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Epidemiology of osteoarthritis

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SUMMARY

Objective: To summarize the current state of the evidence regarding osteoarthritis (OA) prevalence, incidence and risk factors at the person-level and joint-level.

Design: This was a narrative review that took a comprehensive approach regarding inclusion of potential risk factors. The review complements prior reviews of OA epidemiology, with a focus on new research and emerging topics since 2017, as well as seminal studies.

Results: Studies continue to illustrate the high prevalence of OA worldwide, with a greater burden among older individuals, women, some racial and ethnic groups, and individuals with lower socioeconomic status. Modifiable risk factors for OA with the strongest evidence are obesity and joint injury. Topics of high interest or emerging evidence for a potential association with OA risk or progression include specific vitamins and diets, high blood pressure, genetic factors, metformin use, bone mineral density, abnormal joint shape and malalignment, and lower muscle strength/quality. Studies also continue to highlight the heterogenous nature of OA, with strong interest in understanding and defining OA phenotypes.

Conclusions: OA is an increasingly prevalent condition with worldwide impacts on many health outcomes. The strong evidence for obesity and joint injury as OA risk factors calls for heightened efforts to mitigate these risks at clinical and public health levels. There is also a need for continued

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Contributions

KDA, LMT and YMG contributed to the conception and design of the review and interpretation of data, drafted the article and revised it critically for important intellectual content, and approved the final version of the manuscript to be submitted.

Conflict of Interest

The authors have no competing interests to declare regarding this manuscript.

research regarding how potential person- and joint-level risk factors may interact to influence the development and progression of OA.

Keywords

Osteoarthritis; Epidemiology; Risk factors

Introduction

Osteoarthritis (OA) is a disease involving multiple anatomic and physiological alterations of joint tissues, including cartilage degradation, bone remodeling and osteophyte formation; this leads to clinical manifestations including pain, stiffness, swelling and limitations in joint function[1]. OA is one of the most common chronic health conditions, impacting not only pain and physical function but also many other outcomes including mental health, sleep, work participation, and even mortality[1]. Because there have been prior reviews of OA epidemiology[2,3], this narrative review emphasizes new research since 2017. However, we include results from earlier work, particularly seminal studies and topics not represented newer studies. Similar to some other reviews, potential risk factors are grouped according to person-level and joint-level characteristics. We note that this review does not include a review of spine OA or genetic factors associated with OA, as these will be covered in separate manuscripts in this series[4].

OA prevalence and incidence

Table I provides estimates of radiographic and symptomatic OA prevalence and incidence from recent cohort studies (2017 to present), along with details on sample weights when appropriate; the text below also summarizes data from key earlier studies, with come cohort studies from China being described in the Demographic Characteristics section. Estimates have varied across studies, based on the populations examined (including age ranges), data sources, and different definitions of OA. A prior review summarized prevalence and incidence data from studies of knee, hip and hand OA data, illustrating this variability[5].

While most research has focused on OA at specific sites, some studies have provided data on OA prevalence and incidence more generally. An estimated 240 million individuals worldwide have symptomatic OA, including 10% of men and 18% of women age 60 and older[6]. Recent estimates from the Global Burden of Diseases, Injuries and Risk Factors Study (GBD) found that globally, the age-standardized point prevalence and annual incidence rate of symptomatic, radiographically confirmed hip and knee OA were 3754.2 (Uncertainty Index (UI) 3389.4–4187.6) and 181.2 (UI 162.6–202.4) per 100,000, respectively; these represent 9.3% and 8.2% increases since 1990[7]. Of note, GBD utilized available data sources on radiographic OA, and when data were not available for a country, values were estimated based on similar countries and territories, using disease-relevant country characteristics. Population-based studies of OA prevalence and incidence have been conducted in multiple countries. In a large survey study of individuals age ≥50 in England, about half of respondents indicated having OA in at least one joint, including the hand, hip, knee and foot[8]. A recent survey study of individuals age ≥20 years in Spain found that

29% of individuals (weighted prevalence) had OA at one or more locations (including spine, hand, hip and knee), based on screening questions corresponding to American College of Rheumatology (ACR) clinical criteria[9]. A United Kingdom (UK)-based study, using a large nationally representative primary care database, found there were 494,716 incident cases of clinical OA between 1997 and 2017, corresponding to 6.8 (95% Confidence Interval (CI) 6.7–6.9) per 1000 person years (age- and sex-standardized)[10]. Another study using this data source showed that among patients age ≥45 years, the annual age and sex-adjusted incidence rate for clinical OA increased from 29.2 (95% CI 28.8, 29.5) to 40.5 (95% CI 40.3, 40.7) per 1000 person years from 1992 to 2013[11].

There has also been interest in multiple-joint OA (MJOA), which has been defined in at least 10 different ways[12]. Because of this variability, it has been difficult to establish a consensus of the prevalence of MJOA. A systematic review found prevalence estimates ranging from 5% to 25%[13]. Overall, MJOA has been associated with poorer OA-related outcomes compared with single joint involvement.

Knee OA

The prevalence and incidence of knee OA has been more widely studied than other joints[2,3,9,14–18]; data from recent studies are shown in Table I. The prevalence of symptomatic knee OA has varied across studies. For example, among adults age ≥45 years in the US-based Framingham cohort, the prevalence of symptomatic knee OA was 7%; in the US-based Johnston County Osteoarthritis project, the prevalence was 17%[17,18]. A recent meta-analysis found the overall pooled estimate of symptomatic knee OA prevalence in China was 14.6%[19]. Using data from the National Health Interview Survey, along with a validated simulation model, an estimated 14 million people in the US have symptomatic knee OA[20]. Data from the Korean National Health and Nutrition Examination Survey (NHANES) reported the weighted prevalence of radiographic knee OA among adults age ≥50 years was 35.1%[21].Data from among individuals aged 60–74 years in the US NHANES showed that from 1974 to 1994, the age- and BMI-adjusted prevalence of knee pain increased by approximately 65% in demographic groups including non-Hispanic white and Mexican American individuals and African American women[22]. In the Framingham Osteoarthritis Study, among adults aged ≥70 years, from 1983 to 2005, the age- and BMI-adjusted prevalence of knee pain and symptomatic knee OA (but not radiographic knee OA) approximately doubled among women and tripled among men[22]. Results from these two studies importantly suggest that increases in the prevalence of knee pain and knee OA over time are not fully explained by increased rates of obesity. There has also been interest in estimating the prevalence of patellofemoral OA specifically[23]. A meta-analysis including 85 studies found that about half of individuals with knee pain or radiographic knee OA have patellofemoral involvement[24].

Analyses from The Chingford Study found that the cumulative 5-year incidence of “typical” radiographic knee OA among women age 45–64 years was 17.6%, and the incidence of “accelerated” radiographic knee OA was 3.7%[25]. The lifetime risk of symptomatic knee OA has been estimated to be between 14% and 45%, using different cohorts and methodologies[26,27]. Another key study reported that the age- and sex-standardized incidence

rate of symptomatic knee OA among individuals in a community health plan was 240 per 100,000 person years, rising substantially after age 50[28].

Hip OA

Recent cohort studies of the prevalence and incidence of hip OA are shown in Table I. In a population-based study of adults age ≥40 years in Spain, the weighted prevalence of hip OA, based on ACR clinical and radiographic criteria, was 5.1%[9]. In the Framingham cohort, the age-standardized prevalence of radiographic hip OA among adults age ≥50 years was 19.6%, and the prevalence of symptomatic hip OA was 4.2%[29]. The prevalence of symptomatic hip OA in the Johnston County Osteoarthritis Project (adults age ≥45 years) was higher, 10%[30]. Recent data from the Research on Osteoarthritis/osteoporosis Against Disability cohort showed that the incidence rate of radiographic hip OA adults age ≥23 years was 5.6 per 1,000 person years for men and 8.4 per 1,000 person years in women[31]. Among adults in a community health plan, the age- and sex-standardized incidence rate of symptomatic hip OA was 88 per 100,000 person years, rising substantially after age 50[28]. One US-based study estimated that the weighted lifetime risk of symptomatic hip OA is 25%[32].

Hand

The prevalence of hand OA has been highly variable across studies, with large differences between radiographic and symptomatic disease, as well as based on different disease definitions; results from recent cohort studies are shown in Table I. In a study including three English cohorts age ≥50 years, the weighted prevalence of radiographic, symptomatic hand OA was 22%, with first carpometacarpal joint OA being the most common subtype[15]. In a Spanish study of adults age ≥40 years, using ACR clinical criteria, the weighted prevalence of hand OA was 7.7%[9]. Earlier research from the Framingham Osteoarthritis study reported the age-standardized prevalence of symptomatic hand OA was 14% in women and 7% in men[33]; this increased to 26% and 13% among those age 71 and older in the Framingham cohort[34].

In the US-based Johnston County Osteoarthritis Project, the incidence of radiographic hand OA among adults age ≥45 years was 60%, and the incidence of symptomatic hand OA was 13% over a 12-year average follow-up period[35]. In the same cohort, the weighted lifetime risk of symptomatic hand OA was 40%[36]. In the Framingham Osteoarthritis study, the 9-year incidence of radiographic hand OA at any joint was about 35%, with an incidence of symptomatic hand OA (at one or more joints) being 4% in men and 10% in women[33]. Among adults in a community health plan, the age- and sex-standardized incidence rate of symptomatic hand OA was 100 per 100,000 person years, rising substantially after age 50[28].

Foot & ankle

A recent systematic review of 18 studies found no true general population prevalence estimates of radiographic ankle OA; prevalence estimates in various cohorts ranged widely from 0.0 to 97.1%[37]. Results of recent cohort studies are shown in Table I. The Clinical Assessment Study of the Foot (CASF), including 5109 adults age ≥50 years in four UK based general practices, found the weighted prevalence of ankle pain was 11.7% and symptomatic, radiographic ankle OA (grade≥2) was 3.4%[37]. In the Johnston County

Osteoarthritis Project, 28% of adults age ≥55 years developed incident radiographic ankle OA over 3.5 years; among those with ankle OA at baseline, 4% had radiographic worsening[38]. In a UK-based study of a large nationally representative primary care database including adults age ≥20 years, the age- and sex-standardized incidence of ankle and foot OA was 0.2 per 1,000 person years[10]. A review of midfoot and forefoot OA found that most studies focused on radiographic OA, with wide variability in prevalence estimates (0.1–61%) based on age, gender and joint(s) studied[39]. The CASF study reported the weighted prevalence of symptomatic OA in the foot was 16.7%[40] among adults age ≥50 years, with 7.8% symptomatic OA in the first metatarsophalangeal joint[40] and 12.0% in the midfoot[41]. In the Johnston County Osteoarthritis Project, among adults age ≥50 years the frequency of radiographic foot OA was 22.1%, and symptomatic foot OA was less common (5.3%)[42,43]. A community-based longitudinal cohort study of adults aged 40–91 years in Clearwater, Florida estimated a 25% incidence of first metatarsophalangeal joint OA over an average of 7 years[44].

Person-level risk factors

Table II presents key person-level risk factors for OA.

Demographic Characteristics

Many studies have shown that OA risk increases with age and is greater among women compared with men[2,3]. Gender differences in OA seem to be present across joint sites, with the potential exception of cervical spine OA[2]. Racial and ethnic differences are also well documented[45]. In the US, multiple studies have found that Blacks have greater prevalence and severity of lower extremity OA than Whites[45]. A recent study of the Osteoarthritis Initiative cohort found that Black participants had lower odds of radiographic (OR = 0.79, 95% CI 0.66, 0.94) and symptomatic (OR = 0.63, 95%CI 0.49, 0.82) hand OA compared to Whites; however, it should be noted that this cohort includes only individuals with or at risk for knee OA[46]. Studies have observed that Chinese women have about 45% higher prevalence of radiographic and symptomatic knee OA than white women, with no difference between Chinese and white men[47,48]. However, hip OA is less common among Chinese individuals, compared with whites[49]. Studies from multiple countries have shown that OA prevalence, particularly at the knee and hip, is higher among individuals with lower socioeconomic status, as well as in rural communities[45].

Obesity and metabolic and inflammatory factors

The associations of obesity and metabolic syndrome with OA have continued to be a major research focus[50–54]. There is a clear association of overweight with increased risk for OA, particularly at the knee; one systematic review found that obesity increased the risk of OA about 3-fold[2,3,55,56]. A systematic review found no association of metabolic syndrome with hip OA, insufficient evidence for hand OA, and no significant association with knee OA in studies that controlled for weight[57]. However, there have been mixed results in other studies. One recent study reported that metabolic syndrome and low high density lipoprotein levels were associated with medial compartment cartilage volume loss and bone marrow lesion size increase, even when controlling for body mass index; however, some individual

components of metabolic syndrome were not associated with these changes, and there were no significant associations for lateral compartment OA[58]. There is also some evidence that some components of metabolic syndrome are associated with greater knee pain[59–61]. One potential pathway linking obesity and metabolic syndrome with OA outcomes is inflammation. Several recent studies have identified associations of inflammatory factors (e.g., resistin, interleukin-8, S100A8/S100A9) with knee OA some aspects of knee OA severity and symptoms; however, results have been mixed, with one study finding no association of interleukin-8 with non-weight-bearing pain, for example[62,63].

Vitamin and nutritional factors

The role of specific vitamins and diet also continues to be an active research area. Vitamin D has been the most extensively studied, including epidemiological studies and trials of supplementation. Findings of these studies have been conflicting[64,65]. Three trials of vitamin D supplementation failed to find effects on structural or symptomatic outcomes[66–68], though there has some indication that participants who consistently maintain sufficient 25-hydroxyvitamin D levels had better outcomes[69]. Recent data from the Osteoarthritis Initiative cohort indicates greater vitamin D level was associated with some metrics of better knee cartilage architecture on MRI, as well as less progression of joint abnormalities; however, vitamin D level was not associated with all components of cartilage health and joint progression examined in these studies[70,71]. Other research indicates that among individuals with knee OA, vitamin D supplementation may positively impact depressive symptoms and foot pain[72,73]. Vitamins D and K may also be important in combination; among participants in the Health, Aging and Body Composition Study and Osteoarthritis Initiative, sufficient levels of both vitamin D and vitamin K were associated with better physical function[74]. Earlier work also suggested a potential role of low vitamin K with OA risk and progression[3]. There has been conflicting evidence regarding potential roles of vitamins C and E with OA risk and progression[3].

In addition to research on specific vitamins, other studies have examined the association of various types of diets with OA. There is some evidence for a positive influence of higher dietary fiber, soy milk intake, and Mediterranean diet on various OA outcomes, but additional studies are needed to confirm these findings[3].

Bone density and bone mass

Multiple studies have found that higher bone mineral density is associated with greater risk for radiographic knee and hip OA[2,3,75–77]. A recent Mendelian randomization study using UK Biobank data found evidence for a causal relationship of high femoral neck bone mineral density with all OA, knee OA and hip OA; methods applied in this study provide strong support that the association of bone mineral density and OA risk is not due to collider bias[78]. Another study identified an association of bone mineral density with hip and knee replacements[79]. Although most studies have not observed an association with high bone mineral density with OA progression[75], a recent study found that high bone mass was associated with progression of osteophytes[79], but only when combining incidence and progression outcomes.

Other person-level factors

Some studies have found that smoking confers a small protective effect for the development of radiographic knee and hip (but not hand) OA[80,81], though findings have not been consistent[82]. Studies have also evaluated the association of statin use with OA, and a recent meta-analysis found no significant relationship with OA incidence or progression[83]. However, there have been some promising data regarding the potential role of metformin in reducing OA risk and progression. For example, in the Osteoarthritis Initiative, medial cartilage volume loss was lower in metformin users than non-users, with a difference of −0.86% (95% CI −1.58%, −0.15%) per year after adjustment for key covariates; however, there was no relationship of metformin with lateral compartment cartilage volume loss or change in symptoms[84]. Some studies found an association of blood pressure with OA, including a recent analysis of Osteoarthritis Initiative data that observed a correlation between higher diastolic blood pressure and increased cartilage matrix degenerative changes over time[85]. However, other research has failed to observe an association between blood pressure and OA[51]. There has been evidence for an association of low birth weight with hip and knee OA[3]. Studies have examined associations of various environmental pollutants with OA, with potential positive relationships for lead and organic pollutants including polychlorinated biphenyls[86,87].

Joint risk factors

Table II presents key joint-level risk factors for OA.

Bone/joint shape

Variation in bone/joint shape previously has been linked with OA at the hip and knee[2,88], and more recent cohort studies have added to our understanding of the relationship at these joints. In a nested case–control study using Johnston County Osteoarthritis Project data, compared to control hips, hips with moderate radiographic OA (Kellgren–Lawrence grade ≥3) were more likely to have cam morphology (abnormality of the femoral head–neck junction linked to femoroacetabular impingement) in both men and women and to have protrusio acetabuli (acetabulur overcoverage defect) only in women[89]. In the Rotterdam Study, cam deformity and acetabular dysplasia were independent risk factors for incident radiographic hip OA (mean follow up 9.2 years)[90]. Data from the Chingford Study, the Johnston County Osteoarthritis Project, and Beijing Osteoarthritis Study showed variation by race in hip joint morphological characteristics related to hip OA. Compared to hips from European Caucasians, American Caucasians, and African Americans, hips from Chinese individuals were less likely to have hip morphology features commonly seen in hip OA[91], which is consistent with a prior study showing that morphological differences associated with hip OA (i.e., femoral head asphericity) were less common in Chinese than Caucasian individuals[92]. For the knee, data from the Osteoarthritis Initiative showed varying mediation effects between sex and incident knee OA for two tibial modes (distinct joint shapes) and one distal femoral mode that reflect the relative angles of the heads to the shafts of the femur and tibia[93]. In a case–control study nested in the Osteoarthritis Initiative, specific baseline morphological features of the proximal tibiofemoral joint T2-weighted MRI (i.e., greater contact area, load-bearing area and posterior stress-bolstering area) were associated

with incident radiographic knee OA, predominantly in the medial compartment[94]. A recent extensive genetic epidemiology review suggests specific genes are linked to both joint shape and OA, including Growth Differentiating Factor 5, SOX9, Parathyroid hormone-like hormone, Collagen type XI, and Astrotactin 2[95].

Injury and surgery

Prior traumatic joint injury and subsequent surgery are potent risk factors for OA. Most evidence for post-traumatic OA exists for the knee. An updated systematic review and meta-analysis found that the odds for knee OA were 4.2 (95%CI 2.2, 8.0) times as high after isolated anterior cruciate ligament (ACL) injury, 6.3 (95%CI 3.8, 10.5) times as high after isolated meniscus injury, and 6.4 (95%CI 4.9, 8.3) times as high for those after combined ACL and meniscus injury compared to the uninjured knee[96]. There is growing evidence that increased risk for post-traumatic OA extends to the patellofemoral joint, in addition to the tibiofemoral joint[97]. In older adults, a recent knee injury is a risk factor for the accelerated development of knee OA[98]. However, there is strong evidence that prior knee injury is not associated with radiographic OA progression[99]. In other joints where idiopathic OA is rare, such as the elbow or ankle, cases of OA are often attributable to prior joint injury[100,101]. However, more high-quality research is needed to further understand post-traumatic OA at other joints.

Evidence regarding surgery alone as a risk factor for knee OA is mixed. Data from observational cohorts suggest that surgery via arthroscopic meniscectomy is a risk factor for incident radiographic knee OA and OA progression[102], particularly in those without a history of knee trauma[103]. In contrast, results from a recent randomized controlled trial found that adults with degenerative meniscal tears who received surgery (i.e., arthroscopic partial meniscectomy) did not have higher risk for developing radiographic OA compared to adults who received no surgery (i.e., exercise therapy only)[104].

Limb length inequality

Previous analyses from the Johnston County Osteoarthritis Project and the Multicenter Osteoarthritis Study demonstrated associations between limb length inequality and prevalent radiographic, incident symptomatic, and progressive radiographic knee OA[3]. For the hip, associations were observed in the Johnston County Osteoarthritis Project, Multicenter Osteoarthritis Study, and Osteoarthritis Initiative between limb length inequality and prevalent[3,105], incident[105,106], and progressive radiographic hip OA[106]. Radiographic OA in the knee and hip may be more common in the shorter limb[3,105].

Muscle strength, mass, and quality

Several recent studies and reviews have examined the role of muscle strength in knee OA. A systematic review and meta-analysis of 27 studies found low quality evidence that adults with medial and/or lateral knee OA had 4.0 (95%CI 2.7, 6.0) times the odds of having knee extensor muscle weakness compared to adults without knee OA, while nine studies indicated that adults with knee OA had 4.1 (95%CI 1.5, 11.3) times the odds of having knee flexor weakness[107]. A meta-analysis of five studies (5700 participants) found that men and women with knee extensor muscle weakness had 1.7 (95%CI 1.2, 2.2) times the odds of developing

knee OA over the next 2.5−14 years[108]. A subsequent meta-analysis of 15 studies (>8000 participants) found that lower knee extension strength was associated with increased risk for worsening knee symptoms and function over the next 1.5−8 years[109]. They did not observe increased risk for structural deterioration. Recent studies continue to show variable associations of thigh strength with the development and progression of knee OA. A series of studies by Culvenor and colleagues observed that knee extensor and flexor weakness was associated incident radiographic OA in women but not men, and with radiographic OA progression in men but not women[110–112]. However, other studies observed that knee extensor weakness was not associated with OA progression in both men and women[99,113]. Further, knee extensor and flexor strength loss was associated with symptomatic progression in women[112]. Poor muscle quality, including increased intramuscular fat, was associated with radiographic OA progression and greater cartilage volume loss[112].

Joint alignment and loads

Static joint alignment, particularly frontal plane knee alignment, is a strong, well-established predictor of knee OA progression[2,3]. Consistent with the syntheses of prior work[2,3], new data regarding the association of static alignment with prevalent or incident knee OA remains mixed. A meta-analysis observed that adults with prevalent knee OA have similar odds of valgus and varus malalignment as adults without OA[107]. However, a more recent population-based longitudinal study in rural China found that varus malalignment was associated with prevalent medial knee OA and valgus malalignment was associated with prevalent lateral knee OA[114]. Among knees with varus malalignment, increased coronal tibial slope was associated with incident accelerated knee OA in a case–control study[115]. In the patellofemoral joint, patellofemoral malalignment and trochlear morphology were associated with incident patellofemoral osteophytes 1 year after ACL reconstruction; however the effect size was small[116].

Regarding dynamic alignment and knee loading, altered knee joint loading during walking is consistently observed in adults with medial knee OA. A meta-analysis of 10 studies of moderate quality found that adults with medial knee OA had 3.0 (95%CI 1.9, 4.9) times the odds of demonstrating a higher adduction moment while walking compared to adults without knee OA[107].

Occupation and physical activity

Physically demanding occupations are associated with increased risk for OA[2,3]. In a recent systematic review, physically demanding occupations including construction workers, floor layers, brick layers, fishermen, farmers, and service personnel were associated with a higher risk for hip and knee OA[117]. In some occupations, a dose–response relationship existed. For example, farmers who reported over 5 h of work in an animal barn had a higher risk of OA compared to farmers with <5 h[117]. The review also identified occupational tasks associated with risk for developing hip or knee OA, including lifting and carrying, kneeling with or without squatting, climbing, standing, crawling, walking, and higher overall physical load[117].

Participating in physical activity is generally not associated with OA and may even reduce the risk for OA. In one study, adults who participated in moderate levels of pedometer-based physical activity had less risk for knee osteophyte progression compared to those with low level of physical activity[118]. However, risk for OA is elevated for those who participated in certain sports. A systematic review of studies investigating runners found that prevalence of hip and/or knee OA was lower in recreational compared to competitive runners and non-runners[119]. Further, competitive runners had greater odds of OA compared to recreational runners, but the odds were not higher than non-runners. In addition to competitive distance running, another systematic review found that participation in recreational and competitive soccer, competitive weight lifting, and wrestling were associated with knee OA[120]. Taken together, these data suggest a potential U-shape relationship where insufficient physical activity and frequent, highly-intensive physical activity both associated with OA, though further research is needed, particularly for hip OA, which has been less studied.

Other joint-level factors

Multiple recent analyses of data from the Osteoarthritis Initiative have elucidated the role of MRI features in the prediction of OA. T2 relaxation times on MRI (changes in collagen integrity and cartilage water content) were associated with radiographic knee OA at 2 years and total knee replacement at 5 years, suggesting that this measure may be an early biomarker in the diagnosis and prediction of OA[121]. Certain characteristics of meniscal shape predicted knee OA progression at 24 months, including a larger meniscal longitudinal diameter, larger meniscal width, and smaller meniscal angle[122]. Infrapatellar fat pad signal intensity alterations were associated with incident radiographic knee OA over 4 years[123], as well as incident knee replacement over 5 years among participants with baseline knee OA[124]. Additionally, higher signal intensity of the infrapatellar fat pad was related to progression of knee OA on MRI over 2 years, as noted by greater loss of tibial cartilage volume, larger increases in tibiofemoral cartilage defects, and increases in tibiofemoral bone marrow lesions[125]. Periarticular bone measures (i.e., higher medial:lateral ratio, greater bone volume fracture, trabecular thickness and number, lower trabecular spacing) were strongly related to progression of radiographic medial tibiofemoral joint space narrowing over 12 months[126].

Phenotypes

There is great interest in understanding and defining OA phenotypes that involve combinations of disease characteristics. A major motivation underlying this research is the identification of subgroups of patients who may respond differently to treatment strategies, thereby enhancing the personalization and effectiveness of care. Prior reviews summarized the literature on OA phenotypes in depth[127,128]. These studies included clinical, laboratory and imaging phenotypes and varied considerably in the variables included[128]. One systematic review found evidence that pain sensitization, psychological distress, radiographic severity, body mass index, muscle strength, inflammation and comorbidities are associated with clinically distinct phenotypes; gender, obesity, metabolic abnormalities, pattern of cartilage damage, and inflammation may be important factors with respect to structural phenotypes[128]. Another review identified six main phenotypes: 1) chronic pain

in which central mechanisms are prominent; 2) inflammatory; 3) metabolic syndrome; 4) bone and cartilage meta-bolism; (5) mechanical overload/varus malalignment; 6) minimal joint disease[127]; a recent study classified 84% of Osteoarthritis Initiative participants based on these subgroups, with 20% having overlap across subgroups[129]. Because approaches to studying OA phenotypes have varied markedly, an international group of researchers recently led an effort to develop consensus-based definitions and recommendations that create a common framework for conducting and reporting OA phenotype research[130].

Conclusion

Studies across the world have continued to illustrate the high prevalence and negative impacts of OA, with a disproportionate burden among some racial/ethnic groups and individuals with lower socioeconomic status. The most established modifiable person-level risk factor for OA is clearly obesity, highlighting the importance of research, clinical, and public health efforts aimed at successful weight loss and weight maintenance interventions. At the joint-level, the clearest modifiable risk factor is injury. This supports the need for continuing efforts to both reduce injury risk, particularly sport-related ACL tears, and understand the pathway from injury to OA in order to develop interventions that can disrupt this trajectory. Gaps remain in our understanding of OA epidemiology. There are limited data on the prevalence and incidence of spine OA, and varying OA definitions (particularly for the hand) create challenges when comparing across cohorts. The role of some potential risk factors (e.g., specific diets, some vitamins, blood pressure, joint surgery, muscle strength, static joint alignment) is still unclear, and additional rigorous studies are still needed. Finally, there continues to be recognition and study of the heterogenous nature of OA. This calls for more complex study designs and analyses that consider interrelationships among multiple risk factors, as well as continued exploration of phenotypic definitions that help to define patterns of OA.

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Table I

Results of recent (2017-present) cohort studies of the prevalence and incidence of OA

Joint(s)	Cohort/Data Source	Country	Age Group	OA Definition(s)	Findings
Any Joint					
	EPISER-2016	Spain	≥50 years	Screening questions based on ACR clinical criteria – hand, hip, knee or spine OA	• Weighted prevalence of self-reported OA: 29.3% (weights based on probability of selection in each sampling stage)
	Clinical Practice Research Datalink	United Kingdom	≥20 years	General practitioner diagnosis of OA from electronic medical records	• Age- and sex-standardized: 6.8 cases of OA per 1000 person years, prevalence of OA: 10.7%
	Clinical Practice Research Datalink	United Kingdom	≥45 years	General practitioner diagnosis of OA from electronic medical records	• Annual age- and sex-adjusted rate for clinical OA: 29.2 per 1000 person years in 1992, 40.5 (95% CI 40.3, 40.7) per 1000 person years in 2013
Knee					
	Korean National Health and Nutrition Examination Survey	Korea	≥50 years	KL Grade ≥2	• Weighted prevalence of radiographic knee OA: 35.1% (weights from sampling and response rates and age/sex proportions of 2005 Korean National Census Registry)
	Chingford Study (Women)	United Kingdom	45–64 years	Incident typical OA: KL 0 to 1, 0 to 2, 1 to 2 Incident accelerated OA: KL 0 to 3	• Cumulative 5-year incidence of typical knee OA: 17.6% • Cumulative 5-year incidence of accelerated knee OA: 3.7%
	EPISER-2016	Spain	≥40 years	ACR clinical and radiological criteria	• Weighted prevalence of symptomatic knee OA: 13.8% (weights based on probability of selection in each sampling stage)
	Clinical Assessment Study of the Knee, Clinical Assessment Study of the Hand, and Clinical Assessment Study of the Foot	United Kingdom	≥50 years	Radiographic evidence plus self-reported pain in the past 4 weeks	• Weighted prevalence of radiographic, symptomatic knee OA: 17.4% (weights accounted for initial selective non-response, age, gender, and practice location)
Hip					
	EPISER-2016	Spain	≥40 years	ACR clinical and radiological criteria	• Weighted prevalence of symptomatic hip OA: 5.1% (weights based on probability of selection in each sampling stage)
	Research on Osteoarthritis/ osteoporosis Against Disability	Japan	≥23 years	KL Grade ≥2	• Incidence rate of radiographic hip OA: 5.6 per 1,000 person years for men and 8.4 per 1,000 person years in women

Osteoarthritis Cartilage. Author manuscript; available in PMC 2023 December 21.

Joint(s)	Cohort/Data Source	Country	Age Group	OA Definition(s)	Findings
Hand					
	Clinical Assessment Study of the Knee, Clinical Assessment Study of the Hand, and Clinical Assessment Study of the Foot	United Kingdom	≥50 years	Radiographic evidence plus self-reported pain in the past 4 weeks	• Weighted -prevalence of radiographic, symptomatic hand OA: 22.4% (weights accounted for initial selective non-response, age, gender, and practice location)
	EPISER-2016	Spain	≥ 40 years	ACR clinical criteria	• Weighted prevalence of symptomatic hand OA: 7.7% (weights based on probability of selection in each sampling stage)
	Johnston County Osteoarthritis Study	United States	≥ 45 years	KL Grade ≥2 in at least one hand joint	• Incidence of radiographic hand OA (average 12-year period): 60.5% • Incidence of symptomatic hand OA (average 12-year period): 12.9%
	Johnston County Osteoarthritis Study	United States	≥ 45 years	KL grade ≥2 in at least three total joints in each hand (excluding metacarpophalangeal (joints) and at least one affected distal interphalangeal joint plus self-reported pain, aching or stiffness on most days	• Lifetime risk of symptomatic hand OA: 39.8% (sampling weights applied based on selection probability, nonresponse adjustments, and post-stratification adjustment)
Foot and Ankle					
	Clinical Assessment Study of the Foot	United Kingdom	≥ 50 years	KL Grade ≥2 plus pain in the same ankle	• Weighted radiographic, symptomatic ankle OA: 3.4% (weights accounted for initial selective non-response)
	Clinical Assessment Study of the Knee, Clinical Assessment Study of the Hand, and Clinical Assessment Study of the Foot	United Kingdom	≥50 years	Radiographic evidence plus self-reported pain in the past 4 weeks	• Weighted prevalence of radiographic, symptomatic foot OA: 16.5% (weights accounted for initial selective non-response, age, gender, and practice location)
	Clinical Practice Research Datalink	United Kingdom	≥20 years	General practitioner diagnosis of OA from electronic medical records	• Age- and sex-standardized Incidence of ankle and foot OA: 0.2 per 1,000 person years
	Johnston County Osteoarthritis Project	United States	≥50 years	Score of two or more for osteophytes or joint space narrowing in at least one of five joint sites plus foot pain on most days of any month in the past 12 months	• Prevalence of radiographic foot OA: 22.1% • Prevalence of symptomatic foot OA: 5.3%
	Johnston County Osteoarthritis Project	United States	≥55 years	Incident ankle OA: KL Grade ≥1 at follow-up among ankles with baseline KL Grade <1; Progressive ankle OA: ≥1 KL Grade increase at follow-up among ankles with KL Grade ≥one at baseline	• Incidence of radiographic ankle OA at 3.5 years: 28.2% • Progression of radiographic ankle OA at 3.5 years: 4.0%

ACR = American College of Rheumatology; KL= Kellgren Lawrence; OA = osteoarthritis.

KL Grade ≥2 = definite osteophytes and possible joint space narrowing.

ACR Clinical Criteria available here: https://www.rheumatology.org/Practice-Quality/Clinical-Support/Criteria.

Table II

Person- and joint-level factors with evidence for impacting risk for developing OA

Person-Level Factors	Joint-Level Factors
Age	Joint Injury
Sex	Joint malalignment (Mixed evidence)
Race/Ethnicity	Joint Deformity/Abnormal Joint Shape
Socioeconomic Status	Muscle Weakness (Mixed evidence)
Rural Residence	Leg length Inequality
Family History and Genetic Factors	Physically Demanding Occupational Tasks
Obesity	Elite sports
High Blood Pressure (Mixed evidence)	
High Bone Mineral Density	
Metformin Use	