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Are Joint Injury, Sport Activity, Physical Activity, Obesity, or Occupational Activities Predictors for Osteoarthritis? A Systematic Review

STUDY DESIGN: Systematic review with meta-analysis.

OBJECTIVES: To identify risk factors for osteoarthritis (OA) of the knee, hip, and ankle, including joint injury, sport, physical activity, overweight/obesity, and occupational activity, in all age groups.

BACKGROUND: OA is a significant health problem worldwide, affecting up to 10% of men and 18% of women over 60 years of age. There has not been a comprehensive review examining modifiable physical risk factors associated with the onset of OA. This evidence is important to inform the physiotherapy management of individuals following onset of OA.

METHODS: Twelve electronic databases were systematically reviewed. The studies selected met the following criteria: (1) original data; (2) joint injury, sport activity, physical activity, overweight/obesity, and/or occupational activity investigated as risk factors; (3) outcomes included OA (hip, knee, and/or ankle); and (4) analytic component of study design. The data extracted included study design, years of follow-up, study population, OA definition, risk factors, and results (effect estimates reported or calculated where available). The quality of evidence was assessed based on a modified version of the Downs and Black checklist.

RESULTS: Joint injury, obesity, and occupational activity were associated with an increased risk of OA of the knee and hip. Sport and physical activity produced inconsistent findings. Joint injury was identified as a significant risk factor for knee OA (combined odds ratio = 3.8; 95% confidence interval: 2.0, 7.2) and hip OA (combined odds ratio = 5.0; 95% confidence interval: 1.4, 18.2), as was previous meniscectomy with or without anterior cruciate ligament injury for knee OA (combined odds ratio = 7.4; 95% confidence interval: 4.0, 13.7). There is a paucity of research examining risk factors associated with ankle OA; this review identified only 2 studies with this outcome.

CONCLUSION: Joint injury, obesity, and occupational activity are associated with an increased risk of knee and hip OA. Some findings remain inconclusive, including levels of physical activity and sport specificity in individuals who do not suffer an injury. Early identification of individuals at risk for OA provides an opportunity for physiotherapy management or other interventions to modify risk-related behavior. There is a need in the literature for additional high-quality studies, such as prospective cohort studies, that minimize potential bias in examining the relationship between physical risk factors and OA.

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KEY WORDS: *arthritis, athletic injury, risk factors*

Osteoarthritis (OA) is a significant health problem worldwide, affecting approximately 10% of men and 18% of women over 60 years of age.[73] OA typically affects weight-bearing joints, is historically diagnosed later in life, and is a major cause of morbidity, disability, and pain.[20,36] The onset of OA increases with age, and up to half of people over 50 years of age report symptomatic OA.[35] Some physical risk factors may also be associated with an increased rate of early onset of OA and require further investigation. For example, longitudinal studies provide evidence of a significantly increased risk of knee OA 12 to 20 years post–knee injury (ie, meniscus or anterior cruciate ligament injury).[61] In addition, there is evidence that knee and ankle injuries,

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TABLE MAIN CONCEPTS FOR MEDICAL SUBJECT HEADINGS AND TEXT WORDS (USED FOR ARTICLE SEARCH)

Concept A	Concept B	Concept C	Concept D	Concept E	Concept F
1. OA (MeSH)	6. Sports (MeSH)	11. Athletic injuries (MeSH)	15. Menisci, tibial (MeSH)	18. Ankle (MeSH)	21. Obesity (MeSH)
2. OA (tw)	7. Motor activity (MeSH)	12. Accidents, occupational (MeSH)	16. Anterior cruciate ligament (MeSH)	19. Knee (MeSH)	...
3. OA, hip (MeSH)	8. Physical activity (MeSH)	13. Occupational injury (tw)	17. Femoral acetabular impingement (MeSH)	20. Hip (MeSH)	...
4. OA, knee (MeSH)	9. Recreation (MeSH)	14. Sport injury (tw)	...	...	...
5. OA (tw)	10. Sport (tw)	...	...	...	...

Abbreviations: MeSH, medical subject headings; OA, osteoarthritis; tw, text words.

specifically, result in an increased risk of early development of OA.[19,26,39,44,61,62]

There is an increasing need to address joint damage related to injury, sport specificity, physical activity, overweight/obesity, and occupational activity to inform OA prevention and address rising healthcare costs. Identification of potentially modifiable risk factors for lower extremity joint OA is critical to inform the development and evaluation of primary and secondary prevention strategies targeted to reduce the significant burden of OA. While there are several contributions in the literature identifying risk factors for knee OA, there has not been a comprehensive review examining modifiable physical risk factors associated with the onset of hip, knee, and ankle OA. Therefore, the purpose of this review was to identify potentially modifiable risk factors for OA of the knee, hip, and ankle, including previous joint injury, meniscectomy, sport activity, physical activity, obesity, and occupational activity. It was hypothesized that these identified modifiable physical risk factors would be associated with lower extremity OA.

METHODS

Data Sources and Selection of Eligible Studies

To identify observational studies targeted at the research question, search terms were used (**TABLE**) and electronic databases were systematically searched. The search strategy summary can be found in **APPENDIX A** (available online). The identification of relevant studies involved a 2-step process. First, titles were reviewed by 3 independent reviewers, and potentially relevant article abstracts were screened, based on inclusion and exclusion criteria established a priori. Second, the full text of all potentially relevant studies was obtained, and the 3 reviewers assessed each study using a standard inclusion/exclusion form. Any discrepancies were resolved in discussion between the 3 reviewers, and the fourth reviewer when necessary. Studies that were selected for further critical appraisal met the following selection criteria determined a priori: (1) original data; (2) joint injury, sport activity, physical activity, overweight/obesity, and/or occupational activity investigated as risk factors; (3) outcomes of interest that included OA of the hip, knee, and/or ankle; and (4) an analytic component to the study design (ie, the study examined the relationship between risk factor and outcomes), including cohort, case-control, cross-sectional, longitudinal, and case series designs. Risk factors included in this study were determined a priori, based on a pilot review of existing individual risk factor systematic reviews and meta-analyses.

Quality Assessment

The methodological quality of all studies selected was examined using the validated Downs and Black method, modified to suit the observational designs of the current study.[12] Six questions (items 4, 8, 14, 23, 24, and 27) on the quality index (QI) score were not applicable due to the nature of the observational study designs of this review. Eight reviewers assessed study quality using a data-extraction form, such that 2 independent reviewers assessed all studies. Quality was assessed for all studies, including those not published in peer-reviewed journals (eg, dissertations).

Data Extraction and Meta-analyses

A structured form was used for uniform data extraction and summaries from all studies. The data extracted included study design, years of follow-up, study population (ie, study participants, sample size), OA outcome (definition), risk factors (exposure variables), and results (effect estimates reported or calculated where data were sufficient, including 95% confidence intervals [CIs]) (**APPENDIX B**, available online). Many studies reported more than 1 risk factor and were therefore categorized according to all reported risk factors of interest individually (joint injury, sporting activity, physical activity, obesity, and occupational activity). When appropriate, a meta-analysis of risk factors was conducted for available outcomes to produce combined estimates of measures of effect (odds ratio [OR]), based on a random-effects model. All analyses were done using Stata Version 10.0 (StataCorp LP, College Station, TX). The random-effects model provides wider interval estimates than a fixed-effects model. Where the CI around all ORs excluded 1, it indicated enough power with the conservative random-effects approach.[1,11,22] Heterogeneity was assumed across studies, as suggested by systematic review/meta-analysis guidelines.[16]

RESULTS

Study Characteristics

A total of 1294 studies were identified through title review. Of these, 1229 were excluded at the abstract-review stage, leaving a total of 43 articles included in this review. The results of the papers identified from the search strategy are summarized in **APPENDIX A** (available online). Studies that were identified as thesis dissertations were further searched for published manuscripts. If peer-reviewed papers based on the dissertation existed, they replaced were used or in addition to the thesis. Three studies were identified in this manner.[15,24,60] Overall, the number of participants in each study ranged from 16[49] to 8000,[33] and the duration of study periods varied from 30 months[54] to greater than 40 years.[69] Of the 43 included studies, 10 were cross-sectional, 12 were case-control, 17 were cohort (prospective or historical), 2 were longitudinal, and 2 were reportedly case series (with the ability to extract an analytic component) design. The median Downs and Black quality score for all papers included in this review was 17 (interquartile range [IQR], 14.0-19.5).

Joint Injury

Sixteen studies met the inclusion criteria for previous injury (3 case-controls, 3 cross-sectional, 4 prospective cohorts, 3 historical cohorts[5,7,8,13,17,18,25,27,30,33,40,48,52,53,64,72]), including studies that were further categorized as meniscectomy as the risk factor for OA. Meta-analyses were performed to synthesize the results of studies examining previous injury or meniscectomy as a risk factor for knee or hip OA. A separate analysis was completed for meniscectomy to differentiate between known intra-articular injuries versus self-report and/or previous history of knee injury. Sex was combined in the OR estimates included in the meta-analysis due to overlapping 95% CIs for the estimates stratified by sex. For knee OA, 5 case-control or cohort studies examining previous injury as a risk factor were identified.[8,13,25,33,40] The combined estimated OR was 3.8 (95% CI: 2.0, 7.2) (**FIGURE 2**).

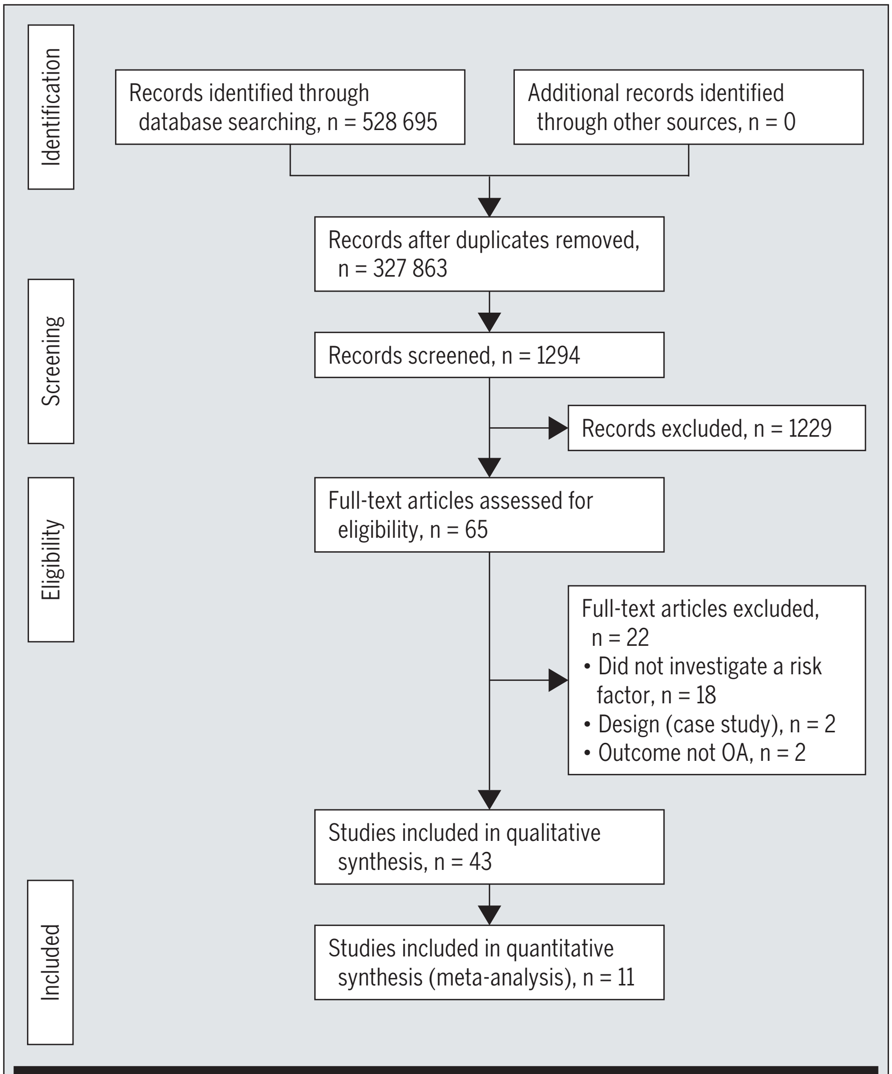

FIGURE 1. Adapted PRISMA flow diagram for study inclusion. Abbreviation: OA, osteoarthritis.

Four case-control or cohort studies examining joint injury as a risk factor for hip OA were identified.[7,13,25,40] The combined estimated OR was 5.0 (95% CI: 1.4, 18.2) (**FIGURE 3**). Consistently, there was an association between history of meniscectomy and presence of knee OA. These findings are supported by 5 studies that examined knee OA in individuals with meniscectomy, with or without a history of anterior cruciate ligament injury.[18,30,48,52,64] This resulted in an estimated combined OR of 7.4 (95% CI: 4.0, 13.7) (**FIGURE 4**). The extent of the proportion of the total meniscus removed and the follow-up timelines, however, varied considerably in these studies.

The follow-up period between injury and OA development across all studies ranged from 1.5 to 36 years[7,25,30,48,52] and was not reported in several studies.[8,13,33,40] The OA definition was not joint specified in the study by Golightly et al[27] (OR = 2.2; 95% CI: 2.1, 2.3), and the exposure time could not be determined in 2 studies in which the odds of injury were 8.9 (95% CI: 3.5, 24.4)[53] and 16.3 (95% CI: 6.1, 54.1).[72] One study identified subjects with meniscectomy over those without meniscectomy; however, there was no true comparison group.[5] Moreover, 1 study reported the association of a specific injury at the knee (meniscus injury) and the development of knee OA (OR = 5.2; 95% CI: 3.2, 8.4).[17] Therefore, these studies were removed from the meta-analysis. No studies identified in this review examined joint injury and ankle OA. The median QI score for these studies was 16 (IQR, 11.8-19.5).

Sport Activity

Twelve articles met the inclusion criteria for sport activity as a risk factor for OA (1 retrospective cohort, 2 case series, 7 case-controls, 1 cross-sectional survey, and 1 study that was a cohort study with a nested case-control design).[4,7,29,37,38,40,41,50,56,67,70,71] The majority of studies defined OA based on radiographic features[7,29,38,40,41,50,56] or magnetic resonance imaging, but some authors used questionnaires,[4] physician diagnosis, and self-reported pain and disability.[37] One study specified OA but did not discuss the specific joint and found no association between recreational sport activity and the onset of OA, although it did find that the odds of OA in collegiate track athletes were 2.4 times those of nonathletes (95% CI: 1.5, 3.3).[4] This study also found that former collegiate football players had lower odds of OA (OR = 0.5; 95% CI: 0.3, 0.7). One study evaluated volleyball as a risk factor for ankle OA and found that volleyball players were more likely to have radiologic evidence of ankle OA.[29]

Exposure to team sports was found to be a risk factor for knee OA onset prior to the age of 45 years, when adjusted for age, body mass index (BMI), and occupation (OR = 3.4; 95% CI: 1.6, 7.4).[37] Exposure to soccer was also shown to be a risk factor for knee OA by 1 author[56] (OR = 5.4; 95% CI: 1.4, 20.3), but not by another study[38] (OR = 1.0; 95% CI: 0.2, 4.6). Females were found to have an increased risk of knee OA if they had previously been exposed to gymnastics (OR = 7.4; 95% CI: 2.6, 20.8) or kung fu (OR = 22.5; 95% CI: 2.5, 199.0).[40] A case-control study found that exposure to soccer, hockey, and tennis did not increase the odds of knee OA, when controlling for previous knee injury.[70]

Sport activity and risk of hip OA were evaluated in 8 articles. One study[7] that evaluated general sport participation did not find any association (OR = 1.2; 95% CI: 0.9, 1.6) between regular sport activity and risk for OA. Soccer was found to be a risk factor for hip OA,[38] as was

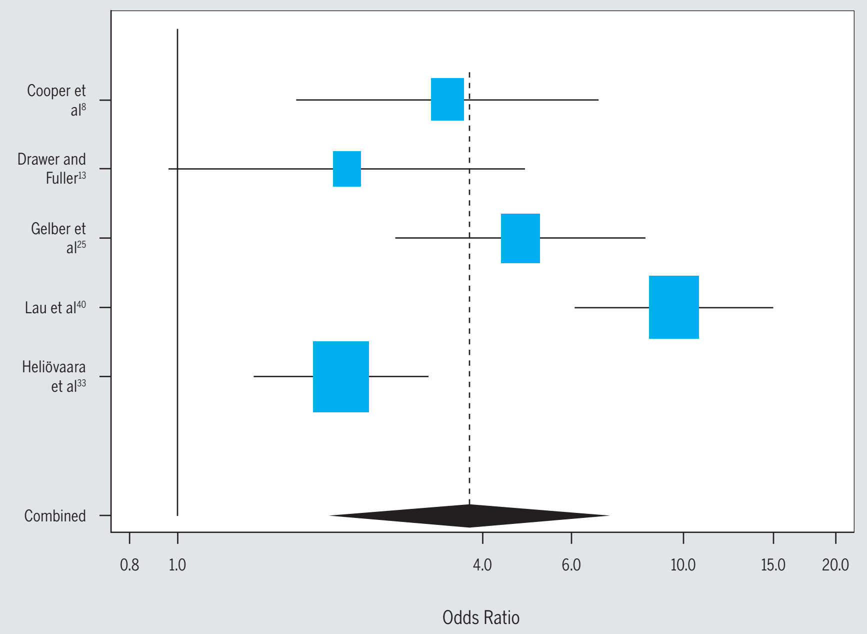

FIGURE 2. Previous injury as a risk factor for knee osteoarthritis.

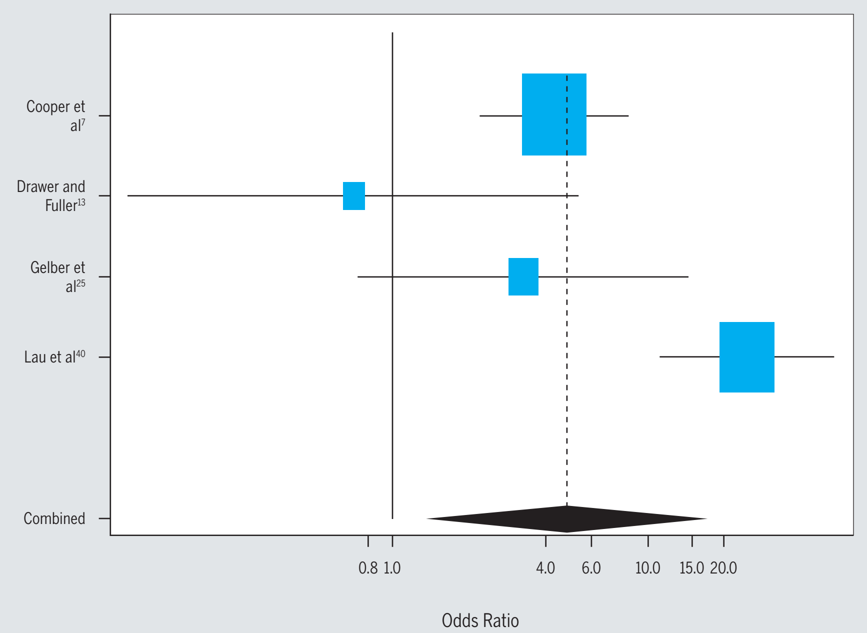

FIGURE 3. Previous injury as a risk factor for hip osteoarthritis.

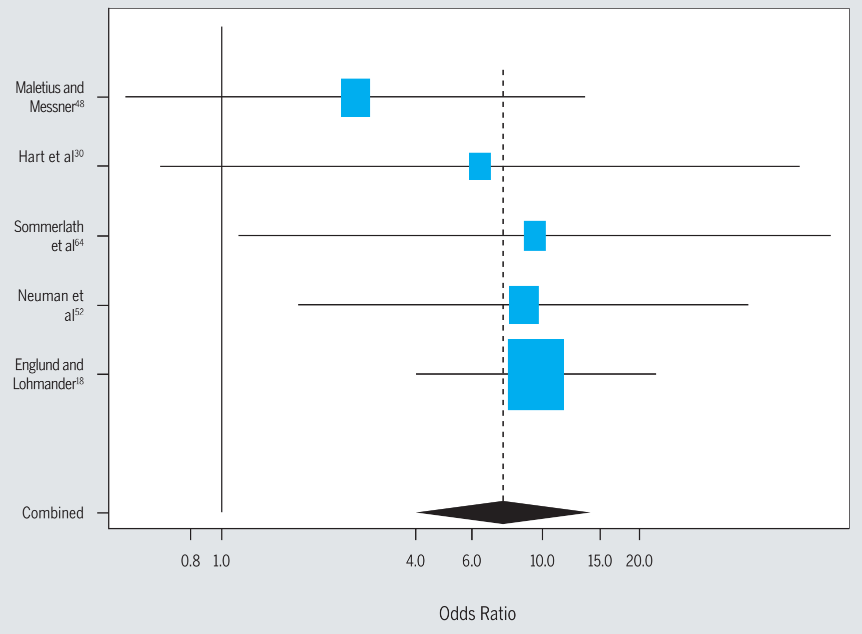

FIGURE 4. Meniscectomy as a risk factor for knee osteoarthritis.

gymnastics in women,[40] but gymnastics in men, running, kung fu, and soccer were not risk factors for hip OA in other studies.[40,56] Compared to low exposure to sport activity (lowest 5% and no participation), high exposure prior to age 50 was found to increase the odds of hip OA (OR = 4.5; 95% CI: 2.7, 7.6), as was medium exposure to sports (OR = 2.6; 95% CI: 1.5, 4.5).[71] In this study, track and field (OR = 3.7; 95% CI: 1.1, 13.2) and racket sports (OR = 3.3; 95% CI: 1.2, 12.7) were associated with the highest odds of hip OA. The median QI score for these studies was 16 (IQR, 12.5-19.0).

Physical Activity

Five articles met the inclusion criteria for physical activity (3 cohort studies and 2 case-control studies) and demonstrated mixed results.[6,23,31,59,68] Definitions of OA were based on self-report of a variety of different severities of arthritis,[6,68] physician diagnosis,[31] or radiographic markers.[23,59] Increased physical activity was found to be protective for knee and hip OA in 1 retrospective cohort study[6] (OR = 0.7; 95% CI: 0.6, 0.9) but was found to be a risk factor for hip and knee OA in other studies.[23,59,68] Cumulative physical activity and physical activity in midlife were not shown to be risk factors for future knee OA; however, exercise in early adult life was shown to be a risk factor (relative risk, 1.8; 95% CI: 1.0, 3.3).[23] A 20-year cohort study of physician-diagnosed hip or knee OA did not find moderate and low fitness to be risk factors for future OA.[31] No studies identified in this review examined joint injury and ankle OA. The median QI score for these studies was 18 (IQR, 14.0-21.0).

Overweight/Obesity

A total of 13 studies examined overweight/obesity as a risk factor for OA in this review. Five were cohort studies,[18,24,31,54,66] 3 were case-control studies,[7,8,40] 3 were cross-sectional studies,[33,45,65] 1 was of longitudinal design,[6] and 1 was a case series with a comparison group.[49] Three studies included only women[31,65,66] and 1 study included only men.[24] Eleven of the 13 studies defined obesity via calculations of BMI (kg/m^2).[7,8,18,24,31,33,45,49,54,65,66] One study examined obesity via body weight (lowest quartile compared to second, third, and fourth).[40] Generally, BMI categories were based on cut points (underweight, normal weight, overweight, and obese [class 1, 2, or 3]) recommended by the World Health Organization.[32] Other studies used slight variations, for example, BMI less than 24.5 kg/m^2 as healthy, BMI 25.0 to 28.0 kg/m^2 as overweight, and BMI greater than 28.0 kg/m^2 as obese.[7] One study[66] examined the risk of OA per unit increase in BMI.

The methods of assessment for both clinical and/or radiographic knee or hip OA varied in all studies. Nine of the 13 studies defined knee or hip OA using radiographic features alone or in combination with clinical outcomes.[7,8,18,40,45,49,54,65,66] Two studies relied on self-report,[6,24] 1 on documented history or definite findings in physical status,[33] and 1 defined OA through physician diagnosis.[31]

Of the 10 studies that utilized categories of BMI as an exposure, all demonstrated an increased risk of OA in either the hip or the knee in either the overweight or obese category, or both categories.[7,8,24,31,33,45,49,54,65,66] The ORs in these studies ranged from 1.6 to 15.4. When examining knee OA, Marks[49] demonstrated an increased risk for knee OA in the overweight and obese category (OR = 15.4; 95% CI: 1.2, 755.2) compared to normal weight. Sowers et al[66] found an 865-fold increase (95% CI: 70.5, 10 617.9) in the risk of knee OA per unit increase in BMI. Niu et al[54] demonstrated an increased risk of incident knee OA in overweight (OR = 1.8; 95% CI: 1.0, 3.2), obese (OR = 2.4; 95% CI: 1.3, 4.3), and very obese (OR = 3.2; 95% CI: 1.7, 5.9) categories compared to subjects without knee OA (Kellgren-Lawrence grade less than 2).

Cooper et al[7] demonstrated an increased risk of both unilateral (OR = 1.6; 95% CI: 1.2, 2.2) and bilateral hip OA (OR = 1.7; 95% CI: 1.3, 2.4) with a BMI greater than 28.0 kg/m^2. However, there was no relationship with unilateral or bilateral hip OA in the BMI category between 25.0 and 28.0 kg/m^2 (unilateral OR = 1.3; 95% CI: 1.0, 1.7 and bilateral OR = 1.3; 95% CI: 0.9, 1.8). Heliövaara et al[33] demonstrated an increased risk for both unilateral and bilateral hip OA in all categories of BMI, including overweight, obese class 1, and obese class 2, but failed to demonstrate a significant increased risk in the obese class 2 category for unilateral hip OA (OR = 1.2; 95% CI: 0.5, 3.0). Most studies examining both knee and hip OA risk demonstrated a greater risk with increasing BMI. Hathwar[31] demonstrated an increased risk in both overweight (OR = 1.4; 95% CI: 1.1, 1.9) and obese (OR = 2.2; 95% CI: 1.6, 3.0) groups compared to the reference healthy-weight group. No studies identified in this review examined joint injury and ankle OA. The median QI score for these studies was 20 (IQR, 14.0-21.0).

Occupational Activity

Nine studies investigating the relationship between occupational activities and hip, knee, or ankle OA were identified. These consisted of 3 case-control studies[4,40,60] and 6 cross-sectional studies.[2,15,33,51,63,69] Of the 8 studies that reported effect sizes,[2,4,15,33,40,60,63,69] all reported a significantly greater risk of OA in individuals whose occupations involved activities such as heavy lifting, squatting, kneeling, working in cramped space, climbing stairs, floor activities, or higher physical demands. Only 3 studies involved female participants.[15,33,40] When stratified by sex, results tended to be less significant for females.[15,33,40]

There were 6 studies that examined knee OA, with ORs ranging from 1.3 to 5.4. Amin et al[2] examined specific knee compartment cartilage morphology in 192 males (mean age, 69 years) and found an OR of 3.0 (95% CI: 1.5, 6.0) for the anterior patellofemoral surface for those exposed to heavy lifting, after controlling for age, BMI, and previous injury. Another survey[15] found that the odds of OA with exposure to cramped space (OR = 1.4; 95% CI: 1.0, 1.8), kneeling (OR = 1.4; 95% CI: 1.1, 1.9), and heavy lifting (OR = 1.3; 95% CI: 1.1, 1.6) were significant.

One case-control study by Lau et al[40] examined 138 men and women with hip OA (Kellgren-Lawrence grades 3-4) and found that climbing stairs increased the risk of OA (OR = 12.5; 95% CI: 1.5, 104.3) in men, whereas heavy lifting increased the risk of OA in women (OR = 2.4; 95% CI: 1.1, 5.3). A cross-sectional survey calculated exposure as the sum index of physical stresses at work and found the adjusted OR to be 2.4 (95% CI: 1.4, 3.8) for unilateral hip OA and 2.8 (95% CI: 1.6, 4.7) for bilateral hip OA in persons exposed to 3 or more physical stresses, defined as lifting, stooping, or using vibration tools.[33]

A single study examined ankle OA in 109 retired veteran military parachutists, 40 of whom had anteroposterior radiographs of their talotibial articulation. This study[51] revealed an OA prevalence of 17.5%. While the descents made by individuals ranged between 7 and 1600, this study found no association between number of descents and ankle OA. The median QI score for these studies was 18 (IQR, 14.0-19.0).

DISCUSSION

Joint Injury

With pooled results in the meta-analyses, previous injury and previous meniscectomy were clear risk factors for both knee and hip OA. The type and nature of injury were not described in all studies. In addition, injuries were self-reported and recall bias is a likely concern. This bias carries the possibility of being differential in nature, as those with OA may be more likely to recall a previous injury that may be related. Age ranges across studies varied (20-95 years). Age could confound the outcome of OA, regardless of the risk factor examined. Nonetheless, Heliövaara et al[33] found an association with joint injury and OA after adjusting the results for age and sex (OR = 2.1; 95% CI: 1.4, 3.1). Sex was considered in most of the studies examining hip and knee OA, and the association was found to be consistent.

Sport Activity

Mixed results were found in examining the association between sport activity and OA. Different definitions of sport activity, OA, and exposure to sport activities were used, which resulted in the heterogeneity of results. This variability may have led to a nondifferential misclassification bias, resulting in a bias toward the null. Some studies evaluated a single sport or were stratified based on sport type, whereas others examined all sports. Some studies evaluated the amount and type of sport. Recall bias might have been a factor, as many studies included subject recollection of previous sport activity. Sporting exposure time, intensity, sporting level, and other pertinent risk factors were seldom measured, potentially leading to bias due to the effects of unmeasured confounding. The heterogeneous nature of the studies included in this review makes it difficult to draw any conclusions.

Physical Activity

Mixed results were also found when examining the relationship between physical activity and OA. This was likely due to the heterogeneity of OA and physical activity definitions. The difference in diagnoses may have resulted in misclassification of the outcome of interest. In studies where diagnoses based on pain and limited function were not used, a nondifferential misclassification bias toward the null could result. It is reported that clinical decision making in hip OA is more often influenced by pain and limited function scoring than by radiographic changes.[14,47] This may explain the results seen by Hathwar[31] and Charles,[6] where no relationship and a protective effect, respectively, were observed. Differences in definitions of physical activity were evident among the studies included, with 1 study evaluating physical fitness rather than physical activity.[31] Recall bias may have occurred, as physical activity exposure was often recalled retrospectively and may have been overestimated in individuals with OA, leading to an overestimation in the relationship between OA and physical activity.[59,68] Some risk factors were not adjusted for in the analysis, thus the results, secondary to confounding by unmeasured variables, may have been overestimated (eg, Sutton et al[68] had BMI data available for only 45% of the study population). Time, type, and intensity of exposure to physical activity are variables that may have affected this relationship and were variably measured in the studies that were included. Thus, conclusions regarding physical activity and OA cannot be drawn based on the studies included in this review.

Overweight/Obesity

Included studies that examined obesity as a risk factor for OA demonstrated an increased risk for hip or knee OA with increasing BMI category. This is consistent with previous reviews examining risk factors associated with the onset of hip OA[43] or knee OA.[21,57] In all studies that used international BMI cut points, there was an even greater risk of hip or knee OA in obese individuals compared to overweight individuals. The mixed results within strata of some studies are likely due to the heterogeneity of both the BMI and OA definitions. Cooper et al[7] compared unilateral and bilateral hip OA in BMI categories 2.0 kg/m^2 under the overweight range (BMI 25.0-28.0 kg/m^2) to the reference group and demonstrated ORs lower than most studies. Also, Gelber et al[24] compared a BMI category of 22.8 to 24.7 kg/m^2 (still considered healthy weight by international standards) to the reference group, with similar results (OR = 1.0; 95% CI: 0.4, 2.5).

Four of the 13 studies were cross-sectional in design and were thus unable to determine a temporal relationship as to whether weight gain predated or followed the development of OA. There may be an inverse relationship, such that patients with OA in weight-bearing joints adopt a more sedentary lifestyle due to arthritis pain and limited mobility, and subsequently gain more weight. Despite the limitations of the included studies, it can be generalized that individuals with a greater BMI are at a greater risk for knee or hip OA.

Occupational Activity

The findings from all 9 included studies concur that there is increased risk of developing hip or knee OA after occupational exposure to physically demanding tasks. These results are consistent with previous reviews examining the role of occupational activities in hip[42,46] and knee[34,46] OA. Healthcare professionals, such as physiotherapists, should feel comfortable communicating the risks associated with occupational activities to their patients.

The weight-bearing joints of the lower extremity, particularly the knee, are designed to absorb and distribute the forces applied to the body, such as 1 to 1.5 times body weight with walking and 6 times body weight during the descending phase of stair climbing.[3,55] Joint homeostasis relies on moderate mechanical loading, which is necessary to maintain healthy articular cartilage.[28] This loading, however, can become catabolic if appropriate intensity and duration are exceeded or result from abnormal joint mechanics. For example, in a study[9] examining deep knee flexion, a common occupational task, estimated forces on the tibiofemoral joint were 4.7 to 5.6 times body weight in the vertical direction and 2.9 to 3.5 times body weight in the horizontal direction.

Despite the challenges of classifying OA and measuring occupational exposure, the evidence for occupational activity as a risk factor for OA is substantial. This presents an opportunity for physiotherapists to expand their role in primary prevention by educating patients about the role of occupation in the development of joint disease, including the importance of proper body mechanics and how to avoid high loading positions. It is likely that many clinicians inquire about the occupation of their patients during history taking. Perhaps therapists should give more attention to the potential role of these activities. As key stakeholders in OA management, with their expertise in exercise prescription, physiotherapists are positioned to take a more active role in OA prevention.

Strengths

This systematic review has several strengths. First, 12 databases were searched using a tested strategy to identify the greatest number of studies applicable to the research question. However, articles might have been missed due to the heterogeneity of key words and being written in languages other than English. In addition, heterogeneity was not assessed statistically in the meta-analysis but assumed across studies, as suggested by previously published systematic review/meta-analysis guidelines.[16] Given the consistency of the results, the inclusion of large sample sizes, and the varying populations and countries in which the studies were based, the results of this study are likely generalizable to populations at risk for OA, including those with a previous joint injury, overweight or obese individuals, and physically demanding occupational activity.

Limitations

There are some limitations to this systematic review and meta-analysis. Many of the designs included in this review were case-control and cross-sectional studies. Therefore, there is a need for additional high-quality studies, such as prospective cohort studies, that minimize potential bias (eg, recall bias, selection bias, and issues with temporality). The mixed results that were demonstrated with both physical and sport activity could be the result of the heterogeneity of OA definition, the lack of reporting of exposure time, and the intensity and level of sport activity, which could drastically change the results in those areas. For example, a recent study published by Ratzlaff et al[58] collected prospective exposure data on lifetime physical activity type (occupational, household, sport) and dose (frequency, intensity, duration). This study[58] found that there was an independent association with hip OA in the highest quintile of the mean lifetime hip cumulative peak force index (hazard ratio

= 2.3; 95% CI: 1.3, 4.1). Included studies greatly relied on self-report of both physical and sport activity and could have suffered from recall bias, underestimating the exposure, leading to a nondifferential misclassification bias toward the null. It should be noted that the only study that examined exposure to sport activity (high and moderate exposure compared to low exposure) demonstrated a significant relationship with hip OA (OR = 4.5; 95% CI: 2.7, 7.6 and OR = 2.6; 95% CI: 1.5, 4.5, respectively).[71]

Most studies demonstrated results consistently with both males and females; however, women were underrepresented in physically demanding occupational activities, and there appears to be a decreased significance of OA risk in females over males. Many studies included in this review examined multiple risk factors within 1 study group, making the accuracy of these outcomes difficult to measure without a control for potential confounders. Moreover, the studies included in this review did not examine the presence of 2 or more risk factors in combination, which would have provided an interesting assessment of the potential interaction of risk factors that may cause a magnified risk of OA. Finally, this review did not conduct a sensitivity analysis in the meta-analysis of joint injury; however, the meta-analysis did take into account the effect of different sample sizes among studies. With a total of 11 studies in the meta-analysis, the forest plots demonstrated that most studies had wide CIs. If low-quality studies were excluded, the sensitivity analysis would have resulted in 1 or 2 studies, which would not have been of value.

CONCLUSION

The studies evaluated in this review demonstrated an increased risk for either knee or hip OA in those individuals who had a previous joint injury, were overweight or obese, and had physically demanding occupations. Some findings, however, remain inconclusive, including those individuals with increased sport and physical activity without previous injury. The evidence in this case is not strong enough to support an association between increased exposure to sport and/or physical activity and increased risk of knee or hip OA. In addition, there was a paucity of research examining risk factors associated with ankle OA; only 2 studies in this review were identified with this outcome. Finally, there were limitations due to the studies included in this review that had a lower-quality research design.

This review increases the understanding of the relationship of OA in the knee, hip, and ankle with significant risk factors, including joint injury, sport, physical activity, overweight/obesity, and occupational activity. A clear understanding of the implications of these risk factors should be further investigated to increase awareness in the general population of the risks associated with OA. Early identification of individuals at risk for OA provides an opportunity for the development and evaluation of physiotherapy or other interventions to modify risk or to implement early treatment before the disease progresses and more costly solutions are needed. ◉

KEY POINTS

FINDINGS: This review increases the understanding of the relationship of OA in the knee, hip, and ankle with significant risk factors, including joint injury, sport, physical activity, overweight/obesity, and occupational activity.

IMPLICATIONS: Early identification of individuals at risk for OA provides an opportunity for the development and evaluation of physiotherapy or other interventions to modify risk or to implement early treatment before the disease progresses and more costly solutions are needed.

CAUTION: Some findings remain inconclusive, including those individuals with increased sport and physical activity who did not suffer an injury. The evidence in this case is not strong to conclude that increased exposure to sport activity and/or physical activity increases the risk of knee or hip OA. It is possible that sport and/or physical activity may be protective of hip, knee, or ankle OA when controlling for previous joint injury.

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APPENDIX A

SEARCH STRATEGY AND RESULTS OF THE SYSTEMATIC LITERATURE SEARCH, WITH THE TOTAL NUMBER OF UNIQUE ARTICLES PER DATABASE

Electronic Database	Search Terms*	Hits, n	Potentially Relevant (by Title), n	Selected, n†
MEDLINE (OVID), 1950 to June 2012	(A) 1 or 2 or 3 or 4 or 5	42614	...	...
	(B) A AND (11 or 12 or 13 or 14)	249	107	10
	(C) A AND (6 or 7 or 8 or 9 or 10)	1212	...	...
	(D) B AND (6 or 7 or 8 or 9 or 10)	106	7	2
	(E) A AND (15 or 16 or 17)	1084	...	...
	(F) E AND (11 or 12 or 13 or 14)	60	60	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	76	76	2
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	3	3	0
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	10	10	0
	(J) A AND 20 AND (11 or 12 or 13 or 14)	2	2	0
Total		45416	265	14
PsycINFO, inception to June 2012	(A) 1 or 2 or 3 or 4 or 5	924	...	...
	(B) A AND (11 or 12 or 13 or 14)	3	3	0
	(C) A AND (6 or 7 or 8 or 9 or 10)	66	66	0
	(D) B AND (6 or 7 or 8 or 9 or 10)	0	0	0
	(E) A AND (15 or 16 or 17)	5	5	0
	(F) E AND (11 or 12 or 13 or 14)	5	5	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	2	2	0
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	2	2	0
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	1	1	0
	(J) A AND 20 AND (11 or 12 or 13 or 14)	0	0	0
Total		1008	84	0
SPORTDiscus (EBSCO), 1980 to June 2012	(A) 1 or 2 or 3 or 4 or 5	2905	...	...
	(B) A AND (11 or 12 or 13 or 14)	455	...	...
	(C) A AND (6 or 7 or 8 or 9 or 10)	454	...	...
	(D) B AND (6 or 7 or 8 or 9 or 10)	444	...	...
	(E) A AND (15 or 16 or 17)	207	13	4
	(F) E AND (11 or 12 or 13 or 14)	132	13	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	175	13	0
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	338	...	...
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	46	12	0
	(J) A AND 20 AND (11 or 12 or 13 or 14)	37	37	0
Total		5193	88	4
PubMed, 1966 to June 2012	(A) 1 or 2 or 3 or 4 or 5	36147	...	...
	(B) A AND (11 or 12 or 13 or 14)	181	82	3
	(C) A AND (6 or 7 or 8 or 9 or 10)	1080	...	...
	(D) B AND (6 or 7 or 8 or 9 or 10)	75	5	0

APPENDIX A

Electronic Database	Search Terms*	Hits, n	Potentially Relevant (by Title), n	Selected, n†
PubMed, 1966 to June 2012 (*continued*)	(E) A AND (15 or 16 or 17)	924	...	...
	(F) E AND (11 or 12 or 13 or 14)	46	46	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	66	66	0
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	7	7	0
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	10	6	0
	(J) A AND 20 AND (11 or 12 or 13 or 14)	1	1	0
Total		38537	213	3
Web of Science, inception to June 2012	(A) 1 or 2 or 3 or 4 or 5	35401	...	...
	(B) A AND (11 or 12 or 13 or 14)	17	17	5
	(C) A AND (6 or 7 or 8 or 9 or 10)	945	...	...
	(D) B AND (6 or 7 or 8 or 9 or 10)	13	13	1
	(E) A AND (15 or 16 or 17)	1637	...	...
	(F) E AND (11 or 12 or 13 or 14)	3	3	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	137	137	0
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	14	14	0
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	293	138	0
	(J) A AND 20 AND (11 or 12 or 13 or 14)	3	3	0
Total		38463	325	6
EBM reviews (OVID); Cochrane databases for complete review (1975 to June 2012); Cochrane Controlled Trials Registry (1975 to June 2012); ACP journal club; Database of Abstracts of Reviews of Effects (inception to June 2012)	(A) 1 or 2 or 3 or 4 or 5	4050	...	...
	(B) A AND (11 or 12 or 13 or 14)	10	2	0
	(C) A AND (6 or 7 or 8 or 9 or 10)	229	8	0
	(D) B AND (6 or 7 or 8 or 9 or 10)	8	0	0
	(E) A AND (15 or 16 or 17)	49	3	0
	(F) E AND (11 or 12 or 13 or 14)	17	0	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	28	0	0
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	7	0	0
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	61	0	0
	(J) A AND 20 AND (11 or 12 or 13 or 14)	0	0	0
Total		4459	13	0
CINAHL (EBSCO), 1982 to June 2012	(A) 1 or 2 or 3 or 4 or 5	8636	...	...
	(B) A AND (11 or 12 or 13 or 14)	157	30	2
	(C) A AND (6 or 7 or 8 or 9 or 10)	114	17	1
	(D) B AND (6 or 7 or 8 or 9 or 10)	22	3	0
	(E) A AND (15 or 16 or 17)	314	...	0

APPENDIX A

Electronic Database	Search Terms*	Hits, n	Potentially Relevant (by Title), n	Selected, n†
CINAHL (EBSCO), 1982 to June 2012 (*continued*)	(F) E AND (11 or 12 or 13 or 14)	39	12	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	51	15	0
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	95	21	0
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	129	23	0
	(J) A AND 20 AND (11 or 12 or 13 or 14)	28	16	0
Total		9585	137	3
Embase (OVID), 1980 to June 2012	(A) 1 or 2 or 3 or 4 or 5	344939	...	...
	(B) A AND (11 or 12 or 13 or 14)	960	...	...
	(C) A AND (6 or 7 or 8 or 9 or 10)	8543	...	...
	(D) B AND (6 or 7 or 8 or 9 or 10)	862	...	...
	(E) A AND (15 or 16 or 17)	1393	...	...
	(F) E AND (11 or 12 or 13 or 14)	70	3	2
	(G) E AND (6 or 7 or 8 or 9 or 10)	326	...	...
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	322	...	...
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	715	...	...
	(J) A AND 20 AND (11 or 12 or 13 or 14)	90	22	0
Total		358220	25	2
HealthSTAR (OVID), 1966 to June 2012	(A) 1 or 2 or 3 or 4 or 5	24125	...	...
	(B) A AND (11 or 12 or 13 or 14)	163	0	0
	(C) A AND (6 or 7 or 8 or 9 or 10)	716	...	...
	(D) B AND (6 or 7 or 8 or 9 or 10)	56	15	4
	(E) A AND (15 or 16 or 17)	628	...	0
	(F) E AND (11 or 12 or 13 or 14)	44	10	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	100	16	0
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	110	14	0
	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	448	...	...
	(J) A AND 20 AND (11 or 12 or 13 or 14)	31	7	0
Total		26421	62	4
ProQuest (Dissertation Abstracts), inception to June 2012	(A) 1 or 2 or 3 or 4 or 5	1273	...	...
	(B) A AND (11 or 12 or 13 or 14)	2	0	0
	(C) A AND (6 or 7 or 8 or 9 or 10)	69	80	7
	(D) B AND (6 or 7 or 8 or 9 or 10)	2	0	0
	(E) A AND (15 or 16 or 17)	35	0	0
	(F) E AND (11 or 12 or 13 or 14)	1	0	0
	(G) E AND (6 or 7 or 8 or 9 or 10)	6	0	0
	(H) (18 or 19 or 20) AND (1 or 2 or 5) AND (11 or 12 or 13 or 14)	1	0	0

APPENDIX A

Electronic Database	Search Terms*	Hits, n	Potentially Relevant (by Title), n	Selected, n[†]
ProQuest (Dissertation Abstracts), inception to June 2012 (*continued*)	(I) (18 or 19 or 20) AND 21 AND (1 or 2 or 5)	4	2	0
	(J) A AND 20 AND (11 or 12 or 13 or 14)	0	0	0
Total		1393	82	7
Total by title scan		528695	1294	
Total unique articles			43	

The corresponding definitions of search terms are described in* **TABLE 1.
[†]*Additional to previous searches.*

APPENDIX B

DATA EXTRACTION TABLE BY RISK FACTOR (JOINT INJURY [MENISCECTOMY], SPORT ACTIVITY, PHYSICAL ACTIVITY, OBESITY, OCCUPATIONAL ACTIVITY)

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Joint injury								16 (11.75-19.5)
Cooper et al[7]	England	Case-control	18-mo study period. Time frame: suffering hip pain for a median of 3 y (IQR, 1.67-5.5 y)	n = 611; cases and controls; males, n = 210; females, n = 401; mean ± SD age, 70 ± 9 y	OA defined by being on an orthopaedic surgeon's list awaiting total hip arthroplasty for primary hip OA (the overwhelming majority had severe X-ray evidence of OA)	The cases reported previous hip injury at least 1 y before the onset of the hip pain. Injury was defined as the inability to bear weight for at least 1 wk	OR hip injury = 4.3 (2.2, 8.4)	21
Cooper et al[8]	United Kingdom	Case-control	No time frame provided	n = 327; cases, n = 109 (males, n = 30; females, n = 79); controls, n = 218 (males, n = 60; females, n = 158); matched sex and age within 2 y; age, ⩾55 y	OA defined by K-L grades 3-4. Answered yes to "Have you had pain in or around a knee on most days for at least a month, at some time during the last year?"	Previous knee injury that required immobilization more than 1 wk	Gender combined: OR knee injury = 3.4 (1.7, 6.7)	14
Drawer and Fuller[13]	England	Cross-sectional	NA	n = 185 (males); former soccer players; age range, 20-84 y	Medical professional OA diagnosis	Knee injury. They did not report when the injury took place, but reported the average age at which surgery occurred (27.95 y) and the age at which OA was diagnosed (35.65 y)	OR knee OA = 2.15 (0.95, 4.78); hip OA = 0.7 (0.07, 4.1)	12
Gelber et al[25]	United States	Prospective cohort	36 y (median)	n = 1321; former medical students; 91% male; 97% Caucasian; mean ± SD age, 61.4 ± 8.9 y	OA defined by self-report or degenerative arthritis in response to questionnaires every 5 y. The subjects had to answer the following question: "Have you ever had arthritis?"	Injury: a report of trauma to knees or hip joints, including internal derangement and fracture. Adjusted for age, sex, physical activity, BMI	OR gender combined knee OA = 4.75 (2.7, 8.4), hip OA = 3.24 (0.73, 14.43)	19
Lau et al[40]	China (Hong Kong)	Case-control	NA	Hip OA: n = 138; 30 males, 108 females. Knee OA: n = 658; 166 males, 492 females	OA defined by orthopaedic surgeons using K-L grading scale using radiographs of hip or knee. Grade 3 or 4 OA was included.	Joint injury: subjects were asked if they ever had an injury at the hip or knee. Only injuries that resulted in medical consultation were included.	OR hip OA = 24.55 (11.2, 53.73); knee OA = 9.54 (6.08, 14.97)	21

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Joint injury (*continued*)								
Heliövaara et al[33]	Finland	Cross-sectional	NA	n = 8000; 3637 males, 4363 females; age, ≥30 y	Coxarthrosis was diagnosed if there was either a convincingly documented history or definite findings in the physical status of 1 or both hips	Previous traumatic injuries to lower limb, occupational activities, BMI	OR hip OA adjusted for age, sex, previous injury, and occupation: unilateral = 2.1 (1.4, 3.1); bilateral = 2.36 (1.73, 3.19); either unilateral or bilateral = 1.09 (1.4, 2.6)	10
Meniscectomy								16 (12-19)
Chantraine[5]	Switzerland	Historical cohort	Surgery was performed 10-27 y (mean time, 17 y)	n = 81; former soccer players; age range, 40-74 y. All subjects were soccer players and no true group comparison was made; 42/162 knees underwent meniscectomy.	Clinical signs included pain at rest or with activities, stiffness, and swelling. Radiological signs included JSN, marginal lipping with osteophyte formation in varying degrees, bone sclerosis of joint edges.	Meniscectomy, limb axis	Infinity OR	8
Englund and Lohmander[18]	Sweden	Historical cohort. Nested case-control	Post–meniscal resection performed 15-22 y (surgeries in 1973, 1978, 1983-1985)	n = 317; 68 matched controls; 251 males; mean ± SD age, 54 ± 11 y	Symptomatic OA: KOOS score and consensus. Radiographic OA: any of the following criteria in any of the 2 tibiofemoral compartments or patellofemoral compartment: JSN of grade 2 or greater, sum of the 2 marginal osteophyte grades from the same compartment of 2 or greater, or combined JSN of grade 1 or greater combined with grade 1 osteophytes (based on K-L grading scale).	Age, sex, BMI, extent of meniscal resection, cartilage status, knee load	OR = 9.5 (3.96, 27.59)	21

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Joint injury (*continued*)								
Englund et al[17]	United States	Prospective cohort (nested case-control study)	30-mo follow-up	Prospective cohort: n = 2713; cases, n = 121; controls, n = 294	Radiographic evidence of tibiofemoral OA (weight-bearing posteroanterior knee radiography using a fixed flexion protocol. OA considered present if K-L grade ≥2 or patellofemoral OA if either grade 2 osteophyte or grade 1 JSN with the co-occurrence of a bony feature) on 30-mo radiograph.	Meniscal damage: presence of any medial or lateral meniscal tearing, maceration, or destruction as detected on MRI. It was done at baseline and for OA 30 mo later. It was excluded from meta-analysis because the injury was so specific (menisci injury).	OR = 5.16 (3.16, 8.42)	22
Golightly et al[27]	United States	Cross-sectional	NA	n = 2538; retired male football players; mean age, 53.8 y (24-95 y)	Self-reported arthritis: "Have you ever [been] told by a doctor or other health professional that you have arthritis, rheumatoid arthritis, or fibromyalgia?"	Self-reported injury history on an 18-item checklist	OR = 2.2 (2.1, 2.3) compared to age-matched controls (all age groups). Did not specify the OA location.	15
Hart et al[30]	England	Prospective cohort. Nested case-control study for meniscectomy versus nonmeniscectomy	10 y	n = 31; 21 males, 10 females; mean age, 27.8 y	Radiographic evidence by Ahlbäck system and radio-isotope scan	ACL reconstruction. Risk factor for OA was meniscectomy versus nonmeniscectomy	OR = 6.36 (0.64, 62.8)	11
Maletius and Messner[48]	Sweden	Historical cohort. Nested case-control study	12-15 y. Mean ± SD time, 13 ± 1 y	n = 42 (age and sex matched within 3 y); mean ± SD age, 42 ± 7 y	OA classification by radiographs (anteroposterior and lateral with knee extended and bearing weight at 0° and 30° of flexion; scale based on Fairbank signs and Ahlbäck classification of OA	Chondral damage plus meniscal tear treated with partial meniscectomy (control, chondral damage only)	OR = 2.6 (0.53, 14.29). Both groups had chondral damage (confounder)	19

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Joint injury (*continued*)								
Neuman et al[52]	Sweden	Prospective cohort. Nested case-control for meniscectomy versus nonmeniscectomy	6 wk, 3 mo, 6 mo, 1 y, 3 y, 15 y	n = 100; 58 males; mean age, 28 y (range, 15-43 y)	Patellofemoral OA was diagnosed through KOOS, Lysholm score, radiographic examination	ACL injury	OR = 8.7 (1.73, 43.38)	16
Neyret et al[53]	France	Historical cohort	27 y (range, 20-34 y)	n = 77; soccer players with 91 affected knees; 72 knees underwent radiographic examination	Standing anteroposterior radiograph of the knee. Grade II: early degenerative OA with less than 50% JSN. Grade III: established OA with greater than 50% JSN	Partial meniscectomy with ACL rupture versus partial meniscectomy with ACL intact	OR OA any type injury = 8.94 (3.54, 24.37)	19
Sommerlath et al[64]	Sweden	Historical cohort	Mean ± SD time after surgery, 12 ± 2 y	n = 60; 48 males, 12 females; mean ± SD age, 28 ± 10 y	OA diagnosis by Fairbank grades I or II	Meniscus surgical removal	OR = 9.44 (1.44, 100.38)	5
von Porat et al[72]	Sweden	Historical cohort	14 y	n = 154; male soccer players (after ACL injury); n = 89 reconstructions	Advanced radiographic changes comparable with K-L grades ≥2	ACL injury in soccer. Comparison made between reconstruction and insufficient ACL rather than intact versus insufficient	OR = 16.25 (6.06, 54.08)	16
Sport activity								16 (12.5-19)
Carda[4]	United States	Thesis: first part, longitudinal follow-up; second part, nested case-control study	From 1889 to 1937. Questionnaires, 1952, 1960, 1968, 1976, 1984	n = 310; former collegiate athletes, n = 155; nonathletes, n = 155; males, n = 310	OA reported in any or all of the 1968 through 1984 questionnaires as being present (without consideration of anatomical location, medication, or surgical considerations)	Occupational, recreational, and sports activities	Sporting activity: OA as a runner in collegiate track and field versus having OA as a nonathlete, OR = 2.38 (1.49, 3.27); OA for other athletes versus OA nonathletes, OR = 1.22 (0.68, 1.76); former collegiate football players, OR = 0.47 (0.25, 0.69). No relationship was found between recreational activity and OA.	19

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Sport activity (*continued*)								
Cooper et al[7]	England	Case-control study	18 mo	n = 611. Awaiting THA, n = 210 males; n = 401 females (matched on sex and age)	Hip OA diagnosis through orthopaedic surgeon's list awaiting THA	BMI, Heberden nodes, previous hip injury, smoking status, alcohol consumption	OR regular sporting activity = 1.2 (0.9, 1.6)	21
Gross and Marti[29]	Switzerland	Prospective cohort		n = 41. Cases, n = 22; former elite volleyball players; males; mean ± SD age, 34.0 ± 6 y. Controls: n = 19; healthy untrained males, n = 19; mean ± SD age, 34.8 ± 6 y	Radiological index of ankle degeneration (sum of scores for JSN, subchondral, and osteophytes)	At least 3 y of playing in the highest or second-highest volleyball league	Mean ± SD joint space: volleyball players, 3.9 ± 1.0 mm; controls, 3.7 ± 1.1 mm. Subchondral sclerosis: volleyball players, 3.5 ± 2.1 mm; controls, 0.3 ± 0.6 mm (*P*<.001). Osteophyte formation score: volleyball players, 2.1 ± 1.1; controls, 0.5 ± 0.4 (*P*<.001). Radiological index of ankle degeneration score: volleyball players, 2.1 ± 1.1; controls, 0.3 ± 0.3 (*P*<.001).	11

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Sport activity (*continued*)								
Kettunen et al[37]	Finland	Case-control study	NA	n = 1568. Cases: 991 male former elite athletes. Controls: 577 healthy male controls.	Physician-diagnosed hip and knee OA (yes/no)	Self-reported previous lower-limb loading, sporting activity	OR hip OA, adjusted for age, occupation, and BMI: endurance = 1.40 (0.80, 2.45); track and field = 0.66 (0.36, 1.20); team sport = 1.13 (0.66, 1.92); power sport = 1.06 (0.68, 1.67); shooting = 1.10 (0.49, 2.46); all sports = 1.03 (0.72, 1.48). OR knee OA: endurance = 1.11 (0.66, 1.85); track and field = 1.32 (0.85, 2.06); team sport = 2.04 (1.35, 3.07); power sport = 1.04 (0.70, 1.55); shooting = 0.83 (0.37, 1.86); all sports = 1.28 (0.95, 1.73). OR knee OA (before age 45 y): team sport = 2.92 (1.49, 5.73); power sport = 2.13 (1.03, 4.29); team sport = 3.38 (1.55, 7.37); all athletes = 1.98 (1.06, 3.69)	17
Klünder et al[38]	Denmark	Cross-sectional	NA	n = 114 soccer players. Cases, n = 57; mean age, 56.4 y (range, 40-79 y). Controls: n = 57; mean age, 56.6 y (range, 42-80 y)	Radiographs of the hip and knee joints and clinical examination	Top-level soccer playing	OR all OA = 2.22 (0.98, 5.09). OR hip OA = 2.70 (1.15, 6.43). OR knee OA: tibiofemoral = 1.0 (0.22, 4.63); patel-lofemoral = 1.22 (0.29, 5.39)	13
Lau et al[40]	China (Hong Kong)	Case-control	NA	Hip OA: n = 138; 30 males, 108 females. Knee OA: n = 658; 166 males, 492 females	Knee and hip OA defined by orthopaedic sur-geons using K-L grading (grades 3-4) scale us-ing radiographs of hip or knee	Joint injury, climbing stairs frequently, lifting heavy weight, BMI, sporting activity	OR hip OA in women: gymnastics = 1.9 (0.3, 11.1). OR knee OA in women: gymnastics = 7.4 (2.6, 20.8); kung fu = 22.5 (2.5, 199.0)	21

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Sport activity (*continued*)								
L'Hermette et al[41]	France	Case-control	NA	n = 49. Cases, n = 20; 20 male former elite handball players; mean ± SD age, 44.9 ± 4.7 y. Controls: n = 29 (sex, age, and body weight matched); mean ± SD age, 42.5 ± 4.7 y	Radiographic exam of the hip (weight bearing) and K-L (grades 0-4). PROM at hip and knee. WOMAC and Lequesne index for pain and functional status, respectively	Elite handball players for at least 15 y, >4 h of training per wk (joint loading). Controlled for age, occupation, BMI	Hip OA: 60% versus 13% hip OA in handball versus controls. PROM: decreased flexion and IR; increased abduction, extension, and ER in handball players. Those with OA in handball players reported less pain than controls with OA.	19
Moretz et al[50]	United States	Historical cohort	20 y after high school competition	n = 34; 23 male former high school (local class 3A) football players; 11 age-matched males who did not participate in contact sports. No age data given.	Radiographic criteria (K-L grades 0-4); changes in osteophyte formation, sclerosis, cyst formation, JSN: graded 0-4, ranging from no change to severe changes.	Contact sports (football)	RR contact sports = 5.26 (0.77, 35.77)	10
Östenberg[56]	Sweden	Thesis: historical cohort. Nested case-control	Unknown	n = 69. Cases: mean age, 42 y (range, 35-55 y). First division soccer for minimum of 4 y. Controls: (age matched) mean age, 46 y (range, 32-55 y)	Radiographic evidence of hip and knee OA; JSN and osteophytes (graded 0-3 with radiographic atlas). Knee OA defined as presence of JSN greater than grade 2 or JSN grade 1 with osteophytes. Hip OA defined as JSN grade 1 or greater	High-level soccer for at least 4 y (first team league players for at least 4 y)	OR knee OA = 3.2 (0.98, 10.8), adjusted for age, BMI = 5.4 (1.4, 20.3); significant knee injury or surgery = 2.2 (0.3, 12.0). OR hip OA = 0.5 (0.09, 2.7)	16
Stulberg et al[67]	United States	Retrospective case series	NA	n = 23 competitive breaststroke swimmers; mean age, 17 y (range, 6-30 y)	Only one half of the subjects had radiographic imaging. No information was provided regarding the definition of OA. No mention was made as to whether the radiographs were taken weight bearing.	Competitive breaststroke swimming	Prevalence, 0; no subjects with radiographs had developed OA.	16

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Sport activity (*continued*)								
Thelin et al[70]	Sweden	Case-control	NA	n = 1650. Cases, n = 825; controls, n = 825; 356 males, 469 females; mean age, 62.6 y (range, 51-70 y)	Knee OA cases were included if moderate cartilage reduction was noted, or if the joint gap was 3 mm or lower	Sport activity	OR soccer = 1.6 (1.1, 2.2); hockey = 1.9 (1.2, 3.0); tennis = 2.0 (1.1, 3.8). OR adjusted (BMI, heredity, smoking, and occupation) soccer = 1.5 (1.0, 2.2); hockey = 2.1 (1.2, 3.5); tennis = 1.9 (1.0, 3.7). OR adjusted (BMI, heredity, smoking, occupation, joint injury) soccer = 0.9 (0.6, 1.4); hockey = 1.6 (0.9, 3.0); tennis = 1.2 (0.6, 2.5)	20
Vingård et al[71]	Sweden	Case-control	4 y	n = 535; 532 males. Cases: n = 233; controls: n = 302	THA for idiopathic hip OA during the study period	Physical activity level, sporting activity, everyday exposures	OR adjusted (age, BMI, smoking, occupational physical loads): high sport exposure = 4.5 (2.7, 7.6); medium sport exposure = 2.6 (1.5, 4.5); high exposure occupation and sport = 8.5 (4.0, 17.9); high exposure racket sports = 3.3 (1.2, 12.7); track and field = 3.7 (1.1, 13.2)	17
Physical activity								18 (14-21)
Charles[6]	United States	Thesis: retrospective analysis of longitudinal data	20 y: 1973-1993 (data collection in 1979, 1984, 1987, 1990, 1993)	n = 1117 (1993 data used for this study from the Swedish Twin Aging Study); 486 males, 631 females; mean ± SD age, 64.33 ± 10.64 y (range, 45-91 y)	Constant pain in hip or knee for at least 3 mo or taking medications for joint problems or arthritis	Exercise, physical activity at work, obesity, neuroticism, depression, hostility	OR exercise: increased reported exercise = 0.71 (0.55, 0.91). OR physical exertions: higher physical exertion = 1.53 (1.17, 1.99)	22
Gelber[23]	United States	Thesis: prospective cohort	48 y (median)	n = 1008; 1008 male former medical students; mean age, 22 y	Knee and hip OA defined by self-report and substantiated by symptoms and radiographic features	Physical activity	RR knee OA: physical activity = 1.82 (1.00, 3.34); cumulative physical activity = 1.94 (0.64, 5.86)	14

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Physical activity (*continued*)								
Hathwar[31]	United States	Thesis; prospective cohort	20 y	n = 3847 females; age range, 20-87 y	Physician-diagnosed knee or hip OA	Cardiovascular fitness, obesity: overweight and obese by BMI	OR moderate fitness = 1.0 (0.8, 1.3); low fitness = 1.0 (0.8, 1.30)	9
Roach[59]	United States	Thesis: case-control	NA	Cases, n = 99; mean age, 69 y. Controls, n = 230; mean age, 67.3 y	Hip OA grade 3 or 4 diagnosed by X-ray or had received THR due to OA	Biomechanical aspects of past occupation (classified as heavy work that produced hip joint compression forces of 2 times body weight), recreational activity	OR football, soccer, rugby = 2.3 (1.4, 3.6); running, jogging = 2.1 (1.2, 3.9)	21
Sutton et al[68]	United Kingdom	Case-control	5-14 y before diagnosis (time 1); 15-24 y before diagnosis (time 2)	n = 366. Cases, n = 216; 66 males, 150 females; mean age, 57.1 y. Each case was matched with 4 controls	Respond yes to the questions: (1) Have you ever had arthritis? (2) Do you suffer from any recurrent or continuous pain, swelling, or stiffness in your knees? (3) Report age of onset of arthritis as over 40 y. (4) No report of any suffering from pain/swelling/stiffness in the wrist, hands, fingers	Low and/or moderate levels of physical activity	OR time 1: OR long walks = 1.7 (1.1, 2.4). OR ages 20-24: moderate exercise = 1.8 (1.0, 3.0)	18
Obesity								20 (14-21)
Charles[6]	United States	Thesis: retrospective analysis of longitudinal data	20 y: 1973-1993 (data collection in 1979, 1984, 1987, 1990, 1993)	n = 1117 (1993 data used for this study from the Swedish Twin Aging Study); 486 males, 631 females; mean ± SD age, 64.33 ± 10.64 y (range, 45-91 y)	Constant pain in hip or knee for at least 3 mo or taking medications for joint problems or arthritis	Exercise, physical activity at work, obesity, neuroticism, depression, hostility	OA group obesity status: 15% versus 8.7% in no-OA group. Obesity was not significant, except women who reported history of obesity had higher likelihood of future OA: OR = 3.6 (1.32, 10.05)	22
Cooper et al[8]	United Kingdom	Case-control		n = 327. 109 cases; 30 males, 79 females. 218 controls; 60 males, 158 females	K-L grades 3-4. Answered yes to "Have you had pain in or around a knee on most days for at least a month, at some time during the last year?"	Meniscectomy, previous knee injury, arthritis of hand joints, presence of Heberden nodes, family history of knee OA, DM, hypertension, BMI	OR highest third BMI = 3.3 (1.6, 6.9)	14

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Obesity (*continued*)								
Cooper et al[7]	England	Case-control	18 mo	n = 611 awaiting THA; 210 males, 401 females (matched on sex and age)	Hip OA diagnosis through orthopaedic surgeon's list awaiting THA	BMI, Heberden nodes, previous hip injury, smoking status, alcohol consumption	OR highest third BMI = 1.7 (1.3, 2.4)	21
Englund and Lohmander[18]	Sweden	Historical cohort	15-22 y post–meniscal resection (surgeries in 1973, 1978, 1983-1985)	n = 317 (68 matched controls); 251 males; mean ± SD age, 54 ± 11 y	KOOS. Symptomatic OA: KOOS score and consensus. Radiographic OA defined by any 2 of following criteria: in any of the 2 tibiofemoral compartments or patellofemoral compartment; JSN ⩾2; sum of the 2 marginal osteophyte grades from the same compartment ⩾2; or combined JSN ⩾1 combined with grade 1 osteophytes (based on K-L grading scale)	Age, sex, BMI, extent of meniscal resection, cartilage status, knee load	OR radiographic OA: BMI 25-29 kg/m^2 = 1.2 (0.7, 2.1); BMI ⩾30 kg/m^2 = 2.5 (1.1, 5.7). OR symptomatic OA: BMI 25-29 kg/m^2 = 2.6 (1.5, 4.5); BMI ⩾30 kg/m^2 = 3.0 (1.3, 7.0). OR symptomatic radiographic OA: BMI 25-29 kg/m^2 = 2.4 (1.2, 4.8); BMI ⩾30 kg/m^2 = 3.9 (1.6, 9.8)	21
Gelber et al[24]	United States	Prospective cohort	36 y (median)	n = 1180; 1180 male former medical students; mean ± SD age, 23 ± 2 y	Knee and hip OA defined by self-report and substantiated by symptoms and radiographic features	Body weight, BMI	RR knee OA (all ages): all cases BMI >24.7 kg/m^2 = 3.3 (1.6, 7.1); confirmed cases BMI >24.7 kg/m^2 = 3.8 (1.5, 9.5)	14
Hathwar[31]	United States	Thesis; prospective cohort	20 y	n = 3847; 3847 females; age range, 20-87 y	Physician-diagnosed knee or hip OA	Cardiovascular fitness, obesity: overweight, BMI of 25.0-29.9 kg/m^2; obese, BMI ⩾30 kg/m^2	OR overweight = 1.4 (1.1, 1.9); obese = 2.2 (1.6, 3.0)	9
Heliövaara et al[33]	Finland	Case-control	NA	n = 8000; 3637 males, 4363 females; age, ⩾30 y	Coxarthrosis was diagnosed if there was either a convincingly documented history or definite findings in the physical status of 1 or both hips	Occupational activities, previous traumatic injuries to lower limb, BMI	OR BMI versus bilateral coxarthrosis (adjusted): BMI 30.0-34.9 kg/m^2 = 2.3 (1.5, 3.5); BMI ⩾35 kg/m^2 = 2.8 (1.4, 5.7)	10
Lau et al[40]	China (Hong Kong)	Case-control	NA	Hip OA, n = 138; 30 males, 108 females. Knee OA, n = 658; 166 males, 492 females	Knee and hip OA defined by orthopaedic surgeons using K-L grading (grades 3-4) scale using radiographs of hip or knee	Joint injury, climbing stairs frequently, lifting heavy weight, BMI	Hip OA: body weight (univariate): women = 2.3 (1.1, 4.6)	21

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Obesity (*continued*)								
Lübbeke et al[45]	Switzerland	Cross-sectional	NA	n = 855; 381 males	Harris hip score, WOMAC, radiographic evidence by K-L grade, subchondral sclerosis, cysts, osteophyte formation, presence of femoral head deformity	BMI	Increasing BMI in patients undergoing THA was associated with higher pain levels and greater functional disability, but not more radiographic hip joint damage.	17
Marks[49]	United States	Case series	NA	Sample 1: n = 100; unilateral knee OA, n = 58; bilateral knee OA, n = 42; 18 males, 82 females; mean ± SD age, 70.07 ± 9.55 y. Sample 2: n = 16; 16 females; mean ± SD age, 60.9 ± 10.6 y (range, 34-74 y). Sample 3: n = 30; 6 males; mean ± SD age, 66.83 ± 10.52 y; 24 females; mean ± SD age, 71.2 ± 10.34 y	Clinical and radiological evidence of idiopathic or primary knee joint OA	BMI	Sample 1: mean ± SD BMI unilateral knee OA, 28.8 ± 5.4 kg/m^2; BMI bilateral knee OA, 30.3 ± 5.7 kg/m^2. Sample 2: mean ± SD BMI knee OA, 30.1 ± 4.2 kg/m^2; BMI no knee OA, 23.5 ± 1.5 kg/m^2. Sample 3: prevalence of overweight (BMI) was highest in the 60-69-y age range	14
Niu et al[54]	United States	Prospective cohort	30 mo	n = 2623; 1050 males, 1573 females. Mean ± SD age, 62.4 ± 8.0 y	Radiographs: K-L grading, JSN, and osteophytes	Obesity: normal, BMI <25.0 kg/m^2; overweight, 25.0-29.9 kg/m^2; obese, 30-34.9 kg/m^2; very obese, >35 kg/m^2	RR tibiofemoral OA: overweight = 1.8 (1.0, 3.2); obese = 2.4 (1.3, 4.3); very obese = 3.2 (1.7, 5.9). RR progressive tibiofemoral OA: overweight = 1.0 (0.8, 1.2); obese = 1.0 (0.8, 1.2); very obese = 1.1 (0.9, 1.4)	20

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Obesity (*continued*)								
Sowers et al[65]	United States	Cross-sectional	NA	n = 482; females; mean age, 47 y. Without OA: n = 429; mean ± SD age, 47 ± 8 y. With OA: n = 53; mean ± SD age, 50 ± 5 y	Knee OA by X ray using K-L grades ≥2	Obesity: BMI ≥30 kg/m², ≥2 cardiometabolic defects: (1) self-reported DM, use of DM medications, or glucose level >126 mg/dL; (2) CRP level ≥2 mg/L; (3) HDL cholesterol ≤45 mg/dL or LDL >160 mg/dL; (4) triglycerides ≥200 mg/dL; (5) waist-hip ratio ≥0.81 cm; (6) systolic blood pressure >135 mmHg, diastolic blood pressure >85 mmHg, or use of high blood pressure medications	OR nonobese with clustering = 1.28 (0.43, 3.87); obese without clustering = 3.00 (1.03, 8.71); obese with clustering = 6.20 (2.93, 13.07)	20
Sowers et al[66]	United States	Prospective cohort	4 y	n = 541; 485 females; mean ± SD age, 46.9 ± 4.85 y	Knee OA defined by the K-L scale, the presence of at least 1 knee with grade 2 or greater	Age, body composition, fat mass, SMM, BMI	OR knee OA with each unit increase in fat mass, SMM, and BMI: fat mass = 8.02 (2.3, 28.1); SMM = 476.99 (12.8, 17 735.1); BMI = 864.97 (70.5, 10 617.9)	21

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Occupational activity								18 (14-19)
Amin et al[2]	United States	Cross-sectional	NA	n = 192; males; mean ± SD age, 69 ± 9 y	MRI of the more symptomatic knee to examine cartilage morphology at the tibiofemoral and patellofemoral joint	Occupational-related squatting, kneeling, and heavy lifting	Crude OR heavy lifting only: medial tibiofemoral joint = 1.2 (0.6, 2.3); lateral tibiofemoral joint = 1.2 (0.5, 2.8); patellofemoral joint = 1.5 (0.8, 2.6). Crude OR squatting or kneeling and heavy lifting: medial tibiofemoral joint = 1.2 (0.7, 2.2); lateral tibiofemoral joint = 1.2 (0.5, 2.8); patellofemoral joint = 1.6 (1.0, 2.7); anterior patellofemoral surfaces = 3.0 (1.5, 6.0)	18
Carda[4]	United States	Thesis: first part, longitudinal follow-up. Second part, nested case-control	From 1889 to 1937. Questionnaires, 1952, 1960, 1968, 1976, 1984	n = 310; males; former collegiate athletes, n = 155; nonathletes, n = 155	OA reported in any or all the 1968 through 1984 questionnaires as being present (without consideration of anatomical location, medication, or surgical considerations)	Occupational, recreational, and sports activities	OR higher occupation activity = 1.76 (1.28, 2.24)	19
D'Souza et al[15]	United States	Case-control	NA	n = 2589; 1219 males, 1370 females; median age, 70.6 y (range, 60-90 y)	Knee OA defined as K-L score ⩾2 in at least 1 knee and self-reported knee symptoms in the corresponding knee or knee replacement surgery	Occupational activities	OR cramped space = 1.35 (1.02, 1.77); kneeling = 1.41 (1.07, 1.88); heavy lifting = 1.30 (1.05, 1.61)	14
Heliövaara et al[33]	Finland	Cross-sectional	NA	n = 8000; 3637 men, 4363 women; age, ⩾30 y	Coxarthrosis was diagnosed if there was either a convincingly documented history or definite findings in the physical status of 1 or both hips	Occupational (3 or more occupational stress activities), previous traumatic injuries to lower limb, BMI	OR unilateral hip OA: ⩾3 occupational activities = 2.4 (1.4, 3.8); ⩾3 occupational activities = 2.3 (1.2, 4.3). OR bilateral hip: ⩾3 occupational activities = 2.8 (1.6, 4.7); ⩾3 occupational activities = 2.9 (1.5, 5.8)	10

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Occupational activity (*continued*)								18 (14-19)
Lau et al[40]	China (Hong Kong)	Case-control	NA	Hip OA: n = 138; 30 males, 108 females. Knee OA: n = 658; 166 males, 492 females. No report of age range	Knee and hip OA defined by orthopaedic surgeons using K-L grading (grades 3-4) scale using radiographs of hip or knee	Joint injury, climbing stairs frequently, lifting heavy weight, BMI	OR hip OA: climbing stairs frequently men = 12.5 (1.5, 104.3), women = 2.3 (0.6, 8.1); lifting heavy weight frequently men = 3.1 (0.7, 14.3), women = 2.4 (1.1, 5.3). OR knee OA: climbing stairs frequently men = 2.5 (1.0, 6.4), women = 5.1 (2.5, 10.2); lifting heavy weight frequently men = 5.4 (2.4, 12.4), women = 2.0 (1.2, 3.1)	21
Murray-Leslie et al[51]	England	Cross-sectional	NA	Active sport parachutists: n = 112; 112 males; mean age, 29.2 y (range, 23-57 y). Veteran military parachutists (no longer actively parachuting): n = 109; 109 males; mean age, 47.8 y (range, 28-70 y)	Radiological evidence of knee (tibiofemoral or patellofemoral joint), ankle (talotibial joint), graded 0-4 (0 is normal, 1 is doubtful, 2 is mild, 3 is moderate, 4 is severe); same radiologist	Military veteran parachutist	Knee OA: 10.4% prevalence in sport group; 41.3% prevalence in ex-military group. Ankle OA: 17.5% of 40 ex-military parachutists	10
Roach et al[60]	United States	Case-control	NA	Cases: n = 99; mean age, 69 y. Controls: n = 230; mean age, 67.3 y	Hip OA grade 3 or 4 diagnosed by X-ray or had received a THR due to OA	Biomechanical aspects of past occupation (classified as heavy work that produced hip joint compression forces of 2 times body weight), recreational activity	OR exposure to heavy work: standing = 2.7 (1.1, 6.6); walking and mixed heavy work = 2.3 (1.0, 5.5); kneeling = 2.1 (0.8, 5.7). OR adjusted (controlling for cancer, obesity at age 40, and football): heavy work = 2.5 (1.2, 5.0)	21
Rytter et al[63]	Denmark	Cross-sectional	NA	n = 254. Floor layers: n = 134 males; mean age, 52.6 y (range, 39-68 y). Graphic designers: n = 120 males; mean age, 57.8 y (range, 40-70 y). Age divided into 3 strata: ≤49, 50-59, ≥60 y	Tibiofemoral or patellofemoral OA by X-ray in 3 views, grades 1-6, using a modified Ahlbäck scale; OA as JSN of grade 1 or greater	Professional work exposure	OR tibiofemoral OA: floor layers versus graphic designers (ages 50-59 y) = 3.6 (1.1, 12.0); adjusted (trade seniority) = 2.2 (1.0, 5.1)	18

APPENDIX B

Category/Study	Country	Study Design	Follow-up	Participants	Outcome (OA Definition)	Risk Factors (Exposure Variables)	Results*	QI Score†
Occupational activity (*continued*)								18 (14-19)
Tangtrakul-wanich et al[69]	Thailand	Cross-sectional	>40 y (lifetime)	n = 576; 288 males; mean ± SD age, 59.8 ± 11.6 y; 288 females; mean ± SD age, 58.9 ± 11.1 y	Radiographs (weight-bearing anteroposterior and skyline views of both knees). OA was established if the radiographic result was grade 2 or greater in each side and specific compartment	Habitual floor activities (squatting, lotus, side knee bending, kneeling)	RR knee OA: adjusted second tertile = 1.2 (0.7, 2.1); adjusted third tertile = 2.3 (1.3, 4.3) (*P* = .04)	16

Abbreviations: BMI, body mass index; CI, confidence interval; CRP, C-reactive protein; DM, diabetes mellitus; ER, external rotation; HDL, high-density lipoprotein; IR, internal rotation; JSN, joint space narrowing; K-L, Kellgren-Lawrence; KOOS, Knee injury and Osteoarthritis Outcome Score; LDL, low-density lipoprotein; MRI, magnetic resonance imaging; NA, not applicable; OA, osteoarthritis; OR, odds ratio; PROM, passive range of motion; QI, quality index; RR, risk ratio; SMM, skeletal muscle mass; THA, total hip arthroplasty; THR, total hip replacement; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

**Values in parentheses after ORs are 95% CI.*

†Values in parentheses are median (interquartile range).