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Hip and knee pain: Role of occupational factors

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Many people rely economically on occupations involving high loading of the hip or knee joints for lengthy periods, possibly placing them at increased risk of developing chronic pain in these joints. There is a growing body of evidence from large longitudinal cohort studies, case-control studies and population-based surveys that certain occupations, or having work involving considerable heavy lifting, kneeling or squatting, may be associated with increased risk of symptomatic hip or knee osteoarthritis and joint replacement surgery. Only a few studies have evaluated the effectiveness of specific workplace strategies to reduce this risk. Identifying modifiable workplace risk factors and implementing feasible and accessible preventative strategies will be of great public health significance in the next decade.

Worldwide, chronic hip or knee pain is highly prevalent among older people. The large population-based English Longitudinal Study of Ageing has recently shown that 20% of people aged 60 years and over either report moderate to severe hip or knee pain and disability and would be considered in need of joint replacement surgery or have already undergone hip or knee replacement surgery for chronic pain [1]. Many analgesic options are available for people with chronic hip or knee pain; however, the benefits of these treatments for many people are only marginal over placebo, and are often outweighed by their cost or side effects [2]. With the ageing of the population worldwide, the prevalence of chronic hip or knee pain and disability will increase markedly. Many people rely economically on occupations

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involving high loading of the hip or knee joints for lengthy periods, possibly placing them at increased risk of developing chronic joint pain. Identifying modifiable workplace risk factors and implementing feasible and accessible preventative strategies may be of great public health significance in the next decade.

Possible causes of hip pain

The most common cause of chronic hip pain in older people is osteoarthritis. Other common causes include greater trochanteric pain syndrome, referred pain from lumbar spine impingement and acetabular labral tears. The nature and specific location of the pain can often aid diagnosis. As 'hip pain' is difficult to define topographically [3], a physical examination and imaging are often required to differentiate the likely aetiology.

Hip osteoarthritis typically results in pain localised to the anterior groin region, with pain and stiffness particularly present at the initiation of activity. Pain is activity related at first, becoming chronic with increased loss of articular cartilage and structural disease progression. Typically, the passive range of hip motion is increasingly restricted, particularly internal rotation [4]. In fact, decreased internal rotation is often a precursor to symptomatic disease, indicating subtle abnormalities in the structure of the hip joint that would substantially increase the risk of developing osteoarthritis [5].

Acetabular labral tears are demonstrated in more than half of patients with mechanical hip pain [6]. The acetabular labrum functions to increase the stability of the hip joint as well as distribute the load passing through the hip joint. Tears in this innervated fibro-cartilage ring attached to the bony rim of the acetabulum increase the risk of damaging loading of the articular cartilage. Labral tears can be caused by direct trauma or sporting injuries, or simply repetitive microtrauma or hip dysplasia. For many people, labral tears may be the primary precipitator for the early development of painful radiographic hip osteoarthritis. Labral tears may play a role similar to meniscal tears in the knee joint, producing a poor biomechanical environment for the joint and increased risk for the early development of osteoarthritis. Similar to osteoarthritis, the pain associated with labral tears is mostly located in the anterior groin region; however, pain can be located lateral or deep in the posterior buttock region. In addition to pain, symptoms of clicking locking or giving way are reported, the most typical being clicking [6]. In contrast to hip osteoarthritis, restriction in hip range of motion is minimal. However, labral tears are associated with ageing and were demonstrated in more than 90% of cadavers studied in people with a mean age of 78 years [7,8].

Chronic lateral hip pain is often termed 'greater trochanteric pain syndrome' [9]. The differential diagnosis between trochanteric bursitis or gluteus medius pathology and pain referred from the lumbar spine is often difficult, and a combination of all three possible. All can result in aching pain localised in the region of the greater trochanter exacerbated by sleeping on the affected side, going down stairs or standing for long periods of time. A physical examination is usually required to distinguish between mechanical hip pain and pain originating in the lumbar spine. Imaging may be required to identify trochanteric bursitis or gluteus medius pathology as the likely cause of lateral hip pain.

Possible causes of knee pain

The most common cause of chronic knee pain in people aged $\geq$50 years is osteoarthritis. The pain associated with osteoarthritis is mostly related to weight-bearing activity, with joint stiffness experienced on initiation of movement after periods of rest. The pain is typically located on the medial or anterior regions of the knee and experienced as a dull ache, exacerbated when negotiating stairs or walking on uneven ground. Pain and giving way typically experienced while going down stairs is often due to chondromalacia patella or marked osteoarthritis in the patellofemoral joint. Apart from acute trauma or systemic inflammatory diseases, such as rheumatoid arthritis or gout, other common causes of knee pain are intra-articular loose bodies or meniscal tears. Pain is typically episodic and occurs in association with episodes of locking or giving way of the knee, at times followed by gradual swelling around the joint. However, systemic inflammatory diseases, intra-articular loose bodies and meniscal damage or tears can occur concomitantly with radiographic evidence of knee osteoarthritis. The pain descriptors used by the patient can often point to the probable aetiology. Less common causes of chronic knee pain are bursitis and tendinitis. Pain felt at the back of the knee is often caused by a Baker's cyst or referred from lumbar spine impingement. Occasionally, anterior knee pain may be referred pain from hip osteoarthritis.

Descriptive epidemiology

Disease prevalence is best estimated from large population-based surveys with rigorous sampling strategies. However, such large surveys do not generally allow a physical examination by a trained clinician to determine disease status. Disease status is frequently determined by a survey-specific case definition; the reported incidence and prevalence of hip or knee pain are highly associated with the specific case definition used.

Case definitions for the presence of hip or knee pain vary from a simple "current" or "ever" pain through to a more specific "pain in the past 7 days," "pain on most days of 1 month" or "pain on most days of 1 month in the past year." The pain descriptor has also been expanded in several studies to also include "aching or stiffness," [10,11] descriptors likely to inflate pain prevalence estimates. Variation in the specificity of pain location is demonstrated, from "in and around the knee" to a more specific "knee pain," "hip pain" vs. the more specific "anterior groin pain." Furthermore, in contrast to radiographic criteria, there is usually no requirement for a level of pain severity to be reached for case definition. Hip and knee pain prevalence estimates may therefore include cases where pain is referred from other sites as well as those with minimal or occasional pain of no current or future clinical relevance. These differing definitions and descriptors of pain alone could explain much of the large variability in prevalence and risk factor estimates from population-based studies around the world. Importantly, allowing the inclusion of a wide range of pathology is likely to attenuate the magnitude of any detected risk factors for hip or knee pain.

Some prevalence studies require radiographic confirmation of hip or knee osteoarthritis to define cases of hip or knee pain to try to restrict pathology to osteoarthritis. However, a wide range of radiographic criteria for case definition is evident in the literature [12], making comparisons between prevalence estimates difficult. While radiographic confirmation may lead to the exclusion of many cases of referred pain or clinically insignificant joint pain, radiographic case definition criteria will exclude people with early osteoarthritis and usually, as only one view is taken, the not inconsiderable number of women with isolated patellofemoral disease [13]. Furthermore, even in the presence of radiographic changes, hip and knee pain may be not directly attributable to osteoarthritis, as many people with radiographic changes typical of osteoarthritis remain asymptomatic. While possibly resulting in a more homogeneous sample for risk factor analysis, requiring radiographic evidence of osteoarthritis will markedly underestimate the burden of knee or hip pain in the community.

Internationally, prevalence estimates for hip or knee pain show wide variability depending on the age and sex distribution of the studied cohort, even when largely comparable case definitions are used. However, universally, the prevalence of hip and knee osteoarthritis increases exponentially with ageing, with estimates for population-based cohorts aged 45 years and over ranging from 7% to 17% for symptomatic knee osteoarthritis and from 2% to 10% for symptomatic hip osteoarthritis [14–19]. For symptomatic knee osteoarthritis, the prevalence in generally higher among women and among people in rural regions of developing countries compared with urban regions or compared with developed countries [15,20]. In developing countries, a large proportion of the population, while not obese, is engaged in heavy physical occupational activity within informal rural settings for their entire working life. Such exposure has frequently been linked to increased risk of injury and developing chronic musculoskeletal pain and disability [21].

Risk factors for hip pain due to osteoarthritis

The risk of symptomatic hip osteoarthritis clearly increases with age and similarly in men and women [22–25]. While many studies have established being overweight or obese as consistent and strong risk factors for symptomatic knee osteoarthritis, results for hip osteoarthritis have been less consistent [26]. Most studies have only found moderate associations between obesity and incident radiographic hip osteoarthritis. However, the association between obesity and hip osteoarthritis is more likely to be significant, if symptomatic disease was the case definition used in the study [22–24]. It is not surprising, therefore, that a large prospective study demonstrated that being in the highest body mass index (BMI) quartile increased the risk of total hip replacement surgery two- to threefold in men and women, respectively [27].

Childhood hip disorders, such as hip dysplasia and slipped capital femoral epiphysis, are known to substantially increase the risk of developing symptomatic osteoarthritis in later life. There is increasing evidence that more common subtle osseous deformities of the hip joint, such as an acetabular dysplasia or a pistol grip deformity ('femoroacetabular impingement syndrome'), also result in a substantially increased risk of early hip osteoarthritis [28,29]. Overall, the prevalence of these osseous deformities was found to be high, particularly in males [30,31]. The large population-based Copenhagen Osteoarthritis Substudy, among almost 4000 people aged 21–90 years (mean age 61 years), demonstrated hip malformations in 71% and 37% of men and women, respectively [30]. Specifically, while the overall prevalence of acetabular dysplasia (4%) or a deep acetabular socket (17%) was comparable between men and women, a pistol grip malformation was found in 20% and 5% of men and women, respectively. While having a hip malformation was not significantly associated with groin pain, having a deep acetabular socket or a pistol grip malformation was associated with two- to threefold significantly increased odds of having hip osteoarthritis (defined as joint space width $\leq$2 mm) after adjusting for age, sex and BMI [30]. Among cohort participants with hip osteoarthritis, 71% and 37% of men and women, respectively, had concomitant malformations. These findings suggest that subtle hip malformations may be important risk factors for the development of hip osteoarthritis, and particularly in men.

Risk factors for knee pain due to osteoarthritis

Apart from ageing and being female, the other most common risk factor for developing painful knee osteoarthritis is being overweight or obese [19,32–34]. Gaining weight during adult life has also been found to give a slightly higher risk of developing knee osteoarthritis compared with constantly being overweight [35]. For women, weight loss has been found to decrease the risk of knee osteoarthritis substantially [36]. While the prevalence of symptomatic knee osteoarthritis is higher in women, a significantly increased risk of symptomatic knee osteoarthritis associated with being female appears to only commence after menopausal age [25]. Other important risk factors for developing symptomatic knee osteoarthritis include a history of acute knee trauma or meniscectomy [19,33,37,38]. Of the 16 studies evaluating the association between previous knee injury and knee osteoarthritis in a recent systematic review [32], all but two studies concluded that knee injury was a significant and important risk factor. Having a history of substantial knee trauma was associated with a sevenfold increased risk of developing knee osteoarthritis in two recent large prospective cohort studies adjusting for age, gender, BMI, smoking and physical activity [38,39]. A two- to sixfold increased risk has been reported for the development of knee osteoarthritis 15–20 years after meniscectomy, even without concomitant cruciate ligament damage, the higher risk associated with total meniscectomy (compared with partial) or being obese [37]. Events such as substantial knee trauma, with or with surgery, alter the biomechanical environment of the knee joint and likely result in major changes to the load distribution over the articular cartilage and subchondral bone and triggering an ultimately degradative biochemical response.

There are several well-established risk factors for both symptomatic hip and knee osteoarthritis: age, gender, high BMI, history of joint surgery or trauma. These known risk factors will need to be considered in any evaluation of the influence of occupation or the working environment on the development of hip or knee pain.

Occupational risk factors

The highest level of evidence for determining risk factors comes from large population-based longitudinal cohort studies, which allow recording of risk exposure prior to disease incidence.

However, longitudinal cohort studies are very costly, needing to be large and with a lengthy follow-up to accumulate sufficient 'cases' of incident disease, even in fairly prevalent conditions, such as symptomatic hip or knee osteoarthritis. A case-control design is therefore frequently used as a feasible option, even though accurate retrospective reporting of physical workload exposure over a long period is problematic for most people and is vulnerable to differing recall between cases and controls. Furthermore, identifying and assembling what is considered a valid control group is often an issue of ongoing contention. For symptomatic hip or knee osteoarthritis, it may be argued that it is particularly difficult to establish a causal relationship using a case-control study design given the actual timing of disease incidence is uncertain and likely to have a lengthy non-symptomatic lead time. The evidence from case-control studies is therefore generally considered less convincing, compared with prospective cohort studies. However, it is unlikely that developing chronic hip or knee pain will lead people to choose an occupation requiring increased physical loading of these joints.

Evaluation of risk exposure is mostly conducted through self-report or interview questionnaires. For studies evaluating occupational risk factors for hip or knee pain, questions are usually posed to estimate total exposure to activities demonstrated to increase loading of these joints, for example, heavy lifting, standing, climbing stairs or ladders, squatting or kneeling. Some larger national population-based surveys, however, have used occupational class or job title as a surrogate measure of physical load. Using these surrogate measures, particularly if only a few crude classifications are included, is likely to attenuate risk magnitude as one occupational class can cover a range of physical workload exposures.

Evidence from systematic reviews

Two recent well-conducted systematic reviews evaluated studies published up to May 2007 examining causal relationships between physical workload exposures and risk of hip or knee osteoarthritis [40,41]. Studies were only included in these systematic reviews, if controlled and if the case definition 'osteoarthritis' was confirmed by radiographs, relevant World Health Organization (WHO) International Classification of Diseases codes or presence of a total joint replacement (or on the waiting list).

Hip osteoarthritis

For hip osteoarthritis, 22 studies met the inclusion criteria [40]. Most of the 22 studies had a case-control design, with only a few large longitudinal cohort studies included and rated as well conducted by the reviewer [27,42–44]. All studies evaluating work exposure to heavy lifting showed a two- to threefold significantly increased risk of hip osteoarthritis. A dose–response relationship was demonstrated in several studies; 10–25 kg over at least 10–20 years was associated with a clearly increased risk [40]. Only five studies examined the causal relationship between the occupational need to climb stairs or ladders; and three studies demonstrated a twofold significantly increased risk of hip osteoarthritis. However, the only study evaluating the risk associated with stair or ladder climbing, and considered of high methodological quality could not find a significant association in this case-control study of older men [45]. No studies were retrieved that evaluated the influence of heavy lifting combined with kneeling and squatting.

Fourteen studies evaluated the risk of hip osteoarthritis associated with farming. All but one study demonstrated a two- to 12-fold significantly increased risk [40]. This risk estimate is likely to be conservative, as farmers leaving this occupation due to painful hips (healthy worker effect) will not have been included. Six studies evaluated the risk for hip osteoarthritis associated with construction work. While most studies showed significantly increased risk, the magnitude of risk was not as large as that demonstrated for farming. This finding of a smaller risk was attributed to the generally smaller samples in these studies of construction workers, and the anticipated greater heterogeneity of workloads within the classification of 'construction work' compared with farming. All studies in the 2008 systematic review found stronger associations between heavy, physical, occupational demands and hip osteoarthritis in men compared with women. This gender bias has mostly been attributed to the relatively small number of women exposed to heavy, physical, occupational demands in the conducted studies, compared with men. However, the demonstrated higher prevalence of subtle osseous deformities of the hip joint among men would also increase their vulnerability for developing hip osteoarthritis. These hip joint structural characteristics have not been evaluated or considered in any multivariate analyses of occupational risk factors for hip osteoarthritis in studies conducted to date. This review concluded that there was moderate to strong evidence for an association between heavy lifting over a 10–20-year period and hip osteoarthritis and a twofold increased risk for farmers after 10 years' exposure [40]. There was insufficient evidence for other occupational classes or for climbing stairs and ladders, kneeling or squatting.

Knee osteoarthritis

For knee osteoarthritis, the 2008 review retrieved 25 observational studies that met the inclusion criteria [41]. Again, apart from five longitudinal cohort studies, all other risk evaluations were derived from either case-control studies (difficulty of recalling past activity accurately and recall bias) or cross-sectional surveys (difficulty establishing a causal relationship). The results for the 17 studies evaluating the risk associated with heavy lifting were inconsistent, with only nine studies demonstrating a significant association. Restricting analysis to the six studies considered to be of high methodological quality by the reviewer demonstrated a significant odds ratio (OR) for developing knee osteoarthritis ranging from 1.9 to 7.1 associated with heavy lifting [33,46–50]. For kneeling or squatting (usually defined in studies as >1 h per day), eight out of 12 studies demonstrated a significant two- to sevenfold increased odds of developing knee osteoarthritis [41]. When the analysis was restricted to the six studies considered to be of high methodological quality, an OR for incident knee osteoarthritis from 1.1 to 3.0 was demonstrated [33,46–50]. Furthermore, a dose–response relationship was detected by several studies. Four studies evaluating the combination of heavy lifting and kneeling/squatting demonstrated significantly increased ORs in the range of 2.2–5.4 [33,47,51,52]. Two studies compared heavy lifting alone with the combination of heavy lifting with kneeling, both demonstrating a marked increase in risk associated with the combination of activities [47,51]. Only a few case-control studies with marked methodological limitations examined the association between climbing stairs or ladders and knee osteoarthritis; hence, the review considered the evidence of ORs ranging from 1.7 to 6.1 to still be inconclusive.

Twelve studies evaluated the risk of knee osteoarthritis according to occupational class, with highly significant associations demonstrated in most studies for miners, floor layers (patella-femoral disease), farmers and certain professions within the construction industry. The most highly rated study in this group, a case-control study conducted among more than 1000 workers in Sweden, found a two- to threefold significantly increased prevalence of total knee replacement surgery among male construction workers, male forestry workers and farmers (male or female) [50].

Overall, due to the reliance on relatively small case-control studies, the strength of evidence for a causal relationship between occupational workload and hip or knee pain was considered moderate by the author of the reviews.

Review update

The studies

A literature search was conducted in July 2010 to update the evidence provided by the above two systematic reviews. Studies were identified by the keywords (knee or hip), (osteoarthritis or osteoarthrosis or knee pain or hip pain) and (work or occupation). The search was limited to English language full-text articles. Only controlled studies evaluating occupational risk factors for symptomatic disease were included. In total, 10 studies were identified, two evaluating symptomatic hip and knee osteoarthritis, two assessing symptomatic hip osteoarthritis (Table 1) and six restricted to symptomatic knee osteoarthritis (Table 2).

Of the two studies evaluating both symptomatic hip and knee osteoarthritis (Tables 1 and 2), one was a large, prospective, cohort study among 204,741 men employed in the Swedish construction industry (Jarvholm et al., 2008) [53] and the other a large rural community-based cross-sectional

Table 1
Occupational workload and hip pain. Studies published from May 2007–July 2010.

Ref	Size	Age (yrs)	Exposure measure	Diagnostic Criteria	Adjusted/Matched	Significant findings (OR, 95% CI) or (RR, 95% CI)	Design	Strengths/Weakness
Allen 2010 [54]	2729	≥45	*Occupational group* *Occupational activity* Longest held job: Walking, lifting/carrying, sitting, standing, bending/ twisting, squatting, climbing stairs, crawling, crouching/ kneeling, heavy work while standing. Lifetime exposures: heavy work while standing, sitting/ kneeling/walking >50% job; lifting>10x/week.	Symptoms. K/L ≥2.	Age Gender Race BMI Smoking Knee/hip injury Household tasks	Lifting: 1.67 (1.26–2.23) Bend, twist reach: 1.60 (1.18–2.17) Crawling: 2.28 (1.43–3.65) Heavy work standing: 1.75 (1.17–2.61) Lifting 10 kg ≥ 10/week: 1.71 (1.28–2.29)	Cross-sectional	Strengths: Large community-based cohort, detailed exposure information, adjustment for most other important risk factors. Weakness: Recall bias, high prevalence heavy occupational activity, rural community - may limit generalisability
Jarvholm 2008 [53]	204,741 Males	15–67	*Job title*	Surgically treated primary hip OA.	Age BMI	None significant.	Cohort	Strengths: Prospective cohort design, surgery incidence collected from national registry. Weakness: Use of job title as proxy measure of occupational workload exposure, no adjustment history of injury or sporting activities.
Juhakoski 2009 [22]	840	30–72	*Questionnaire* *Occupational activity*: Physical workload (six categories): light sedentary, other sedentary work, light standing/ movements, fairly light or medium heavy, heavy manual or very heavy manual.	Clinical examination of those reporting hip pain in past month.	Sex Age BMI Education Smoking Alcohol Leisure time physical activity Injury	(Compared with light sedentary) Fairly light or medium heavy: 3.1 (1.2–8.0) Heavy manual labour: 6.7 (2.3–19.5)	Cohort	Strengths: Population based prospective study with long follow-up period, symptomatic hip OA diagnosed by physicians. Weakness: Limited number of very heavy manual labour subjects ($n = 12$), wide CI's.
Thelin 2007 [55]	3437 Males	40–60	*Occupational class*: Farmer ($n = 1220$). Rural non-farmer ($n = 1130$). Urban ($n = 1087$).	Hospitalised: Any OA. Hip OA. Hip joint surgery.	Age Residence	(Compared to urban controls) *Farming men* Any OA: 2.1 (1.4–3.2) Hip OA: 3.0 (1.7–5.3) *Non-farming men* No significance findings.	Cohort	Strengths: Large longitudinal cohort, case definition by national registry. Weakness: Limited information on hospital care for hip OA (Prior 1997 not available), no adjustments for BMI, hip/joint injury, smoking.

Table 2
Occupational workload and knee pain. Studies published from May 2007–July 2010.

Ref	Size	Age (yrs)	Exposure measure	Diagnostic Criteria	Adjusted/ Matched	Significant findings (OR, 95% CI) or (RR, 95% CI)	Design	Strengths/ Weakness
Allen 2010 [54]	2729	≥45	*Occupational group* *Occupational activity* Longest held job: Walking, lifting/carrying, sitting, standing, bending/ twisting, squatting, climbing stairs, crawling, crouching/kneeling, heavy work while standing. Lifetime exposures: heavy work while standing, sitting/ kneeling/walking >50% job; lifting>10x/week.	Symptoms K/L ≥2.	Age Gender Race BMI Smoking Knee/hip injury Household tasks	Walking: 1.46 (1.12–1.90) Lifting: 1.42 (1.13–1.80) Standing: 1.38 (1.08–1.77) Sitting: 0.72 (0.57–0.90) Crawling: 1.59 (1.05–2.41) Heavy work standing: 1.44 (1.03–2.02)	Cross-sectional	Strengths: Large community-based cohort, detailed exposure information, adjustment for most other important risk factors. Weakness: Recall bias, high prevalence heavy occupational activity, rural community - may limit generalisability.
Jarvholm 2008 [53]	204,741	15–67	*Job title.*	Surgically treated primary knee OA.	Age BMI	(Compared with white collar workers) Asphalt workers: 2.81 (1.11–7.13) Brick layers: 2.14 (1.08–4.25) Floor layers: 4.72 (1.80–12.33) Plumbers: 2.29 (1.19–4.43) Rock workers: 2.59 (1.18–5.69) Sheet-metal workers: 2.60 (1.06–6.37) Wood workers: 2.02 (1.11–3.69)	Cohort	Strengths: Prospective cohort design, surgery incidence collected from national registry. Weakness: Use of job title as proxy measure of occupational workload exposure, no adjustment history of injury or sporting activities.

Dahaghin 2009 [60]	970 (Cases: 480 Controls: 490)	17–88	*Occupational class*: Sedentary, laborious or housekeeping. *Occupational activity*: >1 h/day: Standing, walking, sitting. >30 min/day: Walking up/downhill, squatting, knee bending, cycling. Lifting >2 kg/day. Climbing stairs >3/day.	ACR clinical criteria.	Age Sex BMI Knee injury	*Occupational class* None significant. *Occupational activity* Walking 1–2 h/day: 0.60 (0.42–0.85) Sitting 1–2 h/day: 0.54 (0.36–0.80) Squatting >30 min/day: 1.51 (1.12–2.04) Cycling >30 min/day: 2.06 (1.23–3.45)	Case-Control	Strengths: Community-based, life grid to help participant plot work activities, adjustment for most other important risk factors. Weakness: Recall bias, controls younger, differential response (80% cases, 47% controls).
D'Souza 2008 [62]	1970	≥60	*Occupational exposure*: (longest held job ≥ 5 years) sitting, standing, walking, lifting >10 kg, kneeling/squatting, working in cramped space. Rated according to job title by ergonomic experts.	K/L ≥2. Pain. TKR.	Age Gender BMI Smoking Sport activities	*Occupational activity* *Females* Standing: 2.28 (1.09–4.77) *Males* Sitting: 0.42 (0.18–0.96) Kneeling: 3.08 (1.31–7.21) Heavy lifting: 2.72 (1.14–6.50) *All* Standing: 1.96 (1.06–3.46) Kneeling: 2.37 (1.27–4.45) Heavy lifting: 2.00 (1.02–3.93)	Cross-sectional	Strengths: National population-based survey (NHANESIII), expert ratings for occupational exposures. Weakness: No adjustment for history of knee injury, housework or other jobs held other than l ongest job.

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Table 2 (*continued*).

Ref	Size	Age (yrs)	Exposure measure	Diagnostic Criteria	Adjusted/ Matched	Significant findings (OR, 95% CI) or (RR, 95% CI)	Design	Strengths/ Weakness
Jones 2007 [56]	859	20–27	*Occupational exposure*: Manual handling activities during the last working day (estimate of weights lifted, time spent squatting, standing, kneeling). Psychosocial factors.	Knee pain past month.	Age Sex BMI Physical activity	(Compared to not carrying/lifting weights) Carrying weights <20: 2.1 (1.3–3.2) Carrying weight >20: 1.7 (1.03–2.8) Lift weights shoulder levelor above <28: 1.8 (1.1–2.9) Psychosocial factors: None significant.	Cohort	Strengths: Prospective cohort, newly employed workers, diverse range of occupations, psychosocial factors included, participation rate 80%. Weakness: Only 2 year follow-up, no adjustment for history of knee pain/injury.
Klussmann 2010 [59]	1310 (Cases: 739 Controls: 571)	25–75	*Questionnaire and Telephone interview*	Cases: K/L ≥2. Knee OA <10 years. No knee injury. Controls: Recruited at accident clinics	Sex BMI Age Smoking Leisure activities Sports risk	*Females* (Highest tertile compared with 0) Kneeling/squatting: 2.5 (1.35–4.68) Lifting and carrying: 2.13 (1.14–3.98) *Males* (Highest tertile compared with 0) Kneeling/squatting: 2.47 (1.41–4.32)	Case-Control	Strengths: Wide range occupational exposure, response rate - moderate, adjustment for most other risk factors. Weakness: Uses of clinical controls, cases/controls not matched for age/ sex, recall bias.

Seidler 2008 [57]	622 males (Cases: 295 Controls: 327)	25–70	*Personal interview* *Occupational class*: Occupational groups. *Occupational activity*: Work time physical workload: kneeling/ squatting, cumulative lifting/carrying, kneeling/ squatting and lifting/ carrying combined. Calculated cumulative exposures up to date diagnosed of OA.	K/L scale ≥2. Chronic complaints.	Age Region BMI Jogging/ athletics	*Occupations class* Chemical/Plastics: 16.1 (3.1–84.8) Plaster, insulators, glaziers, terrazzo workers, construction carpenters, roofers, upholsterers: 4.5 (1.1–19.4) Painters, varnishers: 6.4 (1.5–27.1) Quality inspectors: 6.4 (1.5–27.1) Service workers): 4.3 (1.6–11.7) *Kneeling/squatting combined* Highest quartile: 2.2 (1.1–5.0) *Lifting/carrying combined* 2nd quartile: 2.0 (1.1–3.6) 3rd quartile: 2.0 (1.1–3.9) Highest quartile: 2.6 (1.1–6.1) *Kneeling or squatting* Highest quartile: 3.4 (1.8–6.3) *Both kneeling/ squatting* Highest quartile: 7.9 (2.0–31.5)	Case-Control	Strengths: use of pictures for work activities postures in questionnaire, evaluates dose–response relationship. Weakness: Low response rate (61% cases, 55% controls, recall bias, unknown diagnosis among controls, males only.

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Table 2 (*continued*).

Ref	Size	Age (yrs)	Exposure measure	Diagnostic Criteria	Adjusted/ Matched	Significant findings (OR, 95% CI) or (RR, 95% CI)	Design	Strengths/ Weakness
Vrezas 2010 [58]	622 males (Cases: 295 Controls: 327)	25–70	*Questionnaire and Telephone interview* *Occupational activity*: Evaluating the influence of a high BMI.	K/L ≥2 Chronic complaints.	Age Region BMI Kneeling/ Squatting Lifting/ carrying Jogging/ athletics	BMI ≤25 kg/m^2 and kneeling/squatting: 1.8 (0.8–3.9) BMI of ≥25 kg/m^2 and kneeling/squatting: 5.3 (2.4–11.5) BMI of ≤25 kg/m^2 and lifting/carrying: 2.4 (1.1–5.4) BMI of ≥25 kg/m^2 and lifting/carrying: 5.0 (2.4–10.5)	Case-Control	Strengths: Evaluates the dose response rate. Weakness: Low response rate (61% cases, 55% controls), recall bias, unknown diagnosis among controls, males only.

survey conducted in the USA (Allen et al., 2010) [54]. The Swedish cohort had a 32-year follow-up and used the national registry to determine the incidence of surgically treated hip or knee osteoarthritis. Occupational exposure was measured by job title, and risk comparisons were made to 'white-collar workers' within the industry [53]. The cross-sectional survey was conducted in Johnston County, North Carolina, among people aged 45 years and over [54]. Case definition was symptomatic hip or knee osteoarthritis, confirmed by radiograph. In this study, occupational exposure was evaluated by participant report of 10 specific tasks performed at the longest job held and lifetime exposure of eight tasks conducted more than 50% of the week. While the large, prospective, cohort study only adjusted for age and BMI, the cross-sectional survey was able to adjust the analysis for a much more comprehensive list of potential confounders: age, sex, region, race, BMI, smoking, history of knee or hip injury and household tasks.

The two studies that exclusively examined hip osteoarthritis (Table 1) were both prospective cohort studies conducted in Scandinavia. The first (Juhakoski et al., 2009) was a 22-year follow-up of 840 adults participating in a Finnish national population-based survey [22]. At baseline, information was collected on workload. Workload was then classified into six grades from light sedentary through to very heavy manual. Cases of hip osteoarthritis were diagnosed at follow-up in 41 subjects (5%) by clinical examination. The other longitudinal study (Thelin et al., 2007) was conducted in a large cohort of 3437 men aged between 40 and 60 years in 1989 living in nine Swedish municipalities [55]. The aim of this study was to determine the difference between farmers, rural non-farming men and urban men for incident hip osteoarthritis during the 13-year follow-up period. Cases were identified as hospitalisation for any osteoarthritis ($n = 140$), hospitalisation for hip osteoarthritis ($n = 88$) or hip joint surgery ($n = 96$) by the Swedish national hospital registry.

The six studies that examined occupational risk factors for knee osteoarthritis (Table 2) consisted of one prospective cohort study, four case-control studies and one cross-sectional survey. The prospective cohort study was conducted in England among 859 young (20–27 years) newly employed workers in a diverse range of workplaces and organisations (Jones et al., 2007) [56]. Participants were followed-up for 2 years for new-onset knee pain ($n = 108$). Mechanical (kneeling, squatting, bending and strength and manual handling activities) and psychosocial exposures were measured by questionnaires at baseline and 1 year. Two of the four case-control studies were conducted on one cohort of 622 males aged 25–70 years living in Frankfurt, Germany [57,58]. The 295 cases presented at one of several orthopaedic clinics with radiographic knee osteoarthritis (Kellgren and Lawrence grade ≥ 2) and 'chronic complaints', initially diagnosed within the past 5 years. The male controls were randomly selected from the Frankfurt and Offenbach population registration office records. A personal interview was used to seek job titles and detail occupational workload frequency and duration. The first reported analysis of this case-control study (Seidler et al., 2008) examined the associations between symptomatic knee osteoarthritis and job title or occupational workload [57]. The second analysis (Vrezas et al., 2010) examined the interaction between BMI and physical workload [58]. The third case-control study (Klussman et al., 2010) was conducted in Germany among 1310 men and women aged between 25 and 75 years living in both rural and urban regions [59]. Cases were recruited from surgical orthopaedic wards and outpatient clinics, and defined as knee osteoarthritis confirmed by radiographs (Kellgren and Lawrence grade ≥ 2) and diagnosed within the past 10 years. Controls were recruited from the accident surgery services of these hospitals. A questionnaire was used to collect information on individual and occupational factors, sports, leisure-time activity and medical history. Lifetime exposure to occupational (including housework) kneeling or squatting, sitting, lifting and carrying, jumping or climbing stairs was evaluated. A large range of variables, including BMI, family history, tibiofemoral malalignment, smoking and sports participation were examined as potential confounders in the associations between occupational exposure and knee osteoarthritis in this study. The fourth study (Dahaghin et al., 2009) was conducted in Tehran among 480 cases and 490 controls, with a mean age of 57 years [60]. The cases were defined by the American College of Rheumatology clinical criteria for knee osteoarthritis, and were selected from 1532 adults with knee osteoarthritis participating in the Tehran Community Oriented Program for the Control of Rheumatic Diseases (COPCORD) study [61]. A questionnaire was used to collect information on occupation, sports and details of 10 specific occupational activities. The large cross-sectional study ($n = 1970$) evaluating occupational risk factors for knee osteoarthritis used the national population-based National Health and Nutrition Examination

Survey (NHANES) III data set (D'Souza et al., 2008) [62]. Cases of symptomatic knee osteoarthritis were confirmed by knee radiographs (Kellgren and Lawrence ≥2). Occupational exposures (sitting, standing, walking, kneeling, heavy lifting and working in a cramped space) were evaluated by ergonomic experts from reported job categories.

The risk factors

Heavy lifting

The association between heavy lifting and symptomatic knee and hip osteoarthritis was examined in eight studies (Tables 1 and 2). Out of the eight studies, three found significant associations for hip osteoarthritis with ORs ranging from 1.7 to 6.7 and six studies for knee osteoarthritis with ORs ranging from 1.4 to 5.0.

For hip osteoarthritis, the large prospective cohort study conducted in Finland, (Juhakoski et al., 2009) demonstrated that 'heavy manual work', compared with 'light sedentary work' was associated increased risk (OR 6.7, 95% confidence interval (CI): 2.3–19.5) [22].

The cross-sectional Johnston River Osteoarthritis Project survey (Allen et al., 2010) demonstrated a significant association with hip osteoarthritis for those participants reporting lifting >4.5 kg in the longest job ever held (OR: 1.7, 95% CI: 1.3–2.2) [54]. Lifetime exposure to lifting ≥10 kg, ≥20 and ≥50 kg per week also demonstrated significant associations with symptomatic hip osteoarthritis, but a dose–response was not established. Heavy work while standing in the longest job held and a lifetime exposure of heavy work while standing >50% of the job also demonstrated significant associations with hip osteoarthritis in this study (Table 1).

The 2-year prospective cohort study conducted in England (Jones et al., 2007) [56] demonstrated a significantly increased risk of new-onset knee pain with lifting or carrying weights up to 9 kg (relative risk (RR) 2.1, (95% CI: 1.3–3.2)), and lifting or carrying weights >9kg (RR 1.7 95% CI: 1.03–2.8). Investigations into lifting or carrying weights at or above shoulder levels up to 13kg also showed an increased RR of 1.8 (95% CI: 1.1–2.9), but not weights >13kg. There was no adjustment made for prior knee injury.

Two large cross-sectional studies examined the relationship between occupational activities and knee osteoarthritis. The rural Johnston County Osteoarthritis Project (Allen et al., 2010) [56] measured exposure in the longest job held and lifetime exposures to specific job tasks including lifting, lifting a certain weight and heavy work while standing, while the NHANES III national survey (D'Souza et al., 2008) [62] used ergonomic expertise and categorised heavy lifting into percentage of workday. The Johnston River Osteoarthritis Project conducted weight-bearing knee radiographs (Allen et al., 2010) [54], and after adjusting for multiple covariates, found significant associations for symptomatic knee osteoarthritis with lifting >4.5 kg (OR: 1.4, 95% CI: 1.1–1.8) and heavy work while standing in the longest job ever held (OR: 1.4, 95% CI: 1.03–2.0). Additional analysis was performed on lifetime exposure standing >50% of the job and found a significant association with symptomatic knee osteoarthritis (OR: 1.3, 95% CI: 1.02–1.7). The NHANES III national survey examined symptomatic or severe symptomatic knee osteoarthritis as case definition. A significant association was demonstrated with heavy lifting in the highest quartile (OR: 2.0, 95% CI: 1.02–3.4). Furthermore, a dose–response relationship was demonstrated with heavy lifting in the three highest quartiles and severe knee osteoarthritis (Table 2).

Two of the three case-control studies were conducted among a single cohort of 622 males [57,58]. The first (Seidler et al., 2008) demonstrated a dose–response relationship with reported lifetime of lifting and carrying weights and symptomatic knee (OR: 2. 0, 95% CI: 1.1–3.9; OR: 2.6, 95% CI: 1.1–6.1) (Table 2). The second (Vrezas et al., 2010) examined the interaction between BMI and physical workload and suggested a dose–response relationship for lifting and carrying weights with a higher BMI (Table 2). The third case-control study (Klussman et al., 2010) was conducted among 1310 men and women, and demonstrated a significant association with lifetime exposure to carrying and lifting weights and symptomatic knee osteoarthritis only for women (OR: 2.1, 95% CI: 1.1–4.0) [59].

Adding the evidence provided by these more recently published studies to that provided by the systematic reviews [41,42] indicates that heavy lifting is significantly associated with developing symptomatic hip or knee osteoarthritis, and particularly among people who are overweight or obese.

Kneeling, squatting or crawling

The association between kneeling/squatting/crawling and symptomatic hip osteoarthritis has only been investigated in the large community-based survey (Johnston County Osteoarthritis Project) [54]. A significant association was only demonstrated for crawling (Table 1).

The association between kneeling, squatting or crawling and developing painful knee osteoarthritis was investigated in seven studies (Table 2), six demonstrating significant associations with ORs or RRs ranging from 1.5 to 2.5. Only one study could not demonstrate a significant risk, possibly as this prospective cohort study among new workers only had a 2-year follow-up period [56].

The large rural community-based survey (Johnston County Osteoarthritis Project) evaluated squatting, crawling and crouch/kneeling, and found a significant association with symptomatic knee osteoarthritis for crawling (OR: 1.6, 95% CI: 1.1–2.4), with squatting almost reaching statistical significance (OR: 1.3, 95% CI: 0.97–1.7) in adjusted analysis [54]. A significant dose–response relationship for kneeling was detected in the analysis of NHANES III cohort, the association becoming significant when kneeling was reported to occur >15% of the workday (OR: 2.4, 95% CI: 1.3–4.5) [62]. The case-control study conducted in Tehran (Dahaghin et al., 2009) demonstrated a significant association between knee osteoarthritis and occupational squatting for more than 30 min day^{-1} (OR: 1.5, 95% CI: 1.1–2.0) [60].

One of the two studies conducted on a case-control cohort of 622 males investigated the addition of exposure to high BMI to kneeling or squatting (Vretzas et al., 2010) [58]. The presence of a high BMI (>25 kg m^{-2}) increased the magnitude of the association between squatting or kneeling and painful knee osteoarthritis from an insignificant OR of 1.8 (0.8–3.9) among those within the normal BMI range to 5.3 (2.4–11.5) among overweight or obese participants [58]. The wide 95% CIs possibly reflect the relatively small proportion of participants (<15%), who would be considered obese, in this study.

When this evidence is added to that provided by Jensen's systematic reviews [40,41], it would appear that there is consistent evidence that occupations requiring regular kneeling or crawling are associated with an approximately twofold significantly increased risk of developing painful knee osteoarthritis. The magnitude of risk involved is likely to be markedly increased, if the worker is overweight or obese, and if the occupation also requires regular heavy lifting. The evidence of a significant association between squatting and knee osteoarthritis is limited probably as exposure to long periods of squatting in these mostly Caucasian samples is not usual. There is also currently only limited evidence for an association between occupational kneeling/crawling or squatting and hip osteoarthritis.

Occupational group or job title

The associations between physical workload exposure defined by occupational group or job title and painful knee or hip osteoarthritis have been investigated in four studies. Out of the four studies, one with hip osteoarthritis [55] (Table 1) and two found a significant association with knee osteoarthritis [53,57] (Table 2).

The large, prospective cohort study conducted in nine Swedish municipalities (Thelin et al., 2007) among almost 3500 men found a significantly increased risk of incident hip osteoarthritis for farmers when compared with urban males (ORs 3.0 (95% CI 1.7–5.3)). There was no increased risk demonstrated when comparing rural non-farming men with urban men [55].

The case-control study of 622 German males (Seidler et al., 2008) found that knee osteoarthritis was more common in those who held jobs for ≥10 years in many production and service occupational groups [57]. The longitudinal prospective cohort study conducted in Sweden (Jarvholm et al., 2008) found a significant association, in multivariate analysis, for many categories of male construction workers and surgically treated knee osteoarthritis, compared with white collar workers within the industry [53]. However, these analyses were not adjusted for sporting activities or history of joint injury. No significant associations were found for surgically treated hip osteoarthritis in this large prospective study.

The findings from these two recent large Swedish prospective studies among men support the findings of the systematic reviews. Overall, there appears to be substantial evidence that being a farmer increases the risk of symptomatic hip osteoarthritis and being a male blue-collar worker in the construction industry increases the risk for symptomatic knee osteoarthritis.

Heavy lifting and kneeling/squatting

The associations between heavy lifting with kneeling and squatting and knee or hip osteoarthritis have been investigated in two studies (Juhakoski et al., 2009; Seidler et al., 2008) [22,57]. Only the case-control study found a significant association with knee osteoarthritis [57]. The addition of occupation-related lifting or carrying heavy objects to kneeling or squatting increased the OR (95% CI) from 2.4 (1.1–5.0) to 3.4 (1.8–6.3). This illustrates as previously observed by Jensen's systematic review that occupations that involve heavy lifting/carrying with kneeling/squatting are probably associated with a significantly higher risk for knee osteoarthritis.

Climbing stairs or ladders

The association between occupations involving frequent climbing of stairs and hip or knee osteoarthritis has been investigated in three studies. Only one study found a significant association, and then for hip osteoarthritis [22]. In this prospective study of 840 adult Finns (Juhakoski et al., 2009), workload was divided into six categories ranging from sedentary to very heavy manual work. 'Fairly light or medium heavy work' was defined as "work involving a great deal of moving about and a fair amount of stooping down or carrying light objects, also work involving walking up and down the stairs or fairly rapid motion over rather long distances, e.g. light industrial work, forest surveying, messenger's work." A multivariate analysis was performed with the comparator 'light sedentary work', and an increased risk (OR 3.1, 95% CI: 1.2–8.0) for hip osteoarthritis was demonstrated. This workload description was not restricted to climbing stairs, and the risk of hip osteoarthritis could also be associated with a "great deal of movement," "stooping" or "rapid motion for long distance." Overall, there is still little evidence that climbing stairs or ladders is associated with the increase risk of symptomatic hip or knee osteoarthritis.

Work-related lower limb injury

The previous section indicates that most of the epidemiological research to date has focussed on evaluating the influence of physical work demands on the incidence of symptomatic hip or knee osteoarthritis. In addition to occupational disease, however, work-related soft-tissue injuries in the lower limb are also relatively common and potentially preventable. In 2007–2008, the lower limb accounted for 21% of all Australian compensable injury and disease claims by bodily location [63]. The work injuries were predominately sprains and strains to joints and adjacent muscles caused by body stressing associated with manual handling and working in sustained and constrained postures. The industries with the highest proportion of lower limb injuries were manufacturing and construction, with labourers, tradespersons and intermediate production and transport workers the most-at-risk occupations.

It was recently reported that degenerative medial meniscus tears associated with occupational kneeling were significantly more prevalent amongst floor-layer tradesmen than graphic designers (OR 2.3, 95% CI: 1.1–5.0) and significantly more floor layers had medial tears in both knees (OR 3.5, 95% CI: 1.4–8.5) [64]. Moreover, knee complaints occurred in nearly 50% of all floor layers, irrespective of the presence of meniscal tears. The same research group also found that reports of knee pain (OR 2.7, 95% CI: 1.5–4.6), pain during stair climbing (OR 2.2, 95% CI: 1.3–3.9) and symptoms of catching of the knee joint (OR 2.9, 95% CI: 1.4–5.7) were more prevalent among floor layers compared with graphic designers [65,66]. It has been shown that floor layers spend a high percentage of time in knee-straining work positions. Kneeling work tasks, particularly gluing and crawling, cause high external knee forces ranging from 0.3 N (SD 0.2)-times body weight when floor layers were kneeling back on the heels to 3.5 N (SD 0.3) times body weight in the crawling work position [67]. These findings highlight the need for prevention by minimising the amount of kneeling work positions among floor layers.

Prevention and management

Despite strong evidence of occupationally related risks and a relatively high prevalence of work-related lower limb injuries and disease, very little evidence-based research exists to guide clinicians in the prevention and management of these disorders [68]. In a review of relevant electronic databases (Medline, Cinahl and Cochrane) for publications since 1990, surprisingly, no randomised controlled intervention trials or systematic reviews were identified to provide a high level of evidence for the prevention and management of work-related hip or knee injuries or symptomatic osteoarthritis. To date, only a few cross-sectional, observational and non-controlled intervention studies have investigated the prevention of occupational knee disorders, but no studies specifically related to occupational hip disorders have been identified. Therefore, clinicians and occupational health professionals will need to be mostly guided in prevention and management by taking a risk management approach. A risk management approach implies that exposures to occupational risks are systematically assessed and prioritised to determine the likelihood and extent of any resultant injury or disease, and, then, a hierarchical approach to risk control is used to minimise any risk of harm. In the first instance, an occupational risk should be controlled by eliminating the risk at its source. If this prevention approach is not possible, then alternate controls should be implemented including the adoption of new work methods, use of tools and equipment, administrative controls and/or training and education of workers to minimise any future risk of harm. For example, while it is not practical to eliminate the task of floor laying to prevent knee injuries in tradespersons, it may be possible to develop new work methods and equipment that reduce the frequency and duration of injury-related kneeling and crouching postures normally adopted during floor laying.

One recent study evaluated the effect of a participatory ergonomics implementation strategy in the floor-laying trade, consisting of information, education and facilitation of the use of new tools and working methods [69]. Floor layers ($n = 292$), representing approximately one-third of the total trade population in Denmark, were trained in using new working methods. Floor layers were not randomly selected, but were chosen, if they were interested and if their employers supported their participation. All participants were provided with a complete set of tools, which made it possible to carry out the tasks of gluing, filling, welding, up-cutting and cutting of welding wire from an upright work position. The effects were evaluated by using questionnaires, interviews and assessments of quality and productivity. Following the training, 43% had used the new working methods weekly/daily compared with 11% before training. There was a reduction in the degree of self-reported pain in the knees among the floor layers using the new working methods weekly or daily compared with those using them never or occasionally. Significantly, musculoskeletal complaints did not increase from any other body region, and the quality and the productivity of the work were not decreased. These outcomes indicated that the implementation strategy succeeded in reducing occupational risk and related knee pain in floor layers trained in the new method. In a follow-up study [70] 2 years after the floor layers were trained, the researchers found that 38% of floor layers still used the new upright working methods weekly or daily compared with 37% 3 months after the training course. Among floor layers who did not participate ($n = 454$), only 16% had used the new working methods weekly or daily. The risk of knee complaints >30 days (OR 2.5, 95% CI 1.03–5.8) or locking of the knees (OR 2.9, 95% CI 1.1–7.5) was more than double among floor layers who had used the new working methods for less than 1 year compared with those who had used them for a longer period. The results were adjusted for age, BMI and stress. The reduction in more severe knee complaints was greatest, if floor layers started to use the new working methods before they developed knee problems. Other musculoskeletal complaints did not increase. The authors concluded that within a 2-year perspective, the implementation strategy to introduce new working methods in the floor-laying trade had been effective; the number of floor layers using the new working methods had increased, and severe knee problems had reduced [70]. The lack of uptake of the new working methods in those not trained indicates that, to effect change in practice more fully, a concerted and coordinated approach to training and education across the industry is required, possibly targeted training at the apprentice trade entry level before the hazardous work practices are learnt and adopted.

Due to the strong evidence for the increased risk associated with being overweight or obese and occupational knee osteoarthritis resulting from prolonged kneeling and squatting, it has also been suggested that one approach may lie in the avoidance of obesity in people who perform this sort of work [33]. Exercise and muscle strengthening may also have a limited role in the management of individuals with occupational hip and knee pain. A recent systematic review determined that therapeutic exercise was beneficial for people with symptomatic knee osteoarthritis, with effect sizes for pain relief comparable to estimates reported for non-steroidal anti-inflammatory drugs [71]. A complementary systematic review has also been conducted by the same research group to determine whether land-based therapeutic exercise was beneficial for people with symptomatic hip osteoarthritis in terms of reduced joint pain and/or improved physical function. Combining the results of the five included randomised controlled trials demonstrated a small treatment effect for pain, but the conclusion was that the limited number and small sample size of the included studies restricted the confidence that could be attributed to these results [72]. These strategies, however, rely on active compliance of individual workers in targeted health promotion strategies. Such approaches are likely to be less successful on an industry wide basis than ergonomic or organisational risk reduction approaches, such as those trialled in the floor-layer training.

One recent study demonstrated the importance of looking beyond individual risk factors and examining organisational-level workplace characteristics in relation to knee osteoarthritis [73]. This study examined the associations between employment offering accommodations (switch to physically less demanding jobs; and part-time work for people needing reduced time) and benefits policies (paid sick leave; and disability payment) with knee osteoarthritis outcomes in participants ($n = 1639$) aged <65 years old [73]. Individuals employed in workplaces offering better policies had significantly less knee symptoms and lower prevalence of symptomatic or asymptomatic knee osteoarthritis, independent of socio-demographic features, lifestyle factors, knee injuries, BMI, physical demands in the workplace and job titles. Lower symptomatic knee osteoarthritis prevalence was noted in workplaces offering job-switch accommodation (8% vs. 13%), paid sick leave (9% vs. 16%) and disability payment (8% vs. 16%) than their counterparts. In multivariable models, the difference in symptomatic knee osteoarthritis prevalence was statistically significant for paid sick leave (OR 0.6, 95% CI 0.4–0.9) and disability payment policies (OR 0.5, 95% CI 0.4–0.9).

While there is strong evidence for the influence of physical work demands on the incidence of hip or knee osteoarthritis, there has been scant research on work-related psychosocial factors on hip or knee pain, and no studies have evaluated the interactions between heavy physical loads and low work support or job satisfaction [74]. In addition, most studies were conducted in developed countries, despite a reported high incidence of work-related musculoskeletal disorders in developing countries [21]. The management of work-related musculoskeletal disorders requires workplace interventions. There is some low-level evidence that ergonomic correction of the workplace and working tools may be effective in controlling in the carpet weaving industry [75]; however, it has been argued that, in developing countries, most employers do not have the resources to address substantial workplace changes [21]. In such circumstances, low-cost interventions and administrative controls to reduce risk exposure, such as job rotation or reduced hours of aggravating work, may be alternative prevention and management approaches.

In summary, conclusive high-level evidence in support interventions to prevent and manage occupational knee and hip osteoarthritis and soft-tissue injuries is not available. There is some low-to-moderate level evidence that ergonomic and organisational strategies to minimise risk exposures in traditional kneeling tasks or in those with knee pain may be effective. However, there is no such evidence in relation to prevention of occupational hip or knee pain associated with occupational tasks, such as heavy lifting and climbing stairs and ladders. There is a clear need for further well-designed and controlled trials in this area. It is recommended that clinicians and occupational health professions use a risk management approach for prevention and management of lower limb work-related musculoskeletal disorders.

Conclusions

An updated review of many large longitudinal cohort studies evaluating occupational risk factors clearly demonstrates that long-term exposure to heavy lifting is significantly associated with developing chronic hip or knee pain, and occupations involving regular kneeling or crawling demonstrate an increased risk of chronic knee pain. Farmers and men working in the construction industry appear to be at particular risk. The magnitude of risk from these occupational factors is markedly increased, if the worker is overweight or obese. There is some initial evidence that a flexible and supportive work environment reduces the prevalence of knee pain and work disability. However, there has been little research conducted, apart from the floor-laying trade, on the long-term effect of adoption of new work methods (apart from the floor-laying trade), use of tools and equipment, administrative controls and/or training and education of workers to minimise any future risk of harm. In absence of the ability to dramatically reduce exposure to occupational risk factors, a hierarchical risk management approach covering both individual and workplace risk factors is advocated.

Practice points

- Men involved in either farming or the construction industry are at increased risk of developing chronic hip or knee pain.
- The risk of knee or hip pain from occupational exposure to regular heavy lifting, kneeling and crawling is increased with concomitant obesity.
- Identifying modifiable personal and work environment risk factors and implementing a hierarchical risk management strategy is recommended.

Research agenda

- Develop and evaluate feasible workplace strategies to reduce occupational exposure to heavy lifting, kneeling, squatting and crawling.
- Evaluate the influence of work-related psychosocial factors (low job satisfaction or work support) on hip or knee pain, and possible interactions with heavy physical loads.

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