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Physical job demands in pregnancy and associated musculoskeletal health and employment outcomes: a systematic review

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Abstract

OBJECTIVE: A decline in musculoskeletal health during pregnancy is an under-appreciated adverse outcome of pregnancy that can have immediate and long-term health consequences. High physical job demands are known risk factors for non-traumatic musculoskeletal disorders in the general working population. Evidence from meta-analyses suggest occupational lifting and prolonged standing during pregnancy may increase risk of adverse pregnancy outcomes. This systematic review examined associations between occupational lifting or postural load in pregnancy and associated musculoskeletal disorders and related sequalae.

DATA SOURCES: Five electronic databases (Medline, Embase, CINAHL, NIOSHTIC-2 and Ergonomic Abstracts) were searched from 1990 to July 2022 for studies in any language. A Web of Science snowball search was performed in December 2022. Reference lists were manually reviewed.

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systematic review finds pregnant workers whose jobs require lifting ≥22 lbs (≥10 kg) or postural load, like prolonged standing, may be at greater risk of functionally limiting pelvic girdle pain and employment cessation

CONFLICTS OF INTEREST: the authors report no conflicts of interest.

ELIGIBILITY CRITERIA: Eligible studies reported associations between occupational lifting or postural load and musculoskeletal health or sequelae (e.g., employment outcomes) among pregnant and postpartum workers.

METHODS: Data were extracted using a customized form to document study and sample characteristics, and details of exposures, outcomes, covariates, and analyses. Investigators independently assessed study quality for seven risk of bias domains and overall utility, with discrepant ratings resolved through discussion. A narrative synthesis was conducted due to heterogeneity.

RESULTS: Sixteen studies (11 cohort studies, 2 nested case-control studies, and 3 cross-sectional studies) from 8 countries were included (N=142,320 pregnant and N=1,744 postpartum workers). Limited but consistent evidence with variable quality ratings, ranging from critical concern to high, suggests that pregnant workers exposed to heavy lifting (usually defined as ≥22 lbs or ≥10 kg) may be at increased risk of functionally limiting pelvic girdle pain and antenatal leave. Moreover, reports of dose-response relationships suggest graded risk levels according to lifting frequency, ranging from 21% to 45% for pelvic girdle pain and 58% to 202% for antenatal leave. Limited but consistent evidence also suggests that postural load increases the risk of employment cessation.

CONCLUSION: Limited but consistent evidence suggests that pregnant workers exposed to heavy lifting and postural load are at increased risk of pelvic girdle pain and employment cessation. Job accommodations to reduce exposure levels may promote safe sustainable employment for pregnant workers.

Keywords

analgesics; antenatal leave; ergonomics; heavy lifting; labor market outcomes; low back pain; maternal health; musculoskeletal disorders; physical functioning; physical workload; postural load; postpartum period; work during pregnancy; pelvic girdle pain

Introduction

A decline in musculoskeletal health during pregnancy is an under-appreciated adverse outcome of pregnancy that can have immediate and long-term maternal health consequences. Significant adaptations to the musculoskeletal system occur during pregnancy, and up to 70 percent of pregnant individuals experience at least mild musculoskeletal pain or discomfort that typically resolves after parturition.[1] It is estimated that the occurrence of severe and functionally limiting musculoskeletal pain affects up to 20 percent of pregnancies and persists into the postpartum period.[2–4] Physically demanding work is a known risk factor for musculoskeletal disorders in the general working population,[5,6] and a growing body of evidence from several systematic reviews with meta-analyses report associations between occupational lifting or postural load (e.g., prolonged standing) in pregnancy and adverse pregnancy outcomes.[7–9] However, little is known about associations between these workplace exposures in pregnancy and musculoskeletal disorders or related sequelae, such as fatigue, analgesic use, and employment outcomes.

To evaluate what is known, we synthesized available evidence and identified knowledge gaps addressing: 1) the prevalence and incidence of musculoskeletal disorders among pregnant and postpartum workers occupationally exposed to lifting and postural load and 2) associations between exposure to occupational lifting or postural load and musculoskeletal disorders and related sequelae among pregnant and postpartum workers.

Methods

A protocol for this systematic review was registered *a priori* with PROSPERO, the International Prospective Register of Systematic Reviews (registration number CRD42021223685). This systematic review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-2 and Meta-Analysis of Observational Studies in Epidemiology reporting guidelines.[10,11]

Search strategy and information sources

Five electronic databases (Medline, Embase, the Cumulative Index to the Nursing and Allied Health Literature [CINAHL], the National Institute for Occupational Safety and Health Technical Information Center [NIOSHTIC-2] database, and Ergonomics Abstracts) were searched on July 1, 2022. Controlled-vocabulary terms and text words were used for the following concepts: population (‘pregnancy’ OR ‘postpartum’), occupational exposure (‘lifting’ OR ‘carrying’ OR ‘postural load’), musculoskeletal disorders (‘low back pain’ OR ‘pelvic pain’ OR ‘sacroiliac joint pain’), and sequelae (‘fatigue’ OR ‘analgesic use’ OR ‘employment outcome’ OR ‘work disability’ OR ‘sickness absence’ OR ‘employment withdrawal’ OR ‘return to work’). The full search strategy is reported in Appendix A. We also used included studies as index articles for a snowball search using Web of Science on December 21, 2022, and we manually scanned the reference lists of included studies.

Eligibility criteria

For objectives 1 (prevalence and incidence) and 2 (associations), we considered nonrandomized comparative studies (cohort, case-control, and cross-sectional studies) of employed pregnant or postpartum workers in community, clinical, or industrial settings. For Objective 1, we also considered single-group studies. For both objectives, we restricted to studies published since 1990 so that findings would reflect more modern working conditions and the contemporary work patterns of pregnant workers. Health and health behaviors during pregnancy can vary by employment status,[12] so we excluded studies that did not restrict the sample to, or report subgroup analyses for, employed individuals. Included studies assessed exposure to one or more specific types of physical job demands – lifting (or carrying) or postural load occurring at any anatomical site (e.g., standing, bending or twisting, shoulder flexion). We included studies examining relevant exposures occurring at any stage of pregnancy or up to 6 months postpartum – the period in which pregnancy-induced joint laxity is known to persist.[13] We excluded studies that only reported crude (e.g., “manual work”) or composite physical job demand measures where the effect of stressor components was obscured. Because growing evidence demonstrates that occupational and leisure-time physical activity are associated with differential health impacts,[14] including during pregnancy,[15] we excluded studies that did not distinguish between occupational

and non-occupational physical demands and studies that only assessed physical demands occurring outside of paid employment (e.g., strength training, leisure-time physical activity, domestic activity). Included studies measured musculoskeletal disorders occurring during pregnancy or postpartum, irrespective of anatomical site (studies addressing traumatic musculoskeletal injuries arising from blunt force, such as being struck by an object or falling, were not included). We also included studies measuring the following sequelae, regardless of whether the study authors explicitly stated these outcomes were attributed to musculoskeletal health: fatigue, analgesic use, and employment outcomes (e.g., work disability, sickness absence that included antenatal or maternity leave, and employment outcomes that included quitting, being fired, delayed return to work). We excluded case studies, systematic reviews, editorials, commentaries, and conference proceedings.

Study selection

Records from electronic searches were de-duplicated in EndNote and imported into Abstrackr (http://abstrackr.cebm.brown.edu). After two rounds of pilot screening, two independent investigators (L.A.M. and C.Y.J.) conducted title and abstract screening of all remaining records. Potentially relevant articles were then retrieved for full-text screening by two of five independent investigators (L.A.M., C.Y.J., M-L.L., A.S-C., and I.J.S.). We translated potentially relevant non-English language articles using professional translators and Google Translate®. We resolved screening discrepancies (at both abstract and full-text stages) by discussion between the screeners and by group consensus as needed.

Data extraction

We extracted data from each study into a customized data extraction form within the Systematic Review Data Repository Plus (SRDR+; http://srdrplus.ahrq.gov). One investigator (G.P.A. or H.J.K.) extracted all data that were then independently verified by a second investigator (H.J.K. or G.P.A.). We resolved discrepancies by discussion between the two investigators and by group consensus as needed. Extracted data included citation information, study name, study design, study years, funding source, country, research objectives, enrollment source, sample size, and sample population inclusion and exclusion criteria. Extracted occupational exposure characteristics included exposure definitions, assessment method, directionality of data collection (e.g., prospective), number of assessments performed, and exposure period (i.e., gestational or postpartum period). Extracted outcome characteristics included outcome definitions, assessment method, temporality of outcome assessment (e.g., prospective), number of assessments performed, and outcome period (i.e., gestational or postpartum). We extracted effect measures with confidence intervals or p-values, the full lists of covariates, and the analytic treatment of covariates in reported models.

Risk of bias assessment

Risk of bias assessments were independently performed by two of three investigators (L.A.M., C.Y.J., and A.S-C). We developed a risk of bias form using items from the Risk of Bias in Nonrandomized Studies of Interventions tool and the National Toxicology Program Handbook for Preparing Report of Carcinogens Monographs, two methods used to assess risk of bias in nonrandomized studies.[16,17] Signaling criteria from these tools were adapted

to account for known threats to the external and internal validity of nonrandomized studies involving worker populations and pregnant workers.[12,18–21] We assigned a rating (critical concern [0], low quality [+], medium quality [++], high quality [+++]) to each of seven domains (selection, exposure, outcome, confounding, analysis, reporting, and sensitivity) and for overall utility. The rating for overall utility involved consideration of the individual domain ratings and the predicted degree of aggregate bias. We resolved discrepancies by discussion among L.A.M., C.Y.J., and A.S-C.

Data syntheses

Studies were grouped for synthesis into four exposure-outcome pairs: 1) lifting and musculoskeletal disorders, 2) postural load and musculoskeletal disorders, 3) lifting and employment outcomes, and 4) postural load and employment outcomes. Studies were further sub-grouped based on *a priori* criteria related to exposure and outcome definitions, methods and timing of exposure and outcome assessments, and reported measures of association. Due to considerable heterogeneity in exposure and outcome definitions and in the measures of effect reported, a narrative synthesis was conducted. Conclusions about effect size, direction of effect, and generalizability of findings were drawn from effect estimates and confidence intervals within exposure-outcome pairs and subgroups, coupled with knowledge of the strengths and limitations of the underlying evidence, as reflected in our risk of bias ratings.[22]

RESULTS

Study selection

Figure 1 illustrates the study selection process. The electronic database search identified 6,387 records. Manual review of the reference lists of included studies and the snowball search identified an additional 288 articles. We screened a total of 117 articles in full text (including 16 articles that had been translated into English), of which we excluded 101 articles. The most frequent reasons for exclusion were lack of a relevant exposure (or exposure lacked specificity) (n=44) and the article not reporting a primary study (n=23). Appendix B lists references for all articles excluded during full-text screening, with reasons for exclusion. Sixteen studies met inclusion criteria.

Study and participant characteristics

Table 1 summarizes characteristics of the 16 included studies. Eleven studies (69%) employed a cohort design (eight were prospective), two (13%) a nested case-control design, and three (19%) a cross-sectional design. Half the studies were published since 2010. Most studies (69%) were conducted in northern Europe (Denmark, the Netherlands, Norway), and one study each was conducted in Brazil, Canada, China, France, and the United States. All included studies were published in English. Three studies, including the two largest, used data from the Danish National Birth Cohort.[25,26,35] The other 13 studies involved unique study samples, ranging from 73[37] to 28,611 participants.[28] One industry-based study enrolled pregnant hospital workers employed in clinical, administrative, and support occupations,[32] while all remaining studies enrolled participants from clinical or community-based settings who were employed across a range of blue- and white-collar occupations.

Exposures assessed

All included studies assessed occupational exposure occurring during pregnancy and none assessed exposure postpartum. Nine studies (56%) measured exposure to both occupational lifting and postural load, however none of these studies measured postures assumed during lifting activities. One study assessed only lifting,[26] and six studies assessed only postural load.[24,27–29,31,37] Whole-body postures (standing, walking, or sitting) were the postural load conditions measured most often. Postures of the back or torso (twisting or bending at the waist) were assessed in four studies.[28,33,34,38] Upper extremity posture (i.e., working with hands above the shoulder) was assessed in two studies.[33,34] "Uncomfortable postures" and "static postures" (no anatomical regions specified) were assessed in four studies[27,29,30,32]

Outcomes assessed

Two studies assessed outcomes occurring postpartum: pelvic girdle pain (PGP)[27] and employment (return to work),[31] while most (88%) assessed musculoskeletal or employment outcomes occurring during pregnancy. Eight studies (50%) reported musculoskeletal outcomes. Three of these studies assessed self-reported functionally limiting PGP during pregnancy[26,35,37] or self-reported functionally limiting PGP with a confirmatory clinical assessment of the pelvic girdle region by a rheumatologist.[30] Additionally, one cross-sectional study assessed PGP and low back pain (LBP) during pregnancy, separately and combined (LBP/PGP),[38] while three studies assessed back pain[29,37] and LBP[36] during pregnancy. Among eight studies that reported employment outcomes, five used participant self-reports of antenatal leave[23,24,28,33] or postpartum return to work,[31] two used national registry data to examine antenatal sick leave,[25,32] and one defined a composite measure of 'employment withdrawal' based on participant self-reports of antenatal leave, quitting work, or being fired during pregnancy.[31]

Risk of bias assessment

Risk of bias ratings for all domains and overall utility among included studies are shown in Appendix C. We rated the overall utility of two studies as high, four as medium, seven as low, and three as critical concern. The six studies rated high or medium utility were all published since 2012; the designs of these higher-rated studies included four prospective cohort studies (two musculoskeletal and two employment outcomes),[23,25–27] one nested case-control (employment outcome),[34] and one cross-sectional study (musculoskeletal outcome).[36] The designs of studies rated as low utility included two prospective cohort studies (one musculoskeletal and one employment outcome),[28,30] three retrospective cohorts (employment outcomes),[31–33] one nested case-control,[35] and one cross-sectional study (musculoskeletal outcomes).[38] The utility rating of critical concern was assigned to three smaller postural load studies reporting unadjusted measures of association (Spearman correlation coefficients[24,37] and crude odds ratios[29]). Appendix D includes a narrative summary of risk of bias-related concerns identified among included studies.

Synthesis of results

Objective 1: Prevalence or incidence of musculoskeletal disorders—No studies were identified reporting the prevalence or incidence of musculoskeletal disorders among occupationally exposed pregnant workers.

Objective 2: Associations between occupational exposures and musculoskeletal disorders

Lifting or postural load and musculoskeletal disorders occurring in the extremities: No studies were identified reporting associations between relevant occupational exposures and upper or lower extremity musculoskeletal disorders during pregnancy or postpartum.

Lifting and back pain or PGP during pregnancy: A single medium-utility study examining the occurrence and severity of LBP[36] and a single low-utility study examining the occurrence of LBP/PGP[38] were consistent in reporting increased risk associated with frequent heavy lifting at work (Table 2). Findings for functionally limiting PGP during pregnancy were inconsistent, with one high-utility study reporting elevated risk for any lifting ≥22 lbs (≥10kg) as well as a significant trend of proportionally higher risk as daily volume of lifting increased,[26] while findings were null for one low-utility study that was underpowered to detect small elevations in risk[35] and also for one low-utility study reporting crude effect estimates.[30] Consistency in positive findings among three studies were robust to the lifting threshold being defined qualitatively (‘heavy lifting’) or numerically (e.g., ≥22 lbs or ≥10kg).[26,36,38] Notwithstanding sample size influencing precision in one study,[35] a key factor discriminating three studies reporting a positive from a null effect was the inclusion of lifting ‘frequency.’[26,36,38]

Lifting and postpartum LBP or PGP: No studies were identified reporting associations between exposure to occupational lifting and postpartum LBP or PGP.

Postural load and back pain or PGP during pregnancy: A consistent pattern of null findings was reported for associations between standing or standing and walking and back pain or LBP in four studies ranging from medium utility to critical concern,[29,36–38] and in a single low-utility study examining associations with PGP (Table 3).[35] One small study rated critical concern reported null findings between ‘static postures’ (not otherwise specified) and back pain.[29] In contrast, findings from two single studies reported increased risks for other postural load conditions and LBP or PGP: one low-utility study reported an increased risk of functionally limiting PGP associated with work in ‘uncomfortable postures,’[30] and a second low-utility study reported an increased risk for LBP associated with bending forward at the waist and an increased risk of LBP/PGP associated with hourly twisting and, separately, for bending at the waist and working with hands above the shoulders.[38]

Postural load and postpartum LBP or PGP: A single medium-utility study reported varied associations between exposure to postural load at 30 weeks gestation and PGP occurring 12 weeks postpartum, with null findings reported for the association with prolonged standing and increased risk reported for associations with ‘uncomfortable work

postures' (Table 3).[27] No studies were identified reporting postural load and postpartum LBP.

Musculoskeletal sequelae

No studies were identified reporting associations between relevant physical job demands and fatigue, analgesic use or work disability. Eight studies reported associations for diverse employment outcomes, ranging from employment withdrawal during pregnancy (i.e., quitting work, being fired, and antenatal leave),[34] work absence,[28] sick or antenatal leave,[23–25,32,33] and return to work postpartum.[31]

Lifting and employment outcomes during pregnancy—A consistent pattern of elevated risk was shown for associations between occupational lifting and employment outcomes occurring during pregnancy among all relevant studies having utility ratings of high (one study),[23] medium (two studies),[25,34] and low (two studies)[32,33] (Table 4). The consistency of findings was robust to the lifting threshold being defined qualitatively ("heavy lifting") or quantitatively (variable definitions ranging from >15 lbs [>6.8 kg] to ≥24 lbs [≥11 kg], irrespective of lifting frequency. Findings from one high-utility prospective cohort study suggest that the timing or duration of exposure matters: persistent exposure to 'heavy lifting' (not otherwise specified) through 27 weeks gestation was associated with more than a 3-fold increased risk of antenatal sick leave lasting ≥14 days, while risk was not elevated in those exposed only at 12 weeks gestation.[23] More than a 4-fold increased risk was reported in a medium-utility case-control study for the association between lifting >15 lbs (>6.8 kg) in both the first and second trimesters and employment withdrawal (antenatal leave, quitting or being fired) (this was the only lifting study that excluded those exposed to prolonged standing from the reference group).[34] The only employment outcome study that measured lifting frequency was a medium-utility prospective cohort study that reported a significant dose-response relationship, with graded risk estimates ranging from 58% to 202%, for exposure to progressively higher volumes of lifting per day and antenatal leave lasting >15 days.[25] In two separate low-quality retrospective cohort studies, lifting 22 to 44 lbs (10 to 20 kg) was associated with elevated risk of antenatal leave occurring both at 8 weeks or 3 weeks before delivery[33] and "heavy lifting" was associated with antenatal leave exceeding 10% of work time.[32]

Lifting and postpartum employment outcomes—No studies were identified reporting associations between occupational lifting and postpartum employment outcomes.

Postural load and employment outcomes during pregnancy

Standing work: In contrast to null findings for associations with musculoskeletal disorders, a consistent pattern of elevated risk was shown for associations between standing (or standing and walking) and employment outcomes among six studies with utility ratings ranging from high[23] to medium[25,34] and low[31–33] to critical concern[24] (Table 5). Findings from one high-utility prospective cohort study suggest that the timing or duration of exposure matters: persistent exposure to heavy lifting and prolonged standing through 27 weeks gestation was associated with increased risk of employment cessation, while risk was not elevated in those exposed only at 12 weeks gestation.[23] This finding is similar to

findings from a medium-utility case-control study reporting associations between persistent exposure to prolonged standing ≥4 hours through the end of the second trimester and employment withdrawal (antenatal leave, quitting or being fired) (this was the only study that assessed risk of prolonged standing where the reference group excluded those exposed to prolonged standing *and* lifting >15 lbs (>6.8 kg).[34] A single medium-utility prospective cohort study assessed varying types of whole-body work exposure ('primarily standing,' 'primarily walking,' primarily standing and walking,' 'changeable' (i.e., 'I can change from sitting to standing to walking as I would like'), and 'other' (i.e., cycling, kneeling and standing combined with sitting) reporting elevated risk of sick leave lasting >15 days for each whole-body exposure, compared with 'primarily sitting.'[25]

Other postural load: Except for one low-utility study of turning and bending,[28] a consistent pattern of elevated risk was shown for associations between various non-whole-body postural load conditions (bending forward or twisting or bending at the waist, working with hands above the shoulders, or 'uncomfortable postures') and employment outcomes in three studies with utility ratings ranging from medium[34] to low utility[32,33] (Table 5). A medium-utility case-control study that examined persistent exposure to bending at the waist during the first and second trimesters reported significantly elevated risk (nearly 6-fold) for employment withdrawal (antenatal leave, quitting, or being fired), compared with a reference group not exposed to other physical job demands (bending at the waist, lifting >15 lbs [>6.8 kg] or prolonged standing).[34] A low-utility retrospective cohort study reported a positive association between 'uncomfortable posture' and risk of sick leave lasting more than 10% of total work time,[32] while another low-utility retrospective cohort study reported elevated risk for sick leave (>8 weeks and >3 weeks before delivery) associated with bending at the waist and working with hands above the shoulders.[33]

Postural load and postpartum employment outcomes—A low-utility retrospective cohort study reported associations between 'always' standing at work during pregnancy (gestation period not reported) and postpartum employment defined as return-to-work status at 12 months after delivery.[31] No studies were identified reporting non-whole-body postural load and postpartum employment.

Comment

Principal findings—This systematic review finds that high physical job demands in pregnancy may be associated with a decline in musculoskeletal health and employment cessation. Specifically, occupational exposure to heavy lifting, usually defined as ≥22 lbs (≥10 kg), may increase the risk of functionally limiting pelvic girdle pain,[26,30,38] with graded effects for higher frequency lifting ranging from 21% to 45%.[26] Heavy lifting may additionally increase the risk of employment cessation (usually defined as antenatal leave),[23,25,32–34] with graded effects for higher frequency lifting ranging from 58% to 202%.[22] Limited but consistent evidence also indicates that employment cessation may increase ≥2-fold in association with prolonged standing and walking[23,25,32,34] and ≥30% for bending, twisting, and working with hands above the shoulders.[32–34]

Pelvic girdle pain is a serious but poorly understood cause of morbidity during pregnancy, affecting about 20% of pregnant individuals and becoming chronic and persisting postpartum among 8–10%.[4,39,40] Unlike the more prevalent and generally mild musculoskeletal discomfort that coincides with advancing gravidity and resolves spontaneously after delivery, PGP is distinct in presenting earlier in pregnancy, invoking greater pain severity, impacting physical functioning (e.g., pain in gait) and impeding activities of daily living (self-care, newborn care, employment).[1,41,42,43] PGP refers to non-gynecologic or non-urologic pain disorders of musculoskeletal origin affecting both the anterior (symphysis) and posterior (sacroiliac region).[39,40] Pain affecting both the anterior (symphysis) and posterior (sacroiliac region) or bi-lateral sacroiliac joints generally distinguishes more severe cases.[39] Somatic pain intensity progressing with activities of daily living is indicative of PGP and can aid in differential diagnoses.

Our findings have important implications for clinical practice. Because patients with the worst prognosis for chronic musculoskeletal conditions present with greater pain severity in early pregnancy,[4,29] antenatal providers play a critical role in early diagnosis and management. Moreover, work history and musculoskeletal symptom screenings in early pregnancy could be effective tools for identifying at-risk patients when education about work activity restrictions[44,45,46] and knowledge about safe and effective pain relief[47,48,49] may be preventative. Several guidelines exist to aid the diagnosis and treatment of PGP during gestation and postpartum periods.[39,40,50–54] Clinicians should consider referring patients to specialists (e.g., physical therapy, acupuncturist) in light of evidence showing these modalities are safe and effective during pregnancy,[50–54] and may be more effective than standard obstetric care alone[55–57]

Comparison with existing literature—To our knowledge, this is the first systematic review examining specific physical job demands in pregnancy and associated musculoskeletal health and employment outcomes. Our findings are consistent with other evidence reporting associations between these outcomes and broadly defined measures of job physical demands. For example, pregnant Norwegian workers exposed to ‘physically demanding’ work experienced a 50% increase in severe PGP, compared with non-exposed pregnant workers,[58] while ‘unskilled” pregnant workers in Denmark were more likely to experience unresolved PGP pain 2 years postpartum, compared with skilled pregnant workers whose PGP resolved shortly after delivery.[59] Finally, Swedish workers employed in ‘manual’ work in pregnancy experienced a 89% increased risk of musculoskeletal conditions (mainly LBP) and a 21% increased risk of sick leave, compared with pregnant workers not employed in manual work.[60]

Because heavy lifting and postural load are established risk factors for a range of musculoskeletal disorders in the general workforce,[5,6] we expected to identify studies reporting associations for musculoskeletal outcomes occurring in the upper (e.g., carpal tunnel syndrome) or lower extremities among exposed pregnant workers. Moreover, PGP is not a recognized musculoskeletal condition attributed to physical job demands in the general workforce, thus the concentration of studies identified focusing on functionally limiting pelvic girdle pain is suggestive of a distinct injury susceptibility among exposed pregnant workers. Finally, the limited volume of evidence identified in our review stands in contrast

to considerable evidence summarized in five systematic reviews with meta-analyses that synthesized the quality and strength of associations reported between physical job demands in pregnancy and other adverse pregnancy outcomes.[7–9,61,62] Thus our review contributes to the existing literature by identifying that exposed pregnant workers may additionally face unique musculoskeletal and employment risks warranting further clinical and research attention.

Strengths and limitations

While our exclusion of studies that relied on broadly defined measures of exposure (job title or 'manual work') resulted in a smaller evidence base, we believe this criterion strengthens our review by yielding more specific results that 1) better inform clinical decision making and workplace preventive actions and 2) better delineate critical knowledge gaps that can drive improvements in future research. Data were extracted into SRDR+, so data will be made freely available upon publication of this systematic review to encourage future updates as more relevant studies are published. Other notable strengths of this review include the application of rigorous standards in the search and identification of evidence without language restrictions, restricting evidence to only employed pregnant individuals due to known biases that may otherwise be introduced,[12] and the rigorous risk of bias evaluation performed for each study. Additionally, our synthesis of the evidence considered the gestational timing and duration of exposure and dose-response relationships. Synthesis additionally addressed the quality of the analytic handling of the study variables, including adjustment for covarying co-exposures and exposure proxies and the consideration of probable effect modifiers (see Appendix D).

This systematic review also has some limitations. Because we searched for evidence from 1990 onwards, it is possible that relevant evidence was published prior to our date restriction. However, the findings of older studies may not apply as well to work conditions or work patterns of pregnant workers today; additionally, it is unlikely that inclusion of older studies would have changed our conclusions because the rigor of nonrandomized studies has generally improved with advances in epidemiologic methods and reporting standards. Due to the large number of exposure-outcomes relationships considered in our review, some associations may have been statistically significant by chance. We restricted our search to full research articles published in the peer-reviewed literature, so we risked not identifying relevant unpublished studies. Finally, all employment studies reviewed were conducted in countries (or jurisdictions) with statutory benefits that grant pregnant workers access to paid antenatal leave, thus there may be limitations in the applicability of our findings from those studies to the experience of pregnant workers without such access.

Although half the studies identified in our review addressed employment outcomes, no studies were found examining other sequelae, namely analgesic use and fatigue. The absence of evidence on the use of analgesics to manage LBP/PGP during pregnancy has been reported previously.[63] Our findings, coupled with evidence linking prenatal analgesic use to birth defects, [64,65] suggests the need for future research examining the potential chain of associations linking physical job demands to musculoskeletal outcomes in pregnancy and corresponding analgesic use and adverse birth outcomes. Additionally, further research

is warranted to elucidate the potential mediating role of local and whole-body fatigue on employment outcomes to inform whether energy expenditure criteria used in existing workplace guidelines need revision for application to pregnant workers.[66]

Conclusions and implications

Limited but consistent evidence demonstrated that pregnant workers occupationally exposed to heavy lifting may be at increased risk of functionally limiting PGP. Clinicians can aid in the early identification of at-risk patients, prompting protections from modifiable workplace exposures and the timely initiation of treatments to prevent chronic disabling pain and attendant adverse impacts on daily living and quality of life.[1,41,42,43] Our findings are part of a larger pattern of evidence linking high physical job demands during pregnancy to other adverse health outcomes, thus public health interventions that reduce these exposures during pregnancy may provide additional health protection against adverse pregnancy outcomes.[7–9,67] Moreover, because racialized populations are disproportionately represented in physically demanding jobs, such interventions may improve racial/ethnic inequities in maternal and infant morbidity.[31,68]

Our review findings additionally suggest that heavy lifting and postural load may increase the risk of employment cessation during pregnancy. In recognition that reduced or suspended employment during pregnancy can cause economic hardship, recently enacted federal legislation in the United States (the Pregnant Workers Fairness Act) now requires that employers grant reasonable accommodations to pregnant workers, enabling them to keep working safely.[69] Clinician support can be critical in facilitating pregnant workers' access to needed work accommodations, which could be aided by an occupational medicine referral or a written order for work accomodations.[44] The American College of Obstetricians and Gynecologists Committee Opinion 'Employment Considerations during Pregnancy and the Postpartum Period' addresses practical aspects of writing work accommodations and understanding the variable employment laws and leave programs relevant to pregnant workers, which now includes the federal Pregnant Workers Fairness Act in the United States.[69,70]

This systematic review finds limited but consistent evidence that pregnant workers occupationally exposed to lifting and postural load may be at increased risk of functionally-limiting pelvic girdle pain and employment cessation. Antenatal providers play an important role in early diagnosis and management, as well as patient education about work activity restrictions[44,45,46] and knowledge of safe and effective pain relief[47,48,49] that may be preventative. More prospective research is needed to inform 1) whether the origins of musculoskeletal conditions identified in pregnancy predate gestation among female workers exposed to high physical job demands and 2) if the onset and resolution of gestation-induced joint laxity, which has been shown to occur between about 6 weeks gestation and at least 6 weeks postpartum,[13] coincide with periods of reduced load-bearing capacity that increase susceptibility to adverse musculoskeletal outcomes among exposed workers during pregnancy. While one high-utility study reported that persistent exposure to heavy lifting and prolonged standing was associated with increased risk of employment cessation among those exposed through 27 weeks gestation, but not among those whose exposure was

reduced after 12 weeks gestation,[23] insufficient data exist to inform the optimal timing of work activity restrictions to reduce risks. The emergence of guidelines addressing provisional recommendations for occupational lifting and other physical job demands during pregnancy[44,45,46] and guidelines for prescribing job accommodation requests[70] may be important tools to promote safe and sustainable employment in pregnancy.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

REGISTRATION:

this study was registered with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42021223685) on February 15, 2021.

AVAILABILITY OF DATA

The protocol for this systematic review was registered with PROSPERO, the International prospective register of systematic reviews (registration number CRD42021223685), which is accessible at PROSPERO (york.ac.uk). Data extracted for this systematic review are archived in SRDR+ (ahrq.gov) and will be made publicly accessible online upon publication of this paper.

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AJOG at a Glance

Why was this study conducted?

This study was conducted to identify and evaluate evidence reporting associations between specific physical job demands during pregnancy and risk of poor musculoskeletal health and related sequalae.

Key findings

Limited variable-quality evidence finds heavy lifting during pregnancy (usually defined as ≥22 lbs or ≥10 kg) may be associated with poor musculoskeletal health, consistent with a robust evidence base established for the general working population. The concentration of evidence between physical job demands in pregnancy and functionally limiting pelvic girdle pain is unique and suggestive of a distinct injury susceptibility coincident with gravidity.

What does this study add to what is known?

Workers occupationally exposed to heavy lifting ≥22 lbs (≥10 kg) during pregnancy may face increased risk of functionally limiting pelvic girdle pain. Heavy lifting and postural load, such as prolonged standing, were additionally associated with higher employment cessation (usually defined as antenatal leave).

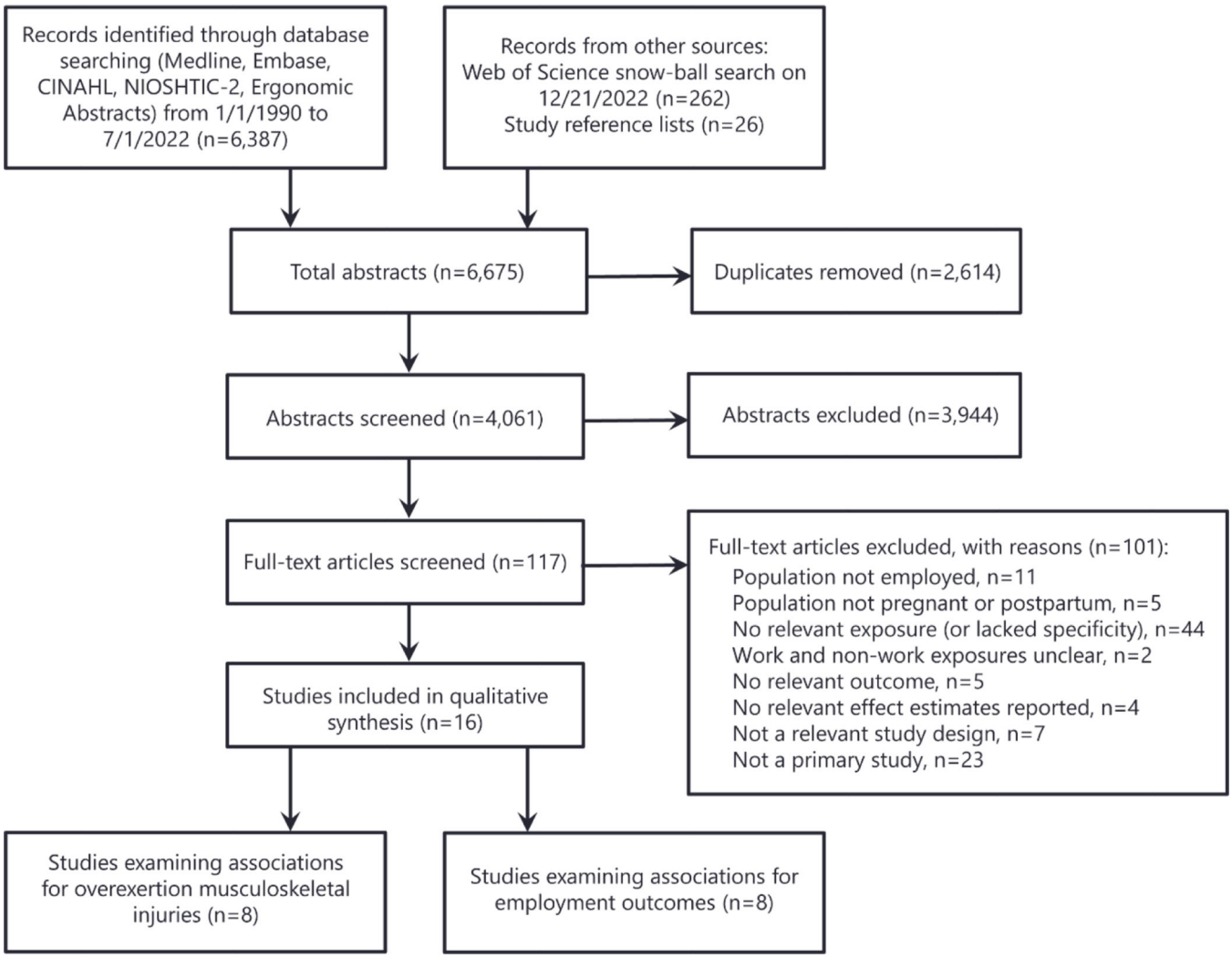

FIGURE 1. PRISMA Flow Diagram

Figure 1 is a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram. The diagram is a visual enumeration of studies identified through a systematic search process, followed by their disposition through each step of the screening process through to the final stage of determining those studies that meet eligibility criteria for inclusion in the systematic review.

TABLE 1

Characteristics of all 16 included studies

Author, Year	Study Years	Country	Population	Sample Analyzed (total sample)	Exposures	Exposure assessment	Outcomes	Outcome assessment
Prospective cohort studies								
Pedersen, 2021[23]	2018–2018	Denmark	General population sample	910 (910)	Heavy lifting Standing, walking	Online questionnaire at 12 and 27 GW	Antenatal leave ≥14 days by 27 GW	Online questionnaire at 27 GW
Safne, 2019[24]	2011–2015	Norway	General population sample	716 (855)	Standing/walking	Questionnaire at 18–22 GW	Antenatal leave due to lumbopelvic pain	Questionnaire at 32–36 GW
Hansen, 2015[25]	1996–2002	Denmark	Danish National Birth Cohort	49,195 (49,708)	Lifting Sitting, standing, walking, mixed (standing and other), kneeling	Telephone interview at 17 GW (median)	Onset of the first episode of antenatal leave lasting >15 days occurring between 10 and 29 GW	National sick leave registry
Larsen, 2013[26]	1996–2002	Denmark	Danish National Birth Cohort	47,935 (91,386)	Lifting	Interview at 12–16 GW and JEM	Functionally limiting pelvic pain during pregnancy	Interview at 6 months postpartum
Stomp-van den Berg, 2012[27]	2004–2006	The Netherlands	Mom@Work Study	548(548)	Standing or mixed standing/sitting Uncomfortable posture	Postal questionnaire at 30 GW (mean)	Pelvic girdle pain at 12 weeks postpartum	Postal questionnaire at 12 weeks postpartum with localized pain intensity registered on an 11-point scale, ranging from 0 (none) to 11 (much pain)
Kristensen, 2008[28]	1999–2005	Norway	Norwegian Mother and Child Cohort Study (MoBa)	28,611 (64 136)	Turning and bending	Questionnaire at 17 GW	Work absence >2 weeks between GW 17 and 30	Questionnaire at 30 GW
To, 2003[29]	NR	China	General population sample	254 (326)	Static posture Standing >4 h/day Walking >4 h/day	Questionnaire between 28 GW and delivery	Back pain symptoms in pregnancy	Questionnaire within 3 days postnatal
Larsen, 1999[30]	NR	Denmark	General population sample	1,516 (1,516)	Lifting Uncomfortable posture	Questionnaire at 16 GW	Functionally limiting pelvic pain from 16 to 40 GW	Screening for functional pelvic pain at GW 16, 20, 30, 33, 38, 40; when screening criteria met, rheumatologist exam performed
Retrospective cohort studies								

Author, Year	Study Years	Country	Population	Sample Analyzed (total sample)	Exposures	Exposure assessment	Outcomes	Outcome assessment
Wallace, 2013[31]	2003–2005	France	EDEN Mother-Child Cohort Study	1,196 (1,196)	Standing	Questionnaire during pregnancy (GW NR)	Return to work within one year after delivery	Questionnaires at 4, 8 and 12 months postpartum
Kaerlev, 2004[32]	1995–1999	Denmark	Healthcare sector	655 (773)	Heavy lifting Standing Walking Uncomfortable posture	Questionnaire at postpartum plus exposure imputation	Length and onset of antenatal leave >10% of work time	Hospital roster and linkage to the national birth registry for births during study period
Strand, 1997[33]	1989	Norway	Pregnancy and Work Survey	2,693 (5,438)	Lifting Hands above shoulder Bend and twist	Questionnaire at delivery	Certified sick leave occurring >3 or >8 weeks before delivery	Questionnaire at delivery
Nested case-control studies								
Guendelman, 2016[34]	2002–2003	United States	Juggling Work and Life During Pregnancy	1,114 (1,114)	Heavy lifting Bending at the waist Standing	Telephone interview a median of 4.5 months PP	Employment withdrawal defined as a composite measure of antenatal leave, quitting work, or being fired while pregnant	Telephone interview a median 4.5 months postpartum
Juhl M, 2005[35]	2000–2001	Denmark	Danish National Birth Cohort	2,758 (3,589)	Lifting Sitting Standing, walking	Interview at 12 to 16 GW	Functional pelvic pain occurring during pregnancy or after delivery	Interview conducted 6 months postpartum
Cross-sectional studies								
Caputo, 2021[36]	2015	Brazil	Pelotas Birth Cohort Study	2,114 (3,827)	Heavy lifting Standing	In-person interview at delivery	Low back pain during pregnancy	In-person interview at 12 months postpartum
Cheng, 2009[37]	NR	Canada	General population sample	43 (73)	Sitting Standing	Interviewer-administered questionnaire at 20 and 34 GW	Functionally limiting back pain during pregnancy	Oswestry disability questionnaire at 20 and 34 GW
Endresen, 1995[38]	1989	Norway	General population sample	3,789 (5215)	Lifting Standing, walking Bending forward Twist and bend Work above shoulder	Questionnaire at delivery	Low back pain during pregnancy; pelvic pain first onset during pregnancy and severity	Questionnaire at delivery

GW, gestational weeks; *JEM*, job exposure matrix; *NR*, not reported.

TABLE 2

Occupational lifting and back and/or pelvic girdle pain during pregnancy

Author, Year	Design	Overall	Exposure Assessment		Lifting Exposure		Effect	Effect Size	
		Utility	Frequency	Timing	Reference	Categories	Measure	(95% CI)	Outcome
Caputo, 2021[36]	Cross-sectional	++	1	Retrospective (at delivery)	Never have to lift heavy items	Heavy lifting			LBP during pregnancy (0, 1)
						Rarely Sometimes Often Always	Adj OR	0.83 (0.54, 1.27) 1.20 (0.93, 1.55) 1.37 (0.94, 2.00) 1.39 (1.01, 1.93)	
						Heavy lifting			LBP severity during pregnancy (0–10, no pain to highest pain)
						Rarely Sometimes Often Always	Adj MD	0.53 (−0.25, 1.31) −0.19 (−0.63, 0.25) 0.81 (0.18, 1.44) 0.92 (0.39, 1.44)	
Larsen, 2013[26]	Prospective cohort	+++	1	12–16 GW	Not defined; assumed no lifting and lifting ≤10 kg	Heavy lifting			Functionally limiting PGP during pregnancy (0, 1)
						Any >11 kg	Adj OR	1.18 (1.12–1.25)	
						Cumulative[a] 15–100 kg 101–200 kg 201–500 kg 501–1k kg >1000 kg	Adj OR	1.06 (0.99, 1.13) 1.21 (1.09, 1.34) 1.45 (1.31, 1.60) 1.45 (1.23, 1.72) 1.31 (1.02, 1.69)	
Juhl, 2005[35]	Case-control	+	1	12–16 GW	Reported 'no,' but assumed ≤10 kg	Heavy lifting			Functionally limiting PGP during pregnancy (0, 1)
						11–20 kg >20 kg	Adj OR	1.12 (0.88, 1.44) 1.14 (0.86, 1.50)	
Larsen, 1999[30]	Prospective cohort	+	1	16 GW	Not defined; assumed no lifting and lifting ≤10 kg	>10 kg	cOR Adj P value	1.90 (1.41, 2.56)[b] NS	Functionally limiting PGP during pregnancy (0, 1)
Endresen, 1995[38]	Cross-sectional	+	1	Retrospective (at delivery)	Not defined; assumed no lifting and lifting <10 kg	Frequent lifting 10–20 kg	Adj β	0.060 (2.18)[c]	LBP/PGP during pregnancy (0, 1)

Adj, adjusted; *CI*, confidence interval; *cOR*, crude odds ratio; *GW*, gestational weeks; *JEM*, Job Exposure Matrix; *kg*, kilograms; *LBP*, low back pain; *LBP/PGP*, low back and pelvic girdle pain combined; *MD*, mean difference; *NS*, not statistically significant; *OR*, odds ratio; *PGP*, pelvic girdle pain; *(0, 1)*, binary outcome (no, yes).

[a] For self-reported cumulative total lifting per day, a positive exposure-response relationship was observed (P-value for trend <0.0001). For JEM-derived cumulative total lifting per day, an exposure-response relationship was not observed (P-value for trend <0.0918);

[b] Effect size and 95% CI was computed from the proportion of exposed participants with and without pelvic girdle relaxation (Table 1);[36]

[c] Numeric value reported in parentheses, t (significance test).

Am J Obstet Gynecol. Author manuscript; available in PMC 2025 June 01.

TABLE 3

Occupational postural load and back and/or pelvic girdle pain during pregnancy or postpartum

Author, Year	Design	Overall	Exposure Assessment		Postural Definition		Effect measure	Effect Size	
		Utility	Freq	Timing	Reference	Categories		(95% CI)	Outcome
Caputo, 2021[36]	Cross-sectional	++	1	Retrospective (at delivery)	Not defined	Mean hours standing	Adj OR Adj MD	1.03 (0.99, 1.06) 0.05 (−0.003, 0.10)	LBP during pregnancy (0, 1) LBP severity during pregnancy (0–10)
Stomp-van den Berg, 2012[27]	Prospective cohort	++	1	30 GW	Mainly sitting Not defined	Standing or mixed standing/ sitting Uncomfortable posture (NOS)	cOR Adj OR	1.14 (0.73, 1.80) 1.31 (1.04, 1.65)	Postpartum PGP 12 weeks after delivery
To, 2003[29]	Prospective cohort	0	1	Retrospective, within 3 days postnatal	Not defined Stand<4h/day walk<4 h/day	Static posture Standing >4 h/day Walking >4 h/day	cORs	1.47 (0.75–2.87) 2.40 (0.89–6.43) 3.47 (0.79–15.10)	Back pain during pregnancy
Cheng, 2009[37]	Cross-sectional	0	2	20 and 34 GW	Less time walking Less time standing	A lot of work time: Walking (1–7) Standing (1–7)	Correlation coefficient	−0.071 (20 GW) −0.235 (34 GW) 0.006 (20 GW) −0.108 (34 GW)	Functionally limiting back pain at 20 and at 34 GW (0–10)
Juhl, 2005[35]	Case-control	+	1	12–16 GW	Mostly sitting Mostly sitting	Predominantly standing or walking Mix of sitting, standing, and walking	Adj OR	1.04 (0.80, 1.35) 1.02 (0.83, 1.25)	Functionally limiting PGP during pregnancy (0, 1)
Larsen, 1999[30]	Prospective cohort	+	1	16 GW	Not defined	Uncomfortable posture (NOS)	Adj OR	1.65 (1.10, 2.48)	Functionally limiting PGP during pregnancy (0, 1)
Endresen, 1995[38]	Cross-sectional	+	1	Retrospective (at delivery)	Not defined	Hourly twist & bend Work > shoulder Bending forward Standing, walking	Adj β	0.069 (2.13) 0.064 (3.23) 0.046 (3.09) NS (NR)	LBP/PGP during pregnancy (0, 1) LBP (0, 1)

Adj, adjusted; *CI*, confidence interval; *cOR*, crude odds ratio; *Freq*, frequency; *GW*, gestational weeks; *h*, hours; *LBP*, low back pain; *LBP/PGP*, low back and pelvic girdle pain combined; *NOS*, not otherwise specified; *NR*, not reported; *NS*, not statistically significant; *OR*, odds ratio; *PGP*, pelvic girdle pain; *(0, 1)*, outcome (no, yes).

TABLE 4

Occupational lifting and employment outcomes during pregnancy

Author, Year	Design	Overall	Exposure Assessment		Lifting Exposure		Effect measure	Effect Size	
		Utility	Freq	Timing	Reference	Categories		(95% CI)	Outcome
Pedersen, 2021[23]	Prospective cohort	+++	2	12 and 27 GW	No heavy lifting	Heavy lifting any GW Heavy lifting at 12 GW but not 27 GW Heavy lifting at 27 GW but not 12 GW Heavy lifting at 12 and 27 GW	Adj OR	2.10 (1.30, 3.50) 0.80 (0.20, 2.80) 3.70 (1.80, 7.60) 3.20 (1.80, 5.40)	Sick leave ≥14 days ≤27 GW (0, 1)
Guendelman, 2016[34]	Case-control	++	1	Retrospective (4.5 months postpartum), for each trimester	No lift >6.8 kg and no standing ≥4 hours	Lift >6.8 kg in trimesters 1 & 2	Adj OR	4.20 (1.98, 8.90)	Employment withdrawal during pregnancy (0, 1)
Hansen, 2015[25]	Prospective cohort	++	1	17 GW (median)	≤10 kg ≤20 kg 0–14 kg	Lifting 11–20 kg Lifting >20 kg Cumulative lifting: 15–100 kg 101–200 kg 201–500 kg 501–1000 kg >1000 kg Trend	Adj HR	1.77 (1.70, 1.84) 1.83 (1.74, 1.92) 1.58 (1.49, 1.67) 2.01 (1.87, 2.17) 2.18 (2.02, 2.35) 2.26 (1.99, 2.56) 3.02 (2.54, 3.58) 1.29 (1.27–1.31)[a]	First sick leave onset lasting >15 days occurring 10–29 GW (0, 1)[b]
Kaerlev, 2004[32]	Retrospective cohort	+	1	Retrospective (after delivery)	No heavy lifting	Heavy lifting NOS	Adj OR	1.90 (1.30, 2.90)	Length of antenatal leave >10% of work time (0, 1)
Strand, 1997[33]	Retrospective cohort	+	1	Retrospective (at delivery) for when pregnancy confirmed	Lift <10 kg	Heavy lifting 10–20 kg	Adj OR Adj OR	1.26 (1.01, 1.57)[c] 1.48 (1.22, 1.80)	Antenatal leave >8 weeks before delivery (0, 1) >3 weeks before delivery (0, 1)

Adj, adjusted; *CI*, confidence interval; *HR, Freq*, frequency; hazard ratio; *kg*, kilograms; *NOS*, not otherwise specified; *OR*, odds ratio; *RR*, relative risk; *(0, 1)*, binary outcome (no, yes).

[a] For self-reported cumulative total lifting per day, a positive exposure-response relationship was observed

[b] The source publication reports time-dependent effects of the exposures measured by time-varying coefficients (Table 4).[25]

[c] The source publication reports a lower confidence interval of 0.01 for 'lifting heavy loads (10–20 kg)' believed to be an error based on the comparable sample size and effect estimate for exposure to 'standing back bent forward' (Table 3).[34]

TABLE 5

Occupational postural load and employment outcomes during pregnancy or postpartum

Author, Year	Design	Overall	Exposure Assessment		Postural Load Definition		Effect		
		Utility	Freq	Timing	Reference	Categories	Measure	Effect Size (95% CI)	Outcome
Pedersen, 2021[23]	Prospective cohort	+++	2	12 and 27 GW	No standing or walking	Stand or walk any time Standing or walking at 12 GW but not 27 GW Stand or walk at 27 GW but not 12 GW Standing or walking at both timepoints	Adj OR	2.00 (1.20, 3.00) 0.70 (0.20, 2.00) 2.30 (1.10, 4.70) 2.80 (1.70, 4.60)	Antenatal leave ≥14 days ≤27 GW (0, 1)
Safne, 2019[24]	Prospective cohort	0	1	18–22 GW	Never/seldom	Walking/standing: Periodically Daily ≤50% time Daily >50% time	r^s	0.144, $p < 0.05$	Antenatal leave due to LBP and/or PGP from 32–36 GW (0, 1)
Guendelman, 2016[34]	Case-control	++	1	Retrospective (4.5 months postpartum), for each trimester	No lifting >6.8 kg and no standing ≥4 hours	Frequent bending in trimesters 1 & 2 Standing ≥4 hours in trimesters 1 & 2	Adj OR	5.89 (2.40, 14.5) 2.91 (1.46, 5.77)	Employment withdrawal during pregnancy (0, 1)
Hansen, 2015[25]	Prospective cohort	++	1	17 GW (median)	Primarily sitting	Primarily standing Primarily walking Primarily stand and walk Changeable Sit, cycle, kneel, stand	Adj HR	2.57 (2.34, 2.82) 2.74 (2.54, 2.96) 2.80 (2.62, 2.99) 1.54 (1.46, 1.64) 2.23 (1.77, 2.82)	First antenatal leave onset lasting >15 days occurring 10–29 GW (0, 1)
Wallace, 2013[31]	Retrospective cohort	+	NR	Retrospective (after delivery)	< always standing	Always standing at work	Adj OR	1.76 (1.07, 2.90)[a]	Return to work ≤1 year after delivery (0, 1)
Kristensen, 2008[28]	Prospective cohort	+	1	~17 GW	≤ seldom	Turning/bending: Sometimes Daily, <50% Daily, >50%	 Adj risk diff	 −0.015 (−0.032, 0.002) −0.022 (−0.39, −0.006) 0.013 (−0.007, 0.032)	Work absence > 2 weeks between GW 17 and 30 (0, 1)
Kaerlev, 2004[32]	Retrospective cohort	+	1	Retrospective (after delivery)	None Not defined	Walking or standing Uncomfortable posture (NOS)	Adj OR	3.40 (1.90, 5.80) 1.60 (1.10, 2.40)	Length of antenatal leave >10% of work time (0, 1)

Author, Year	Design	Overall	Exposure Assessment		Postural Load Definition		Effect		
		Utility	Freq	Timing	Reference	Categories	Measure	Effect Size (95% CI)	Outcome
Strand, 1997[33]	Retrospective cohort	+	1	Retrospective (at delivery) for when pregnancy confirmed	No postural load	Stand and bend forward Hands > shoulder level Twisting/bending Hands > shoulder level Twisting/bending	Adj OR	1.30 (1.02, 1.65) 1.36 (1.06, 1.74) 1.32 (1.05, 1.66) 1.55 (1.22, 1.95) 1.46 (1.24, 1.76)	Antenatal leave >8 weeks before delivery (0, 1) Antenatal leave >3 weeks < delivery (0, 1)

Adj, adjusted; *CI* = confidence interval, *Diff*, difference; *Freq*, frequency; *GW*, gestational weeks; *HR*, hazard ratio; *LBP and/or PGP*, low back pain and/or pelvic girdle pain; *NR*, not reported; *NOS*, not otherwise specified; *OR*, odds ratio; *p*, significance value; r_S, Spearman correlation coefficient; *(0, 1)*, binary outcome (no, yes).

[a]Estimate shown was computed from the reported proportion of exposed versus unexposed participants returning to work within one year postpartum, stratified by parity values 0 or 1, versus for parity ≥2, OR=8.06 (2.06–31.5).[32]

d: July 1, 2022 (for all dates since January 1, 1990).