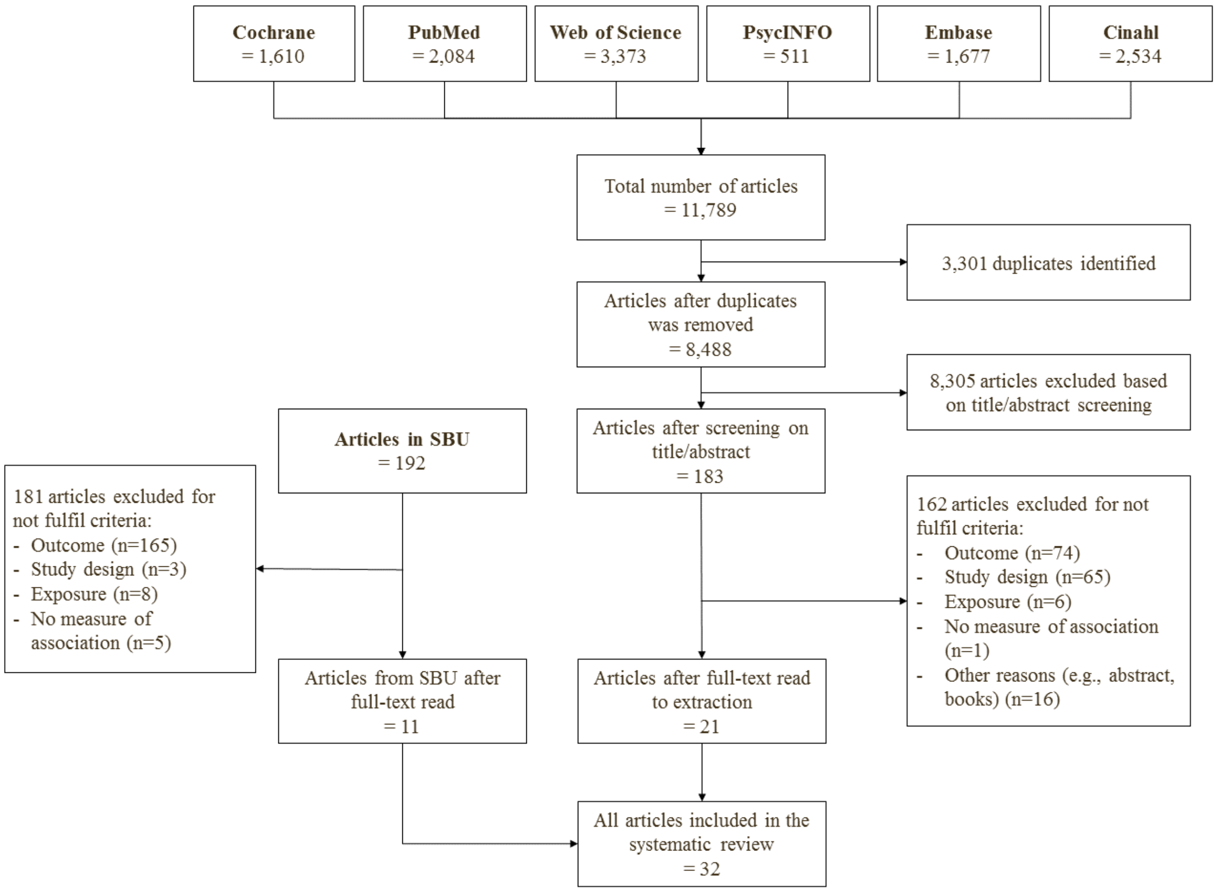


Table 1. Characteristic of the 32 included articles. Abbreviations explained in footnote.

Author	Design	Population	Outcome		Exposure	
			Definition	**Assessment**	**Definition**	**Assessment**
Aghilinejad[33] 2015	Cohort	The cohort consisted of male workers in one of the biggest metal-industry factories in Iran followed from 2012 to 2013. In total, 218 workers received a questionnaire and 33 were excluded. Therefore, 185 workers were eligible for the analysis (49 chronic participants and 136 cured for acute LBP) with a mean age of 35.96 (SD=7.33).	LBP: Self-reported chronic pain ≥3 months. Participants are followed up until 3 months after onset during monthly phone calls. If the pain had ended before the 3 months, they were categorised in the acute group.	Interview.	*Mechanical exposures*: Physical effort, sustained sitting, whole-body vibration, awkward postures, lifting (5-15 kg.), lifting (>15 kg.), and hands above shoulder. *Psychosocial exposures*: Job demand, job control, job satisfaction, social support, and job strain.	Questionnaire.
Ahsan[34] 2013	Case-control	240 cases with LDH were recruited by their physicians from a spinal surgery unit in Dhaka, Bangladesh (2007-2010). 200 cases (124 males and 76 females) were eligible and 200 controls were matched on age, sex, and area of residence from a non-spinal related orthopaedic department. The overall mean age was 39.42 years (SD=NS).	LDH: With low back pain with or without sciatica collected from radiological and physicians' examinations. Diagnostic criteria: - Dominant leg pain than back pain. - Restricted Straight Leg Raise. - Neurological deficit. - Positive MRI findings.	Physical examination, radiological examination, and MRI.	*Mechanical exposures*: Sitting/standing, bending/twisting, lifting/carrying heavy loads, vibration, and physical effort at work. *Psychosocial exposures*: Job satisfaction/stress at work.	Interview.
Alhalabi[35] 2015	Case-control	513 cases (134 males and 379 females) were recruited from an outpatient neurology clinic in Damascus, Syria (2011-2012). 398 controls (135 males and 263 females) were selected from family members and friends. Age ranged from 18 to more than 70 years (SD=NS).	LBP: Chronic low back pain lasting ≥3 months.	Interview.	*Mechanical exposures*: Lifting heavy objects and awkward positions (i.e., bending, standing, and sitting)	Interview.
Bergmann[36] 2017	Case-control	German population-based sample consisting of 915 cases (431 males and 484 females) treated in a hospital or special orthopaedic and neurosurgical practices. 422 controls (220 males and 202 females) were randomly drawn from a 1 % sample of residents aged between 25 to 70 years who stated no LBP in the previous 12 months.	LDH*:* Diagnosed by CT or MRI with radiculopathy related to the herniated segment. Morphological criteria of herniation were used from AJNR "nomenclature ad classification of lumbar disc pathology". Consensus criteria was developed to quantify criteria on the basis of disc displacement metrics. LDN*:* Measured in the sagittal plan using MRT/CT images and x-rays from the lateral native. If the lumbar spine was not met orthogonally, the centre of the vertebral body endplates was determined, and the central disc space was measured from this point.	MRI or CT.	*Mechanical exposures*: - Manual material handling of loads: lifting, carrying, pulling, pushing, throwing, shovelling loads weighing at least 5 kg. - Intensive-load working postures: forward trunk inclination, lateral trunk bending, trunk torsion, over-head working, kneeling, squatting, heel-sitting. - Forces: assembly work and lever activities, manual patient handling; - Whole-body vibration (WBV, horizontal and vertical direction considered).	Interview.
Esquirol[37] 2017	Cohort	3,237 male and female employed and retired workers from south of France were followed with a 5-year follow-up period with age ranging from 32 to 52 years.	LBP: Participants were considered as suffering from chronic LBP if they reported	Questionnaire.	*Mechanical exposures*: carrying heavy loads and awkward postures.	Questionnaire.

		For the analysis, 804 males and 756 females were eligible and divided in: - 231 participants reported “persistent chronic LBP” (they were compared with a non-persistent chronic LBP group containing 199 participants) - 255 participants reported “incidence of chronic LBP” (they were compared with a non-chronic LBP group containing 875 participants).	LBP or a specific treatment for such pain for at least 6 months at both measurements’ points. Participants are divided in three outcome groups: 1. Answering “no” to CLBP at both measurements. 2. Incidence CLBP – answering “no” at baseline but “yes” at follow-up. 3. Persistence CLBP – answering “yes” at both measurements.		*Psychosocial exposures*: shift work, jobs with income linked to productivity, repetitive work under time pressure, job strain, job recognition, occupational support, and difficulty communicating.	
Euro[38] 2019	Cohort	The original study population was selected using a two-stage cluster sample from Finland comprising 8,000 males and females aged 30 to 59 years. A total of 7,217 participated in the screening phase and after exclusions, this cohort comprised 1,900 males and 1,991 females.	Sciatica: Hospitalisations for sciatica were obtained from “Care register for Health Care” covering all Finnish hospitals (public and private) with diagnoses based on ICD-8-10. Sciatica was defined by the codes: - ICD-8 = 353.99, 725.10 or 725.19. - ICD-9 = 7225A, 7227C or 7228C. - ICD-10 = G55.1, M51.1, M51.2, M54.3 or M54.4.	Register information.	*Mechanical exposures*: Physical strenuousness work, lifting, awkward postures, prolonged standing, sitting, whole-body vibration, constant movements and paced work.	Questionnaire.
Gold[39] 2017	Cohort	The study consisted of workers from multiple facilities within a single company in USA; with the vast majority being clinically staff, specifically nurses and nursing aids with a mean age of 41.1 years (SD=13.1). 1291 responded to the survey after 2 years with 1154 participants being eligible for the analyses (>90 % females), and after 6 years, 228 participants were left after attrition.	LBP: Was defined as pain in the low back region the past 3 months with at least mild severity during the prior week.	Questionnaire.	*Psychosocial exposures*: Work-family imbalance.	Questionnaire.
Halonen[40] 2019	Cohort	Participants were selected from the Swedish Longitudinal Occupational Survey of Health Study. Those responding to any two subsequent surveys in 2010 to 2016 were included. Of 17,962 participants, 12,222 participants (55% females) were free of LBP and 5,740 participants (61 % females) had LBP at baseline. Mean age at baseline was 54.1 years (SD=11.3).	LBP: Self-reported pain in the last 3 months defined as either “pain that affects my life a little” or “pain that affects my life a lot”. LBP was dichotomised into: - No affecting pain (no pain or pain that does not affect life). - Affecting pain (pain affecting life a little or a lot). For the main analysis, participants were divided into: - Incident (free from LBP at baseline). - Recurrent (LBP at baseline).	Questionnaire.	*Mechanical exposures*: Twisting and lifting.	Questionnaire.

Halonen[41] 2018	Cohort	A representative Swedish working population consisting of 9,756 individuals. Of these, 4,079 participants were included based on answers to at least 3 out of 4 survey rounds. For the analyses, 1,845 had onset of LBP with (932 males and 913 females) with age NS.	LBP: Self-reported pain in the last 3 months defined as either "pain that affects my life a little" or "pain that affects my life a lot". LBP was dichotomised into: - No affecting pain (no pain or pain that does not affect life). - Affecting pain (pain affecting life a little or a lot).	Questionnaire.	*Psychosocial exposures*: Effort-reward imbalance.	Questionnaire.
Herin[42] 2014	Cohort	Representative sample of subjects randomly selected from 7 French regions using exhaustive lists under the supervision of 400 volunteering occupational physicians. A total of 21,378 participants were included at baseline, 18,695 responded at follow-up, and 12,591 was eligible both at baseline and follow-up. For the analyses, 1206 participants (787 males and 419 females) were presented with LBP who came from 4 years of birth (1938, 1943, 1948 and 1953).	LBP: Self-reported musculoskeletal pain in combination with physicians' examination. Chronic musculoskeletal pain was defined as subjects who, on the day of examination, declared low back pain for at least 6 months who also presented with positive clinical signs.	Interview and physical examination.	*Mechanical exposures*: Forceful effort, effort with tools, heavy loads, movements, postures, and vibration. *Psychosocial exposures*: Psychological demands and decision latitude.	Questionnaire.
Heuch[43] 2017	Cohort	The whole population of Nord-Trøndelag, Norway, above the age of 20 years was invited to participate. The study was restricted to the age of 30-69 years. Follow-up included 24,280 participants, and in the analysis, 14,915 (7,335 males and 7,580 females) were eligible.	LBP: Chronic low back pain was defined as LBP persisting for at least 3 months continuously during the past year (yes/no). Information on LBP were collected from one question: "During the last year, have you suffered from pain and/or stiffness in your muscles and joints that has lasted for at least 3 consecutive months?" If yes, a follow-up question was given: "Where did you have these complaints?" Which included pre-specified body regions.	Questionnaire.	*Mechanical exposures*: Were measured in four categories asking the participants to indicate the baseline level of physical activity at work: 1. Substantially sedentary work. 2. work involving walking, but no heavy lifting. 3. Work involving both walking and heavy lifting. 4. Particularly strenuous physical work.	Questionnaire.
Jansen[44] 2004	Cohort	The cohort consisted of workers from 7 Dutch nursing homes and homes for elderly with various professions such as nurses, care givers, kitchen workers, transportation etc. 1208 subjects were invited to participate in 1998-1999 and 769 agreed to participate. After 1 year, 523 were observed again with a mean age of 40.7 years of age (SD=9.7). Information on sex was not provided.	LBP: Low back pain with disability was defined by Von Korff's disability score >50 points which indicated "high disability".	Questionnaire.	*Mechanical exposures*: Trunk flexion between 20 to 45º, trunk flexion >45º, and lifting and carrying loads >10 kg. *Psychosocial exposures*: Decision authority, skill discretion, and work demands.	Observations and questionnaire

Jørgensen[45] 2013	Cohort	The cohort consisted of Danish participants employed in 14 private and public companies. 5,249 men took part in the baseline examination. 3,833 were without LBP at baseline and was then included for the analyses aged between 40 and 59 years.	LDH: Hospitalisation due to herniated lumbar disc disease was identified in the National Hospital Register between 1977 and 2003 using the ICD-8 code 725.11 and ICD-10 code M51.1.	Register information.	*Mechanical exposures*: strenuous work and ergonomic load to the back. *Psychosocial exposures*: Mental stress at work.	Questionnaire
Krause[46] 2004	Cohort	The cohort consisted of 1974 transit vehicle operators from a railway in California, USA. After exclusion, the eligible study population comprised 1,841 workers. Of these, 1,503 participants responded to an additional questionnaire with the final sample being 1,233 (1055 males and 178 females) study participants for the analyses with a mean age of 46.7 years (SD=7.8).	Low back injury: First incidence of a compensated non-traumatic low back injury to the lumbar or sacral region of the spine. LBI was divided into "more severe" (post-laminectomy syndrome, spinal stenosis, herniated lumbar disc, sciatica, or spinal instability) and less severe (degenerative changes of the lumbar spine or non-specific low back pain). Outcome was measured by linking the participant's social security number to their worker's compensation file including all claims. These claims were then linked to the medical bill review file obtaining the ICD-9 code. Only cases with a "definite" diagnostic ICD-9 code on any physician bill record during the course of the claim were included.	Register information.	*Mechanical exposures:* Driving.	Questionnaire
Latza[47] 2002	Cohort	The cohort consisted of 571 male construction workers (age 17-59 years) from Hamburg, Germany. After 3 years, all workers were approached for a follow-up survey and 488 were willing to participate with a mean age of 33.1 years (SD=10.0).	Chronic LBP: <u>></u>90 days of low back pain during the last 12 months.	Interview.	*Mechanical exposures:* Work tasks including laying 6 different kinds of bricks or stones during shifts in the preceding 12 months and stone load. *Psychosocial exposures*: Monotonous work, time pressure, low job control, poor social support, and satisfaction with own achievements.	Interview
Matsudaira[48] 2014	Cohort	Employees were recruited from 16 local offices (e.g., office workers, nurses, salesmen and manufacturing engineers) in/near Tokyo, Japan. Baseline questionnaire was distributed to 6,140 participants and 5,310 responded. After 1 year, 3,811 participants completed the follow-up questionnaire. Among the 3,811 participants, 1,675 reported mild LBP during the past year at baseline with a mean age of 43.1 years (SD=10.1) and 78.6% males. Of these, 43 participants reported persistent LBP within the 1-year follow-up period.	Persistent LBP: LBP interfering with work (grade 2 or 3) with disability lasting longer than 3 months during a 1-year follow-up period. <u>Grades</u>: - Grade: No LBP. - Grade 1: LBP that does not interfere with work. - Grade 2: LBP that interferes with work but no absence from work. - Grade 3: LBP that interferes with work, leading to sick-leave.	Questionnaire.	*Mechanical exposures*: Manual handling at work, twisting, hours of desk work, and physical workload. *Psychosocial exposures*: Mental workload, interpersonal stress at work, workplace environment stress, job control, utilization of skills and expertise, reward to work.	Questionnaire

Matsudaira[49] 2015	Cohort	Employees were recruited from 16 local offices (e.g., office workers, nurses, salesmen and manufacturing engineers) in/near Tokyo, Japan. Baseline questionnaire was distributed to 6140 participants and 5,310 responded. After 1 year, 3,811 participants completed the follow-up questionnaire. Among the 3,811 employees, 171 reported LBP and experiencing work interferences with or without sick-leave during a month prior to baseline with a mean age of 42.9 years (SD=10.1) (71.4% males). Of these, 29 developed chronic disabling LBP during a year prior to the follow-up period.	Chronic disabling LBP: LBP that interfered with work for $\geq$3 months, regardless of sick leave (grade 2 and 3) during a 1-year follow-up period. <u>Grades</u>: - Grade: No LBP. - Grade 1: LBP that does not interfere with work. - Grade 2: LBP that interferes with work but no absence from work. - Grade 3: LBP that interferes with work, leading to sick-leave.	Questionnaire.	*Mechanical exposures*: Manual handling at work, twisting, hours of desk work, and physical workload. *Psychosocial exposures*: Mental workload, interpersonal stress at work, workplace environment stress, job control, utilization of skills and expertise, reward to work.	Questionnaire
Matsudaira[50] 2019	Cohort	Participants were recruited from different occupational groups in/near Tokyo. Occupational groups varied from nurses, office workers, sales/marketing to transportation. Baseline questionnaire was distributed to 3,187 employees and 2651 returned the questionnaire. Of these, 1809 participants returned the completed follow-up questionnaire. Among the 1809 participant, only 198 participants with disabling LBP during the month before baseline were included. The mean age was 36.0 (SD=9.1) where 69% were males. Of these 198, 35 had chronic disabling LBP during the 1-year follow-up period.	Chronic disabling LBP: LBP that interfered with work for $\geq$3 months regardless of sick leave (grade 2 and 3) during the 1-year follow-up period. <u>Grades</u>: - Grade 0: No LBP. - Grade 1: LBP that does not interfere with work. - Grade 2: LBP that interferes with work but no absence from work. - Grade 3: LBP that interferes with work, leading to sick-leave.	Questionnaire.	*Mechanical exposures*: Use a keyboard, move wrist/finger, bend elbow, hands above shoulder height, lift weights of 25 kg. by hand, kneel/squat 1 hour, stand, twist back/stoop for 4 hours, and drive for 4 hours. *Psychosocial exposures*: Interpersonal stress at work, inadequate breaks at work, lack of control over how to work, lack of control over what to do at work, lack of workplace support, and dissatisfied with job	Questionnaire
Melloh[51] 2013	Cohort	315 patients were recruited from 14 health practitioners across New Zealand due to their first episode of acute to subacute LBP or for recurrent LBP. 147 patients were lost to follow-up resulting in 168 patients participating over the six-months period (62% females) with a mean age of 36 (SD=13.1).	LBP: to determine persistent LBP, follow-up questionnaires were sent after 3, 6, and 12 weeks and at 6 month collecting information on pain intensity (VAS-scale) in the low back the last week. Patients with persistent LBP were then compared to patients with non-persistent LBP.	Questionnaire.	*Psychosocial exposures*: Job satisfaction, job control and social support at work	Questionnaire
Melloh[52] 2013	Cohort	315 patients were recruited from 14 health practitioners in New Zealand due to their first episode of acute to subacute LBP or for recurrent LBP. 169 participants (62 % females) completed the follow-up with a mean age of 36.0 (SD=31.1).	LBP: Persistent low back pain was defined by Oswestry Disability Index scorer of >10 points at baseline and 6 months and an ODI change score of $\leq$10 points between baseline and 6-month follow-up.	Questionnaire.	*Psychosocial exposures:* Job satisfaction and social support at work	Questionnaire
Melloh[53] 2013	Cohort	315 patients were recruited from 14 health practitioners in New Zealand due to their first episode of acute to subacute LBP or for recurrent LBP. 169 participants (62	LBP: Persistent low back pain was defined by Oswestry Disability Index scorer of >10 points at baseline and 6 months and an ODI change	Questionnaire.	*Psychosocial exposures:* Job satisfaction and social support at work	Questionnaire

		% females) completed the follow-up with a mean age of 36.0 (SD=31.1).	score of ≤10 points between baseline and 6-month follow-up.			
Picavet[54] 2016	Cohort	An age and sex stratified random sample of 12,405 inhabitants of Doetinchem, The Netherlands (20-60 years of age) was invited at baseline (1987-1992). At the first out of five follow-ups (1993-2012), a random sample of 7,769 was invited. In this study, data from round 2 to 5 was used. Only working participants were selected resulting in 3,597 participants at baseline. Finally, 1,694 were eligible for all survey-rounds. For the analyses, 1,509 participants were included with a mean age of 54 years (SD=6) for stable sitters and 53 years (SD=6) for stable non-sitters.	LBP: Information on LBP was measured using a single question: "have you had any trouble, discomfort or pain in the lower back during the last 12 months?" (yes/no) and chronic low back pain was measured by a subsequent question on duration defined as pain ≥3 months.	Questionnaire.	*Mechanical exposures*: Stable occupational sitting. Stable sitters were defined as workers who had indicated to have a sedentary job in at least 3 out 4 measurements, whereas stable non-sitters were defined as those having indicated in at least 3 out of 4 measurements to not have a sedentary job.	Questionnaire
Prado-Leon[55] 2014	Case-control	77 cases (57% males) were enrolled from a Family Medicine Units comprising industrial workers from a diverse range of manufacturing plants in Mexico. Cases were selected from a list of disability rulings and between the age of 18 and 55 years. 154 controls (68.8% males) were identified at the same Family Medicine Units as cases from records or files for insured workers. They were randomly selected and within 2-years of age of the cases – but not outside the age of 18 to 55.	Spondylarthrosis: was confirmed through reviewing cases files, and the following parameters were used to confirm the diagnosis: - Clinical exam. - Imaging scan (radiography, computerized axial tomography, and magnetic resonance imaging). - Diagnostic review by a committee of the Mexican Social Security Institute experts.	Physical examination and imaging scan.	*Mechanical exposures*: Pushing/pulling, weight of load when pushing/pulling, hours spent pushing/pulling, job frequency, and daily job frequency.	Questionnaire
Seidler[56] 2003	Case-control	437 male patients recruited at neurological clinics in Germany aged between 25 and 65 years. After exclusion, 225 cases were eligible and divided into: - LDH with osteochondrosis/spondylosis = 131, mean age 43.7 - "Pure" LDH = 94, mean age of 40.0. 107 controls (males) were from a random population group (mean age of 43) and 90 patients (males) admitted to hospital for urolithiasis who had no radiographically confirmed osteochondrosis or spondylosis (mean age of 40).	LBP: Herniation of the lumbar discs or osteochondrosis/spondylosis of the lumbar spine associated with chronic complaints (low back pain, sciatica). The diagnosis of lumbar disc herniation had to have been confirmed by computed tomography or magnetic resonance imaging. The radiographs were reassessed by reference radiologist.	MRI and CT.	*Mechanical exposures:* Manual handling, forward bending, whole-body vibration, and sedentary work. *Psychosocial exposures: M*onotonous work, opportunities to use knowledge and skills, satisfaction with supervisor, satisfaction with workmates, psychic strain, time pressure, and to much responsibility.	Interview
Seidler[57] 2009	Case-control	915 patients with lumbar disc herniation or lumbar disc narrowing were recruited at hospitals or orthopaedic practices in Germany aged between 25 and 70 years. 901 controls were randomly selected from a 1 % random sample of residents aged between 25 and 70 years, drawn by the local population registration offices.	LDH: Confirmed by a reference radiologist by either computerised tomography or by magnetic resonance imaging. LDN: Primarily based on X-ray.	MRI, CT, and X-rays.	*Mechanical exposures* - Manual material handling of loads (e.g., lifting, carrying, pulling, pushing, throwing, shovelling loads weighing at least 5 kg) - Trunk inclination and twisting and whole-body vibration.	Interview

		Females with LDH = 278, mean age of 47.1 (SD=11.8). Females with LDN = 206, mean age of 56.0 (SD=9.8). Controls = 448, mean age of 46.4 (SD=11.8). Males with LDH = 286, mean age of 48.7 (SD=11.1). Males with LDN = 145, mean age of 55.0 (SD=10.7). Controls = 453, mean age of 47.3 (SD=12.6).	To qualify as cases, MRI, CT and X-rays of the lumbar spine were re-assessed by one reference radiologist separately for each disc and vertebral body. Furthermore, the clinical diagnosis had to be verified by one experienced reference orthopaedist			
Seidler[58] 2011	Case-control	915 patients with lumbar disc herniation or lumbar disc narrowing were recruited at hospitals or orthopaedic practices in Germany aged between 25 and 70 years. 901 controls were randomly selected from a 1 % random sample of residents aged between 25 and 70 years, drawn by the local population registration offices. Females with LDH = 278, mean age of 47.1 (SD=11.8). Females with LDN = 206, mean age of 56.0 (SD=9.8). Controls = 448, mean age of 46.4 (SD=11.8). Males with LDH = 286, mean age of 48.7 (SD=11.1). Males with LDN = 145, mean age of 55.0 (SD=10.7). Controls = 453, mean age of 47.3 (SD=12.6).	LDH: Confirmed by a reference radiologist by either computerised tomography or by magnetic resonance imaging. LDN: Primarily based on X-ray. To qualify as cases, MRI, CT and X-rays of the lumbar spine were re-assessed by one reference radiologist separately for each disc and vertebral body. Furthermore, the clinical diagnosis had to be verified by one experienced reference orthopaedist	MRI, CT, and X-rays.	*Mechanical exposures* - Manual material handling of loads (e.g., lifting, carrying, pulling, pushing, throwing, shovelling loads weighing at least 5 kg) - Trunk inclination and twisting and whole-body vibration.	Interview
Seyedmehdi[59] 2016	Cohort	All industrial workers from a large Iranian rubber factory with acute non-specific LBP in the past 2 weeks were included (2011-2912). Diagnosis of acute non-specific LBP at baseline was made by two occupational medicine specialists. The cohort consisted of 542 participants and 511 completed the 1-year follow-up (500 males and 11 females) with a mean age of 37.6 years (SD=5.8).	LBP was assessed 3, 6, 9 months and at 1 year after baseline asking the question: "Have you recovered from your LBP". If the answer was "yes" The question would follow: "How long did it last?" Participants with LBP were divided in 2 groups: 1. LBP lasting <3 months. 2. LBP lasting ≥3 months.	Face-to-face or telephone interview.	*Mechanical exposures*: Standing position in shift work and carrying heavy loads. *Psychosocial exposures*: Job stress.	Questionnaire
Sihawong[60] 2016	Cohort	The cohort consisted of a sample of office workers recruited from nine-scale enterprises in Thailand. 3,446 office workers responded to the questionnaire and 2,483 were excluded. 669 agreed to participate in the physical examination and 615 were followed up after 1 year. Due to incomplete data, 609 were included in the analysis with a mean age of 35.7 (SD=8.3) including 168 males and 501 females.	LBP: Incidence of chronic low back pain was defined as ongoing pain greater than 3 months over the past 6 months. Participants received a self-administered diary to record low back pain, and researches would collect the diaries every month over the course of 12 months.	Diaries.	*Psychosocial exposures:* Psychological job demands.	Questionnaire
Sørensen[61] 2011	Cohort	Participants were employed at 14 different private and public companies in Copenhagen, Denmark, including railway, insurance, fire brigade etc., aged between 40 to	LDH: Hospitalisation due to herniated lumbar disc disease was identified in the National Hospital Register between 1977 and 2003	Register information.	*Mechanical exposures:* Strenuous work and ergonomic load to the back. *Psychosocial exposures:* Mental stress at work	Questionnaire

		59 years. 5249 males were invited at baseline and 3833 without LBP at baseline were entered in the study.	using the ICD-8 code 725.11 and ICD-10 code M51.1.			
Tubach[62] 2004	Cohort	At baseline, the cohort included 20,624 subjects who were employees at a French electricity and gas company. Of these, a random sample of 4,018 subjects received a questionnaire about LBP. 3,240 completed the questionnaire whereas 475 were included in the analyses (405 males and 70 females) aged between 35 to 50 years.	LBP: Assessed by the question regarding suffering from sciatica the last year and if the subjects had visited a physician regarding their symptoms.	Questionnaire.	*Mechanical exposures:* Carrying loads more than 10 kg., and driving more than 2 hours a day. *Psychosocial exposures:* Job satisfaction.	Questionnaire
Vieira[63] 2018	Case-control	119 Brazilian patients (57 males and 62 females) with chronic LBP were recruited from an outpatient hospital clinic of spinal surgery. 112 controls (23 males and 89 females) were recruited from a clinical laboratory. Median age of cases were 40 years and 32 years for controls.	Disc degeneration: Was measured by MRI scans of all patients and performed by two experienced radiologists. The images were evaluated by an orthopaedic spine surgeon. The degree of disc degeneration was graded from T2-weighted images according to Pfirrmann classification, and only patients with grades 3, 4, or 5 were included in the case group.	Imaging scan.	*Mechanical exposures*: Postures at work and load weight at work.	Interview-administered questionnaire
Wahlström[64] 2018	Cohort	389,132 construction workers from Sweden were identified through a national register using a personal ID number assigned all inhabitants. Between 1968 and 1993, due to a nation-wide program, all workers were invited to participate in health examines ever 2-5 year. In total, 288,926 men was included in the analysis and restricted to weight between 50 and 129 kg, height between 150 and 199 cm and BMI between 18.5 and 34.9.	LDH: Occurrence of hospitalisation due to lumbar disc herniation was collected from registers and defined as the ICD-9 code 722.1 or the ICD-10 code M51.1.	Register information.	*Mechanical exposures*: Whole-body vibration.	Job-exposure-matrix

Abbreviations: CT = computed tomography; ICD = International Classification of Diseases; kg = kilogram; LBP = low back pain; LDH = lumbar disc herniation; LDN = lumbar disc narrowing; MRI = magnetic resonance imaging; MS = milliseconds; NS = not specified; SD = standard deviation.

3.2 Overall study characteristics

Table 1 summarizes the characteristics of the 32 included articles, 11 identified from the SBU[44-47 52 56-58 61 62] and 21 from the literature search.[33-43 48-51 54 55 59 60 63 64] In total, 24 cohort studies and 8 case-control studies were included. The outcome was assessed using self-reports in 15 articles (i.e., questionnaires and diaries), interviews (i.e., face-to-face or telephone interview) in 4 articles, imaging modalities (i.e., CT, MRI, and X-ray) in 5 articles, register information in 5 articles, 2 articles used both physical examination and imaging modalities, and 1 article used both physical examination and interview. Exposure information was assessed using questionnaires in 20 articles; interview in 10 articles; observation and questionnaire in 1 article, and a job-exposure-matrix in 1 article.

Studies were conducted in Denmark,[45 61] Sweden,[40 41 64] Norway,[43] Finland,[38] Germany,[36 47 56-58] Netherlands,[44 54] France,[37 42 62] United States,[39 46] Mexico,[55] Brazil,[63] Iran,[33 59] Syria,[35] Bangladesh,[34] Japan,[48-50] Thailand,[60] and New Zealand.[51-53] The articles were published between 2002 and 2019.

Three articles provided a measure of association other than OR, but had an incidence proportion of the outcome of <10%.[38 45 64] One article reported a crude RR of 1.30 (95% CI 1.00 – 1.71) with an equivalent OR calculated to 1.38 (95% CI 0.98 – 1.94).[43] Four articles did not provide sufficient numbers of participants to be used for transformation into OR,[40 41 44 47] but were included in the meta-analysis as we excepted an incidence proportion similar to the included studies.

3.3 Study quality assessment

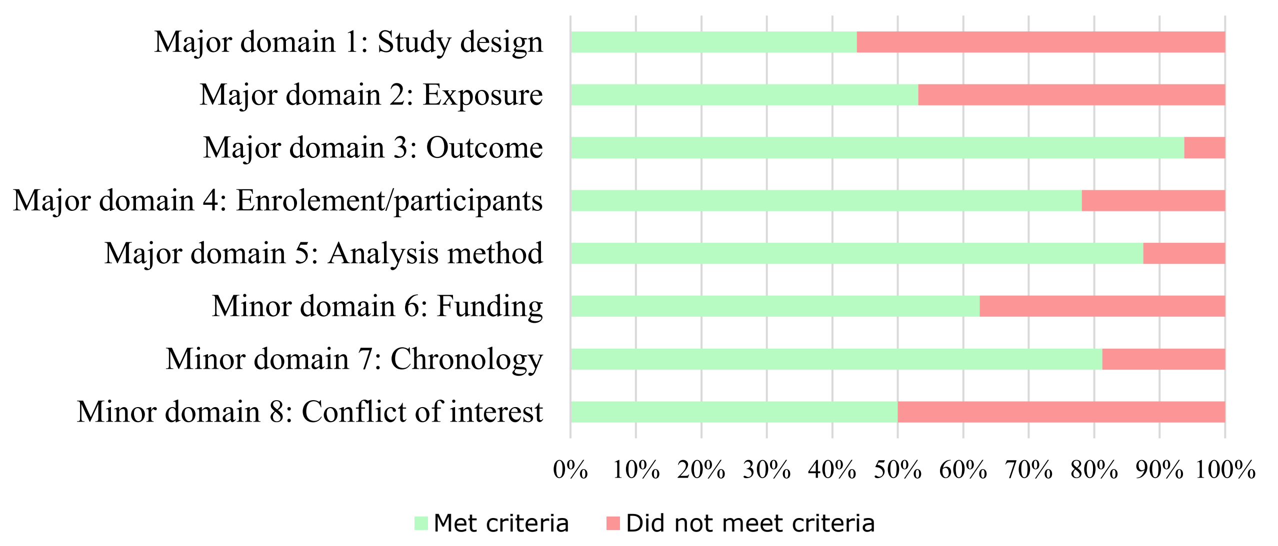
Table 2 contains the methodological quality assessment of the 32 included articles. Of these 32 articles, 5 were rated with a low risk of bias, 16 with a moderate risk of bias, and 11 as having a high risk of bias. The most frequent major domain receiving a high risk of bias assessment was “Study design & follow-up” for cohort studies and “Study design & selection” for case-control studies. The second most frequent major domain receiving a high risk of bias assessment was “Exposure. The most frequent minor domain receiving a high risk of bias assessment was “Conflict of interests” (figure 2).

Table 2. Quality assessment of all 32 included articles.

References	Quality score	Domains							
		Major					Minor		
		1	2	3	4	5	6	7	8
Aghilinejad 2015[33]	Low risk	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(?)
Ahsan 2013[34]	High risk	(-)	(?)	(+)	(-)	(-)	(-)	(?)	(?)
Alhalabi 2015[35]	High risk	(-)	(?)	(?)	(-)	(-)	(-)	(?)	(+)
Bergmann 2017[36]	Moderate risk	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(?)
Esquirol 2017[37]	High risk	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
Euro 2019[38]	Moderate risk	(+)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
Gold 2017[39]	High risk	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
Halonen 2019[40]	Moderate risk	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(?)
Halonen 2018[41]	Moderate risk	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Herin 2014[42]	High risk	(-)	(?)	(+)	(+)	(+)	(+)	(+)	(+)
Heuch 2017[43]	Low risk	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Jansen 2004[44]	Low risk	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(?)
Jørgensen 2013[45]	Low risk	(+)	(+)	(+)	(+)	(+)	(-)	(+)	(?)
Krause 2004[46]	Low risk	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(?)
Latza 2002[47]	High risk	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(-)
Matsudaira 2019[50]	High risk	(-)	(-)	(+)	(+)	(-)	(+)	(+)	(?)
Matsudaira 2015[49]	High risk	(-)	(+)	(+)	(+)	(-)	(-)	(+)	(?)
Matsudaira 2014[48]	Moderate risk	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Melloh 2013[51]	Moderate risk	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(?)
Melloh 2013[52]	Moderate risk	(-)	(+)	(+)	(+)	(+)	(-)	(+)	(+)
Melloh 2013	Moderate risk	(-)	(+)	(+)	(+)	(+)	(-)	(+)	(?)
Picavet 2016[54]	High risk	(-)	(-)	(+)	(?)	(+)	(+)	(+)	(+)
Prado-Leon 2014[55]	High risk	(+)	(+)	(+)	(+)	(+)	(-)	(?)	(-)
Seidler 2011[58]	Moderate risk	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(-)
Seidler 2009[57]	Moderate risk	(-)	(+)	(+)	(+)	(+)	(-)	(-)	(+)
Seidler 2003[56]	Moderate risk	(+)	(+)	(+)	(-)	(+)	(+)	(-)	(?)
Seyedmehdi 2016[59]	Moderate risk	(+)	(-)	(+)	(+)	(+)	(-)	(+)	(?)
Sihawong 2016[60]	Moderate risk	(+)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
Sørensen 2001[61]	Moderate risk	(+)	(-)	(+)	(+)	(+)	(+)	(+)	(+)
Tubach 2004[62]	Moderate risk	(+)	(-)	(+)	(+)	(+)	(-)	(+)	(+)
Vieira 2018[63]	High risk	(-)	(-)	(+)	(-)	(+)	(+)	(-)	(+)
Wahlström 2018[64]	Moderate risk	(+)	(+)	(+)	(?)	(+)	(+)	(+)	(+)

(+) = comply with criteria; (-) = does not comply with criteria; (?) = no information is provided.

Figure 2. Risk of bias summary presented as percentage of the distribution between the 32 included articles for each domain's criteria.



3.4 Association between occupational exposures and chronic LBP

Appendix 7 presents the measure of association between occupational exposures and chronic LBP reported in the 32 articles divided into 9 groups of mechanical and 5 groups of psychosocial exposures. On the association between occupational mechanical exposures and chronic LBP, 17 studies reported on lifting/carrying loads,[33-38 40 42 44 47-50 56 57 59 62] 14 studies reported on exposure to awkward postures,[33-38 40 42 44 48-50 56 57] 7 on exposure to whole-body vibrations,[33 34 36 38 42 56 64] 6 on exposure to standing/walking,[35 38 43 50 59 63] 8 on exposure to sitting,[33-35 38 48 49 54 56] 9 on exposure to combined mechanical exposures,[34 36 38 43 45 56-58 61] 1 on exposure to kneeling/squatting,[50] 2 on exposure to pushing/pulling loads,[48 55] and 6 on "other mechanical exposures".[33 38 42 46 50 62] For psychosocial, 3 studies reported on job strain,[33 37 44] 6 studies on job control,[33 42 47 49-51] 9 studies on job support,[33 37 47-53] 7 studies on job stress,[45 48-51 59 61] and 16 on "other psychosocial exposures.[33 34 37 39 41 42 44 47-52 56 60 62]

3.5 Association between occupational mechanical exposures and chronic LBP

Meta-analyses were only conducted for the following 6 mechanical exposures: lifting/carrying loads, awkward postures, whole-body vibrations, standing/walking, sitting, and combined mechanical exposures. We did not perform meta-analyses for kneeling/squatting and pushing/pulling loads due to few studies and for "other mechanical exposures" which were very heterogeneously defined.

3.5.1 Lifting/carrying loads

Among the 17 studies on lifting/carrying loads, the methodological quality was rated as low risk of bias in 2 studies, moderate in 8 studies, and high in 7 studies. Lifting/carrying loads were defined heterogeneously between studies with 4 studies defining exposure as manual material handling, and 7 studies defined exposure as lifting/carrying heavy objects. Twelve studies indicated a weight of load between 10 to 25 kg daily or weekly (appendix 7).

Of the 17 eligible studies, 4 studies were based on 2 identical study populations, and therefore 2 studies were excluded from the meta-analysis.[36 49] Fifteen studies were included in the meta-analysis comprising 22 exposure groups. We found a pooled OR of 1.7 (95% CI 1.4 – 2.2) showing a considerable degree of heterogeneity with I^2 = 88.4% (figure 3). The funnel plot (appendix 8) indicated publication bias, and the Egger's test showed a significant p-value (0.02%). Three studies tested for exposure-response relation, and all found a positive relation.[44 47 56] However, among 8 studies presenting measure of association for ≥3 exposure groups, only 4 indicated an increase in OR with increasing exposure (appendix 9). No exposure thresholds could be identified.

In the sensitivity analysis, moderate to low risk of bias studies (9 studies) showed a pooled OR of 1.9 (95% CI 1.4 – 2.5), while studies with high risk of bias (6 studies) showed a pooled OR of 1.4 (95% CI 1.0 – 1.9). In the sensitivity analysis based on study design, pooled OR was 1.5 (95% CI 1.2 – 1.8) in cohort studies (11 studies) and 2.2 (95% CI 1.3 – 3.8) in case-control studies (4 studies). Non-specific chronic LBP (10 studies) showed a pooled OR of 1.4 (95% CI 1.2 – 1.7), while specific chronic LBP (5 studies) showed a pooled OR of 2.2 (95% CI 1.4 – 3.4).

Based on the existing literature, some evidence of an association (++) was found between lifting/carrying loads and chronic LBP. It cannot be excluded with reasonable degree of certainty that the association can be explained by change, bias or confounding, although it is not a very probable explanation. There was a risk of publication bias. Some indication of exposure-response relation was found, but we could not conclude on any form of exposure threshold due to heterogeneity in exposure definition.

3.5.2 Awkward postures

Among the 14 studies on awkward postures, the methodological quality was rated as low risk of bias in 2 studies, moderate in 5 studies, and high in 7 studies. Awkward postures were defined heterogeneously but most studies described awkward postures as either trunk bending, flexion, or twisting. Six studies defined the exposure metric as duration either during a work day, a week, or cumulated hours the past year or a cumulated calculation based on frequency and duration (appendix 7).

Of the 14 eligible studies, 4 studies were based on 2 identical study populations and therefor 2 were excluded from the meta-analysis.[36 49] Included in the meta-analysis were 12 studies comprising 19 exposure groups. We found a pooled OR of 1.5 (95% CI 1.2 – 1.9) showing a considerable degree of heterogeneity with I^2 = 87.2% (figure 4). The funnel plot (appendix 8) indicated publication bias and the Egger's test showed a close to significant p-value (0.06%). Two studies tested for exposure-response relation, and both found a positive relation.[44 56] Five studies presented measure of association for ≥3 exposure groups, and 4 found an increase in OR with increasing exposure (appendix 9). No exposure thresholds could be identified.

In the sensitivity analysis, moderate to low risk of bias studies (7 studies) showed a pooled OR of 1.7 (95% CI 1.2 – 2.3), while studies with high risk of bias (5 studies) showed a pooled OR of 1.3 (95% CI 1.1 – 1.4). In the sensitivity analysis based on study design, pooled OR was 1.3 (95% CI 1.1 – 1.5) in cohort studies (8 studies) and 2.1 (95% CI 1.5 – 3.0) in case-control studies (4 studies). Non-specific chronic LBP (8 studies) showed a pooled OR of 1.3 (95% CI 1.2 – 1.5), and specific chronic LBP (4 studies) showed a pooled OR of 1.7 (95% CI 1.0 – 2.8).

Based on the existing literature, some evidence of an association (++) was found between awkward postures and chronic LBP. There might be a risk of publication bias. We found indication of exposure-response relation, but we could not conclude on any form of exposure threshold due to heterogeneity in exposure definition.

3.5.3 Whole-body vibration

Among the 7 studies on whole-body vibration, the methodological quality was rated as low risk of bias in 1 study, moderate in 3 studies, and high in 3 studies. Whole-body vibration was to some degree defined heterogeneously between studies (e.g., whole body vibration, vibration, and shaking of the whole body), but the exposure metric varied considerably (e.g., duration, intensity, and cumulative exposures). Four studies categorised the exposure dichotomously as high/low or yes/no (appendix 7).

Included in the meta-analysis were 7 studies comprising 9 exposure groups. We found a pooled OR of 1.4 (95% CI 1.1 – 1.7) showing a moderate degree of heterogeneity with I^2 = 46.7% (figure 5). The funnel plot (appendix 8) indicated publication bias and the Egger's test showed a significant p-value (0.03%).

In the sensitivity analysis, moderate to low risk of bias studies (5 studies) showed a pooled OR of 1.4 (95% CI 1.2 – 1.7), while studies with high risk of bias (2 studies) showed a pooled OR of 1.3

(95% CI 0.8 – 1.9). In the sensitivity analysis based on study design, pooled OR was 1.3 (95% CI 1.0 – 1.7) in cohort studies (4 studies) and 1.7 (95% CI 1.0 – 2.8) in case-control studies (3 studies). Non-specific chronic LBP (2 studies) showed a pooled OR of 1.3 (95% CI 0.9 – 2.0) and specific chronic LBP (5 studies) showed a pooled OR of 1.4 (95% CI 1.2 – 1.7).

Based on the existing studies, limited evidence of an association (+) exists between whole-body vibration and chronic LBP.

3.5.4 Standing/walking

Among the 6 studies on standing/walking, the methodological quality was rated as low risk of bias in 1 study, moderate in 2 studies, and high in 3 studies. Standing/walking was defined somewhat heterogeneously between studies (e.g., prolonged standing, walking at work, and standing). Five studies categorised the exposure dichotomously as either yes/no (duration), seated vs. standing, sometimes/always or none. One study reported duration as more or less than 4 hours (appendix 7).

Among the 6 studies, none were based on an identical study population. Therefore, all 6 studies were included in the meta-analysis comprising 6 exposure groups. We found a pooled OR of 1.0 (95% CI 0.8 – 1.3) showing moderate degree of heterogeneity with $I^2 = 43.4\%$ (figure 6). The funnel plot (appendix 8) did not indicate publication bias and the Egger's test showed no significant p-value (0.49%).

In the sensitivity analysis, moderate to low risk of bias studies (3 studies) showed a pooled OR of 1.0 (95% CI 0.9 – 1.2), and studies with high risk of bias (3 studies) also showed a pooled OR of 0.9 (95% CI 0.4 – 2.2). In the sensitivity analysis based on study design, pooled OR was 1.0 (95% CI 0.9 – 1.2) in cohort studies (4 studies) and 0.8 (95% CI 0.2 – 3.6) in case-control studies (2 studies). Non-specific chronic LBP (4 studies) showed a pooled OR of 1.1 (95% CI 0.9 – 1.5), and specific chronic LBP (2 studies) showed a pooled OR of 0.7 (95% CI 0.3 – 1.7).

Based on the existing studies, insufficient evidence of an association (0) exists between standing/walking and chronic LBP.

3.5.5 Sitting

Among the 8 studies on sitting, the methodological quality was rated as low risk of bias in 1 study, moderate in 3 studies, and high in 4 studies. Sitting was defined somewhat heterogeneously between studies (e.g., sitting, prolonged sitting, and desk work). Six studies categorised the exposure dichotomously as either yes/no, sustained/prolonged sitting, or frequent/not frequent. Two studies defined the exposure dimension with 6 hours/day or based on cumulated life time dose (appendix 7).

Of the 8 eligible studies, 2 were based on an identical study population and one study failed to provide 95% CI. Therefore, 2 studies were excluded from the meta-analysis.[34 49] Included in the meta-analysis were 6 studies comprising 7 exposure groups. We found a pooled OR of 1.2 (95% CI 1.0 – 1.5) showing a low degree of heterogeneity with I^2 = 2.75% (figure 7). The funnel plot (appendix 8) did not indicate publication bias and Egger's test showed no significant p-value (0.50%).

In the sensitivity analysis, moderate to low risk of bias studies (4 studies) showed a pooled OR of 1.1 (95% CI 0.8 – 1.4) and studies with a high risk of bias (2 studies) showed a pooled OR of 1.5 (95% CI 0.9 – 2.5). In the sensitivity analysis based on study design, pooled OR was 1.1 (95% CI 0.9 – 1.4) in cohort studies (4 studies) and 1.6 (95% CI 0.8 – 3.0) in case-control studies (2 studies). Non-specific chronic LBP (4 studies) showed a pooled OR of 1.2 (95% CI 0.8 – 1.8), and specific chronic LBP (2 studies) showed a pooled OR of 1.1 (95% CI 0.8 – 1.6).

Based on the existing studies, insufficient evidence for a causal association (0) exists between sitting and chronic LBP.

3.5.6 Combined mechanical exposures

Among the 9 studies on combined mechanical exposures, the methodological quality was rated as low risk of bias in 2 studies, moderate in 6 studies, and high in 1 study. Combined mechanical exposures were defined heterogeneously (e.g., lifting combined with forward bending, manual material handling combined with intensive load postures, and strenuousness or physical strenuousness work). Five studies categorised strenuousness/physical workload from sedentary to hard physical work.

Of the 9 eligible studies, 4 were based on identical study populations and 1 study failed to provide a 95% CI. In total, 4 studies were excluded from the meta-analysis.[34 36 58 61] Included in the meta-analysis were 5 studies comprising 9 exposure groups. We found a pooled OR of 2.2 (95% CI 1.4 – 3.6) showing a considerable degree of heterogeneity with I^2 = 89.9% (figure 8). Due to few studies, it was difficult to evaluate the funnel plot (appendix 8), but the Egger's test showed no significant p-value (0.41%). One study tested for exposure-response relation and found a positive relation.[57] Three studies presented measure of association for ≥3 exposure groups, and 2 found an increase in OR with increasing exposure (appendix 9). No exposure thresholds could be identified.

Sensitivity analyses according to study quality and outcome were not conducted since all included studies were assessed as moderate to low risk of bias and only 1 study measured non-specific chronic LBP (RR_{men}=1.2, RR_{women}=1.2). In the sensitivity analysis based on study design, pooled OR was 1.2

(95% CI 1.0 – 1.4) in cohort studies (3 studies) and 4.2 (95% CI 1.4 – 12.9) in case-control studies (2 studies).

Based on the existing literature, some evidence of a causal association (++) exists between combined mechanical exposures and chronic LBP. We found indication of exposure-response relation, however few studies were available. We could not conclude on any form of exposure threshold due to heterogeneity in exposure definition.

3.5.7 Kneeling/squatting

In the 1 study of kneeling/squatting, the methodological quality was rated high. However, due to few studies, a meta-analysis was not conducted and insufficient evidence of a causal association (0) exists between kneeling/squatting and chronic LBP.

3.5.8 Pushing/pulling loads

Among the 2 studies on pushing/pulling loads, the methodological quality was rated as moderate in 1 study and high in 1 study. Due to few studies, a meta-analysis was not conducted and insufficient evidence of a causal association (0) exists between pushing/pulling loads and chronic LBP.

3.5.9 Sex difference

Lifting/carrying loads: Among the 15 studies included in the meta-analysis for lifting/carrying, 2 studies provided sex-specific measure of association.[42 57] One study did not group exposure similar between sex, which makes sex-differences difficult to evaluate,[57] and 1 study found no sex-difference (OR_{men}=1.06, OR_{women}=1.02).[42]

Awkward postures: In the 12 studies included in the meta-analysis, 2 studies provided sex-specific measure of association.[42 57] One study did not group exposure similar,[57] and 1 study found a minimal higher risk among women compared to men (OR_{men}=1.19, OR_{women}=1.33).[42]

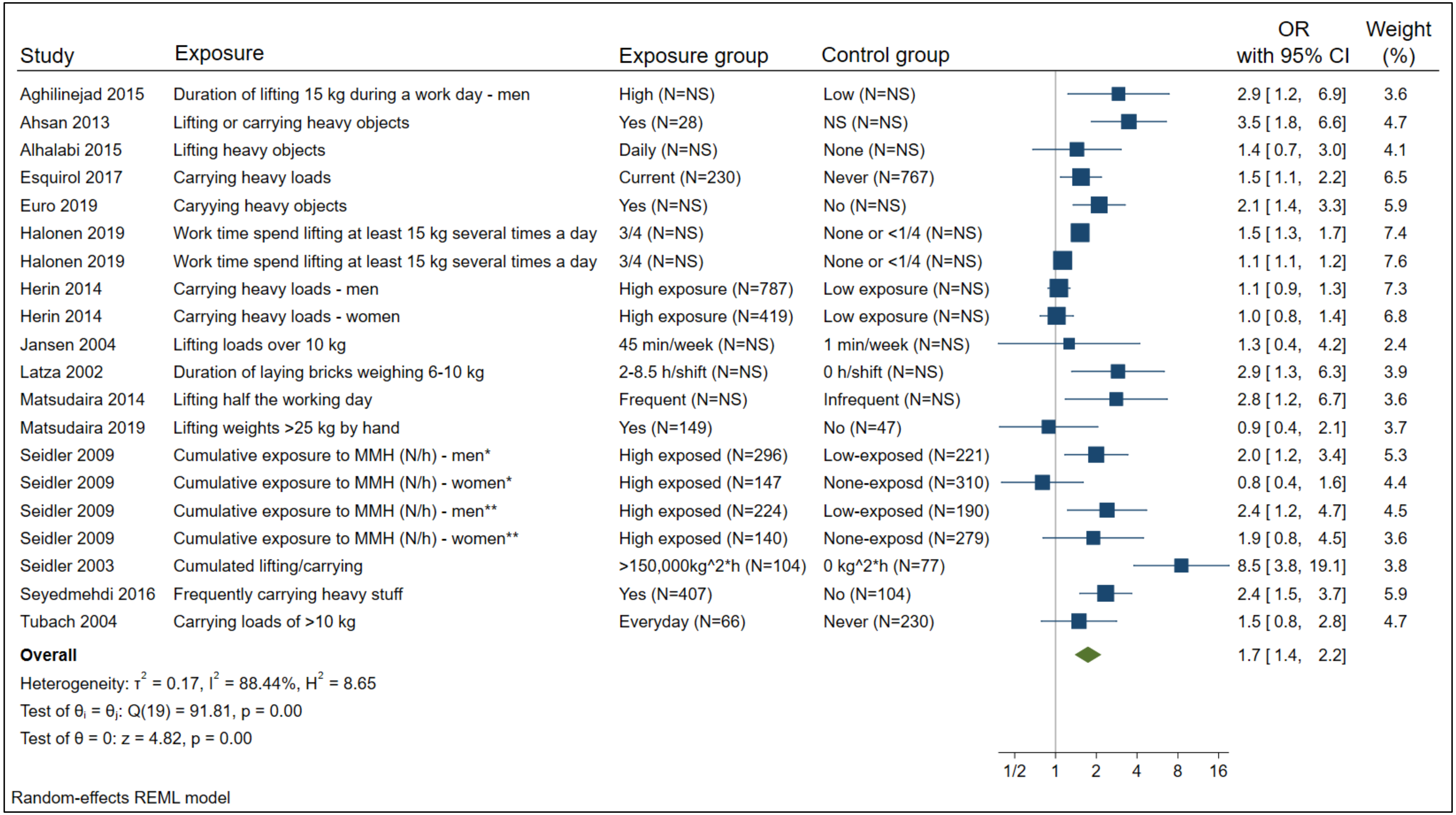
Whole body vibration: One study provided sex-specific measure of association and found a higher risk among women compared to men (OR_{men}=1.00, OR_{women}=1.73).[42]

Standing/walking: One study found a minimal higher risk among women compared to men (OR_{men}=0.96, OR_{women}=1.11).

Sitting, kneeling/squatting, pushing/pulling loads: No sex-specific measure of association was provided.

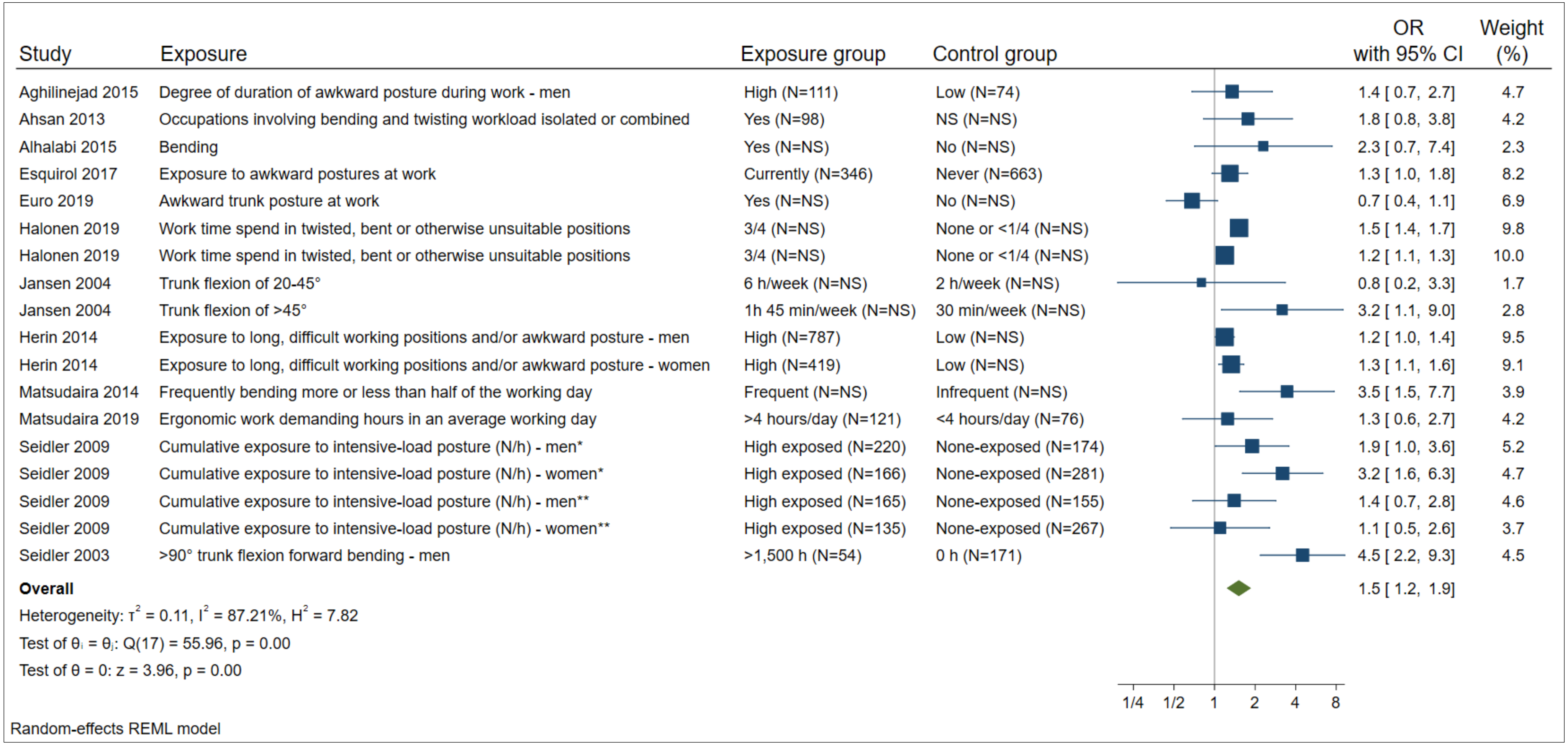
Combined exposures: Two studies provided sex-specific measure of association.[43 57] One study did not categorized exposure similar,[57] while 1 study found no difference between sex (RR_{men}=1.22, RR_{women}=1.24).[43]

Figure 3. Forest plot of the association between lifting/carrying loads and chronic LBP.



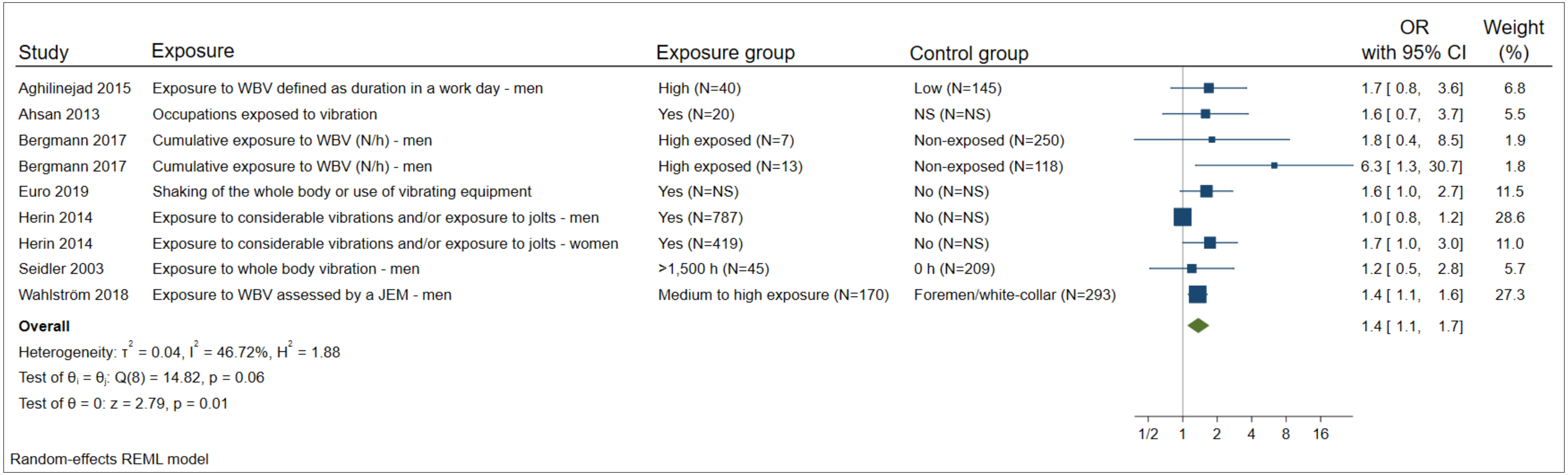
Abbreviations: NS = not stated; kg = kilograms; MMH = manual material handling; N/h = newton hour; h = hour.
*Cases with lumbar disc herniation; **Cases with lumbar disc narrowing.

Figure 4. Forest plot of the association between awkward postures and chronic LBP.



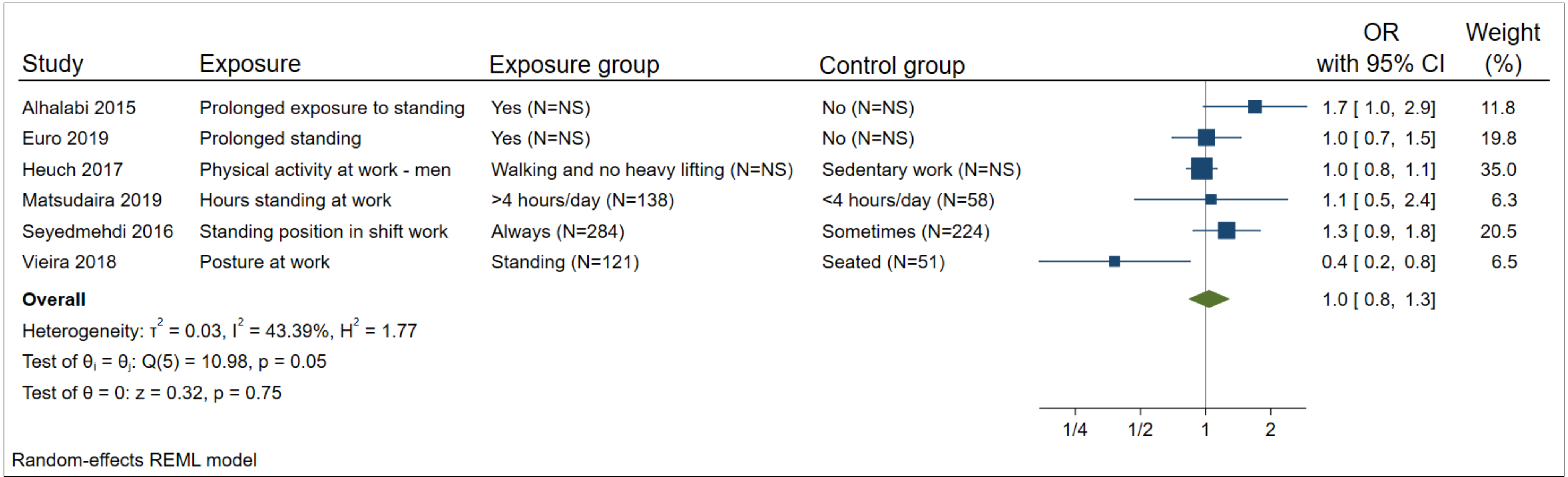
Abbreviations: NS = not stated; N/h = newton hours; h = hours.
*Cases with lumbar disc herniation; **Cases with lumbar disc narrowing

Figure 5. Forest plot of the association between whole-body vibration and chronic LBP.



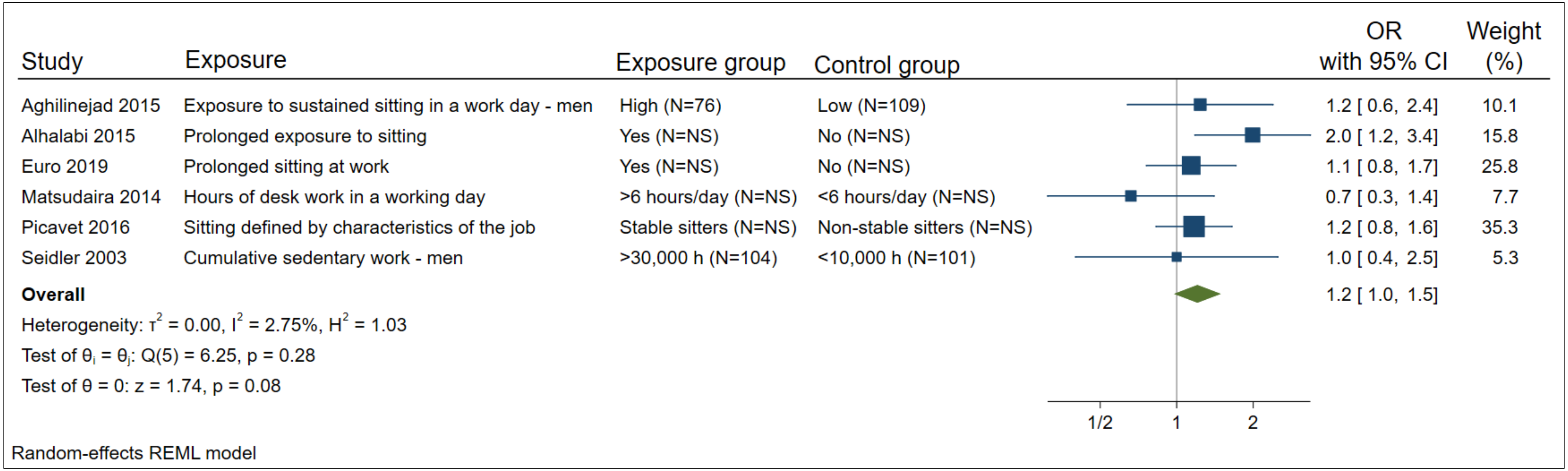
Abbreviations: NS = not stated; N/h = newton hours; JEM = job-exposure matrix; WBV = whole-body vibration.

Figure 6. Forest plot of the association between standing/walking and chronic LBP



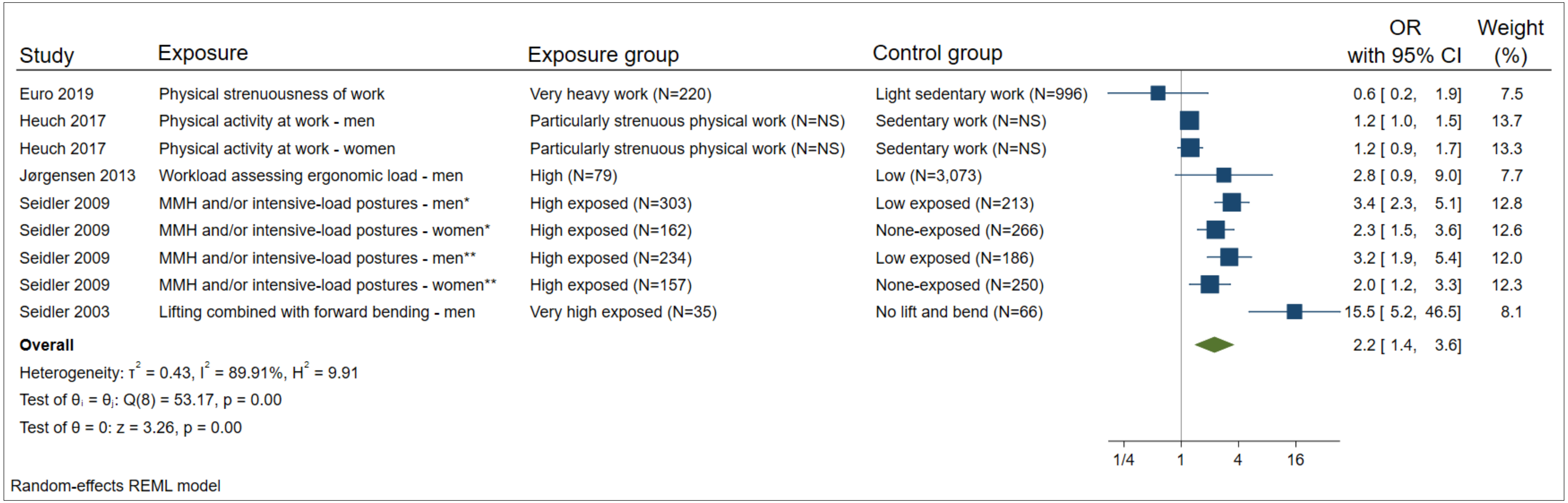
Abbreviations: NS = not stated.

Figure 7. Forest plot of the association between sitting and chronic LBP



Abbreviations: NS = not stated; h = hours

Figure 8. Forest plot of the association between combined mechanical exposures and chronic LBP



Abbreviations: NS = not stated; MMH = manual materials handling.
*Cases with lumbar disc herniation; **Cases with lumbar disc narrowing

Table 3 presents an overview of the association between occupational mechanical exposures and chronic LBP.

Table 3. Overview of results on occupational mechanical exposures and chronic LBP.

Mechanical exposures	No. of studies	Pooled OR	Publication bias	Evidence of an association*
Lifting/carrying loads	15 (11)**	1.7 (95% CI 1.4 – 2.2)	Indication of publication bias (Eggers test of 0.02%).	Some evidence of an association (++).
Awkward postures	12 (8)**	1.5 (95% CI 1.2 – 1.9)	Indication of publication bias (Eggers test of 0.06%).	Some evidence of an association (++).
Whole-body vibrations	7 (4)**	1.4 (95% CI 1.1 – 1.7)	Indication of publication bias (Eggers test of 0.03%).	Limited evidence of an association (+).
Standing/walking	6 (4)**	1.0 (95% CI 0.8 – 1.3)	No indication of publication bias (Eggers test of 0.49%).	Insufficient evidence of an association (0).
Sitting	6 (4)**	1.2 (95% CI 1.0 – 1.5)	No indication of publication bias (Eggers test of 0.50%).	Insufficient evidence of an association (0).
Kneeling/squatting	1	Not included in meta-analysis due to few studies.	Not included in meta-analysis due to few studies.	Insufficient evidence of an association (0).
Pushing/pulling loads	2	Not included in meta-analysis due to few studies.	Not included in meta-analysis due to few studies.	Insufficient evidence of an association (0).
Combined exposures	5 (3)**	2.2 (95% CI 1.4 – 3.6)	Publication bias was difficult to assess due to few studies (Eggers test of 0.41%).	Some evidence of an association (++).

*See Appendix 5 for clarification. ** Number of cohort studies. "Other mechanical exposures" were not evaluated due to heterogeneity.

3.6 Association between occupational psychosocial exposures and chronic LBP

For occupational psychosocial exposures, we performed meta-analyses for job support, control, and stress. We did not perform meta-analysis for job strain due to few studies and for "other psychosocial exposures" due to heterogeneity.

3.6.1 Job control

Among the 6 studies on job control, the methodological quality was rated as low risk of bias in 1 study, and high in 5 studies. In the 6 studies, job control was defined mostly homogenously, however several different types of questionnaires were used (e.g., Karasek-, BJSQ-, and CUPID-questionnaire). All studies were included in the meta-analysis. We found a pooled OR of 1.0 (95% CI 0.9 – 1.1) showing an $I^2 = 0\%$ (figure 9). Funnel plot showed no indication of publication bias (appendix 8) and Egger's test showed no significant p-value (0.87%).

In the sensitivity analysis, moderate to low risk of bias studies (2 studies) showed a pooled OR of 0.9 (95% CI 0.9 – 1.2), while studies with high risk of bias (4 studies) also showed a pooled OR of 1.0 (95% CI 0.9 – 1.2). All 6 studies were cohort studies including non-specific LBP, so we did not perform sensitivity analysis based on study design and outcome. Based on the existing studies, insufficient evidence of a causal association (0) was found between job control and chronic LBP.

3.6.2 Job support

Among the 8 studies on job support, the methodological quality was rated as low risk of bias in 1 study, moderate in 2 studies, and high in 5 studies. In the 8 studies, support was defined as either social support, support form co-workers, or support from supervisors. Two studies were excluded due to identical study population,[49 52] leaving 6 studies included for the meta-analysis. We found a pooled OR of 1.1 (95% CI 0.7 – 1.7) with substantial heterogeneity ($I^2 = 65{,}6\%$) (figure 10). Funnel plot indicated a tendency towards publication bias (appendix 8), but the Egger's test showed no significant p-value (0.95%).

In the sensitivity analysis, moderate to low risk of bias studies (3 studies) showed a pooled OR of 0.9 (95% CI 0.4 – 2.1), while high risk of bias studies (3 studies) showed and OR of 1.4 (95% CI 1.0 – 1.8). All 6 studies were cohort studies including non-specific LBP, so we did not perform sensitivity analysis based on study design and outcome. Based on the existing studies, insufficient evidence of a causal association (0) exists between job support and chronic LBP.

3.6.3 Job stress

Among the 7 studies on job stress, the methodological quality was rated moderate in 4 studies and high in 3 studies. The exposure dimension of job stress was defined fairly homogenously. Two studies were excluded due to identical study populations,[49 61] leaving 5 studies for the meta-analysis. We found a pooled OR of 1.1 (95% CI 0.6 – 1.8) with substantial heterogeneity ($I^2 = 67.6\%$) (figure 11).

Funnel plot did not indicate publication bias (appendix 8) and Egger's test showed no significant p-value (0.29%).

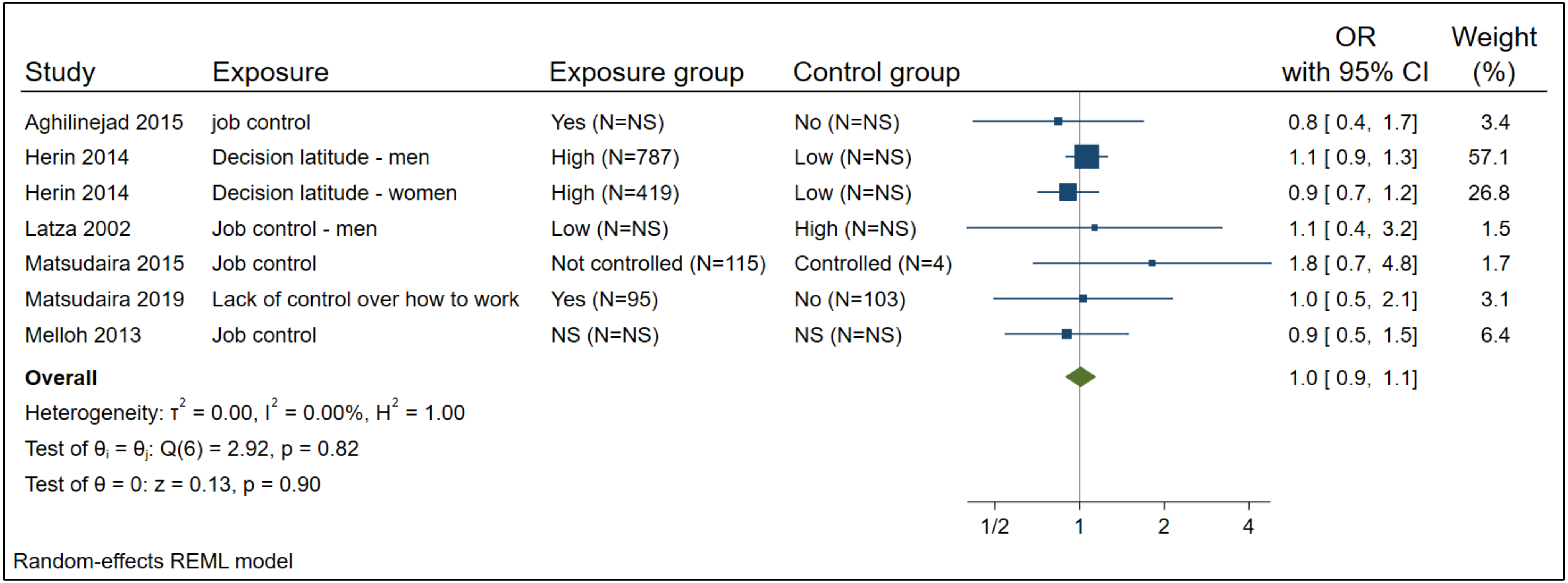
In sensitivity analysis, moderate to low risk of bias studies (4 studies) showed a pooled OR of 1.3 (95% CI 0.6– 1.8), while high risk of bias studies (1 study) found a pooled OR of 0.6 (95% CI 0.3 – 1.2). All studies were cohort studies, so no meta-analysis was performed based on study design. Only 1 study provided a measure of association for specific chronic LBP (OR=0.64), why no sensitivity analysis was conducted between non-specific and specific chronic LBP. Based on the existing studies, insufficient evidence of a causal association (0) exists between job stress and chronic LBP.

3.6.4 Sex difference

Job control: In the 6 studies included in the meta-analysis, 1 study provided sex-specific measure of association.[42] This study found no difference between sex (OR_{men}=1.06, OR_{women}=0.91).[42]

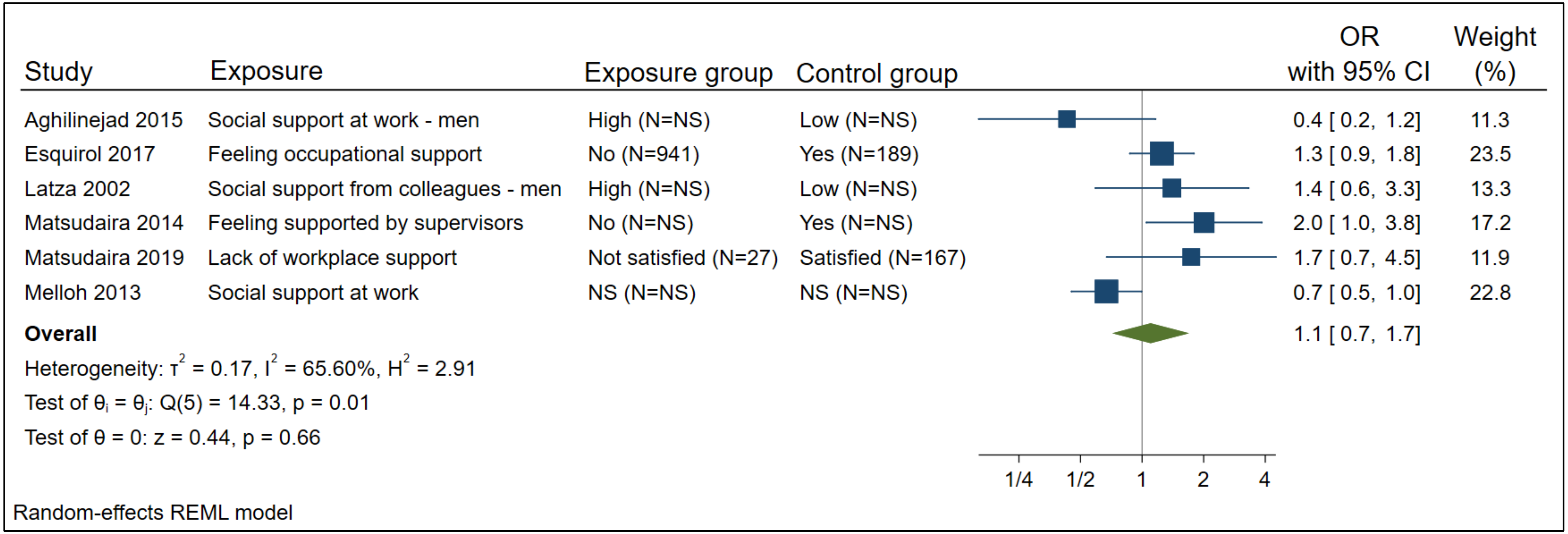
Job strain, job support and job stress: For studies included in the meta-analysis, no sex-specific measure of association was provided.

Figure 9. Forest plot of the association between job control and chronic LBP



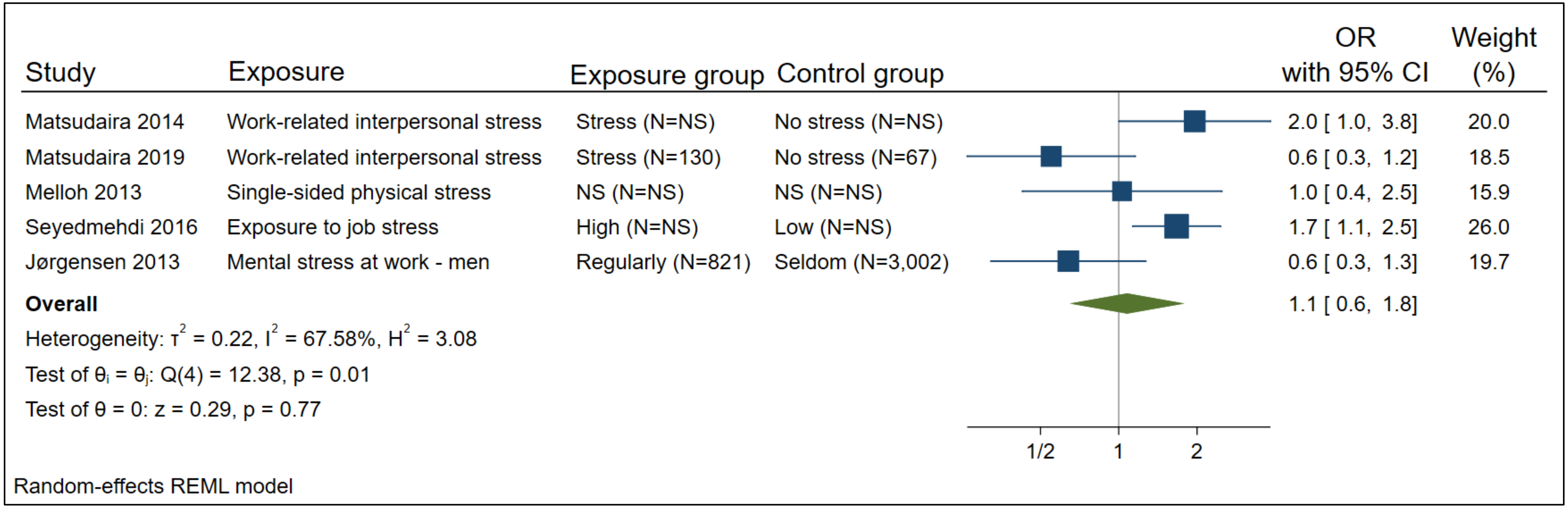
Abbreviations: NS = not stated; CLBP = chronic low back pain.

Figure 10. Forest plot of the association between job support and chronic LBP



Abbreviations: NS = not stated.

Figure 11. Forest plot of the association between job stress and chronic LBP



Abbreviations: NS = not stated.

Table 4 provides an overview of the results on the association between occupational psychosocial exposures and chronic LBP.

Table 4. Overview of results on psychosocial exposures and chronic LBP.

Psychosocial exposures	No. of studies	Pooled OR	Publication bias	Evidence of an association*
Job strain	3	Not included in meta-analysis due to few studies.	Not included in meta-analysis due to few studies.	Insufficient evidence of an association exists (0).
Job control	6	1.0 (95% CI 0.9 – 1.1)	No indication of publication bias (Eggers test of 0.87%).	Insufficient evidence of an association (0).
Job support	6	1.1 (95% CI 0.7 – 1.7)	A tendency towards publication bias (Eggers test of 0.95%).	Insufficient evidence of an association exists (0).
Job stress	5	1.1 (95% CI 0.6 – 1.8)	No indication of publication bias (Eggers test of 0.29%).	Insufficient evidence of an association (0).

*See Appendix 5 for clarification. All included studies were cohort studies. "Other psychosocial exposures" were not evaluated due to heterogeneity.

4. Discussion

4.1 Main results

Thirty-two articles were included in this systematic review on the association between occupational mechanical and psychosocial exposures and chronic LBP. Based on the degree of evidence, we found some evidence of an association for exposure to lifting/carrying loads, awkward postures, and combined mechanical exposures. Pooled estimates of the association ranged between 1.5 and 2.2. Some indication of exposure-response relation was found, however we were not able identify any thresholds based on either duration, frequency or intensity of specific mechanical exposures due to exposure heterogeneity. Limited evidence of an association was found for exposure to whole body-vibration, while insufficient evidence was found for pushing/pulling loads, standing/walking, sitting, and knelling/squatting (pooled OR between 1.0 and 1.4). For all mechanical exposures, higher risks were generally found for studies with low risk of bias, case-control studies, and clinically assessed

chronic LBP. For psychosocial exposures, we found insufficient evidence of an association with pooled OR between from 1.0 and 1.1.
Few studies evaluated the risk of chronic LBP between sex. Generally, found no difference was found, but few studies found a minimal higher risk among women.

4.2 Methodological considerations

Despite large diversity in exposure definition and metric between studies, we pooled data for groups of specific occupational exposures only to visualise the point of direction of an association between exposure and chronic LPB. The exposure heterogeneity made it difficult to compare the measures of association, even when the same exposure domain was evaluated (e.g., lifting). This was further supported by the I-squared values for heterogeneity, which were generally high (>80%). Moreover, different categorical exposure scales were often applied, dividing exposure dichotomously or in three/four groups (low/medium/high) with different cut-points. Based on these considerations, and in relation to the number of studies, no exposure thresholds could be identified nor were we able to perform more specific analysis using homogeneous exposures (e.g., lifts >10 kg per day).

The exposure assessments in the included studies were all based on questionnaires or interviews except for two studies where observations and an expert-based JEM were used. Various studies have shown that self-reported exposure estimates tend to be overestimated (especially for cases) and less reliable compared to objective measures.[65 66] To account for potential bias derived from self-reported exposure assessments, only subjected exposure estimates using validated questionnaires or interviews were rated without major risk of bias. Therefore, studies using quantitative, technical measurements of mechanical exposures are highly warranted.

We included measure of association comparing the lowest exposure group vs. the highest exposure group in the meta-analyses. Since the highest exposure groups often contain fewer participants, it affects the standard error of a given estimate resulting in broader confidence intervals with an increased risk of type 2 error.

An important consideration in this reference document was the definition of chronic LBP. We excluded studies with no precise definition for the location of back pain, e.g., if a study used the term "back problems" without specification of location. Furthermore, chronicity was defined as ≥3 months with LBP. If no clear time period was defined in a study or if a study combined groups of cases with e.g., <30 days and >30 days of LBP, they were excluded.

Specific chronic LBP was included when clinically diagnosed, stated chronic, led to hospitalisation, or otherwise proven disabled (e.g., disability rulings). We used the exact definition of chronic pain as the International Association for the Study of Pain, even though a longer duration of pain, such as 6 months, is suggested by others. Results of our strict definitions of chronic LBP might have reduced the number of included studies to increase the comparability between studies. Restricting the definition of chronic LBP to 6 months would potentially have resulted in even fewer studies. If we had used a broader definition of LPB for example by including studies that grouped LBP in 30-90 days and >90 days, the inclusion would potentially have contributed to increased heterogeneity concerning the outcome but also increased the number of studies included.

The inclusion of confounding variables varied across studies. Most studies did not adjust for other mechanical exposures, which potentially might lead to an overestimation of the association as mechanical exposures often are co-existing. The latter might also apply to the lack of adjustment for psychosocial exposures. In addition, several studies only adjusted for a few confounders or none in the analysis.[33 35 59 63] Despite this variation, we chose to extract adjusted measures of associations when available to increase the internal validity of each estimate and potential our conclusions at the expense of comparability between studies.

4.3 Comparing results with other systematic reviews

The results in our systematic review of chronic LBP generally support an association between specific occupational mechanical exposures and LBP found in other systematic reviews.[16-19] However, our systematic review did not support the conclusion of the overview of systematic reviews conducted by Swain et al. (2020).[15] According to Swain et al., only weak or conflicting evidence of a causal relation was found for occupational mechanical exposures in relation to LBP.[15] Low quality-rated systematic reviews generally ruled in favour of associations, while systematic reviews only including cohort studies identified inconsistent as well as null results.[15] In our systematic review, lower risks were generally found in cohort studies compared to case-control studies, but we found indication of higher risks in high quality rated studies. Swain et al. found a significant association for prolonged standing, lifting, material handling, operating heavy equipment, whole body vibration as well as bending and twisting or maintaining flexed, and non-neutral postures and LBP in systematic reviews with meta-analysis.[15] Our systematic review supports an association using meta-analysis. In general, heterogeneity in study design, study quality, and especially exposure definition and metric have reduced the level of evidence of an association between occupational mechanical exposures and LBP and might explain the discrepancy in study conclusion between studies.

None of the included studies in our systematic review estimated occupational exposure using technical measurements. In a series of studies (the Dutch SMASH-studies), occupational mechanical exposures were assessed by video recordings and force measurements at the workplace.[67 68] These studies were excluded from our systematic review as LBP was defined as regular or prolonged pain in the previous 12 months. This definition could not ensure that LBP was chronic (≥3 months). Coenen et al. (2013) found an adjusted OR of 2.03 (95% CI 1.23 – 3.36) for lifting ≥25 kg >15 times/working day and an adjusted OR of 1.45 (95% CI 0.77-2.73) spending >5% of work time in ≥60 degree trunk flexion.[68] Hamberg-van Reenen et al. (2006) measured employee's physical capacity and exposure to occupational physical factors to define balance and imbalance groups. They found an adjusted RR of 1.35 (95% CI 1.08 – 1.68) for the imbalanced group measuring static endurance and trunk flexion of ≥30 degrees.[67] When comparing the results of our systematic review with those in the Dutch SMASH-studies, no major differences were found despite distinct variations in exposure assessments. However, studies using technical measurements to further study the association between mechanical exposures and chronic LBP are warranted.

Our systematic review did not find evidence of an association between any occupational psychosocial exposures and chronic LBP (pooled OR 1.0-1.1), whereas the SBU report found evidence of an association between both job control (OR=1.7) and job satisfaction with work (OR=1.3) and back problems.[16] Psychosocial exposures might however be more related to symptoms compared to chronic LBP. Based on our systematic review, mechanical exposures seem to be more related to the risk for chronic LBP than psychosocial exposures as higher pooled OR were found for mechanical exposures (pooled OR between 1.0 and 2.2) than for psychosocial exposures (pooled OR between 1.0 and 1.1).

4.4 Practical implications and suggestions for future research

The level of support for an association has practical implications. In the clinical context, it must be taken into account when communicating with patients about the nature of their illness and forming recommendations on sick leave or job change. In a political/administrative context, it is important for decisions on preventive strategies, compensation of illnesses as occupational disorders, and the prioritisation of further research. We suggest that future studies use methods that enable independent assessment of exposure and LBP; that the outcome be measured by a semi-structured clinical interview and/or validated questionnaires that can distinguish between minor pain episodes and chronic LBP for more than 3 months. We also suggest distinguishing between pain that is limited to the LBP and LBP, which occurs in association with pain at other anatomical locations. Exposure intensity, frequency and duration should be given for the whole work time. We also suggest that exposure–response relations should be studied across increasing levels of exposure rather than simple exposure-groups, or even dichotomising, and enlightening exposure measurements of mechanical exposures with objective measurements by the use of new technologies to better assess metrics such as lifting and bending. Finally, we furthermore suggest seeing LBP as a much broader concept. The results from the CUPID-study[69 70] have shown that illnesses such as non-specific musculoskeletal pain appear to depend much more on culturally determined influences than on occupational mechanical exposures. This means to include contextual factors in the understanding of LBP.[71]

4.5 Non-occupational risk factors

Our systematic review did not find a higher risk of chronic LBP among women compared to men. An overview including 15 systematic reviews of LBP (4 reviews of high quality and 11 of moderate quality) found unclear results for sex.[14] Therefor, studies of sex-differences are highly warranted.

Of the 54 risk factors investigated in the overview of systematic reviews, 38 risk factors (including occupational exposures) were significantly associated with increased risk of LBP or sciatica in at least one systematic review with OR ranging from 1.26 to 13.00. Adverse risk factors included characteristics of the individual (e.g., older age, previous LBP, height (>170 cm), and puberty (adolescents >19 y), poor general health (e.g. smoking, chronic diseases, sleep problems, frequently feeling tired, and pain at any other regional site), and psychological stress (e.g., mental distress, dissatisfaction with life, depression, and psychosomatic factors). Appendix 9 presents the non-occupational risk factors associated with LBP.

A systematic review of prognostic risk factors for pain chronicity in LBP patients included 25 articles; 1 article was rated as good quality, 19 articles were rated as having fair quality, and 5 articles were rated as poor quality.[13] The main findings in this review were that higher pain intensity, higher body weight, and depression were the most frequently observed prognostic risk factors for chronic LBP. Moreover, maladaptive behaviour strategies, general anxiety, functional limitation during the episode, and smoking were also explicitly predictive of chronic LBP.[13]

5. Conclusion

In this reference document, we found some evidence of an association for exposure to lifting/carrying loads, awkward postures, and combined mechanical exposures. We found some indications of exposure-response relation, but the current scientific literature did not allow identification of safe exposure thresholds. Limited evidence of an association was found for exposure to whole-body vibration, while insufficient evidence of an association was found for pushing/pulling loads, standing/walking, sitting, and knelling/squatting. For psychosocial exposures, we found insufficient evidence of an association with chronic LBP. We found no sex-differences in risk of chronic LBP between men and women.

6. English summary

Introduction

Low back pain (LBP) is a global health problem and a predominant reason for years lived with a disability affecting everyday activities. LBP increase the risk of sick leave and is a common cause of early retirement from the labour market. Although LBP is often temporary, 4-20% of the adult population develops chronic LBP (pain ≥3 months) gradually increasing with age.

The association between occupational exposures and LBP has been reported in numerous studies including systematic reviews. However, in 2020 an overview of systematic reviews did not support an association between several occupational mechanical exposures and LBP. To our knowledge, no systematic review has investigated the association between occupational exposures and chronic LBP defined as pain in ≥3 months. Therefore, the aim of this reference document was to examine the association between occupational mechanical exposures and chronic LBP. We also evaluated the effect of occupational psychosocial exposures.

Materials and methods

The reference document was conducted as a systematic review. Study population included persons in or above working age. The occupational mechanical exposures included lifting/carrying loads, pushing/pulling loads, awkward postures, standing/walking, sitting, kneeling/squatting, whole-body vibrations, and the combination of different mechanical exposures. Psychosocial exposures including job strain, control, support, and stress. Chronic LBP was defined as self-reported pain in ≥3 months or specific LBP including pain caused by degenerative changes or other pathologies. Study design was restricted to cohort and case-control studies.

Articles published before 2014 were identified using the report of The Swedish Council on Health Technology Assessment (SBU report), which contained a systematic literature search of articles published between 1980 and 10th January 2014. For studies published after 10th January 2014, a systematic literature search was conducted in Cochrane, PubMed, Web of Science, PsycINFO, Embase, and Cinahl from 2014 to 2021. The selection of relevant articles was performed independently by 2 of the authors.

Using predefined tables, information on study design, population, outcome, outcome assessment, exposure, exposure assessment, confounders, and study results was extracted from each article by one author and quality checked by another author. To critically appraise the risk of bias of each included article, we used a modified risk of bias tool used in research on chronic diseases in several systematic reviews. The methodological quality assessment was performed independently by 2 of the authors.

Meta-analysis was conducted using random-effects model with weighted odds ratios (OR) and 95% confidence intervals and heterogeneity was assessed using I-squared statistics. Sensitivity analysis was conducted based on study quality (low/moderate risk of bias vs. high risk of bias), study design (cohort vs. case-control studies), and according to outcome (non-specific LBP vs. specific LBP). Publication bias was evaluated using funnel plots, and we tested the asymmetry of the funnel plots by Egger's test.

Across studies, the quality of evidence of an association between occupational exposures and chronic LBP was assessed according to guidelines provided by The Danish Work Environmental Fund. The quality of evidence could be rated "good" (+++), "some" (++), "limited" (+), "insufficient" (0) evidence of an association, or good evidence for no association (-). If "good" or "some" evidence of an association was indicated for a specific occupational exposure, we further evaluated whether exposure-response relations and/or thresholds could be identified.

Results

Thirty-two articles were included in this reference document, comprising 24 cohort studies and 8 case-control studies. Five studies were rated as having low risk of bias, 16 with moderate risk of bias, and 11 with high risk of bias.

Mechanical exposures: Among the 17 studies on lifting/carrying loads, 15 studies (11 cohort studies) were included in the meta-analysis. We found a pooled OR of 1.7 (95% CI 1.4 – 2.2) showing a considerable degree of heterogeneity (I^2 = 88.4%). Among the 14 studies on awkward postures, 12 studies (8 cohort studies) were included in the meta-analysis. A pooled OR of 1.5 (95% CI 1.2 – 1.9) was found with a considerable degree of heterogeneity (I^2 = 87.2%). Among the 7 studies on whole-body vibration, all 7 cohort studies were included in the meta-analysis. A pooled OR of 1.4 (95% CI 1.1 – 1.7) was found with moderate degree of heterogeneity (I^2 = 46.72%). For standing/walking (6 studies) and sitting (6 studies), pooled OR of 1.0 (95% CI 0.8 – 1.3) and 1.2 (95% CI 1.0 – 1.5) was found. For the combination of mechanical exposures (5 studies), a pooled OR of 2.2 (95% CI 1.4 – 3.6) was found with considerable degree of heterogeneity (I^2 = 89.9%).

For lifting/carrying loads, awkward postures, and combined mechanical exposures, we found some indication of exposure-response relation, however, the current scientific literature did not allow identification of exposure thresholds. For all mechanical exposures, higher risks were generally found for studies with low risk of bias, case-control studies, and studies with clinically assessed LBP. Due to few studies, no meta-analyses were conducted for kneeling/squatting (1 study) and pushing/pulling/loads (2 studies).

Psychosocial exposures: Meta-analyses were performed for job control, support, and job stress. For job control (6 studies) a pooled OR of 1.0 (95% CI 0.9 – 1.1) was found, and for support (6 studies) and stress (5 studies), pooled ORs of 1.0 were found. Due to few studies, no meta-analysis was performed for strain.

Conclusion

For occupational mechanical exposures, we found some evidence of an association between lifting/carrying loads, awkward postures, and combined mechanical exposures and chronic LBP. We found some indication of exposure-response relation, however, the current scientific literature did not allow identification of exposure thresholds. Limited evidence was found for whole-body vibrations, while insufficient evidence was found for standing/walking, sitting, kneeling/squatting, and pushing/pulling loads. For psychosocial exposures, insufficient evidence of an association was found.

7. Dansk resume

Introduktion

Lænderygsmerter er et globalt helbredsproblem, som kan medføre funktionsnedsættelse, øget risiko for sygefravær samt tidlig tilbagetrækning fra arbejdsmarkedet. Prævalensen af lænderygsmerter på verdens plan er omkring 7,5 %, svarende til at ca. 577 millioner mennesker er påvirket af lænderygsmerter. I den voksne befolkning vil 4-20 % opleve kroniske lænderygsmerter. Denne risiko øges i takt med stigende alder.

Anatomisk afgrænses lænden fra nederste ribbenskant til nederste del af sædepartiet. Lænderygsmerter defineres som smerter og ubehag lokaliseret i lænden med eller uden udstråling til ben, og benævnes ofte som lumbago/iskias, lumbal diskusprolaps og degenerative forandringer i lænderyggen. Lænderygsmerter er et symptom snarere end en sygdom, da det ofte er vanskeligt at fastslå, hvilken struktur (muskler, ledbånd, bruskskiver) der er årsag til smerterne. Der skelnes mellem uspecifikke og specifikke lænderygsmerter. Ved uspecifikke lænderygsmerter kan der ikke påvises nogen entydig årsag. Dvs. der er tale om en tilstand, hvor der billeddiagnostisk enten er normale forhold eller almindelige degenerative og strukturelle tilstande. Ved specifikke lænderygsmerter kan billeddiagnostik afsløre fund fx lumbal diskusprolaps. Smerteforløbet er oftest svingende, dog oplever ca. 1/3 af patienterne spontan bedring inden for 3 måneder, imens op til 65 % stadig vil opleve smerte efter 1 år. Kroniske lænderygsmerter defineres typisk som varende ≥3 måneder.

Risikofaktorer for udvikling af lænderygsmerter kan opledes i hhv. arbejdsrelaterede og ikke-arbejdsrelaterede. De ikke-arbejdsrelaterede faktorer omfatter bl.a. alder, rygning, tidligere lænderygsmerter og andre sygdomme, imens de arbejdsrelaterede faktorer omfatter hhv. mekaniske og psykosociale eksponeringer. De mekaniske eksponeringer inkluderer løfte/bære arbejde, akavede arbejdsstillinger, helkropsvibrationer, knæliggende arbejde, stående/gående arbejde, siddende arbejde og kombinationen af flere mekaniske eksponeringer. De psykosociale eksponeringer inkluderer job krav, kontrol, støtte og stress.

Flere systematiske reviews har vist en sammenhæng mellem arbejdsrelaterede mekaniske og til dels psykosociale eksponeringer og lænderygsmerter. På trods af dette har et overview af systematiske reviews fra 2020 konkluderet, at der ikke foreligger evidens for en sammenhæng mellem arbejdsrelaterede mekaniske eksponeringer og lænderygsmerter. Sammenhængen mellem arbejdsrelaterede eksponeringer og kroniske lænderygsmerter er ikke undersøgt i et systematisk review. Formålet med dette referencedokument er derfor på baggrund af den foreliggende litteratur at undersøge sammenhængen mellem arbejdsrelaterede mekaniske eksponeringer og kroniske lænderygsmerter. Derudover vil vi undersøge effekten af arbejdsrelaterede psykosociale eksponeringer.

Metode og materiale

Referencedokumentet blev udarbejdet som et systematisk review. Til inklusion af relevante artikler blev der udarbejdet en PECOS (Population, Exposure, Comparison, Outcome, Study design). Populationen omfattede personer i eller over den arbejdsdygtige alder. De arbejdsrelaterede mekaniske eksponeringer inkluderede fx løfte/bære arbejde, akavede arbejdsstillinger, helkrops-vibrationer, knæliggende arbejde, stående/gående arbejde, skubbe/trække arbejde, siddende arbejde og kombinationen af flere mekaniske eksponeringer. De psykosociale eksponeringer inkluderede fx job krav, kontrol, støtte, og stress. Kroniske lænderygsmerter blev defineret som lænderygsmerter ≥3 måneder herunder lænderygsygdomme (fx degenerative forandringer og diskusprolaps). Pga. en forventet omfattende litteratur inkluderede vi kun kohorte- og case-kontrol-studier.

Artikler publiceret før den 10. januar 2014 blev identificeret via en foreliggende rapport "The Swedish Council on Health Technology Assessment" (SBU-rapport), som indeholder en systematisk litteratursøgning af artikler vedr. sammenhængen mellem arbejdsrelaterede eksponeringer og "lænderygproblemer". Identificering af potentielle relevante artikler blev foretaget via gennemlæsning af 192 potentielle relevante artikler foretaget uafhængigt af to af referencedokumentets forfattere. Artikler publiceret efter januar 2014 blev identificeret via en systematisk litteratursøgning i følgende videnskabelige databaser: Cochrane, PubMed, Web of Science, PsycINFO, Embase og Cinahl. Identificering af relevant artikler blev udført via hhv. titel/abstract screening og gennemlæsning af hele artiklen. Dette blev ligeledes foretaget uafhængigt af to af referencedokumentets forfattere. Ved uenighed blev artiklen diskuteret indtil alle var enige om den endelige afgørelse.

For alle inkluderede artikler blev relevant information herunder forfatter, studiedesign, udfald, udfaldsvurdering, eksponering, eksponeringsvurdering, confoundere og resultater udtrukket og præsenteret i tabeller. Data-udtrækningen blev foretaget af en forfatterne og kvalitetstjekket af en anden forfatter. Efterfølgende blev artiklernes epidemiologiske kvalitet vurderet ved hjælp af et modificeret kvalitetsværktøj, som blev tilpasset projektets formål. Det modificerede værktøj indeholdt otte epidemiologiske domæner herunder fem "vigtige" domæner og tre "mindre vigtige" domæner. Baseret på de otte domæner blev hver artikels epidemiologiske kvalitet vurderet til havende ”lav", ”moderat" eller ”høj" risiko for bias.

Sammenhængen mellem arbejdsrelaterede eksponeringer og kroniske lænderygsmerter blev undersøgt via forest plots og meta-analyser. Forest plots illustrerede de enkelte studiers risikoestimater, det vægtede risikoestimat samt et estimat (i %) som udtrykte graden i forskel/ulighed mellem studiernes risikoestimater. For at undersøge risikoen for publikationsbias blev der udarbejdet Funnel plots og foretaget Egger´s test. Der blev også foretaget sensitivitetsanalyser for at undersøge effekten af studiernes kvalitet (lav/moderate vs. høj risiko for bias), studiedesign (kohorte vs. case-kontrol-studier) samt forskelle mellem specifikke og uspecifikke kroniske lænderygsmerter.

Resultater

I alt blev 192 artikler fra SBU-rapporten publiceret i perioden 1980 til 10. januar 2014 gennemlæst. Blandt de 192 artikler opfyldte 11 artikler inklusionskriterierne. I den systematiske litteratursøgning af artikler publiceret i perioden fra 10. januar 2014 til september 2021 blev 11.789 artikler identificeret, hvoraf 3.301 var dubletter. Efter titel og abstract screening af 8.488 artikler blev yderligere 8.305 artikler ekskluderet. De resterende 183 artikler blev gennemlæst, hvoraf 21 artikler opfyldte inklusionskriterierne. I alt blev 32 artikler inkluderet i det systematiske review. Fem artikler blev vurderet som havende ”lav" risiko for bias, 16 blev vurderet som ”moderat" risiko for bias og 11 vurderet som ”høj" risiko for bias.

Løfte/bære arbejde: Sammenhængen mellem løfte/bære arbejde og kroniske lænderygsmerter blev undersøgt i 17 studier. Selv om der var store forskelle mellem de enkelte studier primært vedr. eksponering (i^2=88,4 %), var der generelt enighed om, at løfte/bære arbejde medfører en øget risiko for kroniske lænderygsmerter. Dette understøttes af at resultater fra meta-analysen (N=15) viste en odds ratio (OR) på 1,7 (95 % CI 1,4 – 2,2). Der var dog indikation af publikationsbias af små studier med positiv sammenhæng (Egger´s test=0.02%). På baggrund heraf vurderes der at foreligge nogen grad af evidens for en årsagssammenhæng (++).

Akavede arbejdsstillinger: Sammenhængen mellem akavede arbejdsstillinger og kroniske lænderygsmerter blev undersøgt i 14 studier. Selv om der var forskelle mellem de enkelte studier primært vedr. eksponeringen (i^2=87,2 %), var der generelt enighed om, at akavede arbejdsstillinger medfører en øget risiko for kroniske lænderygsmerter. Resultater baseret på meta-analysen (N=12) viste en OR på 1,5 (95 % CI 1,2 - 1,9). Der var dog indikation af publikationsbias af små studier med positiv sammenhæng (Egger´s test=0.06%). På baggrund heraf vurderes der at foreligge nogen grad af evidens for en årsagssammenhæng (++).

Helkropsvibration: Helkropsvibrationer blev undersøgt i 7 studier, hvor der primært var forskelle i eksponeringen mellem de enkelte studier (i^2=46,7 %). Resultater baseret på metaanalysen (N=7) viste en OR på 1,4 (CI 95% 1,1 – 1,7) med indikation af publikation bias (Egger´s test=0,03%). På baggrund heraf vurderes der at være begrænset evidens for en årsagssammenhæng (+).

Stående/gående arbejde: Stående/gående arbejde blev undersøgt i 6 studier. Meta-analysen (N=6) viste en OR på 1,0 (95 % CI 0,8 - 1,3) og der var ingen indikation af publikation bias (Egger´s test=0,49%). Graden af evidens vurderes at være utilstrækkelig (0).

Siddende arbejde: Siddende arbejde blev undersøgt i 8 studier. Meta-analysen (N=6) viste en OR på 1,2 (95 % CI 1,0 - 1,5) uden indikation af publikation bias af små studier (Egger´s test=0,50%). Graden af evidens vurderes at være utilstrækkelig (0).

Kombinerede mekaniske eksponeringer: Kombinationen af forskellige mekaniske eksponeringer blev undersøgt i 9 studier, som generel viste enighed om en sammenhæng. Resultater baseret på metaanalysen (N=5) viste en OR på 2,2 (95 % CI 1,1 - 3,6). Pga. få studier var risikoen for publikation bias svær at vurdere (Egger´s test=0,41%). Det vurderes at der foreligger nogen grad af evidens (++).

Knæliggende/hugsiddende og skubbe/trække arbejde: For både knæliggende/hugsiddende og skubbe/trække arbejde kunne der ikke foretages meta-analyser grundet få studier. Der foreligger derfor utilstrækkelig evidens for en sammenhæng (0).

Psykosociale eksponeringer: De psykosociale eksponeringer (kontrol, støtte og stress) blev undersøgt i hhv. 6, 8 og 7 studier. Meta-analyserne viste OR mellem 1,0 og 1,1. Der forelå tendens til publikationsbias for job støtte (Egger´s test=0,95%), hvilket ikke var tilfældet for job kontrol (Egger´s test=0,87%) og stress (Egger´s test=0,29%). Det vurderes, at der foreligger utilstrækkelig evidens for en årsagssammenhæng (0).

Sensitivitetsanalyserne viste generelt højere OR i studier med lav/moderat risiko for bias, case-kontrol-studier og for specifikke kroniske lænderygsmerter. For løfte/bære arbejde, akavede arbejdsstillinger og kombinationen af flere mekaniske eksponeringer var der indikation af eksponeringsrespons-sammenhænge, men pga. store forskelle mellem studierne primært vedr. eksponeringens definition, metric og gruppering var ikke muligt at identificere sikre tærskelværdier.

Få studier undersøgte kønsforskelle. Disse studier fandt generelt ingen forskel mellem køn, dog viste nogle studier en minimal større risiko blandt kvinder.

Konklusion

Baseret på dette referencedokument vurderes det, at der foreligger nogen evidens for en sammenhæng for hhv. løft/bære arbejde, akavede arbejdsstillinger og kombinationen af flere mekaniske eksponeringer. Der var indikation af eksponeringsrespons-sammenhænge, men sikre tærskelværdier kunne ikke identificeres. Der foreligger begrænset evidens for en sammenhæng for helkropsvibrationer, imens der foreligger utilstrækkelig evidens for stående/gående, stillesiddende, knæliggende og skubbe/trække arbejde. Der foreligger ligeledes utilstrækkelig evidens for en sammenhæng mellem arbejdsrelaterede psykosociale eksponeringer (job krav, kontrol, støtte og stress) og kroniske lænderygsmerter.

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Appendix 1. PECOS

Population

- Adults in or above working age.

Exposure

- Occupational mechanical exposures (e.g., working postures, lift, and development of force, whole-body vibration and vibrations from handheld tools, person lifting and moving).
- Occupational psychosocial exposures (e.g., job demand, workload, harassment, conflict, social relation, and support).
- Quantified exposure measure through self-report, interview, observation, technical measure or job-exposure-matrices (JEM).

Comparison

- Studies will only be included if the measure of association between occupational exposures and chronic low back pain is expressed in an appropriate risk estimate or possible to calculate.

Outcome

- Chronic low back pain including lumbago/sciatica, lumbar herniated disc/protrusion and lumbosacral degenerative changes with or without radiculopathy.
- Low back pain lasting ≥3 months.
- Outcome measured with self-report, interview, clinical diagnosis, surgery or another measure (e.g., x-ray, insurance).

Study design

- Randomised control trial studies.
- Cohort studies.
- Case-control studies.
- Original study in full text and peer-reviewed.
- In English, Danish, Swedish or Norwegian.
- Published from January 2014 and forward.

Appendix 2. Exclusion criteria

	Population	Exposure	Outcome	Study design
Criteria	- Adults never in work. - Students.	- Chemical or biological substances. - Radiation. - Heat or cold. - Accidents/injuries. - Job titles or non-related occupational exposures.	- Injuries based on accidents. - Inherent pain. - Pain caused by other diseases or conditions such as cancer, fractures or inflammation. - Proxy to chronic LBP, e.g., sickness absenteeism. - Studies not reporting chronic LBP	- Cross-sectional studies. - Systematic reviews. - In vitro studies. - Studies on health economics. - Studies not addressing any risk factors related to work. - Studies with less than 30 participants. - Animal trials. - Conference notes, books, letters to editor, editorial pages, protocols, reports and abstracts. - Studies in other languages than those specified in PECOS.

Appendix 3. Literature search

The literature search was divided into 4 blocks.

Block 1

Mesh	Free text search in title and abstract
”Occupations”[Mesh]	occupation*
”Occupational Health”[Mesh]	employ*
”Occupational Diseases”[Mesh]	job*
”Occupational Exposure”[Mesh]	working condition*
”Occupational Groups”[Mesh]	work-related
”Work”[Mesh]	work-load*
”Workplace”[Mesh]	work-place*
”Workload”[Mesh]	work environment*
”Women, Working”[Mesh]	
”Employment”[Mesh]	

Block 2

Mesh	Free text search in title and abstract
Mechanical stress ”Stress, Mechanical”[Mesh]	
Organisational and psychosocial factors: "Stress, Psychological”[Mesh]	
Development of force: ”Lifting”[Mesh] ”Weight-Bearing”[Mesh] ”Biomechanics”[Mesh] ”Moving and Lifting Patients”[Mesh] ”Physical Exertion”[Mesh]	**Development of force**: lift*, carry*, hold*, pull*, drag*, push*, manual handling, force*, biomechanic*, physical demand*, physically demand*.
Working postures: ”Torsion, Mechanical”[Mesh] ”Postural Balance”[Mesh] ”Walking”[Mesh]	**Working postures:** flexion*, extension*, turning*, sitting*, kneeling*, twisting*, bending, sedentary, walking*, reaching, squatting, standing, postural balance, static AND posture, awkward AND posture.
Working movement: ”Recovery of Function”[Mesh] ”Relaxation”[Mesh]	**Working movement:** repetitive movement*, monotonous work, dynamic AND posture, relaxation, recovery of function, static work, dynamic load.
Influence and demand:	**Influence and demand:** decision latitude, work demand*, job demand*, high demand*, low control, work control, job control, work influence*, demand resource*, lack of control, job strain, work strain.
Effort and reward:	**Effort and reward:** effort reward*, time pressure*, work overload*, recuperation*, recovery.
Social support and relations in the workplace: ”Social Support”[Mesh] ”Employee Performance "Appraisal”[Mesh] ”Organizational Culture”[Mesh] "Justice/psychology”[Mesh] ”Communication/psychology”[Mesh]	**Social support and relations in the workplace:** social support, support system*, social network*, emotional support, justice*, injustice*, interaction*, interpersonal relation*.
	Job satisfaction: Boredom, job satisfaction, work satisfaction, coping, work

”Interpersonal Relations”[Mesh]	ability.
Job satisfaction: ”Job Satisfaction”[Mesh] ”Employee Grievances”[Mesh]	
Education and learning: ”Staff Development”[Mesh]	**Education and learning:** skill discretion*, staff development.
Conflict, violence or harassment: ”Bullying”[Mesh] ”Prejudice”[Mesh] ”Social Discrimination”[Mesh]	**Conflict, violence or harassment:** harass*, workplace conflict*, workplace violen*, silent workplace*, victimization*, bullying, role ambiguity, role conflict*, work role*, discrimination.
Working time: ”Work Schedule Tolerance”[Mesh]	**Working time:** working hour*, working time, shift work*, work shift*, day-time, night-time, temporary work, full-time, part-time, flexible work*, lean production.
Job insecurity: ”Personnel Downsizing”[Mesh]	**Job insecurity:** organizational change, job security, job insecurity.
Chemical and biological substances: ”Air Pollution”[Mesh] ”Air Pollutants”[Mesh] ”Solvents”[Mesh] ”Fluids and Secretions”[Mesh]	**Chemical and biological substances:** pollut*, indoor air*, airborne, passive smok*, solvent*, smok* AND pollute*.
Contact with chemicals: ”Toxic Actions”[Mesh]	**Contact with chemicals:** hazardous chemical*, hazardous material*, hazardous substance*, toxic action*, pesticide*, poison*.
Noise: ”Noise”[Mesh]	**Noise:** noise*
Vibrations: ”Vibration”[Mesh] ”Automobile Driving”[Mesh] ”Motor Vehicles”[Mesh]	**Vibrations:** vibrat*, driving, vehicle*, truck*, lorry/lorries, automobile*, car/cars, buses, hand tool*, hand-held tool*, power tool*.
Radiation: ”Radiation”[Mesh] ”Air Pollution, Radioactive”[Mesh]	**Radiation:** radiation*
Temperature: ”Hot Temperature”[Mesh] ”Cold Temperature”[Mesh] ”Climate”[Mesh]	**Temperature:** climate*, cold temperature*, hot temperature*.
Infected materials: ”Communicable Diseases”[Mesh]	**Infected materials:** contagious* communicable disease*

Block 3

Mesh	Free text search in title and abstract
Back problems – anatomy and disease: "Back" [Mesh] "Spine" [Mesh] "Pelvis" [Mesh]	**Back problems – anatomy and disease:** back, spine*, spinal*, trunk*, lumbar*, pelvis*, sacrum, lumbo-sacral*, lumbosacral*, intervertebral disk*, intervertebral disc*, thoracic vertebrae, thoracic vertebra.
"Pain" [Mesh] "Pain Measurement" [Mesh] "Cumulative Trauma Disorders" [Mesh] "Musculoskeletal Diseases" [Mesh]	pain, ache*, musculoskeletal disease*, musculoskeletal disorder*, cumulative trauma disorder*, nerve entrapment.
"Back Pain" [Mesh] "Back Injuries" [Mesh] "Spinal Diseases" [Mesh "Pelvic Pain" [Mesh] "Sciatica" [Mesh]	back pain, backache*, back injur*, spinal disease*, spine disease*, spinal injur* OR spine injur*, intervertebral disk degeneration, intervertebral disc degeneration, spinal osteochondros*, spine osteochondros*, Scheuermann*, spinal stenos*, spondylitis, spondylarthritis, spondylosis, lumbago, sciatica, pelvic pain.

Block 4

Limits: English, Danish, Norwegian, Swedish.
Publication Date: from 2014/01/01 to 2021/09/21.

Aggregated search string:
((("Back"[MeSH Terms] OR "spine"[MeSH Terms] OR "Pelvis"[MeSH Terms] OR ("Back"[Title/Abstract] OR "spine*"[Title/Abstract] OR "spinal*"[Title/Abstract] OR "trunk*"[Title/Abstract] OR "lumbar*"[Title/Abstract] OR "pelvis*"[Title/Abstract] OR "sacrum"[Title/Abstract] OR "lumbo sacral*"[Title/Abstract] OR "lumbosacral*"[Title/Abstract] OR "intervertebral disk*"[Title/Abstract] OR "intervertebral disc*"[Title/Abstract] OR "thoracic vertebrae"[Title/Abstract] OR "thoracic vertebra"[Title/Abstract])) AND ("Pain"[MeSH Terms] OR "Pain Measurement"[MeSH Terms] OR "Cumulative Trauma Disorders"[MeSH Terms] OR "Musculoskeletal Diseases"[MeSH Terms] OR ("Pain"[Title/Abstract] OR "ache*"[Title/Abstract] OR "musculoskeletal disease*"[Title/Abstract] OR "musculoskeletal disorder*"[Title/Abstract] OR "cumulative trauma disorder*"[Title/Abstract] OR "nerve entrapment"[Title/Abstract]))) OR ("Back Pain"[MeSH Terms] OR "Back Injuries"[MeSH Terms] OR "Spinal Diseases"[MeSH Terms] OR "Pelvic Pain"[MeSH Terms] OR "Sciatica"[MeSH Terms] OR ("Back Pain"[Title/Abstract] OR "backache*"[Title/Abstract] OR "back injur*"[Title/Abstract] OR "spinal disease*"[Title/Abstract] OR "spine disease*"[Title/Abstract] OR "spinal injur*"[Title/Abstract] OR "spine injur*"[Title/Abstract] OR "intervertebral disk degeneration"[Title/Abstract] OR "intervertebral disc degeneration"[Title/Abstract] OR "spinal osteochondros*"[Title/Abstract] OR "spine osteochondros*"[Title/Abstract] OR "scheuermann*"[Title/Abstract] OR "spinal stenos*"[Title/Abstract] OR "spondylitis"[Title/Abstract] OR "spondylarthritis"[Title/Abstract] OR "spondylosis"[Title/Abstract] OR "lumbago"[Title/Abstract] OR "Sciatica"[Title/Abstract] OR "Pelvic Pain"[Title/Abstract]))) AND ("Work"[MeSH Terms] OR "Workload"[MeSH Terms] OR "Workplace"[MeSH Terms] OR "Occupations"[MeSH Terms] OR "Occupational Health"[MeSH Terms] OR "Occupational Diseases"[MeSH Terms] OR "Occupational Groups"[MeSH Terms] OR "Occupational Exposure"[MeSH Terms] OR "women, working"[MeSH Terms] OR "Employment"[MeSH Terms:noexp] OR (("work-related"[Title/Abstract] OR "work load*"[Title/Abstract] OR "workload*"[Title/Abstract] OR "workplace*"[Title/Abstract] OR "workplace*"[Title/Abstract] OR "work environment*"[Title/Abstract] OR "working condition*"[Title/Abstract] OR "occupation*"[Title/Abstract] OR "job"[Title/Abstract] OR "employ*"[Title/Abstract]) NOT ("medline"[Filter] OR "oldmedline"[Filter]))) AND ("stress, mechanical"[MeSH Terms] OR "Lifting"[MeSH Terms] OR "Moving and Lifting Patients"[MeSH Terms] OR "Weight-Bearing"[MeSH Terms] OR "Physical Exertion"[MeSH Terms] OR "torsion, mechanical"[MeSH Terms] OR "Postural Balance"[MeSH Terms] OR "Walking"[MeSH Terms] OR "recovery of function"[MeSH Terms] OR "Relaxation"[MeSH Terms] OR ("static"[Title/Abstract] AND ("postural"[All Fields] OR "posturally"[All Fields] OR "posture"[MeSH Terms] OR "posture"[All Fields] OR "postures"[All Fields] OR "postured"[All Fields] OR "posturing"[All Fields])) OR ("awkward"[Title/Abstract] AND ("postural"[All Fields] OR "posturally"[All Fields] OR "posture"[MeSH Terms] OR "posture"[All Fields] OR "postures"[All Fields] OR "postured"[All Fields] OR "posturing"[All Fields])) OR ("dynamic"[Title/Abstract] AND ("postural"[All Fields] OR "posturally"[All Fields] OR "posture"[MeSH Terms] OR "posture"[All Fields] OR "postures"[All Fields] OR "postured"[All Fields] OR "posturing"[All Fields])) OR "static work"[Title/Abstract] OR "dynamic load*"[Title/Abstract] OR "lift*"[Title/Abstract] OR "carry*"[Title/Abstract] OR

"hold*"[Title/Abstract] OR "pull*"[Title/Abstract] OR "drag*"[Title/Abstract] OR "push*"[Title/Abstract] OR "manual handling"[Title/Abstract] OR "force*"[Title/Abstract] OR "biomechanic*"[Title/Abstract] OR "walking*"[Title/Abstract] OR "Postural Balance"[Title/Abstract] OR "flexion*"[Title/Abstract] OR "extension*"[Title/Abstract] OR "turning"[Title/Abstract] OR "sitting"[Title/Abstract] OR "kneeling"[Title/Abstract] OR "squatting"[Title/Abstract] OR "twisting"[Title/Abstract] OR "bending"[Title/Abstract] OR "reaching"[Title/Abstract] OR "standing"[Title/Abstract] OR "sedentary"[Title/Abstract] OR "repetitive movement*"[Title/Abstract] OR "monotonous work"[Title/Abstract] OR "Relaxation"[Title/Abstract] OR "recovery of function"[Title/Abstract] OR "physical demand*"[Title/Abstract] OR "physically demand*"[Title/Abstract] OR ("stress, psychological"[MeSH Terms] OR "Social Support"[MeSH Terms] OR "Job Satisfaction"[MeSH Terms] OR "Work Schedule Tolerance"[MeSH Terms] OR "Employee Performance Appraisal"[MeSH Terms] OR "Employee Grievances"[MeSH Terms] OR "social justice/psychology"[MeSH Terms] OR "Personnel Downsizing"[MeSH Terms] OR "Staff Development"[MeSH Terms] OR "Organizational Culture"[MeSH Terms] OR "Bullying"[MeSH Terms] OR "Prejudice"[MeSH Terms] OR "Social Discrimination"[MeSH Terms] OR "Interpersonal Relations"[MeSH Terms] OR "communication/psychology"[MeSH Terms] OR "psychosocial"[Title/Abstract] OR "job strain"[Title/Abstract] OR "work strain"[Title/Abstract] OR "work demand*"[Title/Abstract] OR "job demand*"[Title/Abstract] OR "high demand*"[Title/Abstract] OR "low control"[Title/Abstract] OR "lack of control"[Title/Abstract] OR "work control"[Title/Abstract] OR "job control"[Title/Abstract] OR "decision latitude"[Title/Abstract] OR "work influence*"[Title/Abstract] OR "demand resource*"[Title/Abstract] OR "effort reward*"[Title/Abstract] OR "time pressure*"[Title/Abstract] OR "recuperation*"[Title/Abstract] OR "work overload*"[Title/Abstract] OR "work over load*"[Title/Abstract] OR "recovery"[Title/Abstract] OR "coping"[Title/Abstract] OR "work ability"[Title/Abstract] OR "Social Support"[Title/Abstract] OR "support system*"[Title/Abstract] OR "social network*"[Title/Abstract] OR "emotional support"[Title/Abstract] OR "interpersonal relation*"[Title/Abstract] OR "interaction*"[Title/Abstract] OR "justice*"[Title/Abstract] OR "injustice*"[Title/Abstract] OR "Job Satisfaction"[Title/Abstract] OR "work satisfaction"[Title/Abstract] OR "boredom"[Title/Abstract] OR "skill discretion*"[Title/Abstract] OR "Staff Development"[Title/Abstract] OR "discrimination"[Title/Abstract] OR "harass*"[Title/Abstract] OR (("workplace"[MeSH Terms] OR "workplace"[All Fields] OR ("work"[All Fields] AND "place"[All Fields]) OR "work-place"[All Fields]) AND "conflict*"[Title/Abstract]) OR "workplace violen*"[Title/Abstract] OR "work place violen*"[Title/Abstract] OR "Bullying"[Title/Abstract] OR "victimization*"[Title/Abstract] OR (("silent"[All Fields] OR "silently"[All Fields] OR "silents"[All Fields]) AND "workplace*"[Title/Abstract]) OR "role ambiguity"[Title/Abstract] OR "roleconflict*"[Title/Abstract] OR "work role*"[Title/Abstract] OR "working hour*"[Title/Abstract] OR "working time"[Title/Abstract] OR "daytime"[Title/Abstract] OR "night-time"[Title/Abstract] OR "shift work*"[Title/Abstract] OR "work shift*"[Title/Abstract] OR "temporary work*"[Title/Abstract] OR "full-time"[Title/Abstract] OR "part-time"[Title/Abstract] OR "flexible work*"[Title/Abstract] OR "organizational change"[Title/Abstract] OR "organisational change"[Title/Abstract] OR "lean production"[Title/Abstract] OR "job security"[Title/Abstract] OR "job insecurity"[Title/Abstract]) OR ("Air Pollutants"[MeSH Terms] OR "Air Pollution"[MeSH Terms] OR "Fluids and Secretions"[MeSH Terms] OR "Toxic Actions"[MeSH Terms] OR "Solvents"[MeSH Terms] OR "pollut*"[Title/Abstract] OR "indoor air*"[Title/Abstract] OR "airborne"[Title/Abstract] OR ("smok*"[Title/Abstract] AND "pollut*"[Title/Abstract]) OR "passive smok*"[Title/Abstract] OR "hazardous chemical*"[Title/Abstract] OR "hazardous material*"[Title/Abstract] OR "hazardous substance*"[Title/Abstract] OR "toxic action*"[Title/Abstract] OR "pesticide*"[Title/Abstract] OR "poison*"[Title/Abstract] OR "solvent*"[Title/Abstract]) OR ("Radiation"[MeSH Terms] OR "air pollution, radioactive"[MeSH Terms] OR "Hot Temperature"[MeSH Terms] OR "Cold Temperature"[MeSH Terms] OR "Climate"[MeSH Terms] OR "radiation*"[Title/Abstract] OR "climate*"[Title/Abstract] OR "cold temperature*"[Title/Abstract] OR "hot temperature*"[Title/Abstract]) OR ("Communicable Diseases"[MeSH Terms] OR "communicable disease*"[Title/Abstract] OR "contagious*"[Title/Abstract]) OR ("Noise"[MeSH Terms] OR "noise*"[Title/Abstract]) OR ("Vibration"[MeSH Terms] OR "Motor Vehicles"[MeSH Terms] OR "Automobile Driving"[MeSH Terms] OR "driving"[Title/Abstract] OR "automobile*"[Title/Abstract] OR "car"[Title/Abstract] OR "cars"[Title/Abstract] OR "vibrat*"[Title/Abstract] OR "vehicle*"[Title/Abstract] OR "truck*"[Title/Abstract] OR "lorry"[Title/Abstract] OR "lorries"[Title/Abstract] OR "buses"[Title/Abstract] OR "hand held tool*"[Title/Abstract] OR "hand tool*"[Title/Abstract] OR "power tool*"[Title/Abstract])) AND ("english"[Language] OR "danish"[Language] OR "norwegian"[Language] OR "swedish"[Language])

Appendix 4. Methodological quality assessment tool

Case-Control Study	Yes	No	Unclear
Major domain 1 – study design and selection			
Were the cases recruited in an acceptable way? Consider the following: ● Are the cases representative of a population, clearly defined and differentiated from controls? ● Was there an established reliable system for selecting all the cases? ● Were inclusion and exclusion criteria explicit and applied similarly to all eligible cases?			
Were the controls selected in an acceptable way? Consider the following: ● Are the controls representative of a population and clearly defined? ● Are the same inclusion and exclusion criteria for cases used to select controls (equally applied) and matched appropriately? ● Is it clearly established that controls are non-cases?			
Is the participation rate satisfactory? Consider the following: ● Are there large differences between the two groups? ● Is the participation rate low?			
Major domain 2 – Exposure			
Was the exposure accurately measured to minimise bias? Consider the following: ● Is the exposure clearly defined? ● Do measurements truly reflect what it is supposed to measure (have they been validated?). ● Is the method of assessment reliable?			
Major domain 3 – Outcome			
Was the outcome accurately measured to minimise bias? Consider the following: ● Is the outcome clearly defined? ● Do measurements truly reflect what it is supposed to measure (have they been validated?). ● Is the method of assessment reliable?			
Major domain 4 – Non-participants			
Is comparison made between participants and non-participants? Consider the following: ● Is similarities or differences established?			
Major domain 5 – Analysis method			
Was the analysis method adequate? Consider the following: ● Are the main potential confounders identified and taken into account in the analysis? ● Were adequate statistical models used to reduce bias?			
Minor domain 1 – Funding			
Was the source of funding provided? Consider the following: ● Was the study affected by sponsors? ● Did sponsoring organization participate in the analysis?			
Minor domain 2 – Chronology			
Could chronology be established? Consider the following: ● Was the timeframe sufficient to see an association between the exposure and outcome?			
Minor domain 3 – Conflict of interest			
Was the study without any conflict of interest? Consider the following: ● Was the study affected by the authors affiliations or interests?			

Cohort Study	Yes	No	Unclear
Major domain 1 – study design and selection			
Was the cohort recruited in an acceptable way? Consider the following: ● Is it representative of a defined population and clearly specified? ● Are groups comparable in all respects other than the factor under investigation? ● Was everybody included who should have been?			
Was the follow-up of subjects acceptable? Consider the following: ● Conventionally, a 20% drop out rate is acceptable, but observational studies conducted over longer periods, a higher drop-out rate is to be expected. ● Were losses to follow-up taken into account in the analysis (sensitivity analysis, described etc.)?			
Major domain 2 – Exposure			
Was the exposure accurately measured to minimise bias? Consider the following: ● Is the exposure clearly defined? ● Do measurements truly reflect what it is supposed to measure (have they been validated?). ● Is the method of assessment reliable? ● Were all the subjects classified into exposure groups using the same procedure?			
Major domain 3 – Outcome			
Was the outcome accurately measured to minimise bias? Consider the following: ● Is the outcome clearly defined? ● Do measurements truly reflect what it is supposed to measure (have they been validated?). ● Is the method of assessment reliable? ● Were the measurement methods similar in the different groups? ● If blinding is not possible, is there some recognition that knowledge of exposure status could influence the assessment of the outcome?			
Major domain 4 – Enrolment			
Was the outcome taken into account at enrolment? Consider the following: ● Some participants might have the outcome at the time of enrolment. Is it assessed at baseline in the analysis?			
Major domain 5 – Analysis method			
Was the analysis method adequate? Consider the following: ● Are the main potential confounders identified and taken into account in the analysis? ● Were adequate statistical models used to reduce bias?			
Minor domain 1 – Funding			
Was the source of funding provided? Consider the following: ● Was the study affected by sponsors? ● Did sponsoring organization participate in the analysis?			
Minor domain 2 – Chronology			
Could chronology be established? Consider the following: ● Was the timeframe sufficient to see an association between the exposure and outcome? ● Was the follow-up long enough for the outcome to occur?			
Minor domain 3 – Conflict of interest			
Was the study without any conflict of interest? Consider the following: ● Was the study affected by the authors affiliations or interests?			

Appendix 5. Causality criteria

Danish Labour Market Insurance and Occupational Diseases Committee

Degree of evidence for a causal association between exposure to a specific risk factor and a specific outcome.
The following categories are applied:

+++	Good evidence of a causal association
++	Some evidence of a causal association
+	Limited evidence of a causal association
0	Insufficient evidence of a causal association - evidence suggesting lack of a causal association
-	Good evidence for no causal association

Description of categories:
Good evidence of a causal association (+++): A causal association is very likely. A positive relation between exposure to a risk factor and outcome has been observed in several epidemiological studies. It can be excluded with a reasonable degree of certainty that this association can be explained by chance, bias or confounding.

Some evidence of a causal association (++): A causal association is likely. A positive relation between exposure to a risk factor and outcome has been observed in several epidemiological studies. It cannot be excluded with a reasonable degree of certainty that this association can be explained by chance, bias or confounding, although this is not a very probable explanation.

Limited evidence of a causal association (+): A causal association is possible. A positive relation between exposure to a risk factor and outcome has been observed in several epidemiological studies. It is not unlikely that this association can be explained by chance, bias or confounding.

*Insufficient evidence of a causal association (0): A*vailable studies are of insufficient quality, consistency, or statistical weight to allow a conclusion on the presence or absence of a causal association.

Evidence suggesting lack of a causal association (-): Several studies of sufficient quality, consistency and statistical weight suggest that the specific risk factor is not causally related to the specific outcome.

Comments: The classification does not include a category for which a causal association is considered to be established without any doubt. The key criterion is the epidemiological evidence. The probability that chance, bias and confounding can explain observed associations are criteria that includes criteria such as consistency, number of 'high quality' studies, types of design etc. Biological plausibility and contributory information can support the evidence of a causal association.

Appendix 6. Excluded articles from the full-text reading

	Reference	Reason for exclusion
	Ahlholm, V. H., Ronkko, V., Ala-Mursula, L., Karppinen, J., & Oura, P. (2021). Modeling the Multidimensional Predictors of Multisite Musculoskeletal Pain Across Adulthood-A Generalized Estimating Equations Approach. *Front Public Health*, *9*, 709778.	Outcome criteria not fulfilled.
2	Alghadir, A., Zafar, H., & Iqbal, Z. A. (2015). Work-related musculoskeletal disorders among dental professionals in Saudi Arabia. *J Phys Ther Sci*, *27*(4), 1107-1112.	Study design criteria not fulfilled.
3	Alghadir, A., Zafar, H., Iqbal, Z. A., & Al-Eisa, E. (2017). Work-Related Low Back Pain Among Physical Therapists in Riyadh, Saudi Arabia. *Workplace Health Saf*, *65*(8), 337-345.	Study design criteria not fulfilled.
4	Alziyadi, R. H., Elgezery, M. H., & Alziyadi, R. H. (2021). Prevalence of Low Back Pain and Its Associated Risk Factors among Female Nurses Working in a tertiary hospital in Dhahran, Eastern Province, Saudi Arabia. *World Family Medicine*, *19*(1), 173-182.	Study design criteria not fulfilled.
5	Amin, R., Safdar, B., & Masood, M. H. (2019). PSYCHOSOCIAL DETERMINANTS OF BACKACHE IN FEMALES. *Indo American Journal of Pharmaceutical Sciences*, *6*(6), 12915-12921.	Outcome criteria not fulfilled.
6	Andersen, L. L., Vinstrup, J., Sundstrup, E., Skovlund, S. V., Villadsen, E., & Thorsen, S. V. (2021). Combined ergonomic exposures and development of musculoskeletal pain in the general working population: A prospective cohort study. *Scand J Work Environ Health*, *47*(4), 287-295.	Outcome criteria not fulfilled.
7	Andersen, L. L., Vinstrup, J., Villadsen, E., Jay, K., & Jakobsen, M. D. (2019). Physical and Psychosocial Work Environmental Risk Factors for Back Injury among Healthcare Workers: Prospective Cohort Study. *Int J Environ Res Public Health*, *16*(22).	Outcome criteria not fulfilled.
8	Arcury, T. A., Chen, H., Mora, D. C., Walker, F. O., Cartwright, M. S., & Quandt, S. A. (2016). The effects of work organization on the health of immigrant manual workers: A longitudinal analysis. *Arch Environ Occup Health*, *71*(2), 66-73.	Outcome criteria not fulfilled.
9	Arvidsson, I., Gremark Simonsen, J., Lindegard-Andersson, A., Bjork, J., & Nordander, C. (2020). The impact of occupational and personal factors on musculoskeletal pain - a cohort study of female nurses, sonographers and teachers. *BMC Musculoskelet Disord*, *21*(1), 621.	Outcome criteria not fulfilled.
10	Badarin, K., Hemmingsson, T., Hillert, L., & Kjellberg, K. (2021). Physical workload and increased frequency of musculoskeletal pain: a cohort study of employed men and women with baseline occasional pain. *Occup Environ Med*, *78*(8), 558-566.	Outcome criteria not fulfilled.
11	Bazazan, A., Dianat, I., Bahrampour, S., Talebian, A., Zandi, H., Sharafkhaneh, A., & Maleki-Ghahfarokhi, A. (2019). Association of musculoskeletal disorders and workload with work schedule and job satisfaction among emergency nurses. *Int Emerg Nurs*, *44*, 8-13.	Study design criteria not fulfilled.
12	Bontrup, C., Taylor, W. R., Fliesser, M., Visscher, R., Green, T., Wippert, P. M., & Zemp, R. (2019). Low back pain and its relationship with sitting behaviour among sedentary office workers. *Appl Ergon*, *81*, 102894.	Study design criteria not fulfilled.
13	Bonzini, M., Bertù, L., Conti, M., D'Amato, A., Veronesi, G., Coggon, D. N., & Ferrario, M. M. (2014). 0168 Somatising tendency, occupational strain and musculoskeletal symptoms: results from a longitudinal study among Italian nurses. *Occupational and Environmental Medicine*, *71*(Suppl 1), A21.22-A21.	Outcome criteria not fulfilled.
14	Bonzini, M., Bertu, L., Veronesi, G., Conti, M., Coggon, D., & Ferrario, M. M. (2015). Is musculoskeletal pain a consequence or a cause of occupational stress? A longitudinal study. *Int Arch Occup Environ Health*, *88*(5), 607-612.	Other reasons (e.g., abstract, books).
15	Bovenzi, M., & Schust, M. (2021). A prospective cohort study of low-back outcomes and alternative measures of cumulative external and internal vibration load on the lumbar spine of professional drivers. *Scand J Work Environ Health*, *47*(4), 277-286.	Outcome criteria not fulfilled.
16	Bovenzi, M., Schust, M., Menzel, G., Hofmann, J., & Hinz, B. (2015). A cohort study of sciatic pain and measures of internal spinal load in professional drivers. *Ergonomics*, *58*(7), 1088-1102.	Outcome criteria not fulfilled.

17	Bovenzi, M., Schust, M., Menzel, G., Prodi, A., & Mauro, M. (2015). Relationships of low back outcomes to internal spinal load: a prospective cohort study of professional drivers. *Int Arch Occup Environ Health*, *88*(4), 487-499.	Outcome criteria not fulfilled.
18	Brauer, C., Mikkelsen, S., Pedersen, E. B., Moller, K. L., Simonsen, E. B., Koblauch, H., Alkjaer, T., Helweg-Larsen, K., & Thygesen, L. C. (2020). Occupational lifting predicts hospital admission due to low back pain in a cohort of airport baggage handlers. *Int Arch Occup Environ Health*, *93*(1), 111-122.	Exposure criteria not fulfilled.
19	Bugajska, J., Zolnierczyk-Zreda, D., Jedryka-Goral, A., Gasik, R., Hildt-Ciupinska, K., Malinska, M., & Bedynska, S. (2013). Psychological factors at work and musculoskeletal disorders: a one year prospective study. *Rheumatol Int*, *33*(12), 2975-2983.	Outcome criteria not fulfilled.
20	Chaiklieng, S., & Suggaravetsiri, P. (2020). Low Back Pain (LBP) Incidence, Ergonomics Risk and Workers' Characteristics in Relations to LBP in Electronics Assembly Manufacturing. *Indian J Occup Environ Med*, *24*(3), 183-187.	Outcome criteria not fulfilled.
21	Chakrabarty, S., Sarkar, K., Dev, S., Das, T., Mitra, K., Sahu, S., & Gangopadhyay, S. (2016). Impact of rest breaks on musculoskeletal discomfort of Chikan embroiderers of West Bengal, India: a follow up field study. *J Occup Health*, *58*(4), 365-372.	Outcome criteria not fulfilled.
22	Chan, E. W. M., Hamid, M. S. A., Din, F. H. M., Ahmad, R., Nadzalan, A. M., & Hafiz, E. (2019). Prevalence and factors associated with low back pain among Malaysian army personnel stationed in Klang Valley. *Biomedical Human Kinetics*, *11*(1), 9-18.	Study design criteria not fulfilled.
23	Chand, R. K., Roomi, M. A., Begum, S., & Mudassar, A. (2020). Prevalence of musculoskeletal disorders, associated risk factors and coping strategies among secondary school teachers in fiji. *Rawal Medical Journal*, *45*(2), 377-381.	Study design criteria not fulfilled.
24	Chang, K. C., Lee, H. C., Yen, C. L., Liao, Y. H., Hung, J. W., & Wu, C. Y. (2021). Low back pain-associated factors in female hospital-based personal care attendants. *Work*, *69*(1), 315-322.	Study design criteria not fulfilled.
25	Christensen, J. O., Johansen, S., & Knardahl, S. (2017). Psychological predictors of change in the number of musculoskeletal pain sites among Norwegian employees: a prospective study. *BMC Musculoskelet Disord*, *18*(1), 140.	Outcome criteria not fulfilled.
26	Christensen, J. O., Nielsen, M. B., Finne, L. B., & Knardahl, S. (2018). Comprehensive profiles of psychological and social work factors as predictors of site-specific and multi-site pain. *Scand J Work Environ Health*, *44*(3), 291-302.	Outcome criteria not fulfilled.
27	Clausen, T., Andersen, L. L., Holtermann, A., Jorgensen, A. F., Aust, B., & Rugulies, R. (2013). Do self-reported psychosocial working conditions predict low back pain after adjustment for both physical work load and depressive symptoms? A prospective study among female eldercare workers. *Occup Environ Med*, *70*(8), 538-544.	Outcome criteria not fulfilled.
28	Clays, E., Ketels, M., & Oakman, J. (2021). Low back and neck-shoulder pain: What is the role of objective and subjective measures in determining physical and psychosocial workplace hazards in non-sedentary jobs? *International Journal of Behavioral Medicine*, *28*(SUPPL 1), S134-S135.	Study design criteria not fulfilled.
29	Coenen, P., Douwes, M., van den Heuvel, S., & Bosch, T. (2016). Towards exposure limits for working postures and musculoskeletal symptoms - a prospective cohort study. *Ergonomics*, *59*(9), 1182-1192.	Outcome criteria not fulfilled.
30	Coenen, P., Kingma, I., Boot, C. R., Bongers, P. M., & van Dieen, J. H. (2014). Cumulative mechanical low-back load at work is a determinant of low-back pain. *Occup Environ Med*, *71*(5), 332-337.	Outcome criteria not fulfilled.
31	Coenen, P., Kingma, I., Boot, C. R., Twisk, J. W., Bongers, P. M., & van Dieen, J. H. (2013). Cumulative low back load at work as a risk factor of low back pain: a prospective cohort study. *J Occup Rehabil*, *23*(1), 11-18.	Other reasons (e.g., abstract, books).
32	Coenen, P., Mathiassen, S. E., Kingma, I., Boot, C. R., Bongers, P. M., & van Dieen, J. H. (2015). The effect of the presence and characteristics of an outlying group on exposure-outcome associations. *Scand J Work Environ Health*, *41*(1), 65-74.	Outcome criteria not fulfilled.
33	Coggon, D., Ntani, G., Palmer, K. T., Felli, V. E., Harari, F., Quintana, L. A., Felknor, S. A., Rojas, M., Cattrell, A., Vargas-Prada, S., Bonzini, M., Solidaki, E., Merisalu, E., Habib, R. R., Sadeghian, F., Kadir, M. M., Warnakulasuriya, S. S. P., Matsudaira, K., Nyantumbu-Mkhize, B., . . . Harcombe, H. (2019). Drivers of international variation in prevalence of disabling low	Study design criteria not fulfilled.

	back pain: Findings from the Cultural and Psychosocial Influences on Disability study. *Eur J Pain*, *23*(1), 35-45.	
34	Damrongsak, M., Prapanjaroensin, A., & Brown, K. C. (2018). Predictors of Back Pain in Firefighters. *Workplace Health Saf*, *66*(2), 61-69.	Study design criteria not fulfilled.
35	Das, B., & Gangopadhyay, S. (2015). Prevalence of musculoskeletal disorders and physiological stress among adult, male potato cultivators of West Bengal, India. *Asia Pac J Public Health*, *27*(2), NP1669-1682.	Study design criteria not fulfilled.
36	Das, D., Kumar, A., & Sharma, M. (2021). Risk factors associated with musculoskeletal disorders among gemstone polishers in Jaipur, India. *Int J Occup Saf Ergon*, *27*(1), 95-105.	Study design criteria not fulfilled.
37	de Alwis, M. P., & Garme, K. (2020). Effect of occupational exposure to shock and vibration on health in high-performance marine craft occupants. *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment*, *235*(2), 394-409.	Other reasons (e.g., abstract, books).
38	de Alwis, M. P., LoMartire, R., Äng, B. O., & Garme, K. (2020). Exposure aboard high-performance marine craft increases musculoskeletal pain and lowers contemporary work capacity of the occupants. *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment*, *235*(3), 750-762.	Other reasons (e.g., abstract, books).
39	Dick, R. B., Lowe, B. D., Lu, M. L., & Krieg, E. F. (2020). Trends in Work-Related Musculoskeletal Disorders From the 2002 to 2014 General Social Survey, Quality of Work Life Supplement. *J Occup Environ Med*, *62*(8), 595-610.	Study design criteria not fulfilled.
40	Dragioti, E., Gerdle, B., & Larsson, B. (2019). Longitudinal Associations between Anatomical Regions of Pain and Work Conditions: A Study from The SwePain Cohort. *Int J Environ Res Public Health*, *16*(12), 16.	Outcome criteria not fulfilled.
41	Duenas, M., Moral-Munoz, J. A., Palomo-Osuna, J., Salazar, A., De Sola, H., & Failde, I. (2020). Differences in physical and psychological health in patients with chronic low back pain: a national survey in general Spanish population. *Qual Life Res*, *29*(11), 2935-2947.	Other reasons (e.g., abstract, books).
42	Ekblom-Bak, E., Stenling, A., Salier Eriksson, J., Hemmingsson, E., Kallings, L. V., Andersson, G., Wallin, P., Ekblom, O., Ekblom, B., & Lindwall, M. (2020). Latent profile analysis patterns of exercise, sitting and fitness in adults - Associations with metabolic risk factors, perceived health, and perceived symptoms. *PLoS One*, *15*(4), e0232210.	Study design criteria not fulfilled.
43	Ervasti, J., Pietilainen, O., Rahkonen, O., Lahelma, E., Kouvonen, A., Lallukka, T., & Manty, M. (2019). Joint contribution of rotation of the back and repetitive movements to disability pension using job exposure matrix data. *Eur J Public Health*, *29*(6), 1079-1084.	Outcome criteria not fulfilled.
44	Essien, S. K., Bath, B., Koehncke, N., Trask, C., & Saskatchewan Farm Injury Cohort Study, T. (2016). Association Between Farm Machinery Operation and Low Back Disorder in Farmers: A Retrospective Cohort Study. *J Occup Environ Med*, *58*(6), e212-217.	Outcome criteria not fulfilled.
45	Euro, U., Knekt, P., Rissanen, H., Aromaa, A., Karppinen, J., & Heliovaara, M. (2018). Risk factors for sciatica leading to hospitalization. *Eur Spine J*, *27*(7), 1501-1508.	Exposure criteria not fulfilled.
46	Farioli, A., Mattioli, S., Quaglieri, A., Curti, S., Violante, F. S., Coggon, D., & Andersen, B. (2014). Musculoskeletal pain in Europe: the role of personal, occupational, and social risk factors. *Scand J Work Environ Health*, *40*(1), 36-46.	Study design criteria not fulfilled.
47	Fliesser, M., De Witt Huberts, J., & Wippert, P. M. (2018). Education, job position, income or multidimensional indices? Associations between different socioeconomic status indicators and chronic low back pain in a German sample: a longitudinal field study. *BMJ Open*, *8*(4), e020207.	Exposure criteria not fulfilled.
48	Friel, C. P., Pascual, C. B., Duran, A. T., Goldsmith, J., & Diaz, K. M. (2020). Joint associations of occupational standing and occupational exertion with musculoskeletal symptoms in a US national sample. *Occup Environ Med*.	Study design criteria not fulfilled.
49	Gaowgzeh, R. A. M. (2019). Low back pain among nursing professionals in Jeddah, Saudi Arabia: Prevalence and risk factors. *J Back Musculoskelet Rehabil*, *32*(4), 555-560.	Study design criteria not fulfilled.
50	Garg, A., Boda, S., Hegmann, K. T., Moore, J. S., Kapellusch, J. M., Bhoyar, P., Thiese, M. S., Merryweather, A., Deckow-Schaefer, G., Bloswick, D., & Malloy, E. J. (2014). The NIOSH lifting equation and low-back pain, Part 1: Association with low-back pain in the backworks prospective cohort study. *Hum Factors*, *56*(1), 6-28.	Outcome criteria not fulfilled.

51	Garg, A., Kapellusch, J. M., Hegmann, K. T., Moore, J. S., Boda, S., Bhoyar, P., Thiese, M. S., Merryweather, A., Deckow-Schaefer, G., Bloswick, D., & Malloy, E. J. (2014). The NIOSH lifting equation and low-back pain, Part 2: Association with seeking care in the backworks prospective cohort study. *Hum Factors*, *56*(1), 44-57.	Outcome criteria not fulfilled.
52	Glambek, M., Nielsen, M. B., Gjerstad, J., Einarsen, S., & Croft. (2018). Gender differences in the relationship between workplace bullying and subjective back and neck pain: A two-wave study in a Norwegian probability sample. *J Psychosom Res*, *106*, 73-75.	Outcome criteria not fulfilled.
53	Gunal, A., & Demirturk, F. (2021). Occupational hazards, sleep quality and musculoskeletal problems of pregnant workers. *J Obstet Gynaecol*, 1-5.	Study design criteria not fulfilled.
54	Gustafsson, K., Marklund, S., Aronsson, G., & Leineweber, C. (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. *BMJ Open*, *9*(10), e026491.	Outcome criteria not fulfilled.
55	Habib, M. M. (2015). Ergonomic risk factor identification for sewing machine operators through supervised occupational therapy fieldwork in Bangladesh: A case study. *Work*, *50*(3), 357-362.	Study design criteria not fulfilled.
56	Halonen, J. I., Shiri, R., Manty, M., Sumanen, H., Solovieva, S., Viikari-Juntura, E., Kahonen, M., Lehtimaki, T., Raitakari, O. T., & Lallukka, T. (2019). Exposure to heavy physical work from early to later adulthood and primary healthcare visits due to musculoskeletal diseases in midlife: a register linked study. *BMJ Open*, *9*(8), e031564.	Outcome criteria not fulfilled.
57	Hansen, B. B., Kirkeskov, L., Begtrup, L. M., Boesen, M., Bliddal, H., Christensen, R., Andreasen, D. L., Kristensen, L. E., Flachs, E. M., & Kryger, A. I. (2019). Early occupational intervention for people with low back pain in physically demanding jobs: A randomized clinical trial. *PLoS Med*, *16*(8), e1002898.	Outcome criteria not fulfilled.
58	Hemati, K., Darbandi, Z., Kabir-Mokamelkhah, E., Poursadeghiyan, M., Ghasemi, M. S., Mohseni-Ezhiye, M., Abdolahian, Y., Aghilinejad, M., Ali Salehi, M., & Dehghan, N. (2020). Ergonomic intervention to reduce musculoskeletal disorders among flour factory workers. *Work*, *67*(3), 611-618.	Other reasons (e.g., abstract, books).
59	Henriques, M., Sacadura-Leite, E. M., & Serranheira, F. (2019). Low back pain among hospital nursing assistants. *Rev Bras Med Trab*, *17*(3), 370-377.	Study design criteria not fulfilled.
60	Hong, C., Lee, C. G., & Song, H. (2021). Characteristics of lumbar disc degeneration and risk factors for collapsed lumbar disc in Korean farmers and fishers. *Annals of Occupational and Environmental Medicine*, *33*(1), e16.	Study design criteria not fulfilled.
61	Hung, Y. J., Shih, T. T., Chen, B. B., Hwang, Y. H., Ma, L. P., Huang, W. C., Liou, S. H., Ho, I. K., & Guo, Y. L. (2014). The dose-response relationship between cumulative lifting load and lumbar disk degeneration based on magnetic resonance imaging findings. *Phys Ther*, *94*(11), 1582-1593.	Study design criteria not fulfilled.
62	Hviid Andersen, J., Frost, P., Frølund Thomsen, J., Donbaek Jensen, L., & Wulff Svendsen, S. (2014). Back Surgery in relation to occupational lifting. A cohort study based on the Musculoskeletal Research Database at the Danish Ramazzini Centre. *Occupational and Environmental Medicine*, *71*(Suppl 1), A33.31-A33.	Other reasons (e.g., abstract, books).
63	Ishimoto, Y., C. Cooper, G. Ntani, H. Yamada, H. Hashizume, K. Nagata, et al. (2019). Is radiographic lumbar spondylolisthesis associated with occupational exposures? Findings from a nested case control study within the Wakayama spine study. BMC Musculoskelet Disord 2019 Vol. 20 Issue 1 Pages 618.	Outcome criteria not fulfilled.
64	Y. Ishimoto, C. Cooper, G. Ntani, H. Yamada, H. Hashizume, K. Nagata, et al. (2019). Factory and construction work is associated with an increased risk of severe lumbar spinal stenosis on MRI: A case control analysis within the wakayama spine study. Am J Ind Med 2019 Vol. 62 Issue 5 Pages 430-438.	Outcome criteria not fulfilled.
65	Jo, H., Lim, O. B., Ahn, Y. S., Chang, S. J., & Koh, S. B. (2021). Negative Impacts of Prolonged Standing at Work on Musculoskeletal Symptoms and Physical Fatigue: The Fifth Korean Working Conditions Survey. *Yonsei Med J*, *62*(6), 510-519.	Study design criteria not fulfilled.

66	Jorgensen, M. B., Nabe-Nielsen, K., Clausen, T., & Holtermann, A. (2013). Independent effect of physical workload and childhood socioeconomic status on low back pain among health care workers in Denmark. *Spine (Phila Pa 1976)*, *38*(6), E359-366.	Outcome criteria not fulfilled.
67	Kapellusch, J. M., Garg, A., Boda, S., Hegmann, K. T., Moore, J. S., Thiese, M. S., Merryweather, A., Tomich, S., Foster, J. C., Bloswick, D., & Malloy, E. J. (2014). Association between lifting and use of medication for low back pain: results from the Backworks Prospective Cohort Study. *J Occup Environ Med*, *56*(8), 867-877.	Outcome criteria not fulfilled.
68	Kawaguchi, M., Matsudaira, K., Sawada, T., Koga, T., Ishizuka, A., Isomura, T., & Coggon, D. (2017). Assessment of potential risk factors for new onset disabling low back pain in Japanese workers: findings from the CUPID (cultural and psychosocial influences on disability) study. *BMC Musculoskelet Disord*, *18*(1), 334.	Outcome criteria not fulfilled.
69	Khansa, I., Khansa, L., Westvik, T. S., Ahmad, J., Lista, F., & Janis, J. E. (2018). Work-Related Musculoskeletal Injuries in Plastic Surgeons in the United States, Canada, and Norway. *Plast Reconstr Surg*, *141*(1), 165e-175e.	Study design criteria not fulfilled.
70	Kim, Y. H., & Jung, M. H. (2016). Effect of occupational health nursing practice on musculoskeletal pains among hospital nursing staff in South Korea. *Int J Occup Saf Ergon*, *22*(2), 199-206.	Study design criteria not fulfilled.
71	Korshoj, M., Jorgensen, M. B., Hallman, D. M., Lagersted-Olsen, J., Holtermann, A., & Gupta, N. (2018). Prolonged sitting at work is associated with a favorable time course of low-back pain among blue-collar workers: a prospective study in the DPhacto cohort. *Scand J Work Environ Health*, *44*(5), 530-538.	Outcome criteria not fulfilled.
72	Lagersted-Olsen, J., Thomsen, B. L., Holtermann, A., Sogaard, K., & Jorgensen, M. B. (2016). Does objectively measured daily duration of forward bending predict development and aggravation of low-back pain? A prospective study. *Scand J Work Environ Health*, *42*(6), 528-537.	Outcome criteria not fulfilled.
73	Lallukka, T., Viikari-Juntura, E., Viikari, J., Kahonen, M., Lehtimaki, T., Raitakari, O. T., & Solovieva, S. (2017). Early work-related physical exposures and low back pain in midlife: the Cardiovascular Risk in Young Finns Study. *Occup Environ Med*, *74*(3), 163-168.	Outcome criteria not fulfilled.
74	Liu, H.-C., Cheng, Y., & Ho, J.-J. (2020). Associations of ergonomic and psychosocial work hazards with musculoskeletal disorders of specific body parts: A study of general employees in Taiwan. *International Journal of Industrial Ergonomics*, *76*, 8.	Study design criteria not fulfilled.
75	Liu, L., Chen, S. G., Tang, S. C., Wang, S., He, L. H., Guo, Z. H., Li, J. Y., Yu, S. F., & Wang, Z. X. (2015). How Work Organization Affects the Prevalence of WMSDs: A Case-control Study. *Biomed Environ Sci*, *28*(9), 627-633.	Study design criteria not fulfilled.
76	Lovgren, M., Gustavsson, P., Melin, B., & Rudman, A. (2014). Neck/shoulder and back pain in new graduate nurses: A growth mixture modeling analysis. *Int J Nurs Stud*, *51*(4), 625-639.	Outcome criteria not fulfilled.
77	Lu, M. L., Waters, T. R., Krieg, E., & Werren, D. (2014). Efficacy of the revised NIOSH lifting equation to predict risk of low-back pain associated with manual lifting: a one-year prospective study. *Hum Factors*, *56*(1), 73-85.	Outcome criteria not fulfilled.
78	Lundberg, U. (2015). Work conditions and back pain problems. *Stress Health*, *31*(1), 1-4.	Other reasons (e.g., abstract, books).
79	Lunde, L. K., Koch, M., Knardahl, S., & Veiersted, K. B. (2017). Associations of objectively measured sitting and standing with low-back pain intensity: a 6-month follow-up of construction and healthcare workers. *Scand J Work Environ Health*, *43*(3), 269-278.	Outcome criteria not fulfilled.
80	Lunde, L. K., Koch, M., Merkus, S. L., Knardahl, S., Waersted, M., & Veiersted, K. B. (2019). Associations of objectively measured forward bending at work with low-back pain intensity: a 2-year follow-up of construction and healthcare workers. *Occup Environ Med*, *76*(9), 660-667.	Outcome criteria not fulfilled.
81	Luo, Y., Wang, J., Pei, J., Rong, Y., Liu, W., Tang, P., Cai, W., & Yin, G. (2020). Interactions between the MMP-3 gene rs591058 polymorphism and occupational risk factors contribute to the increased risk for lumbar disk herniation: A case-control study. *J Clin Lab Anal*, *34*(7), e23273.	Exposure criteria not fulfilled.
82	Magnusson Hanson, L. L., Madsen, I. E., Rugulies, R., Peristera, P., Westerlund, H., & Descatha, A. (2017). Temporal relationships between job strain and low-back pain. *Scand J Work Environ Health*, *43*(5), 396-404.	Other reasons (e.g., abstract, books).

83	Matsudaira, K., Kawaguchi, M., Isomura, T., Arisaka, M., Fujii, T., Takeshita, K., Kitagawa, T., Miyoshi, K., & Konishi, H. (2013). Identification of risk factors for new-onset sciatica in Japanese workers: findings from the Japan epidemiological research of Occupation-related Back pain study. *Spine (Phila Pa 1976)*, *38*(26), E1691-1700.	Other reasons (e.g., abstract, books).
84	Mierswa, T., & Kellmann, M. (2017). Psychological detachment as moderator between psychosocial work conditions and low back pain development. *Int J Occup Med Environ Health*, *30*(2), 313-327.	Outcome criteria not fulfilled.
85	Mierswa, T., Kellmann, M., & Alexopoulos. (2017). Differences in low back pain occurrence over a 6-month period between four recovery-stress groups. *Work*, *58*(2), 193-202.	Study design criteria not fulfilled.
86	Minghelli, B., Ettro, N., Simao, J., & Mauricio, K. (2019). Work-related self-reported musculoskeletal disorders in hypermarket cashiers: a study in south of Portugal. *Med Lav*, *110*(3), 191-201.	Study design criteria not fulfilled.
87	Mishra, S., & Sarkar, K. (2021). Work-related musculoskeletal disorders and associated risk factors among urban metropolitan hairdressers in India. *J Occup Health*, *63*(1), e12200.	Study design criteria not fulfilled.
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100	Ng, Y. M., Voo, P., & Maakip, I. (2019). Psychosocial factors, depression, and musculoskeletal disorders among teachers. *BMC Public Health*, *19*(1), 234.	Study design criteria not fulfilled.
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106	Palfreyman, S. (2015). The effect of daily walking steps on preventing neck and low back pain in sedentary workers: A 1-year prospective cohort study. *International Journal of Osteopathic Medicine*, *18*(2), 155-156.	Outcome criteria not fulfilled.
107	Pandalai, S. P., Wheeler, M. W., & Lu, M. L. (2017). Non-chemical Risk Assessment for Lifting and Low Back Pain Based on Bayesian Threshold Models. *Saf Health Work*, *8*(2), 206-211.	Outcome criteria not fulfilled.
108	Park, J., Han, B. Y., & Kim, Y. (2017). Gender differences in occupations and complaints of musculoskeletal symptoms: Representative sample of South Korean workers. *Am J Ind Med*, *60*(4), 342-349.	Study design criteria not fulfilled.
109	Park, J., & Kim, Y. (2020). Factors Related to Physical and Mental Health in Workers With Different Categories of Employment. *J Occup Environ Med*, *62*(7), 511-518.	Study design criteria not fulfilled.
110	Piranveyseh, P., Motamedzade, M., Osatuke, K., Mohammadfam, I., Moghimbeigi, A., Soltanzadeh, A., & Mohammadi, H. (2016). Association between psychosocial, organizational and personal factors and prevalence of musculoskeletal disorders in office workers. *Int J Occup Saf Ergon*, *22*(2), 267-273.	Study design criteria not fulfilled.
111	Plouvier, S., Chastang, J. F., Cyr, D., Bonenfant, S., Descatha, A., Goldberg, M., & Leclerc, A. (2015). Occupational biomechanical exposure predicts low back pain in older age among men in the Gazel Cohort. *Int Arch Occup Environ Health*, *88*(4), 501-510.	Outcome criteria not fulfilled.
112	Prakash, K. C., Neupane, S., Leino-Arjas, P., von Bonsdorff, M. B., Rantanen, T., von Bonsdorff, M. E., Seitsamo, J., Ilmarinen, J., & Nygard, C. H. (2017). Work-Related Biomechanical Exposure and Job Strain as Separate and Joint Predictors of Musculoskeletal Diseases: A 28-Year Prospective Follow-up Study. *Am J Epidemiol*, *186*(11), 1256-1267.	Outcome criteria not fulfilled.
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114	Ramond-Roquin, A., Bodin, J., Serazin, C., Parot-Schinkel, E., Ha, C., Richard, I., Petit Le Manach, A., Fouquet, N., & Roquelaure, Y. (2015). Biomechanical constraints remain major risk factors for low back pain. Results from a prospective cohort study in French male employees. *Spine J*, *15*(4), 559-569.	Outcome criteria not fulfilled.
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116	Rasmussen-Barr, E., Grooten, W. J. A., Hallqvist, J., Holm, L. W., & Skillgate, E. (2017). Are job strain and sleep disturbances prognostic factors for low-back pain? A cohort study of a general population of working age in Sweden. *J Rehabil Med*, *49*(7), 591-597.	No measure of an association.
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122	Roy, T. C., Lopez, H. P., & Piva, S. R. (2013). Loads worn by soldiers predict episodes of low back pain during deployment to Afghanistan. *Spine (Phila Pa 1976)*, *38*(15), 1310-1317.	Outcome criteria not fulfilled.
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124	Rufa'i, A. A., Sa'idu, I. A., Ahmad, R. Y., Elmi, O. S., Aliyu, S. U., Jajere, A. M., & Digil, A. A. (2015). Prevalence and Risk Factors for Low Back Pain Among Professional Drivers in Kano, Nigeria. *Arch Environ Occup Health*, *70*(5), 251-255.	Study design criteria not fulfilled.
125	Runeson-Broberg, R., Lindgren, T., & Norback, D. (2014). Musculoskeletal symptoms and psychosocial work environment, among Swedish commercial pilots. *Int Arch Occup Environ Health*, *87*(7), 685-693.	Study design criteria not fulfilled.
126	Sadeghian, F., Coggon, D., Ntani, G., & Hosseinzadeh, S. (2015). Predictors of low back pain in a longitudinal study of Iranian nurses and office workers. *Work*, *51*(2), 239-244.	Outcome criteria not fulfilled.
127	Sain, M. K., & Meena, M. (2019). Identifying musculoskeletal issues and associated risk factors among clay brick kiln workers. *Ind Health*, *57*(3), 381-391.	Study design criteria not fulfilled.
128	Sain, M. K., & Meena, M. L. (2018). Exploring the musculoskeletal problems and associated risk-factors among brick kiln workers. *International Journal of Workplace Health Management*, *11*(6), 395-410.	Outcome criteria not fulfilled.
129	Salve, U. R. (2015). Prevalence of musculoskeletal discomfort among the workers engaged in jewelry manufacturing. *Indian J Occup Environ Med*, *19*(1), 44-55.	Other reasons (e.g., abstract, books).
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137	Solecki, L. (2014). Complaints of low back pain among private farmers exposed to whole body vibration. *Med Pr*, *65*(1), 55-64.	Other reasons (e.g., abstract, books).
138	Solovev, A., Watanabe, Y., Kitamura, K., Takahashi, A., Kobayashi, R., Saito, T., Takachi, R., Kabasawa, K., Oshiki, R., Platonova, K., Tsugane, S., Iki, M., Sasaki, A., Yamazaki, O., Watanabe, K., & Nakamura, K. (2020). Total physical activity and risk of chronic low back and knee pain in middle-aged and elderly Japanese people: The Murakami cohort study. *Eur J Pain*, *24*(4), 863-872.	Exposure criteria not fulfilled.
139	Sterud, T., Johannessen, H. A., & Tynes, T. (2016). Do Work-Related Mechanical and Psychosocial Factors Contribute to the Social Gradient in Low Back Pain?: A 3-Year Follow-Up Study of the General Working Population in Norway. *Spine (Phila Pa 1976)*, *41*(13), 1089-1095.	Outcome criteria not fulfilled.
140	Sterud, T., & Tynes, T. (2013). Work-related psychosocial and mechanical risk factors for low back pain: a 3-year follow-up study of the general working population in Norway. *Occup Environ Med*, *70*(5), 296-302.	Outcome criteria not fulfilled.
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143	Tang, R., Kapellusch, J. M., Hegmann, K. T., Thiese, M. S., Wang, I., & Merryweather, A. S. (2020). Evaluating Different Measures of Low Back Pain Among U.S. Manual Materials Handling Workers: Comparisons of Demographic, Psychosocial, and Job Physical Exposure. *Hum Factors*, 18720820971101.	Outcome criteria not fulfilled.
144	Telaprolu, N., & Anne, S. D. (2014). Physical and psychological work demands as potential risk factors for musculoskeletal disorders among workers in weaving operations. *Indian J Occup Environ Med*, *18*(3), 129-134.	Study design criteria not fulfilled.
145	Thiede, M., Liebers, F., Seidler, A., Gravemeyer, S., & Latza, U. (2014). Gender specific analysis of occupational diseases of the low back caused by carrying, lifting or extreme trunk flexion--use of a prevention index to identify occupations with high prevention needs. *Am J Ind Med*, *57*(2), 233-244.	Study design criteria not fulfilled.
146	Thiese, M. S., Lu, M. L., Merryweather, A., Tang, R., Ferguson, S. A., Malloy, E. J., Marras, W. S., Hegmann, K. T., & Kapellusch, J. (2020). Psychosocial Factors and Low Back Pain Outcomes in a Pooled Analysis of Low Back Pain Studies. *J Occup Environ Med*, *62*(10), 810-815.	Study design criteria not fulfilled.
147	Udom, C., Kanlayanaphotporn, R., & Janwantanakul, P. (2019). Predictors for Nonspecific Low Back Pain in Rubber Farmers: A 1-Year Prospective Cohort Study. *Asia Pac J Public Health*, *31*(1), 7-17.	Outcome criteria not fulfilled.
148	Urquhart, D. M., Kelsall, H. L., Hoe, V. C., Cicuttini, F. M., Forbes, A. B., Sim, M. R., & Burton. (2013). Are psychosocial factors associated with low back pain and work absence for low back pain in an occupational cohort? *Clin J Pain*, *29*(12), 1015-1020.	Study design criteria not fulfilled.
149	Vargas-Prada, S., Serra, C., Martinez, J. M., Ntani, G., Delclos, G. L., Palmer, K. T., Coggon, D., & Benavides, F. G. (2013). Psychological and culturally-influenced risk factors for the incidence and persistence of low back pain and associated disability in Spanish workers: findings from the CUPID study. *Occup Environ Med*, *70*(1), 57-62.	Outcome criteria not fulfilled.
150	Vinstrup, J., Jakobsen, M. D., & Andersen, L. L. (2020). Perceived Stress and Low-Back Pain Among Healthcare Workers: A Multi-Center Prospective Cohort Study. *Front Public Health*, *8*, 297.	Outcome criteria not fulfilled.
151	Vinstrup, J., Jakobsen, M. D., Madeleine, P., & Andersen, L. L. (2020). Physical exposure during patient transfer and risk of back injury & low-back pain: prospective cohort study. *BMC Musculoskelet Disord*, *21*(1), 715.	Outcome criteria not fulfilled.
152	Wixted, F., & O'Sullivan, L. (2019). Task engagement as a mediator between the cognitive demands of sustained attention and musculoskeletal complaints: A structural equation modelling approach. *Work*, *64*(3), 623-634.	Study design criteria not fulfilled.

153	Wurzelbacher, S. J., Lampl, M. P., Bertke, S. J., & Tseng, C. Y. (2020). The effectiveness of ergonomic interventions in material handling operations. *Appl Ergon*, *87*, 103139.	Outcome criteria not fulfilled.
154	Xiao, H., McCurdy, S. A., Stoecklin-Marois, M. T., Li, C. S., & Schenker, M. B. (2013). Agricultural work and chronic musculoskeletal pain among Latino farm workers: the MICASA study. *Am J Ind Med*, *56*(2), 216-225.	Study design criteria not fulfilled.
155	Yang, S. T., Park, M. H., & Jeong, B. Y. (2020). Types of manual materials handling (MMH) and occupational incidents and musculoskeletal disorders (MSDs) in motor vehicle parts manufacturing (MVPM) industry. *International Journal of Industrial Ergonomics*, *77*, 9.	Study design criteria not fulfilled.
156	Yovi, E. Y., & Prajawati, W. (2015). High Risk Posture on Motor-Manual Short Wood Logging System in Acacia mangium Plantation. *Jurnal Manajemen Hutan Tropika (Journal of Tropical Forest Management)*, *21*(1), 11-18.	Study design criteria not fulfilled.
157	Yovi, E. Y., & Yamada, Y. (2019). Addressing Occupational Ergonomics Issues in Indonesian Forestry. *Croatian Journal of Forest Engineering*, *40*(2), 351-363.	Study design criteria not fulfilled.
158	Yue, P., Xu, G., Li, L., & Wang, S. (2014). Prevalence of musculoskeletal symptoms in relation to psychosocial factors. *Occup Med (Lond)*, *64*(3), 211-216.	Study design criteria not fulfilled.
159	Zamri, E. N., Hoe, V. C. W., & Moy, F. M. (2020). Predictors of low back pain among secondary school teachers in Malaysia: a longitudinal study. *Ind Health*, *58*(3), 254-264.	Outcome criteria not fulfilled.
160	Zarra, T., & Lambrianidis, T. (2014). Musculoskeletal disorders amongst Greek endodontists: a national questionnaire survey. *Int Endod J*, *47*(8), 791-801.	Study design criteria not fulfilled.
161	Zhang, D., & Huang, H. (2017). Prevalence of work-related musculoskeletal disorders among sonographers in China: results from a national web-based survey. *J Occup Health*, *59*(6), 529-541.	Study design criteria not fulfilled.
162	Zhang, M. Y., Bai, Z. Z., Zhao, X. F., Ieee, Ieee, & Dalian Univ Technol, F. I. E. D. C. M. D. P. R. C. (2017). Real-time Risk Assessment for Construction Workers' Trunk Posture Using Mobile Sensor. *International Conference on Robotics and Automation Sciences (ICRAS)*, 153-157.	Study design criteria not fulfilled.

Appendix 7. Associations between occupational exposures and chronic LBP

Author	Exposure	Outcome	Confounders	Categories of exposures	Results: Men – Measure of association	Men – 95% CI	Women – Measure of association	Women – 95% CI	Total – Measure of association	Total – 95% CI
Mechanical exposures										
Lifting/carrying loads										
Aghilinejad[33] 2015	*Lifting*: Duration of lifting >15 kg. during a work day measured by a five-point scale and dichotomised (N=185, 49 cases and 136 controls).	Self-reported chronic pain for ≥3 months.	Age, BMI, smoking, LBP history, family LBP history, education, shift working, job type, other physical and psychosocial factors.	- Low - High	1.0 OR 2.9 OR	- 1.2 – 6.9	- -	- -	- -	- -
Ahsan[34] 2013	*Lifting*: Lifting or carrying heavy objects (daily labourer, loader, construction worker) (N=28) compared to controls (N=56).	Lumbar disc herniation.	Matched on age, sex, and area of residence.	- No - Yes	- -	- -	- -	- -	1.00 OR 3.48 OR	- 1.84 – 6.59
Alhalabi[35] 2015	*Lifting*: Heavy objects (N=346).	Chronic low back pain lasting ≥3 months.	None.	- None - Non-daily - Daily	- - -	- - -	- - -	- - -	1.00 OR 0.92 OR 1.44 OR	- 0.44 – 1.93 0.68 – 3.05
Bergmann[36] 2017	*Lifting*: 10 dose models were applied comprising various thresholds for the lumbosacral compressive force, trunk inclination, or shift-related minimum threshold. Models consider loads 5 kg or more and trunk inclination from 20 to 90 degrees. The calculation includes frequency and duration of all handlings. A cumulative lifetime dose for the compressive force on the disc L5/S1 in kNh was computed (N=564 for LDH and N= 531 for SDN, whereas N=422 for controls).	Lumbar disc herniation (LDH) and severe disc narrowing (SDN).	Age, unemployment, work stress, trunk inclination, and study region.	LDH: - 0 to < 2.34*10^6 Nh - 2.34 to < 8.98*10^6Nh - ≥8.98*10^6Nh SDN: - 0 to < 2.34*10^6 Nh - 2.34 to < 8.98*10^6Nh - ≥8.98*10^6Nh	 1.0 OR 1.4 OR 2.2 OR 1.0 OR 1.7 OR 2.7 OR	 - 0.8 – 2.6 1.2 – 4.1 - 0.8 – 3.6 1.3 – 5.8	 - - - - - -	 - - - - - -	 - - - - - -	 - - - - - -
				LDH: - 0 - 0 to <1.58*10^6 Nh - 1.58 to <9.06 *10^6Nh - ≥9.06*10^6Nh SDN: - 0 - 0 to <1.58*10^6 Nh	 - - - - - -	 - - - - - -	 1.0 OR 0.8 OR 1.1 OR 1.1 OR 1.0 OR 1.2 OR	 - 0.4 – 1.8 0.5 – 2.5 0.5 – 2.5 - 0.4 – 3.5	 - - - - - -	 - - - - - -

				- 1.58 to <9.06 *10^6Nh - ≥9.06*10^6Nh	- -	- -	3.0 OR 2.0 OR	1.1 – 8.1 0.7 – 5.9	- -	- -
Esquirol[37] 2017	*Lifting*: Carrying heavy loads (N=1,130 for incidence).	Self-reported chronic LBP for ≥6 months. Incidence compared to non-chronic LBP group.	Sex, age, history of rheumatologically events., BMI, number of different jobs held, job changes, productivity-related income, and work recognition.	Incidence chronic LBP: - Never - Former - Current	 - - -	 - - -	 - - -	 - - -	 1.00 OR 1.12 OR 1.54 OR	 - 0.71 – 1.77 1.09 – 2.18
	Lifting: Carrying heavy loads (N= 430 for persistence).	Self-reported chronic LBP for ≥6 months. Persistence compared with participants with chronic LBP at baseline but no LBP at follow-up.	None.	Persistence chronic LBP: - Never - Former - Current	 - - -	 - - -	 - - -	 - - -	 1.00 OR 0.99 OR 1.11 OR	 - 0.61 – 1.62 0.72 – 1.73
Euro[38] 2019	*Lifting*: Lifting or carrying heavy objects – measured by typicality of working time (N=NS).	Hospitalisation of Sciatica classified by ICD-8/9/10 codes.	Age, sex, BMI, educational level, smoking, physical sedentary work, heavy work, awkward trunk postures, prolonged sitting, and whole-body vibration.	- No - Yes	- -	- -	- -	- -	1.00 HR 2.10 HR	- 1.35 – 3.26
Halonen[40] 2019	*Lifting*: Lifting at least 15 kg several times a day (N=12,222 for incident LBP and N=5,740 for recurrent LBP).	Self-reported LBP in the last 3 months divided into: - Incident LBP (free from LBP at baseline). - Recurrent LBP (LBP at baseline).	Age, sex, study survey, education, BMI, smoking, physical activity, depressive symptoms, and sleep problems.	Incident LBP: - None or < 1/4 of work time - 1/4 to 1/2 of work time - 3/4 of work time Recurrent LBP: - None or < 1/4 of work time - 1/4 to 1/2 of work time - 3/4 of work time	 - - - - - -	 - - - - - -	 - - - - - -	 - - - - - -	 1.00 RR 1.31 RR 1.52 RR 1.00 RR 1.08 RR 1.13 RR	 - 1.17 – 1.46 1.32 – 1.74 - 1.03 – 1.14 1.07 – 1.20
Herin[42] 2014	*Lifting*: exposure to carrying heavy loads (N=1,206, 787 men and 419 women).	Self-reported LBP for 6 months + clinical symptoms.	Age, sports participation, BMI, and social class.	- Low - High	1.00 OR 1.06 OR	- 0.88 – 1.28	1.00 OR 1.02 OR	- 0.77 – 1.35	- -	- -
Jansen[44] 2004	*Lifting*: Lifting and carrying loads over 10 kg. was taken as the average load for the entire occupational group. It was measured using observations on 212	Self-reported LBP with disability.	Trunk flexion between 20 to 45º, trunk flexion >45º, decision authority,	- 1 min/week - 5 min/week - 15 min/week - 30 min/week - 45 min/week	- - - - -	- - - - -	- - - - -	- - - - -	1.00 RR 1.05 RR 1.18 RR 1.33 RR 1.26 RR	- 0.94 – 1.17 0.79 – 1.77 0.60 – 2.95 0.38 – 4.20

	workers that were randomly selected at baseline with at least 10 workers representing each occupational group included in the study. Observations were made on selected workers every 20 seconds during four periods of 30 minutes each in one working day. For each occupation, the average exposure to each type of physical load was calculated as the mean percentage of time devoted to that activity (N=523).		skill discretion, and work demands.							
Latza[47] 2002	*Manual material handling*: Duration of laying 3DF lime stones weighing about 6-10 kg. was used as proxy measure for manual material handling (N=404 without CLBP at baseline and all workers N= 488).	Self-reported chronic LBP.	Age.	Without chronic LBP at baseline: - 0 h/shift - >0 – <2.0 h/shift - 2.0 – 8.5 h/shift All workers: - 0 h/shift - >0 – <2.0 h/shift - 2.0 – 8.5 h/shift	 1.00 PR 0.50 PR 2.89 PR 1.00 PR 1.13 PR 1.80 PR	 - 0.12 – 2.14 1.32 – 6.35 - 0.59 – 2.16 1.04 – 3.14	 - - - - - -	 - - - - - -	 - - - - - -	 - - - - - -
	Manual material handling: Duration of laying 2DF lime stones weighing about 4 - 6.5 kg. was used as proxy measure for manual material handling (N=404 without CLBP at baseline and all workers N= 488).	Self-reported chronic LBP.	Age.	Without chronic LBP at baseline: - 0 h/shift - >0 – <2.0 h/shift - 2.0 – 8.5 h/shift All workers: - 0 h/shift - >0 – <2.0 h/shift - 2.0 – 8.5 h/shift	 1.00 PR 0.87 PR 1.98 PR 1.00 PR 0.78 PR 1.45 PR	 - 0.29 – 2.57 0.80 – 4.89 - 0.39 – 1.54 0.80 – 2.62	 - - - - - -	 - - - - - -	 - - - - - -	 - - - - - -
	Stone load: Assessed by the sum of average stone mass for each type of brick or stone multiplied by hours per day working with that stone type (N=404 without CLBP at baseline and all workers N= 488).	Self-reported chronic LBP.	Age.	Without chronic LBP at baseline: - Low - Medium - High All workers: - Low - Medium - High	 1.00 PR 0.57 PR 2.10 PR 1.00 PR 0.63 PR 1.44 PR	 - 0.17 – 1.96 0.95 –4.65 - 0.31 – 1.30 0.85 – 2.46	 - - - - - -	 - - - - - -	 - - - - - -	 - - - - - -
Matsudaira[49] 2015	*Manual materials handling*: Measured by manual handling of 20 kg objects (N=171).	Self-reported LBP interfering with work for ≥3 months.	None.	- No manual handling - Manual handling of <20 kg objects - Manual handling of ≥20 kg objects	- - -	- - -	- - -	- - -	1.00 OR 1.40 OR 1.84 OR	- 0.43 – 4.50 0.72 – 4.72

Matsudaira[48] 2014	*Lifting*: Measured by frequency dichotomized by half the day (N=1,675).	Self-reported LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking, and education	- Infrequent	-	-	-	-	1.00 OR	-
				- Frequent	-	-	-	-	2.81 OR	1.18 – 6.66
	Manual materials handling: Measured by manual handling of materials at work defined as 20 kg. objects or working as a caregiver (N=1,675).	Self-reported LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking, and education	- Manual handling of <20 kg. objects including desk work	-	-	-	-	1.00 OR	-
				- Manual handling of ≥20 kg. objects or working as a caregiver	-	-	-	-	2.70 OR	1.98 – 8.67
Matsudaira[50] 2019	*Lifting*: Lifting weights of more than 25 kg by hand (N=196).	Self-reported LBP interfering with work for ≥3 months.	None.	- No	-	-	-	-	1.00 OR	-
				- Yes	-	-	-	-	0.89 OR	0.39 – 2.07
Seidler[56] 2003	*Cumulated lifting/carrying*: Was measured by the squares of the weights lifted or carried at work, multiplied by the corresponding durations and summed (N=152 controls and 129 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, and other disease of the lumbar spine.	- 0 kg^2 * hours	1.0 OR	-	-	-	-	-
				- >0–10 000 kg^2 * hours	2.3 OR	0.9 – 5.6	-	-	-	-
				- >10 000–150 000 kg^2 * hours	5.4 OR	2.3 – 12.6	-	-	-	-
				- >150 000 kg^2 * hours	8.5 OR	3.8 – 19.1	-	-	-	-
Seidler[57] 2009	*Manual materials handling*: Assessed by a two-step procedure. 1) A standardised computer-assisted interview identifying subjects that exceeded a certain minimum workload, 2) Comprehensive semi-standardised interview by ergonomic expert with those exceeding minimum workloads. Quantification of compressive force on the lumbosacral disc assessed with a biomechanical tool (N=453 for men with LDH, and N= 145 for men with LDN. N=448 for women with LDH and N=206 for LDN).	Lumbar disc herniation and lumbar disc narrowing.	Men, LDH: Adjusted for age, region, unemployment and Intensive-load postures. Men, LDN: Adjusted for age, region, and intensive-load postures. Women: Adjusted for age, region psychosocial workload and intensive-load postures.	LDH:						
				- 0-<5.0*10^6 Nh	1.0 OR	-	-	-	-	-
				- 5.0–<21.51*10^6 Nh	1.2 OR	0.7 – 2.0	-	-	-	-
				- ≥21.51*10^6 Nh	2.0 OR	1.2 – 3.5	-	-	-	-
				LDN:						
				- 0-<5.0*10^6 Nh	1.0 OR	-	-	-	-	-
				- 5.0–<21.51*10^6 Nh	1.3 OR	0.7 – 2.6	-	-	-	-
				- ≥21.51*10^6 Nh	2.4 OR	1.2 – 4.6	-	-	-	-
				LDH:						
				- 0 Nh	-	-	1.0 OR	-	-	-
				- 0 – <1.58*10^6 Nh	-	-	0.8 OR	0.4 – 1.6	-	-
				- 1.58 – <9.06*10^6 Nh	-	-	1.0 OR	0.5 – 1.9	-	-
				- >9.06*10^6 Nh	-	-	0.8 OR	0.4 – 1.6	-	-
				LDN:						
				- 0 Nh	-	-	1.0 OR	-	-	-
				- 0 – <1.58*10^6 Nh	-	-	1.3 OR	0.5 – 3.3	-	-
				- 1.58 – <9.06*10^6 Nh	-	-	3.0 OR	1.3 – 6.8	-	-
				- >9.06*10^6 Nh	-	-	1.9 OR	0.8 – 4.4	-	-
Seyedmehdi[59] 2016	*Heavy Physical load*: Was measured by the question: "Do you frequently carry heavy stuff?" (N=511).	Self-reported LBP lasting >3 months.	None.	- No	-	-	-	-	1.00 OR	-
				- Yes	-	-	-	-	2.35 OR	1.51 – 3.64
Tubach[62] 2004	*Carrying loads*: Was measured by carrying loads of >10 kg. (N=409).	Sciatica	Sex, driving, home repair, visit to a medical practitioner, sick leave, pain intensity, psychosomatic	- Never	-	-	-	-	1.00 OR	-
				- <Once a week	-	-	-	-	1.74 OR	1.02 – 2.96
				- >Once a week	-	-	-	-	1.22 OR	0.69 – 2.19
				- Everyday	-	-	-	-	1.49 OR	0.79 – 2.83

			score, depression score, job satisfaction, long lasting LBP in 1991, sciatica in 1990.							

Awkward postures

Aghilinejad[33] 2015	*Awkward postures*: Duration of awkward back posture during a work day measured by five-point scale and dichotomised (N=185, 49 cases and 136 controls).	Self-reported chronic pain for ≥3 months.	None	- Low	1.00 OR	-	-	-	-	-
				- High	1.35 OR	0.68 – 2.68	-	-	-	-
Ahsan[34] 2013	*Bending/twisting*: Occupations involving bending and twisting postural work load isolated or combined with other factors (N=98) compared with controls (N=60).	Lumbar disc herniation.	Matched on age, sex, and area of residence.	- No	-	-	-	-	1.00 OR	-
				- Yes	-	-	-	-	1.77 OR	0.83 – 3.78
Alhalabi[35] 2015	*Awkward positions*: Bending (N=137).	Chronic low back pain lasting ≥3 months.	None	- None	-	-	-	-	1.0 OR	-
				- Bending	-	-	-	-	2.3 OR	0.73 – 7.63
Bergmann[36] 2017	*Trunk inclination*: 10 dose models were applied comprising various thresholds for the lumbosacral compressive force, trunk inclination, or shift-related minimum threshold. Models consider loads 5 kg or more and trunk inclination from 20 to 90 degrees. The calculation includes frequency and duration of all handlings. A cumulative lifetime dose for the compressive force on the disc L5/S1 in kNh was computed (N=564 for LDH and N= 531 for SDN, whereas N=422 for controls).	Lumbar disc herniation (LDH) and severe disc narrowing (SDN).	Age, unemployment, work stress, manual materials handling, and study region.	LDH:						
				- 0 Nh	1.0 OR	-	-	-	-	-
				- >0 to <4.85*10^6Nh	1.1 OR	0.6 – 2.1	-	-	-	-
				- 4.85 to 14.62*10^6Nh	1.7 OR	0.8 – 3.4	-	-	-	-
				- ≥14.62*10^6Nh	2.4 OR	1.2 – 5.0	-	-	-	-
				SDN:						
				- 0 Nh	1.0 OR	-	-	-	-	-
				- >0 to <4.85*10^6Nh	1.6 OR	0.7 – 3.6	-	-	-	-
				- 4.85 to 14.62*10^6Nh	1.6 OR	0.7 – 3.6	-	-	-	-
				- ≥14.62*10^6Nh	2.1 OR	0.9 – 4.9	-	-	-	-
				LDH:						
				- 0 Nh	-	-	1.0 OR	-	-	-
				- >0 to <2.77*10^6Nh	-	-	2.7 OR	1.2 – 6.3	-	-
				- 2.77 to 8.83*10^6Nh	-	-	2.6 OR	1.2 – 6.0	-	-
				- ≥8.83*10^6Nh	-	-	3.7 OR	1.6 – 8.6	-	-
				SDN:						
				- 0 Nh	-	-	1.0 OR	-	-	-
				- >0 to <2.77*10^6Nh	-	-	1.2 OR	0.4 – 3.7	-	-
				- 2.77 to 8.83*10^6Nh	-	-	1.2 OR	0.4 – 3.2	-	-
				- ≥8.83*10^6Nh	-	-	1.6 OR	0.6 – 4.5	-	-

Esquirol[37] 2017	*Awkward postures*: Classified into three modalities (N= 1,130 for incidence and N=430 for persistence).	Self-reported chronic pain for ≥6 months. Incidence compared to non-chronic LBP and persistence compared to non-persistence group.	None.	Incidence chronic LBP:						
				- Never	-	-	-	-	1.00 OR	-
				- Former	-	-	-	-	1.20 OR	0.76 – 1.90
				- Current	-	-	-	-	1.30 OR	0.96 – 1.76
				Persistence chronic LBP:						
				- Never	-	-	-	-	1.00 OR	-
				- Former	-	-	-	-	1.41 OR	0.81 – 2.44
				- Current	-	-	-	-	1.11 OR	0.73 – 1.68
Euro[38] 2019	*Awkward postures*: Measured by typicality of awkward trunk postures at work (N=NS).	Hospitalisation of Sciatica classified by ICD-8/9/10 codes.	Age, sex, BMI, educational level, smoking, physical sedentary work, heavy work, lifting, prolonged sitting, and whole-body vibration.	- No	-	-	-	-	1.00 HR	-
				- Yes	-	-	-	-	0.68 HR	0.43 – 1.03
Halonen[40] 2019	*Twisting*: Working in twisted, bent, or otherwise unsuitable positions (N= 12,222 for incident LBP and N=5,740 for recurrent LBP).	Self-reported LBP during the last 3 months divided into: - Incident LBP (free from LBP at baseline). - Recurrent LBP (LBP at baseline).	Age, sex, study survey, education, BMI, smoking, physical activity, depressive symptoms, and sleep problems.	Incident LBP:						
				- None or < 1/4 of working time	-	-	-	-	1.00 RR	-
				- 1/4 to 1/2 of working time	-	-	-	-	1.22 RR	1.11 – 1.34
				- 3/4 of working time	-	-	-	-	1.52 RR	1.37 – 1.70
				Recurrent LBP:						
				- None or < 1/4 of working time	-	-	-	-	1.00 RR	-
				- 1/4 to 1/2 of working time	-	-	-	-	1.10 RR	1.05 – 1.16
				- 3/4 of working time	-	-	-	-	1.19 RR	1.07 – 1.20
Herin[42] 2014	*Postures*: exposed to long, difficult working positions and/or awkward postures (N=1,206, 787 men and 419 women).	Self-reported LBP for ≥6 months.	Age, sports participation, BMI, and social class.	- Low	1.00 OR	-	1.00 OR	-	-	-
				- High	1.19 OR	1.01 – 1.39	1.33 OR	1.07 – 1.64	-	-
Jansen[44] 2004	*Postures*: Trunk flexion (20-45º) was taken as the average for the entire occupational group. Observations were made on selected workers every 20 seconds during four periods of 30 minutes each in one working day. For each occupation, the average exposure to each type of physical load was calculated as the mean percentage of time devoted to that activity (N=523).	Self-reported LBP with disability.	Trunk flexion between >45º, and lifting/carrying loads >10 kg, decision authority, skill discretion, and work demands.	- 2 h/week	-	-	-	-	1.00 RR	-
				- 3 h/week	-	-	-	-	0.95 RR	0.53 – 1.72
				- 4 h/week	-	-	-	-	0.90 RR	0.28 – 2.87
				- 5 h/week	-	-	-	-	0.83 RR	0.22 – 3.18
				- 6 h/week	-	-	-	-	0.80 RR	0.19 – 3.32
	Postures: Trunk flexion (>45º) was taken as the average for the entire occupational group. Observations were made on selected workers every 20 seconds during four periods of 30 minutes each in one	Self-reported LBP with disability.	Trunk flexion between 20 to 45º, trunk flexion >45º, and lifting/carrying loads >10 kg,	- 30 min./week	-	-	-	-	1.00 RR	-
				- 45 min./week	-	-	-	-	1.31 RR	1.03 – 1.65
				- 1 h/week	-	-	-	-	1.71 RR	1.08 – 2.72
				- 1 h and 30 min/week	-	-	-	-	2.82 RR	1.16 – 6.86
				- 1 h and 45 min./week	-	-	-	-	3.18 RR	1.13 – 9.00

	working day. For each occupation, the average exposure to each type of physical load was calculated as the mean percentage of time devoted to that activity (N=523).		decision authority, skill discretion, and work demands.							
Matsudaira[49] 2015	*Bending:* Was measured by bending more than half of the day (N=169).	LBP interfering with work for ≥3 months.	None.	- Not frequent - Frequent	- -	- -	- -	- -	1.00 OR 1.40 OR	- 0.58 – 3.40
	Twisting: Was measured by twisting more than half of the day (N=168).	LBP interfering with work for ≥3 months.	None.	- Not frequent - Frequent	- -	- -	- -	- -	1.00 OR 1.24 OR	- 0.42 – 3.65
Matsudaira[48] 2014	*Bending*: ≥half of the day was considered frequent (N=1,675).	LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking, and education.	- Infrequent - Frequent	- -	- -	- -	- -	1.00 OR 3.45 OR	- 1.54 – 7.72
	Twisting: ≥half of the day was considered frequent (N=1,675).	LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking, and education.	- Infrequent - Frequent	- -	- -	- -	- -	1.00 OR 4.35 OR	- 1.80 – 10.52
Matsudaira[50] 2019	*Twist back/stoop*: Ergonomic work demands in an average working day (N=197).	Self-reported LBP interfering with work for ≥3 months .	None.	- <4 hours/day - ≥4 hours/day	- -	- -	- -	- -	1.00 OR 1.25 OR	- 0.58 – 2.69
Seidler[56] 2003	*>90 degrees' trunk flexion forward bending*: working postures with extreme forward bending was calculated by the force on the lumbar spine at L5/S1 as Force=1,700 Newton. It was assessed with cumulated hours spent in working postures with extreme forward bending calculated up to the year of diagnosis (N=183 controls and 128 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, and other disease of the lumbar spine.	- 0 hours: - >0 – 1500 hours - >1500 hours	1.0 OR 2.7 OR 4.5 OR	- 1.5 – 5.1 2.2 – 9.3	- - -	- - -	- - -	- - -
Seidler[57] 2009	*Intensive-load postures*: Postures without object handling. Assessed by a two-step procedure. 1) A standardised computer-assisted interview identifying subjects that exceeded a certain minimum workload, 2) Comprehensive semi-standardised interview by ergonomic expert with those exceeding minimum workloads. Quantification of compressive force on the lumbosacral disc assessed with a biomechanical tool (N=453 for men with LDH, and N= 145 for men with LDN. N=448 for women with LDH and N=206 for LN).	Lumbar disc herniation and lumbar disc narrowing.	Men: Adjusted for age, region, and unemployment. Women: Adjusted for age, region psychosocial workload and intensive-load postures.	Men, LDH: - 0 Nh - >0 – <4.85*10^6Nh - 4.85 – 14.62 *10^6Nh - ≥14.62*10^6Nh Men, LDN: - 0 Nh - >0 – <4.85*10^6Nh - 4.85 – 14.62 *10^6Nh - >14.62*10^6Nh Women, LDH: - 0 Nh - >0 – <2.77*10^6Nh - 2.77 – 8.83 *10^6Nh - ≥8.83*10^6Nh Women, LDN: - 0 Nh - >0 – <2.77*10^6Nh	 1.0 OR 1.1 OR 1.7 OR 1.9 OR 1.0 OR 1.3 OR 1.4 OR 1.4 OR - - - - - -	 - 0.6 – 2.0 0.9 – 3.2 1.0 – 3.5 - 0.6 – 2.6 0.7 – 2.9 0.7 – 2.9 - - - - - -	 - - - - - - - - 1.0 OR 1.9 OR 2.4 OR 3.2 OR 1.0 OR 0.7 OR	 - - - - - - - - - 1.0 – 3.7 1.2 – 4.6 1.6 – 6.3 - 0.3 – 1.7	 - - - - - - - - - - - - - -	 - - - - - - - - - - - - - -

				- 2.77 – 8.83 *10^6Nh - ≥ 8.83*10^6Nh	- -	- -	0.8 OR 1.1 OR	0.3 – 1.9 0.5 – 2.7	- -	- -

Whole-body vibrations

Aghilinejad[33] 2015	Whole-body vibrations: Duration of whole-body vibration in a work day measured on a five-point scale and dichotomised (N=185, 49 cases and 136 controls).	Self-reported chronic pain for ≥3 months.	None.	- Low - High	1.00 OR 1.69 OR	- 0.79 – 3.59	- -	- -	- -	- -
Ahsan[34] 2013	*Vibrations*: Driver and machine operator involving causal exposure to vibration (N=20) compared to controls (N=46).	Lumbar disc herniation.	Matched on age, sex, and area of residence.	- No - Yes	- -	- -	- -	- -	1.00 OR 1.58 OR	- 0.67 – 3.72
Bergmann[36] 2017	Whole-body vibrations: 10 dose models were applied comprising various thresholds for the lumbosacral compressive force, trunk inclination, or shift-related minimum threshold. The calculation includes frequency and duration of all handlings. A cumulative lifetime dose for the compressive force on the disc L5/S1 in kNh was computed. For WBV, horizontal and vertical direction was considered. (N=564 for LDH and N= 531 for SDN, whereas N=422 for controls).	Lumbar disc herniation (LDH) and severe disc narrowing (SDN).	Age, unemployment, work stress, manual materials handling, and study region.	LDH: - 0, (m/s^2)^2 - >0 to <364 (m/s^2)^2 - 364 to <1190(m/s^2)^2 - ≥1190(m/s^2)^2 SDN: - 0, (m/s^2)^2 - >0 to <364 (m/s^2)^2 - 364 to <1190(m/s^2)^2 - ≥1190(m/s^2)^2	 1.0 OR 1.6 OR 0.7 OR 1.8 OR 1.0 OR 1.1 OR 1.0 OR 6.3 OR	 - 0.5 – 4.9 0.3 – 1.6 0.4 – 9.0 - 0.3 – 4.3 0.4 – 2.6 1.3 – 30.8	 - - - - - - - -	 - - - - - - - -	 - - - - - - - -	 - - - - - - - -
Euro[38] 2019	*Vibrations*: Shaking of the whole-body or use of vibrating equipment – measured by typicality of working time (N=NS).	Hospitalisation of Sciatica classified by ICD-8/9/10 codes.	Age, sex, BMI, educational level, smoking, physical sedentary work, heavy work, awkward trunk postures, lifting, and prolonged sitting.	- No - Yes	- -	- -	- -	- -	1.00 HR 1.61 HR	- 0.95 – 2.72
Herin[42] 2014	Vibrations: Exposure to considerable vibrations and/or exposure to jolts (N=1,206, 787 males and 419 female).	Self-reported LBP for ≥6 months.	Age, sports participation, BMI, and social class.	- Low - High	1.00 OR 1.00 OR	- 0.85 – 1.18	1.00 OR 1.73 OR	- 1.01 – 3.01	 - -	 - -
Seidler[56] 2003	*Whole-body vibration*: Was measured by showing illustrated tables of possible vehicles and classified into smooth asphalt	Lumbar disc herniation combined with	Age, region, nationality, other disease of the lumbar spine, and	- 0 hours - >0 – 1500 hours - >1500 hours Weighted factor for type of terrain:	1.0 OR 0.9 OR 1.2 OR	- 0.5 – 1.9 0.5 – 2.7	- - -	- - -	- - -	- - -

	(factor 0), damaged asphalt (factor 1), cobbled streets (2), and rough terrain (3) (N=193 controls and 129 cases).	osteochondrosis/spondylosis.	sum lumbar spine force through lifting/carrying and/or extreme forward bending.	- 0 hours - >0 – 1800 hours * weighing factor - >1800 hours * weighing factor	1.0 OR 1.3 OR 1.2 OR	- 0.6 – 2.9 0.5 – 2.7	- - -	- - -	- - -	- - -
Wahlström[64] 2018	*Whole-body vibrations*: Using a Job-exposure-matrix, whole-body vibration was graded on a 0-5 scale assessed as mean daily exposure. Referent group included foremen and white-collar workers (N=288,926).	Lumbar disc herniation.	Age, height, weight, and smoking.	- Ref. - None/low exposure - Medium/high exposure	1.00 RR 1.23 RR 1.35 RR	- 1.08-1.39 1.12-1.63	- - -	- - -	- - -	- - -
Standing/walking										
Alhalabi[35] 2015	*Standing*: Prolonged standing was measured by if it is the most of the working time compared to "no awkward position" (N=911).	Chronic low back pain lasting ≥3 months.	None.	- None - Prolonged	- -	- -	- -	- -	1.00 OR 1.69 OR	- 0.98 – 2.92
Euro[38] 2019	*Standing*: Prolonged standing was measured by continuous or almost continuous standing typical for one's work (N=3,891).	Hospitalisation of sciatica classified by ICD-8/9/10 codes.	Age and sex.	- No - Yes	- -	- -	- -	- -	1.00 HR 1.01 HR	- 0.70 – 1.45
Heuch[43] 2017	*Physical activity*: Occupational exposures was measured by physical activity at work divided into four categories (N=14,915).	Self-reported LBP in ≥3 months.	Age, leisure time activity, BMI, smoking, education, and occupational category.	- Sedentary work - Walking at work and no heavy lifting	1.00 RR 0.96 RR	- 0.82 – 1.13	1.00 RR 1.11 RR	- 0.97 – 1.26	- -	- -
Matsudaira[50] 2019	*Standing*: Standing was measured by hours standing in an average working day (N=196).	LBP interfering with work for ≥3 months.	None.	- <4 hours/day - ≥4 hours/day	- -	- -	- -	- -	1.00 OR 1.06 OR	- 0.47 – 2.38
Seyedmehdi[59] 2016	*Standing position in shift work*: Assessed by asking "what is your working postures most of the time?" with answers 1) always standing, 2) sometimes seated sometimes standing and 3) always standing (N=511).	Self-reported LBP lasting ≥3 months.	None.	- Sometimes -Always					1.00 OR 1.25 OR	- 0.88 – 1.78
Vieira[63] 2018	*Seated vs. standing*: Measured by if the participant worked seated or standing (N=184, 88 cases and 96 controls).	Disc degeneration.	Age and sex.	- Seated - Standing	- -	- -	- -	- -	1.00 OR 0.38 OR	- 0.17 – 0.84

Sitting										
Aghilinejad[33] 2015	*Sitting*: Duration of sustained sitting in a work day measured on a five-point scale and dichotomised (N=185, 49 cases and 136 controls).	Self-reported chronic pain for ≥3 months.	None.	- Low - High	1.000 OR 1.237 OR	- 0.64 – 2.39	- -	- -	- -	- -
Ahsan[34] 2013	*Sitting or standing*: Jobs that are performed in sitting or standing postures (employee in public, private, professionals, and students) cases (N=46) compared to controls (N=68).	Lumbar disc herniation.	Matched on age, sex, and area of residence.	- No - Yes	- -	- -	- -	- -	1.00 OR 0.78 OR	- NS
Alhalabi[35] 2015	*Sitting*: Prolonged sitting was measured by if it is the most of the working time compared to "no awkward position" (N=911).	Chronic low back pain lasting ≥3 months.	Age.	- None - Prolonged	- -	- -	- -	- -	1.00 OR 1.99 OR	- 1.18 – 3.36
Euro[38] 2019	*Sitting*: Prolonged sitting was measured by continuous or almost continuous sitting typical for one's work (N=NS).	Hospitalisation of sciatica classified by ICD-8/9/10 codes.	Age, sex, BMI, educational level, smoking, physical sedentary work, heavy work, awkward trunk postures, lifting, and whole-body vibration.	- No - Yes	- -	- -	- -	- -	1.00 HR 1.14 HR	- 0.76 – 1.71
Matsudaira[49] 2015	*Desk work*: Sitting was measured by hours of desk work (≥half of the day as frequent) (N=167).	LBP interfering with work for ≥3 months.	None.	- Not frequent - Frequent	- -	- -	- -	- -	1.00 OR 0.74 OR	- 0.30 – 1.81
Matsudaira[48] 2014	*Desk work*: Was measured by hours of desk work longer than 6 hours per day (N=1,675).	LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking habits, education, and manual handling of materials at work.	- <6 hours/day - ≥6 hours/day	- -	- -	- -	- -	1.00 OR 0.66 OR	- 0.31 – 1.40
Picavet[54] 2016	*Sitting*: workers were divided into stable sitters or stable non sitters based on the characterization of their job (N=1,509).	Self-reported chronic pain for ≥3 months.	Age, sex, education, working hours, smoking, complying with physical activity guideline, leisure time sitting, mental health, BMI, hypertension, and hypercholesterolemia.	- Non-stable sitters - Stable sitters	- -	- -	- -	- -	1.00 OR 1.17 OR	- 0.83 – 1.65

Seidler[56] 2003	*Cumulative sedentary work*: Referring to the Nordic Questionnaire, sedentary work was measured in hours (N=182 controls and 129 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, other disease of the lumbar spine, and sum lumbar spine force through lifting/carrying and/or extreme forward bending.	- ≤10,000 hours - >10,000-30.000 hours - >30,000 hours	1.0 OR 0.6 OR 1.0 OR	- 0.2 – 1.0 0.4 – 2.5	- - -	- - -	- - -	- - -

Kneeling/squatting

Matsudaira[50] 2019	*Kneel/squat*: Measured by kneel/squat during an average work day (N=197).	LBP interfering with work for ≥3 months.	None.	- <1 hour - ≥1 hour	- -	- -	- -	- -	1.00 OR 0.76 OR	- 0.36 – 1.57

Pushing/pulling

Matsudaira[48] 2014	*Pushing*: Was measured by frequency of a working day considering half of the day as frequent (N=1,675).	LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking habits, and education.	- Infrequent - Frequent	- -	- -	- -	- -	1.00 OR 3.48 OR	- 1.24 – 9.76
Prado-Leon[55] 2014	*Pushing/pulling*: Measured by jobs that subjects had performed in the past involving pushing/pulling (N=231, 77 cases and 154 controls).	Spondyloarthrosis.	Lifting, carrying, and driving.	- No - Yes	- -	- -	- -	- -	1.0 OR 2.4 OR	- 1.1 – 4.7
	Pushing/pulling: Former jobs working with pushing/pulling measured by weight of load (kg.) when pushing/pulling (N=231, 77 cases and 154 controls).	Spondyloarthrosis.	Lifting, carrying, and driving.	- 0 - 20-60 kg. - >60-500 kg.	- - -	- - -	- - -	- - -	1.0 OR 1.7 OR 2.9 OR	- 0.6 – 4.8 1.2 – 7.3
	Pushing/pulling: Hours spent daily on work with pushing/pulling in formers jobs (N=231, 77 cases and 154 controls).	Spondyloarthrosis.	Lifting, carrying, and driving.	- 0 - 1-7 hours - >7-10 hours	- - -	- - -	- - -	- - -	1.0 OR 2.0 OR 2.6 OR	- 0.7 – 6.0 1.0 – 7.4
	Pushing/pulling: Time spent pushing/pulling in former jobs measured by months and years (N=231, 77 cases and 154 controls).	Spondyloarthrosis.	Lifting, carrying, and driving.	- 0-9 months - 1 year and 8 m. to 9 years - 10-32 years	- - -	- - -	- - -	- - -	1.0 OR 2.3 OR 1.9 OR	- 0.8 – 6.5 0.7 – 5.2
	Pushing/pulling: Frequency of pushing/pulling was measured by 25 or more times per day (N=231, 77 cases and 154 controls).	Spondyloarthrosis.	Lifting, carrying, and driving.	- No - Yes	- -	- -	- -	- -	1.0 OR 2.7 OR	- 0.8 – 8.8

	Pushing/pulling: Daily job frequency performing tasks of pushing/pulling was measured by yes or no (N=231, 77 cases and 154 controls).	Spondyloarthrosis.	Lifting, carrying, and driving.	- No	-	-	-	-	1.0 OR	-
				- Yes	-	-	-	-	3.7 OR	1.4 – 9.5

Combined exposures

Ahsan[34] 2013	*Effort*: The physical effort exerted at work (N=200 cases and 200 controls).	Lumbar disc herniation.	Matched on age, sex, and area of residence.	- Sedentary or minimal	-	-	-	-	0.43 OR	NS
				- Moderate	-	-	-	-	1.68 OR	NS
				- Hard	-	-	-	-	3.14 OR	NS
Bergmann[36] 2017	*Lumbar load and/or trunk inclination*: 10 dose models were applied comprising various thresholds for the lumbosacral compressive force, trunk inclination, or shift-related minimum threshold. Models consider loads 5 kg or more and trunk inclination from 20 to 90 degrees. The calculation includes frequency and duration of all handlings. A cumulative lifetime dose for the compressive force on the disc L5/S1 in kNh was computed (N=564 for LDH and N= 531 for SDN, whereas N=422 for controls).	Lumbar disc herniation (LDH) and severe disc narrowing (SDN).	Age, unemployment, work stress, manual materials handling, and study region.	LDH:						
				- 0 to <5.0*10^6Nh	1.0 OR	-	-	-	-	-
				- 5.0 to <21.51*10^6 Nh	1.9 OR	1.1 – 3.0	-	-	-	-
				- >21.51*10^6Nh	3.7 OR	2.3 – 6.0	-	-	-	-
				SDN:						
				- 0 to <5.0*10^6Nh	1.0 OR	-	-	-	-	-
				- 5.0 to <21.51*10^6 Nh	1.9 OR	1.0 – 3.7	-	-	-	-
				- >21.51*10^6Nh	4.1 OR	2.2 – 7.6	-	-	-	-
				LDH:						
				- 0 Nh	-	-	1.0 OR	-	-	-
				- >0 to <4.04*10^6Nh	-	-	2.2 OR	1.3 – 3.8	-	-
				- 4.04 to <14.47*10^6 Nh	-	-	3.6 OR	2.1 – 6.1	-	-
				- >14.47*10^6Nh	-	-	3.5 OR	2.0 – 5.9	-	-
				SDN:						
				- 0 Nh	-	-	1.0 OR	-	-	-
				- >0 to <4.04*10^6Nh	-	-	1.5 OR	0.8 – 3.0	-	-
				- 4.04 to <14.47*10^6 Nh	-	-	3.6 OR	1.9 – 6.8	-	-
				- >14.47*10^6Nh	-	-	3.3 OR	1.8 – 5.9	-	-
Euro[38] 2019	*Physical strenuousness of work*: Classified in six categories by the physical strenuousness of the participants' work (N=3,891).	Hospitalisation of sciatica classified by ICD-8/9/10 codes.	Age and sex.	- Light sedentary	-	-	-	-	1.00 HR	-
				- Other sedentary	-	-	-	-	2.72 HR	1.36 – 5.44
				- Physically light	-	-	-	-	1.78 HR	1.06 – 3.02
				- Fairly light/medium heavy	-	-	-	-	1.46 HR	0.86 – 2.50
				- Heavy	-	-	-	-	0.92 HR	0.49 – 1.75
				- Very heavy	-	-	-	-	0.57 HR	0.17 – 1.90
	Physical strenuousness of work: Classified in six categories by the physical strenuousness of the participants work and then dichotomised by collapsing "Other sedentary work", "physically light work" and "Fairly light/medium heavy work" vs. all other categories (N=NS).	Hospitalisation of sciatica classified by ICD-8/9/10 codes.	Age, sex, BMI, educational level, smoking, heavy work, awkward trunk postures, prolonged sitting, and whole-body vibration.	- All other categories	-	-	-	-	1.00 HR	-
				- Other sedentary work, physically light work and fairly light/medium heavy work	-	-	-	-	1.57 HR	1.05 – 2.34

	Physical strenuousness of work: Classified in six categories by the physical strenuousness of the participants work and then dichotomised by collapsing “Heavy” and “Very heavy” work vs. all other categories (N=NS).	Hospitalisation of sciatica classified by ICD-8/9/10 codes.	Age, sex, BMI, educational level, smoking, awkward trunk postures, prolonged sitting, and whole-body vibration.	- All other categories - Heavy work and very heavy work					1.00 HR 0.48 HR	- 0.26 – 0.89
Heuch[43] 2017	*Physical activity*: Occupational exposures was measured by physical activity at work divided into four categories (N=14,915).	Self-reported LBP in ≥3 months.	Age, leisure time activity, BMI, smoking, education, and occupational category.	- Sedentary work - Walking at work and heavy lifting - Particularly strenuous physical work	1.00 RR 1.08 RR 1.22 RR	- 0.90 – 1.29 1.01 – 1.49	1.00 RR 1.21 RR 1.24 RR	- 1.06 – 1.38 0.92 – 1.67	- - -	- - -
Jørgensen[45] 2013	*Workload*: Was measured by from one question addressing ergonomic load to the back “is your work a) sedentary, b) slightly physical without lifting, c) physical with some lifting, or d) hard physical with heavy lifting, shovelling, or the like?” with the two first categories condensed (N=3,734).	Hospitalisation for lumbar disc disease.	Age.	- Low - Medium - High	1.00 HR 1.54 HR 2.80 HR	- 0.83 – 2.84 0.87 – 9.00	- - -	- - -	- - -	- - -
	Strenuous work: was measured by the question: “do you perform strenuous work (regularly resulting in sweating)?” (N=3,761).	Hospitalisation for lumbar disc disease.	Age, height, weight, and physical fitness.	- Seldom/never - Occasionally - Often	1.00 HR 2.37 HR 3.91 HR	- 1.36 – 4.13 1.82 – 8.38	- - -	- - -	- - -	- - -
Sørensen[61] 2011	*Physical workload*: Was measured by one question addressing ergonomic load to the back “is your work a) sedentary, b) slightly physical without lifting, c) physical with some lifting, or d) hard physical with heavy lifting, shovelling, or the like?” with the two first categories condensed (N=3,724).	Hospitalisation for lumbar disc disease.	Age.	- Low - Medium - High	1.00 HR 1.54 HR 2.80 HR	- 0.83 – 2.84 0.87 – 9.00	- - -	- - -	- - -	- - -
	Strenuous workload: Was measured by the question “Do you perform strenuous work (regularly resulting in sweating)?” (N=3,761).	Hospitalisation for lumbar disc disease.	Age, height, and weight.	- Seldom/never - Occasionally - Often	1.00 HR 2.37 HR 3.90 HR	- 1.36 – 4.12 1.82 – 8.38	- - -	- - -	- - -	- - -
Seidler[58] 2011	*Manual materials handling and/or intensive-load postures*: Assessed by a two-step procedure. 1) A standardised computer-assisted interview identifying subjects that exceeded a certain minimum workload, 2) Comprehensive semi-	Lumbar disc narrowing.	Men adjusted for region Females adjusted for region and psychosocial workload	Men - 0-<5.0*10^6 Nh - 5.0–<21.51*10^6 Nh - ≥21.51*10^6 Nh Women - 0 Nh - >0–<4.04*10^6 Nh	 1.0 OR 1.5 OR 3.1 OR - -	 - 0.9 – 2.8 1.8 – 5.2 - -	 - - - 1.0 OR 1.2 OR	 - - - - 0.7 – 2.2	 - - - - -	 - - - - -

	standardised interview by ergonomic expert with those exceeding minimum workloads. Quantification of compressive force on the lumbosacral disc assessed with a biomechanical tool (N=598 men and N=654 women).			- 4.04–<14.47*10^6 Nh	-	-	2.4 OR	1.4 – 4.1	-	-
				- ≥14.47*10^6 Nh	-	-	2.0 OR	1.2 – 3.3	-	-
Seidler[57] 2009	*Manual materials handling and/or intensive-load postures*: Assessed by a two-step procedure. 1) A standardised computer-assisted interview identifying subjects that exceeded a certain minimum workload, 2) Comprehensive semi-standardised interview by ergonomic expert with those exceeding minimum workloads. Quantification of compressive force on the lumbosacral disc assessed with a biomechanical tool (N=884 men and N=932 women).		Men, LDH: adjusted for age, region, and unemployment as severe life events	LDH:						
				- 0 to <5.0*10^6Nh	1.0 OR	-		-	-	-
				- 5.0 to <21.51*10^6 Nh	1.7 OR	1.1 – 2.7		-	-	-
				- >21.51*10^6Nh	3.2 OR	2.2 – 5.0		-	-	-
				LDN:						
			Men, LDN: adjusted for age and region	- 0 to <5.0*10^6Nh	1.0 OR	-		-	-	-
				- 5.0 to <21.51*10^6 Nh	1.6 OR	0.9 – 2.8		-	-	-
				- >21.51*10^6Nh	3.2 OR	1.9 – 5.5		-	-	-
			Women, LDH	LDH:						
				- 0 Nh	-	-	1.0 OR	-	-	-
				- >0 to <4.04*10^6Nh	-	-	1.6 OR	1.1 – 2.7	-	-
			Women, LDN:	- 4.04 to <14.47*10^6 Nh	-	-	2.4 OR	1.6 – 3.8	-	-
				- >14.47*10^6Nh	-	-	2.3 OR	1.5 – 3.6	-	-
				LDN:						
				- 0 Nh	-	-	1.0 OR	-	-	-
				- >0 to <4.04*10^6Nh	-	-	1.2 OR	0.6 – 2.1	-	-
				- 4.04 to <14.47*10^6 Nh	-	-	2.3 OR	1.3 – 3.9	-	-
				- >14.47*10^6Nh	-	-	2.0 OR	1.2 – 3.2	-	-
Seidler[56] 2003	*Lifting/carrying combined with forward bending*: to create a combined value for lumbar spine exposure to lifting or carrying and for trunk flexion, the Mainz-Dortmund dose model, which is based on over-proportional weighting of the lumbar disc compression force relative to the respective duration of lifting, was applied with modifications (N=187 controls and 129 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, and other disease of the lumbar spine.	- No lifting/carrying; no extreme forward bending	1.0 OR	-	-	-	-	-
				- Lifting/carrying >0–150,000 kg^2*hours and/or extreme forward bending >0–1500 hours	4.3 OR	1.8 – 10.2	-	-	-	-
				- Lifting/carrying >150,000 kg^2*hours; extreme forward bending ≤1500 hours	8.2 OR	3.2 – 20.9	-	-	-	-
				- Lifting/carrying ≤150,000 kg^2*hours; extreme forward bending ≤1500 hours	8.2 OR	2.4 – 28.7	-	-	-	-
				- Lifting/carrying >150,00 kg^2*hours; extreme forward bending >1500 hours.	15.5 OR	5.2 – 46.9	-	-	-	-

Other mechanical exposures

Aghilinejad[33] 2015	*Hand above shoulder*: Duration of working with hands above shoulder in a working day measured on a five-point scale and dichotomised (N=185, 49 cases and 136 controls).	Self-reported chronic pain for ≥3 months.	None.	- Low	1.00 OR	-	-	-	-	-
				- High	2.08 OR	0.98 – 4.12	-	-	-	-
Euro[38] 2019	*Constant movements*: Was assessed in the domain “work postures and	Hospitalisation of Sciatica classified	Age and sex.	- No	-	-	-	-	1.00 OR	-
				- Yes	-	-	-	-	0.94 OR	0.59 – 1.48

	working methods" by the measurement: a constantly repeated series of movements (N=3,891).	by ICD-8/9/10 codes.								
Herin[42] 2014	*Movements*: Was measured by exposure to precise movements and/or repetitive work (N=1,206, 787 males and 419 female).	Self-reported LBP for ≥6 months.	Age, sports participation, BMI, and social class.	- Low - High	1.00 OR 0.97 OR	- 0.84 – 1.12	1.00 OR 1.10 OR	- 0.86 – 1.41	- -	- -
	Forceful effort: Exposure to considerable physical effort (N= 787 males and 419 females)	Self-reported LBP for 6 months + clinical symptoms.	Age, sports participation, BMI, and social class.	- Low - High	1.00 OR 1.20 OR	- 1.01 – 1.44	1.00 OR 1.21 OR	- 0.91 – 1.60	- -	- -
	Effort with tools: Exposure to physical effort with tools (N= 787 males and 419 females)	Self-reported LBP for 6 months + clinical symptoms.	Age, sports participation, BMI, and social class.	- Low - High	1.00 OR 1.07 OR	- 0.88 – 1.32	1.00 OR 0.80 OR	- 0.44 – 1.46	- -	- -
Krause[46] 2004	*Driving*: Years of professional driving was used as a proxy measure of past physical workload (N=1,233).	First incidence of low back injury.	Age, sex, ethnicity, personal factors and psychosocial job factors (psychological demands, decision latitude, supervisor support, co-worker support).	- ≤ 5 years - 6-15 years - >15 years Less severe injuries: - ≤ 5 years - 6-15 years - >15 years More severe injuries: - ≤ 5 years - 6-15 years - >15 years	- - - - - - - - -	- - - - - - - - -	- - - - - - - - -	- - - - - - - - -	1.36 HR 1.00 HR 0.86 HR 1.55 HR 1.00 HR 0.91 HR 1.05 HR 1.00 HR 0.69 HR	1.01 – 1.83 - 0.63 1.18 1.08 – 2.21 - 0.62 – 1.34 0.59 – 1.87 - 0.40 – 1.20
Matsudaira[50] 2019	*Use of keyboard*: Measured by using a keyboard at work for more than four hours on an average working day (N=197).	LBP interfering with work for ≥3 months.	None.	- <4 hours/day - ≥4 hours/day	- -	- -	- -	- -	1.00 OR 1.55 OR	- 0.63 – 3.79
	Move wrist/finger: Measured by other tasks involving repeated movements of the wrist or fingers for more than four hours on an average working day (N=198).	LBP interfering with work for ≥3 months.	None.	- <4 hours - ≥4 hours	- -	- -	- -	- -	1.00 OR 0.90 OR	- 0.41 – 1.97
	Bend elbow: Measured by repeated bending and straightening of elbow for longer than one hour on an average working day (N=196).	LBP interfering with work for ≥3 months.	None.	- <1 hour - ≥1 hour	- -	- -	- -	- -	1.00 OR 1.72 OR	- 0.62 – 4.75
	Hands above shoulder: Measured by working for longer than one hour with hands above shoulder height on an average working day (N=197).	LBP interfering with work for ≥3 months.	None.	- No - Yes	- -	- -	- -	- -	1.00 OR 1.44 OR	- 0.66 – 3.15

	Driving: Measured by driving four or more hours on an average working day (N=197).	LBP interfering with work for ≥3 months.	None.	- <4 hours/day - ≥4 hours/day	- -	- -	- -	- -	1.00 OR 0.72 OR	- 0.34 – 1.53
Tubach[62] 2004	*Driving*: Was measured by driving >2 hours a day (N=317).	Sciatica	Gender.	- Never - <Once a week - >Once a week - Everyday	- - - -	- - - -	- - - -	- - - -	1.00 OR 2.37 OR 1.79 OR 1.01 OR	- 1.16 – 4.87 0.97 – 3.32 0.62 – 1.63

Psychosocial exposures

Job strain

Aghilinejad[33] 2015	*Job strain*: Domains of job demands, job control and social support, and job satisfaction were summed, cut in the mid-point and divided into low and high (N=185, 45 cases and 140 controls).	Self-reported chronic pain for ≥3 months.	None.	- No - Yes	1.000 OR 1.174 OR	- 0.56 – 2.48				
Esquirol[37] 2017	*Job strain*: Was assessed using Karasek model by combining levels of four dimensions based on psychological demands and decision latitude with low=low psych. and high decision, passive=low psych. and low decision, active=high psych. and high decision, and high=high psych. and low decision (N=1,130 for incidence and 430 for persistence).	Self-reported chronic pain for ≥6 months. Incidence group compared to non-chronic LBP group and persistence group compared to non-persistence.	None.	Incidence chronic LBP: - Low - Passive - Active - High Persistence chronic LBP: - Low - Passive - Active - High	 - - - - - - - -	 - - - - - - - -	 - - - - - - - -	 - - - - - - - -	 1.00 OR 1.05 OR 1.69 OR 0.95 OR 1.00 OR 0.77 OR 1.30 OR 0.67 OR	 - 0.59 – 1.88 0.81 – 3.55 0.55 – 1.63 - 0.36 – 1.64 0.49 – 3.45 0.34 – 1.35
Jansen[44] 2004	*Work demands*: was assessed using Karasek's model with 11 questions reflecting working fast, hard, excessive work etc. and based on the centile of distribution (N=523).	Self-reported LBP with disability.	Trunk flexion between 20 to 45º, trunk flexion >45º, lifting/carrying loads >10 kg, decision authority, and skill discretion.	- 10th centile - 25th centile - 50th centile - 75th centile - 90th centile	- - - - -	- - - - -	- - - - -	- - - - -	1.00 RR 0.86 RR 0.75 RR 1.41 RR 1.45 RR	- 0.61 – 1.21 0.33 – 1.73 0.63 – 3.18 0.60 – 3.53

Job control

Aghilinejad[33] 2015	*Job control*: Was assessed using Karasek model and measured by 6 questions on a four-point scale and dichotomised (N=185, 126 cases and 59 controls).	Self-reported chronic pain for ≥3 months.	None.	- No - Yes	1.00 OR 0.84 OR	- 0.42 – 1.68	- -	- -	- -	- -

Herin[42] 2014	*Decision latitude*: Was assessed using Karasek model and considered “low” when answering “no” to two out of three questions regarding room for learning, variety of work, and choosing how to do one’s work (N=1,206, 787 males and 419 females).	Self-reported LBP for ≥6 months.	Age, sports participation, BMI, and social class.	Men - Low - High Women - Low - High	1.00 OR 1.06 OR	- 0.90 – 1.26	1.00 OR 0.91 OR	- 0.71 – 1.16	- -	- -
Latza[47] 2002	*Job control*: Was measured by the question “Regulations and instructions hinder my performance very much” using a 5-point Likert scale (without chronic LBP N=404 at baseline and all workers N= 488).	Self-reported chronic LBP.	Age.	Without chronic LBP at baseline - High - Medium - Low All workers - High - Medium - Low	 1.00 PR 1.48 PR 1.13 PR 1.00 PR 1.45 PR 1.39 PR	 - 0.53 – 4.12 0.40 – 3.20 - 0.71 – 2.96 0.69 – 2.83	 - - - - - -	 - - - - - -	 - - - - - -	 - - - - - -
Matsudaira[49] 2015	*Control*: Job control was assessed with the BJSQ on a five-point Likert scale and dichotomised (N=119, 4 controlled and 115 not controlled)	LBP interfering with work for ≥3 months.	None.	- Controlled - Not controlled		- -	- -	- -	1.00 OR 1.81 OR	- 0.69 – 4.79
Matsudaira[50] 2019	*Control*: Lack of control over how to work was assessed with the CUPID-Questionnaire on a five-point scale and dichotomised (N=198).	LBP interfering with work for ≥3 months.	None.	- No - Yes	- -	- -	- -	- -	1.00 OR 1.03 OR	- 0.50 – 2.14
	Control: Lack of control over what to do at work was assessed with the CUPID-Questionnaire on a five-point scale and dichotomised (N=198).	LBP interfering with work for ≥3 months.	None.	- No - Yes	- -	- -	- -	- -	1.00 OR 1.08 OR	- 0.51 – 2.25
Melloh[51] 2013	*Job control*: Was assessed using the JCQ and measured on a seven-point scale (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Persistent group	-	-	-	-	0.90 OR	0.55 – 1.50
Job support										
Aghilinejad[33] 2015	*Social support*: Was assessed using the MUSIC-questionnaire and measured by 6 questions on a four-point scale and dichotomised (N=185, 49 cases and 136 controls).	Self-reported chronic pain for ≥3 months.	Age, BMI, smoking, LBP history, family LBP history, education, shift working, job type,	- Low - High	1.000 OR 0.432 OR	- 0.16 – 1.17	- -	- -	- -	- -

			other physical and psychosocial factors.							
Esquirol[37] 2017	*Support*: Occupational support was dichotomised (N=1,130 for incidence and 430 for persistence).	Self-reported chronic pain for ≥6 months. Incidence group compared to non-chronic LBP group and persistence group compared to non-persistence.	None.	Incidence chronic LBP:						
				- No	-	-	-	-	1.00 OR	-
				- Yes	-	-	-	-	1.25 OR	0.87 – 1.79
				Persistence chronic LBP:						
				- No	-	-	-	-	1.00 OR	-
				- Yes	-	-	-	-	1.15 OR	0.74 – 1.81
Latza[47] 2002	*Social support*: Was measured by the question "Colleagues impede my work" using a 5-point Likert scale (without chronic LBP N=404 at baseline and all workers N= 488).	Self-reported chronic LBP.	Age.	Without chronic LBP at baseline						
				- Low	1.00 PR	-	-	-	-	-
				- Medium	1.39 PR	0.58 – 3.36	-	-	-	-
				- High	1.40 PR	0.59 – 3.31	-	-	-	-
				All workers						
				- Low	1.00 PR	-	-	-	-	-
				- Medium	1.46 PR	0.82 – 2.60	-	-	-	-
				- High	1.50 PR	0.86 – 2.62	-	-	-	-
Matsudaira[49] 2015	*Support by supervisors*: Was assessed with the BJSQ on a five-point scale and dichotomised (N=167).	LBP interfering with work for ≥3 months.	None.	- Supported	-	-	-	-	1.00 OR	-
				- Not supported	-	-	-	-	2.00 OR	0.88 – 4.55
	Support by co-workers: Was assessed with the BJSQ on a five-point scale and dichotomised (N=168).	LBP interfering with work for ≥3 months.	None.	- Supported	-	-	-	-	1.00 OR	-
				- Not supported	-	-	-	-	0.97 OR	0.43 – 2.18
Matsudaira[48] 2014	*Support by supervisors*: Was assessed with the BJSQ on a five-point scale and dichotomised (N=1,675).	LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking, education, and manual materials handling at work.	- Support	-	-	-	-	1.00 OR	-
				- No support	-	-	-	-	2.01 OR	1.05 – 3.85
Matsudaira[50] 2019	*Lack of workplace support*: Was assessed with the CUPID-Questionnaire (N=194).	LBP interfering with work for ≥3 months.	None.	- Support	-	-	-	-	1.00 OR	-
				- No support	-	-	-	-	1.74 OR	0.67 – 4.50
Melloh[51] 2013	*Support*: Social support at work was assessed with the JCQ on a seven-point scale (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, BMI, and somatization.	- Social support	-	-	-	-	0.67 OR	0.45 – 0.99
Melloh[52] 2013	*Social support*: Were assessed by questionnaires based on the recommendations of a multinational musculoskeletal cohort study addressing occupational, psychological risk factors (N=169).	Persistent LBP for 6 months.	Age, gender, BMI, and resigned attitude towards the job.	- Social support	-	-	-	-	0.44 OR	0.26 – 0.75

Melloh[53] 2013	*Social support*: Social support was assessed with Caplan, Cobb, French, et al.’s scale combining score of 6–30 points with higher scores expressing higher social support on a 5-point scale (N=195).	Persistent LBP for 6 months.	Age, gender, and BMI	- Social support	-	-	-	-	1.78	1.20 – 2.66
Job stress										
Jørgensen[45] 2013	*Mental stress at work*: Was measured by the question: “do you feel under mental stress when performing your job/during leisure time?” (N=3,823).	Hospitalisation for lumbar disc disease.	Age.	- Seldom - Regularly	1.00 HR 0.64 HR	- 0.32 – 1.26	- -	- -	- -	- -
Matsudaira[49] 2015	*Interpersonal stress*: Was assessed with the BJSQ on a five-point scale and dichotomised (N=171).	LBP interfering with work for ≥3 months.	None.	- Not stressed - Stressed	- -	- -	- -	- -	1.00 OR 1.15 OR	- 0.49 – 2.68
Matsudaira[48] 2014	*Interpersonal stress*: Was assessed with the BJSQ on a five-point scale and dichotomised (N=1,675).	LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking, education, and manual materials handling at work.	- No stress - Stress	- -	- -	- -	- -	1.00 OR 1.96 OR	- 1.00 – 3.82
Matsudaira[50] 2019	*Interpersonal stress*: Was assessed with the CUPID-Questionnaire (N=197).	LBP interfering with work for ≥3 months.	None.	- Stressed	-	-	-	-	0.55 OR	0.26 – 1.15
Melloh[51] 2013	*Stress*: Single-sided physical stress was assessed using the JCQ and measured on a seven-point scale (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Persistent group	-	-	-	-	1.03 OR	0.43 – 2.51
Seyedmehdi[59] 2016	*Stress*: Job stress was assessed with the JCQ on a four-point scale and dichotomised (N=511).	Self-reported LBP lasting ≥3 months.	Age, Job experience, smoking, educational level, BMI, heavy physical load, and general health.	- Low - High	- -	- -	- -	- -	1.00 OR 1.67 OR	- 1.13 – 2.46
Sørensen[61] 2011	*Mental stress at work*: Was measured by the question: “do you feel under mental stress when performing your job/during leisure time?” (N=3,823).	Hospitalisation for lumbar disc disease	Age	- Seldom - Regularly	1.00 HR 0.64 HR	- 0.32 – 1.26	- -	- -	- -	- -

Other psychosocial exposures

Aghilinejad[33] 2015	*Job demand*: Was assessed using Karasek model and measured by 5 questions on a four-point scale and dichotomised (N=185, 150 cases and 35 controls).	Self-reported chronic pain for ≥3 months.	None.	- No	1.00 OR	-	-	-	-	-
				- Yes	1.94 OR	0.75 – 5.00	-	-	-	-
	Satisfaction: Was assessed using the MUSIC-questionnaire and measured by 4 questions on a five-point scale and dichotomised (N=185, 49 cases and 136 controls).	Self-reported chronic pain for ≥3 months.	Age, BMI, smoking, LBP history, family LBP history, education, shift working, job type, other physical and psychosocial factors.	- Low	1.000 OR	-	-	-	-	-
				- High	0.501 OR	0.22 – 1.16	-	-	-	-
Ahsan[34] 2013	Less job satisfaction or stress at work.	Lumbar disc herniation.	Matched on age, sex, and area of residence.	- No					1.00 OR	-
				- Yes					2.45 OR	NS
Esquirol[37] 2017	*Repetitive work:* Repetitive work under time pressure were categorised into three classes according to exposure (N=1,130 for incidence and 430 for persistence).	Self-reported chronic pain for ≥6 months. Incidence compared to non-chronic LBP and persistence compared to non-persistence group.	None.	Incidence chronic LBP:						
				- Never	-	-	-	-	1.00 OR	-
				- Former	-	-	-	-	1.39 OR	0.87 – 2.20
				- Current	-	-	-	-	1.25 OR	0.78 – 2.01
				Persistence chronic LBP:						
				- Never	-	-	-	-	1.00 OR	-
				- Former	-	-	-	-	1.09 OR	0.60 – 1.99
				- Current	-	-	-	-	0.86 OR	0.44 – 1.68
	Communicating: Difficulty communicating with colleagues (N=430 for persistence).	Self-reported chronic pain for ≥6 months. Persistence group compared to non-persistence.	Age, sex, history of rheumatologically events, history of depression, leisure time physical activity (sport), leisure time activity (gardening), and job changes between instances of data collection.	Persistence chronic LBP:						
				- No	-	-	-	-	1.00 OR	-
				- Yes	-	-	-	-	1.45 OR	0.87 – 2.42
	Recognition: Work recognition was dichotomised (N=1,130 for incidence).	Self-reported chronic pain for ≥6 months. Incidence group compared to non-chronic LBP group.	Sex, age, history of rheumatologically events., BMI, number of different jobs held, job changes, productivity-related income, and work recognition	Incidence chronic LBP:						
				- Yes	-	-	-	-	1.00 OR	-
				- No	-	-	-	-	1.76 OR	1.21 – 2.56

Gold[39] 2017	*Work-family imbalance:* Was assessed with the sum of three items regarding tiredness after work, so much work it takes away personal interests, and preoccupation with work while being home (N=228).	Self-reported LBP the last 3 months.	No information is given.	- Yes	-	-	-	-	1.82 OR	1.12 – 2.98
Halonen[41] 2018	*Effort-reward*: Effort-reward imbalance (ERI) perception was assessed using the ERI-Questionnaire and measured by an Effort-reward ratio and dichotomised (N=1,845).	Self-reported pain in past 3 months.	Age, sex, number of pseudo-trials, marital status, socioeconomic status, and physically strenuous work.	LBP after onset of ERI:						
				- Affecting	-	-	-	-	1.21 RR	0.97 – 1.50
				- Any	-	-	-	-	1.05 RR	0.85 – 1.29
Herin[42] 2014	*Demand*: Was assessed using Karasek model and psychological demand was measured by pace at work, interruption at work, and number of job tasks dichotomised (N=1,206, 787 males and 419 females).	Self-reported LBP for ≥6 months.	Age, sports participation, BMI, and social class.	Men	1.00 OR	-	1.00 OR	-	-	-
				- Low	1.00 OR	0.87 – 1.15	1.11 OR	0.92 – 1.34	-	-
				- High						
				Women						
				- Low						
				- High						
Jansen[44] 2004	*Decision authority*: was assessed using Karasek's model with 11 questions reflecting planning, influence on pace, pauses etc. and based on the centile of distribution (N=523).	Self-reported LBP with disability.	Trunk flexion between 20 to 45º, trunk flexion >45º, and lifting/carrying loads >10 kg, skill discretion, and work demands.	- 10th centile	-	-	-	-	1.00 RR	-
				- 25th centile	-	-	-	-	1.07 RR	0.64 – 1.78
				- 50th centile	-	-	-	-	1.13 RR	0.42 – 3.04
				- 75th centile	-	-	-	-	1.50 RR	0.55 – 4.14
				- 90th centile	-	-	-	-	0.76 RR	0.21 – 2.72
	Skill discretion: was assessed using Karasek's model with 6 questions reflecting skills, task variety, learning etc. and based on the centile of distribution (N=523).	Self-reported LBP with disability.	Trunk flexion between 20 to 45º, trunk flexion >45º, lifting/carrying loads >10 kg, decision authority, and work demands.	- 10th centile	-	-	-	-	1.00 RR	-
				- 25th centile	-	-	-	-	1.10 RR	0.63 – 1.89
				- 50th centile	-	-	-	-	1.22 RR	0.45 – 3.31
				- 75th centile	-	-	-	-	1.44 RR	0.53 – 3.91
				- 90th centile	-	-	-	-	1.09 RR	0.38 – 3.16
Latza[47] 2002	*Monotonous work*: Was measured by the question "Altogether, my work is uniform" using a 5-point Likert scale (without chronic LBP N=404 at baseline and all workers N= 488).	Self-reported chronic LBP.	Age.	Without chronic LBP at baseline						
				- Low	1.00 PR	-	-	-	-	-
				- Medium	1.39 PR	0.58 – 3.36	-	-	-	-
				- High	1.40 PR	0.59 – 3.31	-	-	-	-
				All workers						
				- Low	1.00 PR	-	-	-	-	-
				- Medium	1.46 PR	0.82 – 2.60	-	-	-	-
				- High	1.50 PR	0.86 – 2.62	-	-	-	-
	Time pressure: Was measured by the question "I am under time pressure" using a 5-point Likert	Self-reported chronic LBP.	Age.	Without chronic LBP at baseline						
				- Low	1.00 PR	-	-	-	-	-
				- Medium	7.43 PR	1.70 – 32.6	-	-	-	-
				- High	6.30 PR	1.41 – 28.2	-	-	-	-

	scale (without chronic LBP N=404 at baseline and all workers N= 488).			All workers						
				- Low	1.00 PR	-	-	-	-	-
				- Medium	1.63 PR	0.87 – 3.06	-	-	-	-
				- High	1.70 PR	0.92 – 3.15	-	-	-	-
	Satisfaction with own achievements at work: Was measured by the question “I am satisfied with my achievements at work” using a 5-point Likert scale (without chronic LBP N=404 at baseline and all workers N= 488).	Self-reported chronic LBP.	Age.	Without chronic LBP at baseline						
				- Low	1.00 PR	-	-	-	-	-
				- Medium	1.53 PR	0.55 – 4.23	-	-	-	-
				- High	1.85 PR	0.67 – 5.01	-	-	-	-
				All workers						
				- Low	1.00 PR	-	-	-	-	-
				- Medium	1.67 PR	0.88 – 3.13	-	-	-	-
				- High	2.07 PR	1.10 – 3.88	-	-	-	-
Matsudaira[50] 2019	*Inadequate breaks at work:* Assessed using the JCQ (N=197).	LBP interfering with work for ≥3 months.		- Yes	-	-	-	-	0.71 OR	0.30 – 1.67
	Dissatisfied with job: Was assessed with the CUPID-Questionnaire (N=198).	LBP interfering with work for ≥3 months.	None.	- Not dissatisfied	-	-	-	-	1.00 OR	-
				- Dissatisfied	-	-	-	-	1.14 OR	0.52 – 2.50
Matsudaira[49] 2015	*Utilization of skills and expertise:* Assessed using the JCQ (N=140).	LBP interfering with work for ≥3 months.	None.	- Utilization of skills and expertise	-	-	-	-	1.00 OR	-
				- No utilization of skills and expertise	-	-	-	-	1.59 OR	0.66 – 3.85
	Job Fitness: Feeling fit for the job (N=121).	LBP interfering with work for ≥3 months.	None.	- Feeling fit	-	-	-	-	1.00 OR	-
				- Not feeling fit	-	-	-	-	2.04 OR	0.91 – 4.60
	Reward: Reward to work was assessed with the BJSQ on a five-point scale and dichotomised (N=171).	LBP interfering with work for ≥3 months.	Anxiety and daily-life satisfaction.	- Feel rewarded	-	-	-	-	1.00 OR	-
				- Not feeling rewarded	-	-	-	-	3.59 OR	1.57 – 8.20
	Mental workload: The quantitative aspect was assessed with the BJSQ on a five-point scale and dichotomised (N=170).	LBP interfering with work for ≥3 months.	None.	- Not stressed	-	-	-	-	1.00 OR	-
				- Stressed	-	-	-	-	1.08 OR	0.47 – 2.46
	Mental workload: The qualitative aspect was assessed with the BJSQ on a five-point scale and dichotomised (N=170).	LBP interfering with work for ≥3 months.	None.	- Not stressed	-	-	-	-	1.00 OR	-
				- Stressed	-	-	-	-	0.63 OR	0.28 – 1.42
	Physical workload: Was assessed with the BJSQ on a five-point scale and dichotomised (N=171).	LBP interfering with work for ≥3 months.	None.	- Not stressed	-	-	-	-	1.00 OR	-
				- Stressed	-	-	-	-	1.62 OR	0.70 – 3.73
	Environment stress: Was assessed with the BJSQ on a five-point scale and dichotomised (N=171).	LBP interfering with work for ≥3 months.	None.	- Not stressed	-	-	-	-	1.00 OR	-
				- Stressed	-	-	-	-	1.95 OR	0.87 – 4.38

Matsudaira[48] 2014	*Job satisfaction*: Was assessed with the BJSQ on a five-point scale and dichotomised (N=1,675).	LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking, education, manual materials handling at work, somatic symptoms, and family history of LBP with disability.	- Satisfied - Not satisfied	- -	- -	- -	- -	1.00 OR 2.03 OR	- 1.01 – 4.07
	Physical workload: Was assessed with the BJSQ on a five-point scale and dichotomised (N=1,675).	LBP interfering with work for ≥3 months.	Age, sex, obesity, smoking, education, and manual materials handling at work.	- No stress - Stress	- -	- -	- -	- -	1.00 OR 1.53 OR	- 0.70 – 3.33
Melloh[51] 2013	*Work absenteeism:* Assessed using the JCQ (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Yes	-	-	-	-	1.00 OR	0.99 – 1.01
	Resigned attitude towards the job: Assessed using the JCQ (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Yes	-	-	-	-	1.48 OR	0.99 – 2.20
	Uncertainty: Assessed using the JCQ (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Yes	-	-	-	-	0.92 OR	0.47 – 1.83
	Work organisational problems: Assessed using the JCQ	Persistent LBP for 6 months.	Age, sex, and BMI.	- Yes	-	-	-	-	0.63 OR	0.30 – 1.34
	Work interruptions: Assessed using the JCQ (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Yes	-	-	-	-	0.87 OR	0.47 – 1.58
	Concentration requirements: Assessed using the JCQ (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Yes	-	-	-	-	1.84 OR	0.95 – 3.77
	Time pressure: Assessed using the JCQ (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Yes	-	-	-	-	0.76 OR	0.40 – 1.47
	Emotional suppression: Assessed using the JCQ (N=168, 38 with	Persistent LBP for 6 months.	Age, sex, and BMI.	- Yes	-	-	-	-	1.09 OR	0.67 – 1.75

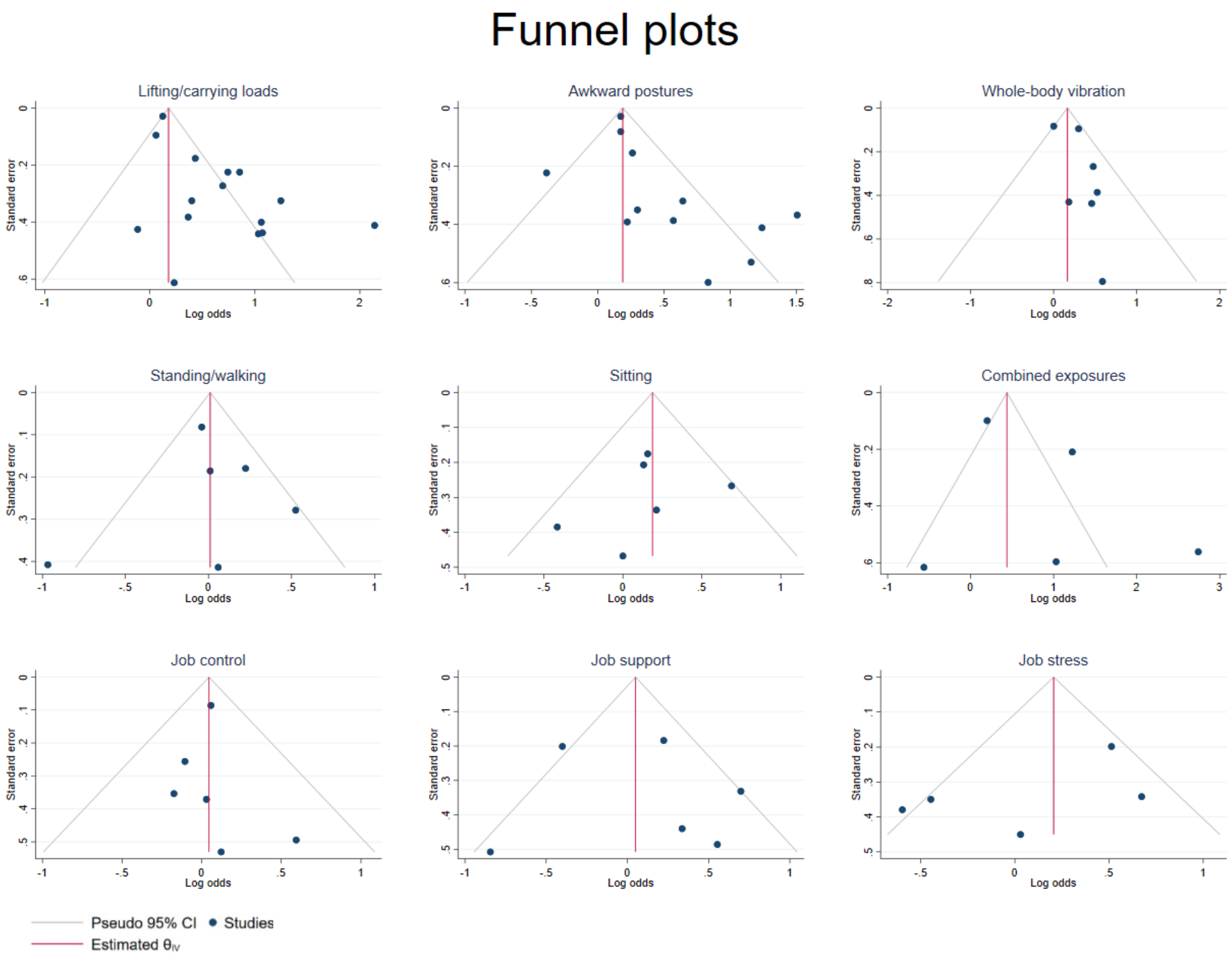
	persistent LBP and 130 with non-persistent LBP).								
	Satisfaction: Job satisfaction was assessed with the JCQ on a seven-point scale (N=168, 38 with persistent LBP and 130 with non-persistent LBP).	Persistent LBP for 6 months.	Age, sex, and BMI.	- Persistent group	-	-	-	-	1.15 OR	0.75 – 1.78
Melloh[52] 2013	*Resigned attitude towards the job*: Were assessed by questionnaires based on the recommendations of a multinational musculoskeletal cohort study addressing occupational, psychological risk factors (N=169).	Persistent LBP for 6 months.	Age, gender, BMI, and social support.	Resigned attitude towards the job	-	-	-	-	1.83 OR	1.23 – 2.72
	Job satisfaction: Were assessed by questionnaires based on the recommendations of a multinational musculoskeletal cohort study addressing occupational, psychological risk factors (N=169).	Persistent LBP for 6 months.	Age, gender, and BMI.	Job satisfaction	-	-	-	-	0.74 OR	0.57 – 0.96
	Time pressure: Were assessed by questionnaires based on the recommendations of a multinational musculoskeletal cohort study addressing occupational, psychological risk factors (N=169).	Persistent LBP for 6 months.	Age, gender, and BMI.	Time pressure	-	-	-	-	1.20 OR	0.83 – 1.75
	Uncertainty: Were assessed by questionnaires based on the recommendations of a multinational musculoskeletal cohort study addressing occupational, psychological risk factors (N=169).	Persistent LBP for 6 months.	Age, gender, and BMI.	Uncertainty	-	-	-	-	1.22 OR	0.81 – 1.83
	Physically demanding work activities: Were assessed by questionnaires based on the recommendations of a multinational musculoskeletal cohort study addressing occupational, psychological risk factors (N=169).	Persistent LBP for 6 months.	Age, gender, and BMI.	Physically demanding work activities	-	-	-	-	0.90 OR	0.39 – 2.04
	Ergonomics: Were assessed by questionnaires based on the recommendations of a multinational musculoskeletal cohort study	Persistent LBP for 6 months.	Age, gender, and BMI.	Ergonomics	-	-	-	-	0.80 OR	0.46 – 1.42

	addressing occupational, psychological risk factors (N=169).									
Seidler[56] 2003	*Opportunities to use knowledge and skills*: Was measured from 1 = very often to 6 = very seldom and classified by number of working years as 5 or 6 (N=176 controls and 127 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, other diseases of the lumbar spine, and lifting/carrying combined with extreme forward bending.	- 0 years - >0 - <10 years - ≥10	1.0 OR 1.6 OR 0.5 OR	- 0.9 – 2.9 0.1 – 2.2	- - -	- - -	- - -	- - -
	Satisfaction with supervisors: Was measured from 1 = very satisfied to 6 = very dissatisfied and classified by number of working years as 5 or 6 (N=175 controls and 128 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, other diseases of the lumbar spine, and lifting/carrying combined with extreme forward bending.	- 0 years - >0 - <10 years - ≥10	1.0 OR 1.1 OR 1.1 OR	- 0.6 – 2.1 0.3 – 4.0	- - -	- - -	- - -	- - -
	Satisfaction with workmates: Was measured from 1 = very satisfied to 6 = very dissatisfied and classified by number of working years as 5 or 6 (N=175 controls and 125 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, other diseases of the lumbar spine, and lifting/carrying combined with extreme forward bending.	- 0 years - >0 - <10 years - ≥10	1.0 OR 2.7 OR -	- 0.8 – 9.3 -	- - -	- - -	- - -	- - -
	Psychic strain through contact with clients: Was measured from 1 = very little to 6 = very much and classified by number of working years with high degree of psychic strain as 5 or 6 (N=184 controls and 130 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, other diseases of the lumbar spine, and lifting/carrying combined with extreme forward bending.	- 0 years - >0 - <10 years - ≥10	1.0 OR 6.9 OR -	- 1.2 – 40.1 -	- - -	- - -	- - -	- - -
	Time pressure: Was measured from 1 = very little to 6 = very much and classified by number of working years under high degree of time pressure as 5 or 6 (N=176 controls and 128 cases).	Lumbar disc herniation combined with osteochondrosis/spondylosis.	Age, region, nationality, other diseases of the lumbar spine, and lifting/carrying combined with extreme forward bending.	- 0 years - >0 - <10 years - ≥10	1.0 OR 1.3 OR 2.3 OR	- 0.7 – 2.8 1.1 – 4.8	- - -	- - -	- - -	- - -
Sihawong[60] 2016	*Job demand*: Was assessed using the JCQ and measured by a seven-scale (N=609).	Self-reported low back pain for ≥3 months.	History of LBP, frequency of rest breaks, and	- Rate of chronic LBP	-	-	-	-	1.12 OR	0.99 – 1.26

			frequency of exercise.							
Tubach[62] 2004	*Job satisfaction*: Was measured with an analogic visual scale and divided into tertiles (N=475).	Sciatica.	Gender.	- High - Intermediate - Low	- - -	- - -	- - -	- - -	1.00 OR 1.52 OR 1.13 OR	- 0.90 – 2.58 0.71 – 1.78

Abbreviations: BJSQ = Brief Job Stress Questionnaire; BMI = body mass index; CUPID = Cultural and Psychosocial Influences on Disability; HR = Hazard Ratio; JCQ = Job Content Questionnaire; kg = kilogram; LDH = lumbar disc herniation; LDN = lumbar disc narrowing; Musculoskeletal Intervention Centre; NS = Not stated; OR = Odds Ratio; PR = Prevalence Ratio; RR = Relative Risk.

Appendix 8. Funnel plots



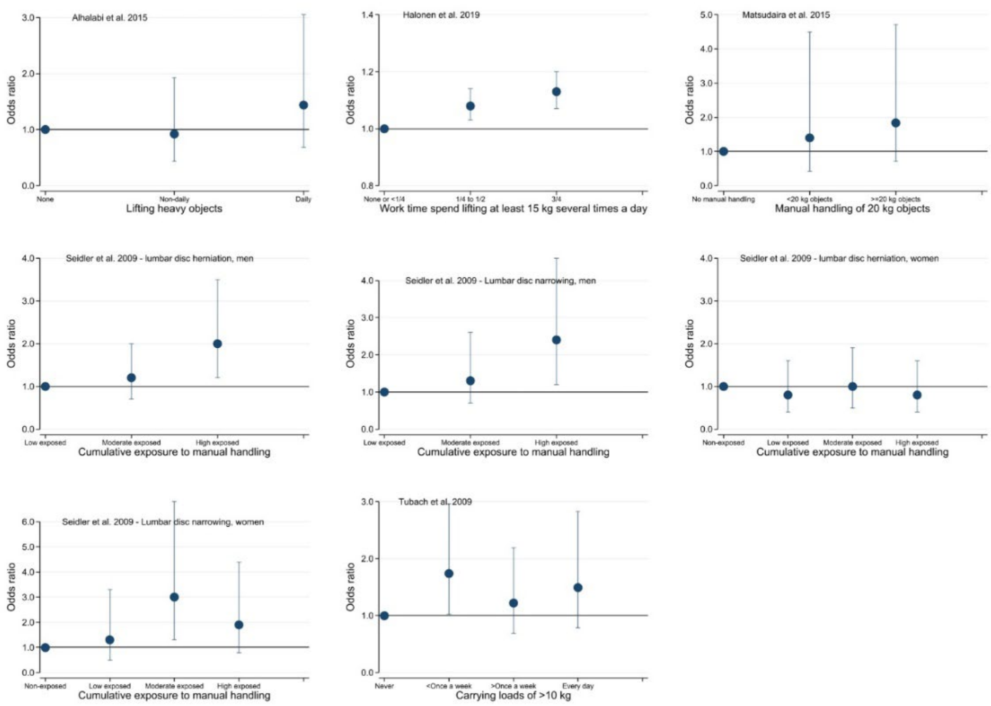
Appendix 9. Exposure-response relation

For occupational mechanical exposures with "some evidence for a causal association (++)" we further examined exposure-response relation. First, we examined whether trend tests were conducted. If trend test were not conducted, we graphically visualized potential exposure-response relation.

Lifting/carrying loads

Three articles from the meta-analysis evaluated exposure-response relation. Using hierarchical regression analyses, Jansen et al.[44] presents exposure-response relation between lifting and carrying loads >10 kg and risk of LBP with disability resulting in "more linear than the conventional model" changing from non-monotonic or inconsistent. Latza et al.[47] examined a linear trend test between laying large lime sandstone (6 to 10 kilograms) and chronic LBP using Wald test and showing a p-value under 5% across 3 levels the exposure. Seidler et al. from 2003[56] calculated a test for trend using exposure categories as interval scaled variables in a logistic regression model showing a significant exposure-response gradient on cumulated lifting/carrying.

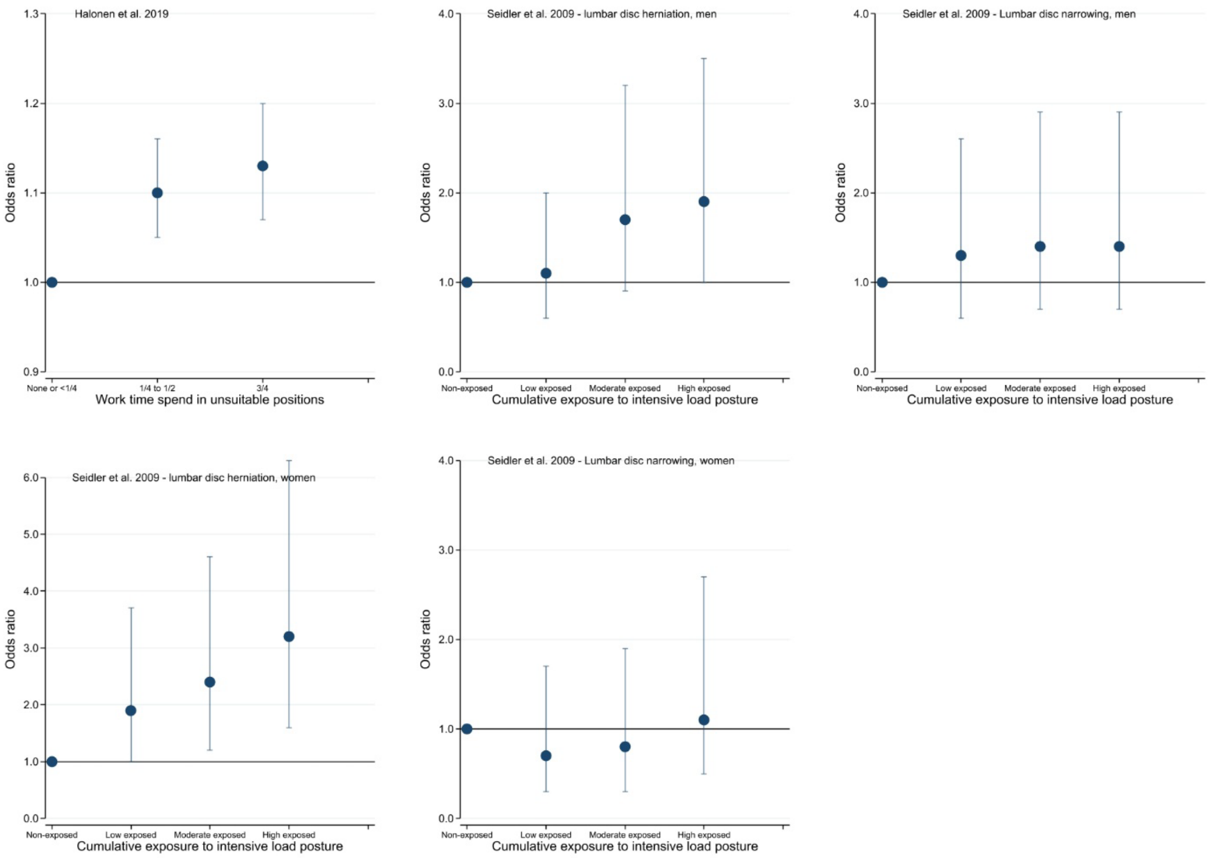
Figure. Eight studies of lifting/carrying loads presented measure of association for ≥3 exposure groups.



Awkward postures

Jansen et al.[44] found both in the conventional and hierarchical model increasing risk estimates that increased with time spend in trunk flexion over 45 degrees per week. Seidler et al.[56] found a significant exposure-response gradient for extreme forward bending (>90°) and risk of lumbar disc herniation with osteochondrosis/spondylosis.

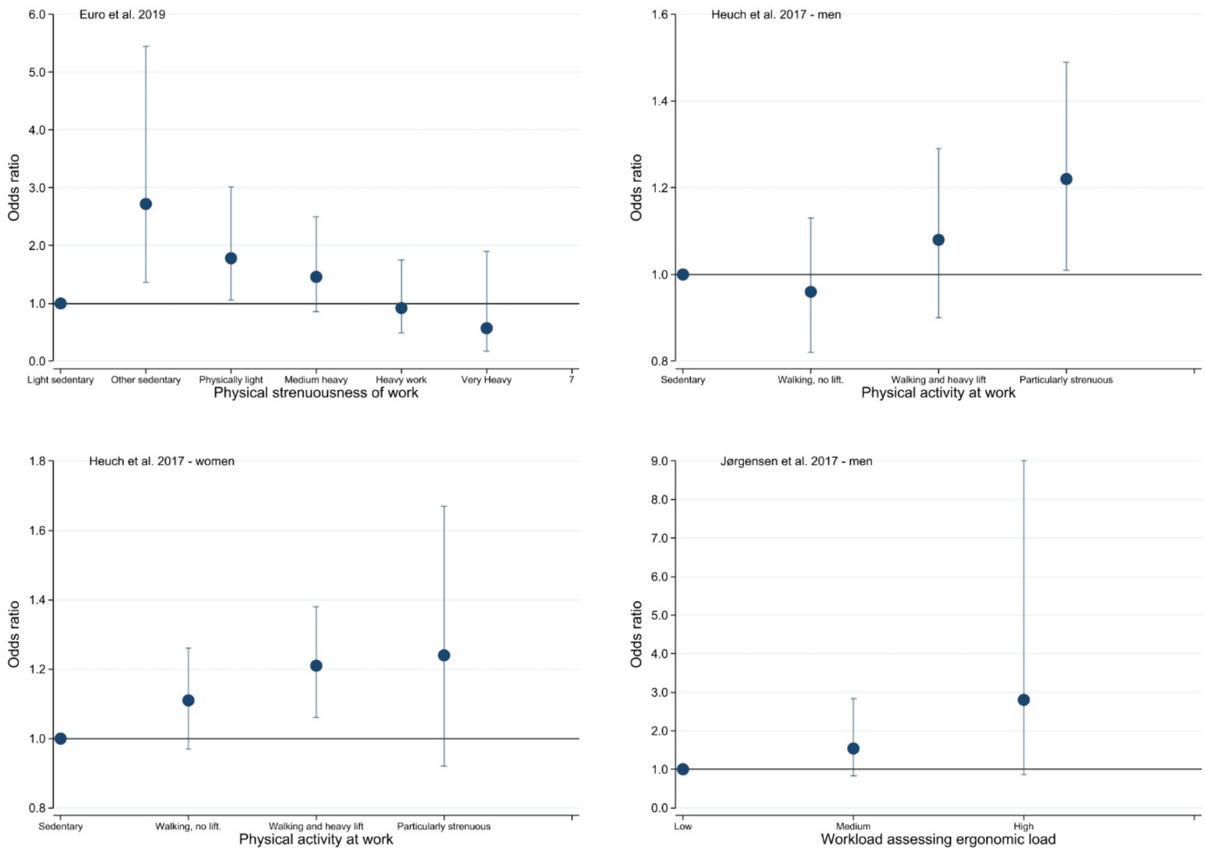
Figure. Five studies of awkward postures presented measure of association for ≥3 exposure groups.



Combined mechanical exposures

Seidler et al.[57] from 2009 found a positive exposure-response relation between cumulative lumbar load (manual handling of objects of about 5 kilograms or more and/or intensive load postures) and lumbar disc disease (herniation and disc narrowing) for both men and women.

Figure. Four studies of combined mechanical exposures presented measure of association for ≥3 exposure groups.



Appendix 10. Non-occupational risk factors

Results from an overview of systematic review of the association between non-occupational risk factors and low back pain and sciatica.[14]

Risk factor	Odds ratio (95% CI)
Individual	
Age (18–44 y versus 44–75 y)	2.8 (95% CI 1.3–5.9)
Sex	Unclear
Previous low back pain (yes/no)	From 1.71 (95% CI 1.32–2.20) to 6.1 (95% CI 4.1–9.1)
Height (>170 cm)	1.7 95% CI (1.0–2.6)
Puberty (adolescents >19 y)	1.5 (95% CI 1.2–1.8)
Poor general health	
Smoking (current smokers)	1.88 (95% CI 1.3–2.7)
Obesity (BMI<24)	1.43 (95% CI 0.9–1.0)
Alcohol (>1 unit/day)	0.9 (95% CI 0.6–1.2)
Physical activity	Unclear
Chronic diseases ("having chronic disease") (yes/no)	1.7 (95% CI 1.2–2.4)
Sleep problems	3.2 (95% CI 1.9–5.5)
Frequently feeling tired	1.8 (95% CI 1.4-2.3)
Pain at any other regional site (yes/no)	1.7 (95% CI 1.2–2.4)
Psychological stress	
Mental distress—being stressed, nervous, or tense (yes/no)	2.2 (95% CI 1.3–3.7)
Dissatisfaction with life (yes/no)	1.8 (95% CI 1.2–2.6)
Depression (yes/no)	1.6 (95% CI 1.3–2.0)
Psychosomatic factors	2.5 (95% CI 1.2–5.1)
Other	
Comfort of car seat	1.9 (95% CI 1.0–3.7)