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SYMPOSIUM: FEMOROACETABULAR IMPINGEMENT: CURRENT STATUS OF DIAGNOSIS AND TREATMENT

Systematic Review of the Prevalence of Radiographic Primary Hip Osteoarthritis

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Abstract Hip osteoarthritis is a common cause of musculoskeletal pain in older adults and may result in decreased mobility and quality of life. Although the presentation of hip osteoarthritis varies, surgical management is required when the disease is severe, longstanding, and unresponsive to nonoperative treatments. For stakeholders to plan for the expected increased demand for surgical procedures related to hip osteoarthritis, including arthroplasty, it is important to first understand its prevalence. We conducted a systematic review by searching MEDLINE® and EMBASE to identify recent English language articles reporting on the prevalence of radiographic primary hip osteoarthritis in the general adult population; references including studies and primary studies from previous systematic reviews were also searched. This strategy yielded 23 studies reporting 39 estimates of overall prevalence ranging from 0.9% to 27% with a mean of 8.0% and a standard deviation of 7.0%. Heterogeneity was noted in study populations, eligibility criteria, age and gender distribution, type of radiographs, and method of diagnosis. Although the association between radiographic hip osteoarthritis and the need for eventual surgical management is still unclear, this study supports assertions that hip osteoarthritis is a prevalent condition whose treatment will continue to place important demands on health services.

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Introduction

Osteoarthritis (OA) is the most common rheumatic condition, the most frequent cause of musculoskeletal disability in developed countries, and one of the most common causes of disability resulting in limited activities of daily living in the general adult population [1, 26, 40]. Although OA may affect any joint in the body, it most commonly affects the knee followed closely by the hip [56]. The effects of OA in the lower limbs include reduced mobility and a resulting loss of independence as well as increased levels of healthcare utilization [1, 48]. Hip OA has been identified as one of the most common causes of debilitating pain in the general population [26]. The two main categories of hip OA are primary hip OA (also termed idiopathic) and secondary hip OA (ie, from a known cause) [21]. Although the precise proportion of each category remains controversial, primary hip OA is commonly believed to account for the majority of all hip OA [21].

OA is generally considered a multifactorial disease that involves an interplay of systemic risk factors (eg, age, gender, hormone levels, genetics, and nutrition), intrinsic joint risk factors (eg, anatomic variants, muscle weakness, misalignment, and joint laxity), and extrinsic risk factors (eg, repetitive physical activities and obesity) [49]. Risk factors for progression of hip OA are similar to those associated with its incidence and include systemic factors (metabolic, hormonal, genetic, age, gender), biomechanical factors (mechanical workload), body mass index, acetabular dysplasia, and severity of existing radiographic OA [48].

The precise etiology of primary OA has been a subject of great interest for decades. Although numerous potential mechanisms of injury have been proposed, including the possibility of motion-induced degeneration known as femoroacetabular impingement (FAI) [14, 15, 20, 41, 50], primary hip OA is often considered of unknown etiology. The role of primary prevention of primary hip OA through interventions aimed at FAI, if any, remains unknown.

Like with other forms of OA, hip OA is characterized by destruction of articular cartilage and reactive bone changes and is associated clinically with regional pain, stiffness, and dysfunction [26]. The first symptom of hip OA is often groin pain, which may also be referred to a wide area, including the buttock, lateral or anterior thigh, knee, and occasionally as distally as the ankle [26]. Signs of hip OA on clinical examination include a painful restriction of both active and passive hip movements and antalgic gait [26]. Radiographically, signs of hip OA include decreased joint space, marginal osteophyte formation, subchondral cysts, and subchondral sclerosis [26].

Although the clinical and radiographic severity of hip OA varies considerably from patient to patient and the relationship between the two can be unclear, severe hip OA leading to complete joint destruction will eventually require surgical intervention in the form of THA [13, 26]. Primary hip OA is the most common indication for THA in Western countries and is generally considered a cost-effective intervention [3, 13, 43]. Given the recent rise in obesity and its reported association with THA as well as the aging Western population with its increased expectations regarding physical functioning and mobility in the elderly, it appears reasonable to assume the demand for THA will rise in the coming decades [49].

To help stakeholders prepare for this predicted rise in THA resulting from primary hip OA, it is essential for them to understand the basic epidemiologic features of this disease. The primary objective of this study was therefore (1) to conduct a systematic review of the medical literature on the radiographic prevalence of primary OA of the hip. Secondary objectives of this study were to examine possible associations between various factors and the prevalence of radiographic primary hip OA, including (2) study publication date; (3) study location; (4) gender; (5) age; (6) gender and age; (7) method of diagnosis; and (8) study methodological quality.

Materials and Methods

In November 2007, we searched MEDLINE® and EMBASE using the following search terms and the Ovid interface to uncover previously published studies on the prevalence of primary OA of the hip: (1) "osteoarthritis, hip/"; (2) "prevalence/"; (3) "incidence/"; (4) "risk factors/"; (5) "epidemiology/"; (6) "case-control/"; (7) "cross sectional studies/"; (8) "cohort studies/"; (9) "or/2–8"; (10) 1 and 9; and (11) "limit 10 to (humans and English language and all adult [19 plus years])." For this study we used the term prevalence rather than incidence, defining the former as including all cases of a disease within a time frame and the latter as including only new cases in that time frame.

Search results were screened independently by two reviewers (SD, SG) as relevant, irrelevant, or uncertain according to study eligibility criteria (Table 1), and conflicts were resolved by consensus discussions; full-text articles were obtained for studies deemed relevant or of uncertain relevance for additional full-text screening to determine relevance. References from the included studies were also searched to identify new studies that may have been missed by the computerized search of databases.

This search strategy yielded 295 studies in MEDLINE® and 147 studies in EMBASE. After removing 56 duplicate studies, a total of 386 studies were identified, of which 356 were deemed irrelevant, 16 were deemed relevant [1, 3, 9, 26–31, 36, 43, 44, 47–49, 55], and 14 were of uncertain relevance [4–6, 8, 12, 16, 17, 19, 24, 25, 32, 45, 52, 53]. On further evaluation of the full-text article for the latter group, only two of the 14 were deemed relevant [5, 19]. We excluded studies on full-text screening for a number of reasons (see Appendix 1). An additional five studies [7, 22, 23, 38, 54] were identified from reference lists of included studies. The 23 studies included 13 cross-sectional studies [1, 7, 9, 19, 23, 27–31, 43, 54, 55], six cohort studies [5, 22, 44, 47–49], one case-control study [3], and three previous review articles on this topic [26, 36, 38]. Older estimates of the prevalence of radiographic primary hip OA reported in the latter group were used to supplement those uncovered by our electronic search. Estimates reproduced from previous review articles are identified as such in the summary tables and were not verified through their primary sources. We noted a number of study designs, populations, numbers

Table 1. Search result study inclusion/exclusion criteria

Inclusion criteria	Exclusion criteria
Related to primary hip osteoarthritis	Related only to risk factors
Radiographic diagnosis	Related only to hip arthroplasty
Results reported as prevalence	Related only to self-reported hip pain
General adult population	Not representative of general population
Study published in English	Review article with no new data
Published from 1996 to 2007	

of participants, and types of radiographs used (see Appendix 2).

Search results were combined electronically using Reference Manager® citation management software (Thomson Corp, Carlsbad, CA). The results from primary studies reported in systematic reviews that met our eligibility criteria were incorporated as reported in the secondary study. In such instances, the study source was identified in evidence tables as the systematic review from which it originated.

The following data were extracted independently by two reviewers (SD, SG) from each included study: (1) design; (2) setting; (3) location; (4) participant eligibility criteria; (5) year of publication; (6) sample size; (7) age distribution; (8) gender distribution; (9) method of diagnosis for radiographic primary hip OA; and (10) overall prevalence of radiographic primary hip OA; conflicts were resolved by consensus discussions.

The methodological quality of the studies included in this review was assessed using the Critical Appraisal Guidelines for Prevalence Studies [39]; each of the following criteria scored 1 point if adequate or 0 points if inadequate or uncertain: (1) random sample or whole population; (2) unbiased sampling frame (ie, census data); (3) adequate sample size (ie, greater than 300 subjects); (4) measures were the standard method of diagnosis; (5) outcomes measured by unbiased assessors; (6) adequate response rate (ie, greater than 70%) and refusers described; (7) confidence intervals and subgroup analysis fully reported; and (8) study subjects described. The maximum score was 8 points. Studies with a score of 0 to 4 were considered of lower quality, and studies with a score of 5 to 8 were considered of higher quality. Methodological quality was not assessed for studies identified from previous review articles whose data were reproduced as they appeared in the secondary report.

We calculated the coefficient of variation (CV) to compare prevalence by method of diagnosis. The CV is a statistical measure of variability independent of the units of measurement and is useful for comparing data sets that use different scales or have widely different means [2]. Lower values of the CV reflect lower variability and higher precision of estimates.

Results

The 23 studies in this review provided a total of 39 estimates of overall prevalence of radiographic primary hip OA (Table 2). This included 20 recent estimates from 17 primary studies [1, 3, 5, 7, 9, 19, 22, 23, 27–30, 43, 44, 47, 54, 55] uncovered in the literature search, three [29, 43, 55] of which reported two estimates each, and 19 older estimates summarized in three previous review articles [26, 36, 38] on this topic. These 39 estimates ranged from 0.9% to 27.0% with a mean of 8.0%, a standard deviation of 7.0%, and a median of 5.3%.

Prevalence by Study Publication Date

The 39 estimates uncovered spanned a period of 65 years with the earliest published in 1941 [26] and the most recent published in 2006 [1]. As many estimates have been published since 1990 as were published in the preceding 50 years. In an attempt to examine possible changes in the prevalence of radiographic primary hip OA over time, means were calculated for each decade of publication, ie, 1940s (n = 2), 17.1%; 1950s (n = 2), 19.1%; 1960s (n = 5), 8.3%; 1970s (n = 6), 4.0%; 1980s (n = 4), 6.1%; 1990s (n = 9), 6.4%; and 2000s (n = 11), 8.6%.

Prevalence by Study Location

The majority of study populations were from Europe (n = 25) [1, 3, 5, 7, 9, 26–30, 44, 47–49, 54, 55] with a much small number of studies from North America (n = 6) [19, 23, 26, 37, 38, 43] or Asia (n = 4) [26, 29, 43, 55] and little representation from other geographic regions, including Africa (n = 2) [26], the Caribbean (n = 1) [26], and the Middle East (n = 1) [26]; there were no studies uncovered from South America or India. The mean prevalence in studies from Asia (1.4%) and Africa (2.8%) was much lower than that in North America (7.2%) or Europe (10.1%).

Prevalence by Gender

Overall, the prevalence of radiographic primary hip OA was higher in men with a mean of 8.5%, a standard deviation of 7.5%, and a median of 5.7% compared with a mean of 6.9%, a standard deviation of 5.9%, and a median of 4.6% for women. There were 43 studies reporting estimates of the prevalence of radiographic primary hip OA separately by gender with the majority reporting on both genders (n = 36) [1, 5, 9, 19, 23, 26–30, 37, 38, 43, 44, 47, 54, 55] (Table 3). A smaller number of studies reported estimates only for men (n = 5) [26] or only for women (n = 2) [26, 43], which was likely related to other gender-specific study eligibility criteria (eg, osteoporotic fractures). The mean difference in prevalence between men and women in the 36 studies reporting estimates for both genders was 1.6% with a standard deviation of 3.4% and

Table 2. Overall prevalence of primary radiographic hip osteoarthritis in the general adult population

Author (year)	Country	Sample age (years)	Osteoarthritis diagnosis	Prevalence (%)
Recent estimates from primary studies uncovered through the literature search				
Andrianakos et al. [1] (2006)	Greece	19+	ACR*	0.9
Birrell et al. [3] (2005)	England	45+	JSW < 1.5 mm†	6.4
Burger et al. [5] (1996)	Netherlands	55+	K&L ≥ 2	8.0
Cvijetic et al. [7] (2000)	Croatia	45+	K&L ≥ 2	23.0
Danielsson and Lindberg [9] (1997)	Sweden	40+	JSW‡	1.9
Grubber et al. [19] (1998)	USA	25–74	K&L ≥ 2	2.4
Helmick et al. [22] (2003)	USA	45+	K&L ≥ 2	27.0
Hirsch et al. [23] (1998)	USA	45+	K&L ≥ 2	3.5
Ingvarsson et al. [28] (1999)	Iceland	35+	JSW ≤ 2.5 mm	10.8
Ingvarsson et al. [27] (2000)	Iceland	35+	K&L ≥ 2	9.2
Inoue et al. [29] (2000)	Japan	20–70	K&L ≥ 3	2.4
Inoue et al. [29] (2000)	France	20–79	K&L ≥ 3	5.3
Jacobsen et al. [31] (2004)	Denmark	60+	JSW ≤ 2.0 mm	7.8
Nevitt et al. [43] (2002)	China	60+	JSW ≤ 1.5 mm§	1.0
Nevitt et al. [43] (2002)	USA	60–74	JSW ≤ 1.5 mm§	4.1
Odding et al. [44] (1998)	Netherlands	55+	K&L ≥ 2	15.2
Reijman et al. [47] (2004)	Netherlands	55+	K&L ≥ 2	7.0
Van Saase et al. [54] (1989)‖	Netherlands	45+	K&L ≥ 2	13.7
Yoshimura et al. [55] (1998)	Japan	60–79	Croft ≥ 3	1.0
Yoshimura et al. [55] (1998)	England	60–75	Croft ≥ 3	10.1
Older estimates as reported in previous review articles [26, 36, 37]				
Danielsson (1966)	Sweden	55+	JSW‡	3.4
Danielsson (1984)	Sweden	40+	JSW‡	2.0
Forsberg (1992)	Sweden	45+	JSW¶	4.7
Hoaglund (1973)	Hong Kong	55–64	K&L ≥ 3	1.0
Jörring (1980)	Denmark	25+	JSW ≤ 3.0 mm	4.7
Lawrence (1954)	England	55–64	K&L ≥ 2	19.8
Lawrence (1958)	England	55+	K&L ≥ 2	18.3
Lawrence (1960)	Germany	55+	K&L ≥ 2	12.5
Lawrence (1961)	England	55+	K&L ≥ 2	9.4
Lawrence (1962)	Czechoslovakia	55+	K&L ≥ 2	13.4
Lawrence (1964)	Jamaica	55–64	K&L ≥ 2	2.6
Lawrence (1970)	Switzerland	55+	K&L ≥ 2	11.1
Maurer (1979)	USA	55–74	#	3.2
Muller (1970)	Nigeria	55+	K&L ≥ 2	2.5
Petersen (1941)	Iceland	40+	**	9.1
Pogrund (1982)	Israel	45+	K&L ≥ 2	4.1
Solomon (1976)	South Africa	55+	K&L ≥ 2	3.0
Steffensen (1941)	Iceland	25+	**	25.0
Tepper (1971)	USA	55–74	K&L ≥ 2	3.1

*American College of Rheumatology (ACR) diagnosis of hip OA hip pain and at least two of the following three items: erythrocyte sedimentation rate less than 20 mm/hour, radiographic femoral or acetabular osteophytes, and/or radiographic joint space narrowing; †or K&L ≥ 4; ‡JSW less than 4 mm in adults younger than 70 years of age or JSW less than 3 mm in adults older than 70 years of age or 1-mm difference of JSW between hips; §hip OA if either hip met at least one of the following criteria: (1) a minimum joint space of ≤ 1.5 mm, (2) an osteophyte of Grade 2 or higher in any location and either (a) superolateral joint space narrowing of Grade 2 or higher or (b) superomedial joint space narrowing of Grade 3 or higher, or (3) any three or more radiographic features of OA; ‖although this study was published before 1996, it was not summarized in previous review articles and was therefore included in this category; ¶JSW less than 2 mm or obvious asymmetry with unilateral hips; #radiographic hip OA diagnosed using atlas of osteoarthritis read by three rheumatologists; **the K&L classification system for radiographic hip OA was developed in 1957; OA = osteoarthritis; JSW = joint space width; K&L = Kellgren and Lawrence.

Table 3. Prevalence of radiographic hip osteoarthritis by gender

Author (year)	Country	Age (years)	Osteoarthritis diagnosis	Male	Female
Recent estimates from primary studies uncovered through the literature search					
Andrianakos et al. [1] (2006)	Greece	19+	ACR[*]	0.3	1.5
Burger et al. [5] (1996)	Netherlands	55+	K&L ≥ 2	10	7
Cvijetic et al. [7] (2000)	Croatia	45+	K&L ≥ 2	27.1	NA
Danielsson and Lindberg [9] (1997)	Sweden	40+	JSW[†]	1.7	2.0
Grubber et al. [19] (1998)	USA	25–74	K&L ≥ 2	2.5	2.3
Helmick et al. [22] (2003)	USA	45+	K&L ≥ 2	25.7	26.9
Hirsch et al. [23] (1998)	USA	45+	K&L ≥ 2	4.8	2.8
Ingvarsson et al. [28] (1999)	Iceland	35+	JSW ≤ 2.5 mm	11.8	10.1
Ingvarsson et al. [27] (2000)	Iceland	35+	K&L ≥ 2	9.9	8.6
Inoue et al. [29] (2000)	Japan	20–70	K&L ≥ 3	1.4	3.5
Inoue et al. [29] (2000)	France	20–79	K&L ≥ 3	5.7	2.5
Jacobsen et al. [31] (2004)	Denmark	20–91	JSW ≤ 2.0 mm	7.5	7.9
Nevitt [42] (1996)	USA	65+	JSW ≤ 2.5 mm	NA	20.8
Nevitt et al. [43] (2002)	China	60+	JSW ≤ 1.5 mm[§]	1.1	0.9
Nevitt et al. [43] (2002)	USA	60–74	JSW ≤ 1.5 mm[§]	4.5	3.8
Nevitt et al. [43] (2002)	USA	65+	JSW ≤ 1.5 mm[§]	NA	5.5
Odding et al. [44] (1998)	Netherlands	55+	K&L ≥ 2	14.1	15.9
Reijman et al. [47] (2004)	Netherlands	55+	K&L ≥ 2	7.8	6.4
Van Saase et al. [54] (1989)[‖]	Netherlands	45+	K&L ≥ 2	12.7	14.6
Yoshimura et al. [55] (1998)	Japan	60–79	Croft ≥ 3	0	2.0
Yoshimura et al. [55] (1998)	England	60–75	Croft ≥ 3	11	4.8
Older estimates as reported in previous review articles [26, 36, 37]					
Croft (1990)	England	60–75	JSW ≤ 2 mm	14.4	NA
Danielsson (1966)	Sweden	55+	JSW[†]	3.8	3.4
Danielsson (1984)	Sweden	40+	JSW[†]	2.0	2.2
Forsberg (1992)	Sweden	45+	JSW[¶]	5.0	4.1
Hoaglund (1973)	Hong Kong	55–64	K&L ≥ 3	1.2	0.8
Maurer (1979)	USA	55–74	[#]	3.5	2.8
Lawrence (1954)	England	55–64	K&L ≥ 2	25.0	15.0
Lawrence (1958)	England	55+	K&L ≥ 2	22.0	16.0
Lawrence (1960)	Germany	55+	K&L ≥ 2	16.0	10.0
Lawrence (1961)	England	55+	K&L ≥ 2	12.0	7.0
Lawrence (1961)	USA	55+	K&L ≥ 2	8.0	11.0
Lawrence (1962)	Canada	55+	K&L ≥ 2	7.0	NA
Lawrence (1962)	Czechoslovakia	55+	K&L ≥ 2	17.0	10.0
Lawrence (1963)	USA	55+	K&L ≥ 2	12.0	5.0
Lawrence (1964)	Jamaica	55–64	K&L ≥ 2	1.0	4.4
Lawrence (1970)	Switzerland	55+	K&L ≥ 2	17.0	7.0
Lindberg (1993)	Sweden		JSW[†]	2.8	NA
Muller (1970)	Nigeria	55+	K&L ≥ 2	3.0	2.0
Ota (1965)	Japan	55–64	K&L ≥ 2	4.6	NA
Pogrund (1982)	Israel	45+	K&L ≥ 2	4.2	3.9
Solomon (1976)	South Africa	55+	K&L ≥ 2	3.0	3.0
Tepper (1971)	USA	55–74	K&L ≥ 2	3.2	3.0

[*]American College of Rheumatology (ACR) diagnosis of hip osteoarthritis; hip pain and at least two of the following three items: erythrocyte sedimentation rate less than 20 mm/hour, radiographic femoral or acetabular osteophytes, and/or radiographic joint space narrowing; [†]JSW less than 4 mm in adults younger than 70 years of age or JSW less than 3 mm in adults older than 70 years of age or 1-mm difference of JSW between hips; [§]hip OA if either hip met at least one of the following criteria: (1) a minimum joint space of ≤ 1.5 mm, (2) an osteophyte of Grade 2 or higher in any location and either (a) superolateral joint space narrowing of Grade 2 or higher or (b) superomedial joint space narrowing of Grade 3 or higher, or (3) any three or more radiographic features of OA; [‖]although this study was published before 1996, it was not summarized in previous review articles and was therefore included in this category; [¶]JSW less than 2 mm or obvious asymmetry with unilateral hips; [#]radiographic hip OA diagnosed using atlas of osteoarthritis read by three rheumatologists; OA = osteoarthritis; K&L = Kellgren and Lawrence; JSW = joint space width; NA = not applicable.

median of 0.6%. In these 36 studies, the prevalence of primary radiographic hip OA was higher for men in 24 (66.7%) studies and higher for women in 12 studies (33.3%). From these 36 estimates, the median relative risk of radiographic primary hip OA was 1.2 for men compared with women. However, the 95% confidence interval for this estimate ranged from 0.2 to 2.4 and was therefore not statistically significant.

Prevalence by Age

Study eligibility criteria differed with respect to age of participants with almost half of the studies (n = 18) having a minimum age of younger than 55 years and the remainder (n = 21) having a minimum age threshold of 55 years or older. The mean prevalence reported in the 18 studies in the former group was 8.7% with a standard deviation of 8.3% and a median of 5.0% compared with a mean of 7.5%, a standard deviation of 5.8%, and a median of 7.0% in the latter group.

A small number of studies (n = 9) [1, 9, 23, 28, 30, 44, 54] provided additional information about age beyond simply the minimum required for inclusion and reported prevalence of radiographic primary hip OA in specific age groups (Table 4). Because many of those studies used the same (or similar) 5-year intervals when reporting prevalence for ages 35 to 85+ years, it was possible to examine summary statistics by incremental age group. Among these studies, there was a clear trend toward an increased mean prevalence with advanced age groups: 35 to 39 years (n = 3), 1.6%; 40 to 44 years (n = 6), 0.7%; 45 to 49 years (n = 8), 1.7%; 50 to 54 years (n = 8), 2.0%; 55 to 59 years (n = 9), 3.5%; 60 to 64 years (n = 9), 4.8%; 65 to 69 years (n = 9), 6.4%; 70 to 74 years (n = 9), 8.3%; 75 to 79 years (n = 9), 10.1%; 80 to 84 years (n = 9), 9.9%; and 85+ years (n = 9), 14.0%. The mean prevalence increased in eight of the 10 incremental age groups, decreasing only from the previous age group for ages 40 to 44 years and 80 to 84 years. The mean increase in prevalence for each 5-year interval was 1.2% for the 11 age group intervals from 35 to 39 years to 85+ years.

Prevalence by Gender and Age

When comparing prevalence of radiographic primary hip OA within each age group for men and women, the mean difference was 0.4% with a higher prevalence in women for six of 11 (54.5%) age groups (35 to 39 years, 50 to 54 years, 65 to 69 years, 75 to 79 years, 80 to 84 years, 85+ years) and a higher prevalence in men for five of 11 (45.5%) age groups (40 to 44 years, 45 to 49 years, 55 to 59 years, 60 to 64 years, 70 to 74 years).

A relatively small number of studies (n = 7) [1, 9, 23, 28, 30, 44, 54] reported the prevalence of radiographic primary hip OA by age group separately for each gender. Because many of these studies used the same (or similar) 5-year intervals spanning ages 35 to 85+ years, it was possible to examine summary statistics by incremental age group.

In men, there was a clear trend toward an increased mean prevalence with advanced age groups: 35 to 39 years (n = 3), 1.3%; 40 to 44 years (n = 4), 1.7%; 45 to 49 years (n = 6), 2.3%; 50 to 54 years (n = 6), 2.4%; 55 to 59 years (n = 7), 4.9%; 60 to 64 years (n = 7), 7.4%; 65 to 69 years (n = 7), 7.4%; 70 to 74 years (n = 7), 9.3%; 75 to 79 years (n = 7), 9.2%; 80 to 84 years (n = 7), 9.7%; and 85+ years (n = 7), 12.4% (Table 5; Fig. 1). The mean prevalence increased in nine of the 10 incremental age groups, decreasing only by 0.1% for ages 75 to 79 years compared with 70 to 74 years. The mean increase in prevalence for each 5-year interval was 1.1% for the 11 age group intervals from 35 to 39 years to 85+ years.

Table 4. Prevalence (%) of radiographic hip osteoarthritis by age group (both genders)

Author (year)	Age group (years)										
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85+
Andrianakos et al. [1] (2006)	0.1	0.1	0.5	0.8	1.8	2.1	2.4	2.6	3.0	1.8	1.8
Danielsson (1966)*	NA	0.6	0.2	0.2	1.2	1.2	2.4	6.2	6.7	6.8	16.2
Danielsson (1984)*	NA	0.2	0.4	0.6	1.2	1.6	1.8	4.0	5.5	7.4	7.6
Danielsson and Lindberg [9] (1997)	NA	0	0	0.6	0.5	0.5	2.1	3.8	4.6	3.7	9.2
Hirsch et al. [23] (1998)	NA	NA	3.1	3.1	3.3	3.3	5.0	5.0	4.8	4.8	4.8
Ingvarsson et al. [28] (1999)	1.9	0.8	3.9	5.3	8.8	11.5	9.8	18.9	25.2	20.2	26.3
Jacobsen et al. [31] (2004)	2.7	2.7	2.7	2.7	2.7	7.8	7.8	7.8	7.8	7.8	7.8
Odding et al. [44] (1998)	NA	NA	NA	NA	8.2	8.2	16.5	16.5	20.9	20.9	37.3
Van Saase et al. [54] (1989)	NA	NA	2.7	2.3	4.2	7.0	9.4	10.2	12.6	15.4	15.4

*As reported in a previous review article [26]; NA = not applicable.

Table 5. Prevalence (%) of radiographic hip osteoarthritis by age group in men

Author (year)	Age group (years)										
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85+
Andrianakos et al. [1] (2006)	0.1	0.1	0	0.3	0.5	0.7	0.5	1.2	0.6	0.6	0.6
Danielsson and Lindberg [9] (1997)	NA	0	0	0.5	0	0.6	1.9	4.4	4.4	1.8	8.9
Hirsch et al. [23] (1998)	NA	NA	3.7	3.7	4.7	4.7	7.3	7.3	6.3	6.3	6.3
Ingvarsson et al. [28] (1999)	0	2.6	3.3	3.7	7.5	16.7	9.9	22.3	19.3	27.3	20.8
Jacobsen et al. [31] (2004)	3.9	3.9	3.9	3.9	3.9	7.5	7.5	7.5	7.5	7.5	7.5
Odding et al. [44] (1998)	NA	NA	NA	NA	11.4	11.4	14.2	14.2	17.1	17.1	35.3
Van Saase et al. [54] (1989)	NA	NA	3.1	2.2	6.2	10.4	10.4	8.3	9.4	7.4	7.4

NA = not applicable.

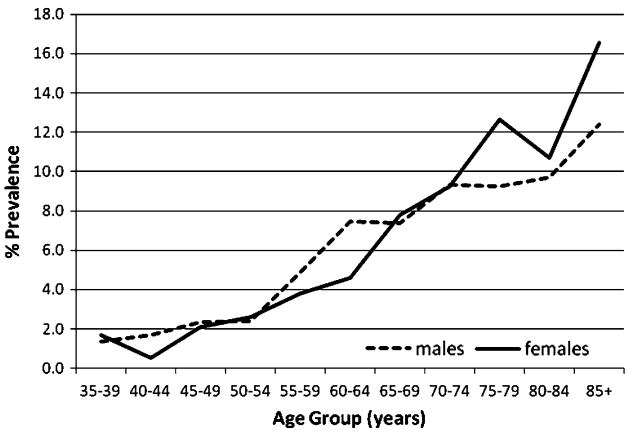

Fig. 1 A graph shows the prevalence of radiographic primary hip osteoarthritis by age group and gender.

In women, there was also a clear trend toward an increased mean prevalence with advanced age groups: 35 to 39 years (n = 3), 1.7%; 40 to 44 years (n = 4), 0.5%; 45 to 49 years (n = 6), 2.1%; 50 to 54 years (n = 6), 2.6%; 55 to 59 years (n = 7), 3.8%; 60 to 64 years (n = 7), 4.6%; 65 to 69 years (n = 7), 7.8%; 70 to 74 years (n = 7), 9.2%; 75 to 79 years (n = 7), 12.7%; 80 to 84 years (n = 7), 10.7%; and 85+ years (n = 7), 16.5% (Table 6; Fig. 1). The mean prevalence increased in eight of the 10 incremental age groups, decreasing only by 1.1% from ages 35 to 39 years to 40 to 44 years and 2.0% for ages 80 to 84 years to 75 to 79 years. The mean increase in prevalence for each 5-year interval was 1.5% for the 11 age group intervals from 35 to 39 years to 85+ years.

Prevalence by Method of Diagnosis

The mean prevalence was higher with K&L (9.5%) than JSW (4.7%) and other methods (8.2%); the standard deviation was highest with other methods (9.1%) than K&L (7.4%) and JSW (3.0%). The most common method used to diagnose overall prevalence of radiographic primary hip OA was that of Kellgren and Lawrence (K&L) (n = 23) [5, 19, 23, 26, 27, 29, 33, 37, 38, 43, 44, 47–49, 54] followed by minimum joint space width (JSW) (n = 10) [3, 9, 26, 28, 30, 43, 49] and other classification schemes such as the Croft index (n = 2) [55], the American College of Rheumatology criteria (n = 1) [1], the Atlas of Osteoarthritis criteria (n = 1) [38], and unspecified methods (n = 2) [26]. The CV for the K&L method of diagnosis was 97.4% for K&L Grade $\geq$ 2 and 73.1% for K&L $\geq$ 3; the Croft $\geq$ 3 method of diagnosis had a CV of 113.6%. For JSW, the CV was 77.8%, 47.1%, 18.2%, and

Table 6. Prevalence (%) of radiographic hip osteoarthritis by age group in women

Author (year)	Age group (years)										
	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85+
Andrianakos et al. [1] (2006)	0.1	0.1	1.1	1.1	3.2	3.5	4.1	3.9	4.3	2.8	2.8
Danielsson and Lindberg [9] (1997)	NA	0	0	0.7	0.9	0.4	2.2	3.4	4.7	4.9	9.3
Hirsch et al. [23] (1998)	NA	NA	2.7	2.7	2.5	2.5	3.5	3.5	3.9	3.9	3.9
Ingvarsson et al. [28] (1999)	2.9	0	4.2	6.7	9.8	8.2	9.6	16.0	30.0	13.9	35.7
Jacobsen et al. [31] (2004)	2.0	2.0	2.0	2.0	2.0	7.9	7.9	7.9	7.9	7.9	7.9
Odding et al. [44] (1998)	NA	NA	NA	NA	5.9	5.9	18.4	18.4	23.3	23.3	38
Van Saase et al. [54] (1989)	NA	NA	2.7	2.4	2.2	3.8	8.8	11.5	14.5	18.2	18.2

NA = not applicable.

Table 7. Prevalence (%) of radiographic hip osteoarthritis by K&L scale

Author (year)	K&L ≥ 2	K&L ≥ 3	K&L ≥ 4
Birrell et al. [3] (2005)	56.0*		6.4†
Burger et al. [5] (1996)	8.0		
Cvijetic et al. [7] (2000)	27.1		
Grubber et al. [19] (1998)	2.4		
Helmick et al. [22] (2003)	27.0		
Hirsch et al. [23] (1998)	3.5		
Hoaglund (1973)‡		1.0	
Ingvarsson et al. [27] (2000)	9.2		
Inoue et al. [29] (2000)		2.4	
Inoue et al. [29] (2000)		5.3	
Lawrence (1954)‡	19.8	5.9	
Lawrence (1958)‡	18.3	10.1	
Lawrence (1960)‡	12.5	5.4	
Lawrence (1961)‡	9.4	2.0	
Lawrence (1962)‡	13.4	2.5	
Lawrence (1964)‡	2.6	2.0	
Lawrence (1970)‡	11.1	5.2	
Muller (1970)‡	2.5	1.5	
Odding et al. [44] (1998)	15.2	4.7	
Pogrund (1982)‡	4.1		
Reijman et al. [47] (2004)	7.0	1.4	
Solomon (1976)‡	3.0	0.3	
Tepper (1971)‡	3.2		
Van Saase et al. [54] (1989)	13.7	3.0	

*Or JSW less than 2.5 mm; †or JSW less than 1.5 mm; ‡as reported in previous review articles [26, 36, 37]; K&L = Kellgren and Lawrence; JSW = joint space width.

44.1% for the ≤ 1.5 mm, ≤ 2 mm, ≤ 2.5 mm, and ≤ 3 mm operational definitions, respectively.

Although the majority of studies used the K&L method of diagnosis for radiographic primary hip OA, different criteria were applied to determine whether a patient had OA according to that method (Table 7). Of the 24 studies that reported results using K&L, 21 reported results for K&L Grade ≥ 2 [3, 5, 7, 10, 19, 22, 23, 26, 27, 44, 47, 54], 15 reported results for K&L ≥ 3 [10, 26, 29, 44, 47, 54], and one reported results for K&L ≥ 4 [3]; this total exceeds 24 because 12 studies reported results for both K&L ≥ 2 and K&L ≥ 3, whereas one reported results for both K&L ≥ 2 and K&L ≥ 4. As expected, the mean prevalence decreased when using stricter methods of diagnosis from 12.8% for K&L ≥ 2 to 3.5% for K&L ≥ 3; the prevalence for the only study reporting on K&L ≥ 4 was 6.4%.

Different criteria were also used when determining whether a patient had OA according to minimum JSW from 1.5 mm or less to 3 mm or less (Table 8). A trend was noted with an increased mean prevalence as the minimum JSW required to define OA was increased with the exception of the last category: ≤ 1.5 mm (n = 3), 2.2%; ≤ 2 mm (n = 3), 5.4%; ≤ 2.5 mm (n = 3), 9.4%; and ≤ 3 mm (n = 4), 4.7%.

Prevalence by Study Methodological Quality

There was only a weak correlation (Spearman's ρ = 0.31) between overall prevalence and methodological quality score. The methodological quality score for the 19

Table 8. Prevalence (%) of radiographic hip osteoarthritis by JSW

Author (year)	JSW ≤ 1.5 mm	JSW ≤ 2.0 mm	JSW ≤ 2.5 mm	JSW ≤ 3.0 mm
Danielsson and Lindberg [9] (1997)				1.9*
Danielsson (1966)†				3.4*
Danielsson (1984)†				2.0*
Forsberg (1992)†		4.7‡		
Ingvarsson et al. [28] (1999)			10.8	
Ingvarsson et al. [27] (2000)			10.0	
Jacobsen et al. [31] (2004)		7.8		
Jörring (1980)†				4.7
Nevitt et al. [43] (2002)	1.0			
China cohort				
Nevitt et al. [43] (2002)	4.1			
USA cohort				
Reijman et al. [47] (2004)	1.4	3.0	7.5	

*JSW less than 3 mm in adults older than 70 years of age, or JSW less than 4 mm in adults younger than 70 years of age, or greater than 1-mm difference of JSW between hips; †as reported in previous review articles [26, 36, 37]; ‡or obvious asymmetry with unilateral hips; JSW = joint space width.

Table 9. Prevalence of radiographic hip osteoarthritis by study methodological quality

Author (year)	Random sample	Sampling frame	Sample size	Method of diagnosis	Blinded assessors	Response rate	Full results	Study subjects	Total
Andrianakos et al. [1] (2006)	1	0	1	0	0	1	1	1	5
Birrell et al. [3] (2005)	0	0	1	1	1	0	1	1	5
Burger et al. [5] (1996)	1	0	1	1	1	0	0	1	5
Cvijetic et al. [7] (2000)	1	1	1	1	1	0	1	1	7
Danielsson and Lindberg [9] (1997)	0	0	1	1	0	1	0	0	3
Grubber et al. [19](1998)	1	1	1	1	0	0	1	1	6
Hirsch et al. [23] (1998)	0	0	1	1	1	1	1	0	5
Ingvarsson et al. [28] (1999)	1	0	1	1	0	1	0	0	4
Ingvarsson et al. [27] (2000)	1	0	1	1	0	1	0	0	4
Inoue et al. [29] (2000)	1	0	1	1	0	1	0	0	4
France cohort									
Inoue et al. [29] (2000)	1	0	1	1	0	1	0	0	4
Japan cohort									
Jacobsen et al. [31] (2004)	1	1	1	1	0	0	0	1	5
Nevitt et al. [43] (2002)	1	0	1	1	0	1	0	1	5
China cohort									
Nevitt et al. [43] (2002)	1	0	1	1	0	1	0	1	5
USA cohort									
Odding et al. [44] (1998)	1	0	1	1	0	1	1	1	6
Reijman et al. [47] (2004)	1	0	1	1	1	0	1	0	5
Van Saase et al. [54] (1989)	1	0	1	1	1	0	1	0	5
Yoshimura et al. [55] (1998)	1	0	1	1	0	1	1	0	5
England cohort									
Yoshimura et al. [55] (1998)	1	0	1	1	0	1	1	0	5
Japan cohort									

estimates of the prevalence of radiographic hip OA reported in the 16 primary studies [1, 3, 5, 7, 9, 19, 23, 27–30, 43, 44, 47, 54, 55] (three of which [29, 43, 55] reported on two separate cohorts each) uncovered in this review had a mean of 4.9 with a standard deviation of 0.9, a median of 5.0, and a range from 3.0 to 7.0 (Table 9). Only five of these estimates from four studies [9, 27–29] were considered of lower methodological quality (ie, score of 4 or lower), whereas 14 estimates from 12 studies [1, 3, 5, 7, 19, 23, 30, 43, 44, 47, 54, 55] were considered of higher methodological quality (ie, score of 5 or higher). The mean prevalence reported in studies of lower methodological quality was 5.9% with a standard deviation of 4.0% and a median of 5.3% compared with a mean of 7.4%, a standard deviation of 6.4%, and a median of 6.7% for studies of higher methodological quality.

Discussion

This review was undertaken primarily to provide a summary of previously reported estimates of the radiographic prevalence of primary hip OA in the general adult population that could be referenced in future research on this topic. This goal was accomplished by summarizing estimates from previous review articles and conducting a literature search to uncover additional studies published in the past decade.

This dual strategy (primary and secondary sources) allowed us to provide a comprehensive review of the topic with estimates spanning several decades. However, we acknowledge including such estimates without verifying the primary studies of review articles may have introduced bias in those estimates if they were incorrectly reproduced in the previous review articles referenced. Although our systematic review focused on summarizing estimates of prevalence according to various factors of interest (eg, gender, age), we were unable to establish any causal relationships between those factors and radiographic primary hip OA. We were also unable to examine the effects of possible confounders (eg, obesity, physical activity) not discussed in previous estimates of prevalence and cannot determine potential interactions between various suspected risk factors. Additional observational and experimental studies attempting to

isolate the effects of specific risk factors on the prevalence of radiographic primary hip OA would be required to confirm the associations noted in this review before instituting measures aimed at primary prevention.

We also focused exclusively on radiographic primary hip OA to minimize variations resulting from self-reported symptoms or physician diagnosis without imaging. However, even with these eligibility criteria in place, a lack of consensus was noted when defining hip OA in the studies reviewed. For instance, the mean prevalence was higher in studies using K&L than those using minimum JSW, the two most commonly reported methods of radiographic diagnosis. Differences were also noted based on the exact definition of hip OA within each method of diagnosis with an inverse association between prevalence and severity. This makes it essential for investigators to report not only the method of radiographic diagnosis when discussing estimates of the prevalence of hip OA, but also the precise definition used (ie, K&L grade, minimum threshold for JSW).

The overall estimates of radiographic primary hip OA uncovered in this review varied 30-fold from the lowest (0.9%) to highest (27.0%), even when examining ostensibly similar general adult populations. The mean of the estimates (8.0%) was substantially higher than the median (5.3%), indicating the data were positively skewed as a result of a few relatively high estimates. This variability underscores the inherent weakness of relying on any single estimate of prevalence when making health services decisions about hip OA and should encourage stakeholders to instead examine a range of studies that together may provide a more accurate representation of the epidemiologic characteristics of this condition.

The majority of estimates of radiographic primary hip OA uncovered in our review had been published in the past decade, perhaps as a reflection of the growing interest in this topic or as a result of the relative scarcity of large, population-based epidemiologic studies in earlier decades. Although an increase in hip OA over time has been theorized given that an aging population, at least in developed countries, is placing increasing demands on its weightbearing joints as a result of obesity and physical activity, we observed no such trends. This may have been the result of the paucity of data in the 1940s and 1950s with estimates from only two studies in each decade providing means twice as high as those reported in subsequent decades. However, by focusing on recent decades for which a greater number of estimates is available, the mean prevalence did in fact rise consistently from 4.0% in the 1970s to 8.6% in the 2000s. Ascribing meaning to such trends is quite challenging as a result of underlying study heterogeneity both over time and within each decade. Although an association between obesity and hip OA has been suggested [1], other studies refuted these findings [30, 49]. This may suggest the association, if any, is weak or may simply take more time to become apparent in the literature given the relatively recent rise in obesity and time lag required for publishing the results of prospective studies.

Although it has been proposed hip that OA is less frequent in Asians [10, 43] and the mean prevalence was in fact lower in the few studies from Asia compared with those from North America or Europe, no firm conclusions can be drawn given the small number of estimates available. If a lower prevalence of hip OA does in fact exist in Asia, it may be partially attributable to lifestyle factors. It has been postulated, for instance, the frequent kneeling or squatting common to life in Asia may protect against hip OA [34]. Other possibilities suggested for lower hip OA in Asia include a lower rate of acetabular dysplasia in Asians as well as differences in physical activity, obesity, and genetic factors [43]. Limiting the language of publication to English for studies considered in this review may have resulted in fewer studies reporting on nonwhite populations.

Given the growing multicultural nature of North America and Europe, it is increasingly difficult to use the country of origin for a study as a proxy for the race or ethnicity of its participants. To separate the effects of genetic and environmental factors requires studying hip OA in adults of different ethnicities living in a similar area. In the United States, it was reported those of Asian origin had lower rates of hip arthroplasty than whites [10]. Although this may imply potential differences in the prevalence of hip OA related to ethnicity, other factors may also be involved in the decision to proceed to arthroplasty. For example, it was reported that blacks with hip OA in the United States were less likely to view arthroplasty as an effective intervention [18]. Differences in surgical rates may therefore be associated not only with prevalence, but also with socioeconomic factors and expectations about the healthcare system [18].

The mean prevalence of radiographic primary hip OA among the studies found was higher in men than women. However, this finding is not consistent with the literature. In fact, several studies have reported women are at greater risk of developing hip OA [1, 10, 48]. It has been suggested that men have a higher prevalence of hip OA before age 50 years, after which women have a higher prevalence [11]. This was somewhat supported in our study, in which the mean prevalence of radiographic primary hip OA was higher for men in two of three age groups before 50 years (ie, 40–44 years, 45–49 years) but in only three of eight age groups after age 50 years (ie, 55–59 years, 60–64 years, 70–74 years). The higher incidence of hip OA in women after age 50 years may be related to hormonal changes from menopause [1, 10]. Bolstering this hypothesis are findings

from several studies reporting a protective effect for estrogen replacement therapy and hip OA [10].

The mean prevalence of radiographic primary hip OA from studies that included participants with a minimum age of younger than 55 years was slightly higher than those requiring a higher minimum age. Although this finding is at odds with advanced age being an independent risk factor for hip OA [1, 11, 48], a more likely explanation is that the minimum age required for study participation is not indicative of the actual age of enrolled participants. Studies have previously suggested the prevalence of symptomatic hip OA increases substantially after age 50 years in both genders, possibly as a result of changes in chondrocytes, ligaments, musculature, and joint viscoelasticity [1, 26] independent of other postmenopausal hormonal changes seen in women. Our study supports these findings with a gradual rise in mean prevalence with advancing age, becoming more pronounced after age 60 years.

One study reported the validity, reliability, and applicability of seven commonly used methods of radiographic diagnosis for hip OA [46]: (1) K&L; (2) Croft; (3) minimum JSW; (4) JSW according to Resnick and Niwayama [51]; (5) American College of Rheumatology criteria; (6) radiographic hip OA with pain; and (7) radiographic index grade according to Lane et al. [35]. The minimum JSW method of diagnosis had the highest level of intra- and interrater reliability, the highest association between radiographic findings and joint pain, and good applicability compared with the other methods; neither the Croft nor the American College of Rheumatology criteria method had high reliability and validity [46]. It was also reported a minimum JSW of $\leq$ 1.5 mm had a stronger association with hip pain than did the presence of osteophytes (56% versus 34%). Given the mean JSW in normal hips is approximately 4 mm [26], using criteria of minimum JSW of $\leq$ 3.0 mm may introduce more error than using lower thresholds that more easily distinguish hip OA.

The K&L method has previously been criticized for being inconsistent in its interpretation [26] and placing undue emphasis on the presence of osteophytes, which correlate poorly with hip pain [46]. Although the limitations of K&L for hip OA have long been apparent [26], familiarity with this method prolongs its use in epidemiologic studies. Considering that K&L is the most commonly used method of diagnosis for hip OA [46], a greater understanding of its validity and relation to clinical presentation is warranted. Despite these shortcomings, one group of authors has suggested the K&L is appropriate to define hip OA for epidemiologic studies [47].

The type of radiograph used to establish a diagnosis of hip OA should also be considered when reporting prevalence of radiographic hip OA, because many of the epidemiologic studies reviewed were conducted in the general adult population without hip pain and therefore relied on incidental findings of hip OA after colon, pelvic, or abdominal radiographs. It has been suggested that these views may not provide sufficient details to evaluate minor structural changes in the hips [28]. Similarly, it has been claimed the nonweightbearing radiographs used in some of these studies may make joint space narrowing less evident than the preferred weightbearing radiographs [37]; this could particularly impact the minimum JSW method of diagnosis.

Based on the difficulties we encountered when attempting to summarize data from previous studies as a result of their heterogeneous methods, it became apparent that a gold standard should be developed to identify radiographic primary hip OA and that its use should be promoted in future studies to facilitate comparisons of results over time and across different study populations.

Further complicating the issue of the method of diagnosis for hip OA is the uncertain association between radiographic and clinical findings. Structural changes in the hip consistent with OA that may be apparent on radiographs are expected with advanced age and may not necessarily be accompanied by symptoms of the disease [3, 37, 44]. One study examined the association between specific radiographic findings other than those used in the method of diagnosis and the prevalence of hip OA [30]. When defining hip dysplasia according to acetabular depth ratio, femoral head extrusion index, or center-edge angle, the authors found an association between the presence of hip dysplasia and hip OA [30]. Other studies have reported much higher rates of radiographic hip OA than symptomatic hip OA [22, 37, 43]. This suggests symptomatic hip OA confirmed by radiographic findings of hip OA according to an established method of diagnosis may be more relevant clinically than either method alone [40].

Making the association between findings of radiographic hip OA and the need for eventual surgical management through arthroplasty presents an even greater challenge. A prospective cohort of 320,192 male Swedish construction workers was conducted from 1971 to 1992 and reported a total of 1495 THAs during that time [32]. Although the association between obesity and prevalence of radiographic primary hip OA is uncertain, body mass index was strongly associated with the incidence of THA in that study [32]. This suggests obesity impacts the severity and clinical outcome of hip OA rather than the occurrence of this disease [32]. Unfortunately, there was no attempt to examine radiographic findings of hip OA predictive of the need for THA in that study.

The mean prevalence of radiographic primary hip OA from studies of higher methodological quality was slightly superior to that from studies of lower methodological quality. However, these results may have been unduly

influenced by the presence of outliers because the study with the highest methodological quality also had the highest reported prevalence [7]. This suggests the methodological quality of the study plays a minor role in the observed prevalence rates with only a slight trend toward higher quality studies reporting generally higher prevalence rates.

This review uncovered numerous previously published reports of the estimated prevalence of radiographic primary hip OA in the general adult population over the past seven decades. The study methods were heterogeneous, reporting on diverse populations with differing eligibility criteria, various age and gender distributions, assorted methods of diagnosis, and divergent criteria used to satisfy those methods. Predictably, the reported estimates varied considerably among these studies. Nevertheless, it appears radiographic primary hip OA is routinely present in approximately 5% to 10% of the general adult population. Higher estimates of prevalence were generally reported in more recent studies, in studies from North America and Europe, in men, although this difference disappeared when also taking age into account, in studies using the K&L method of diagnosis, in studies with lower thresholds used to define OA, and in studies of lower methodological quality. Stakeholders should understand the various factors that may influence the reported prevalence of radiographic hip OA before planning for the demand in related health services. Future studies reporting on the prevalence of radiographic primary hip OA should endeavor to clearly define their methods and use previously validated methods of diagnosis. Establishing a gold standard for the measurement and reporting of the prevalence of radiographic primary hip OA is needed to facilitate comparisons of results across multiple studies, both past and future.

Appendix 1. Reasons for excluding studies after full-text screening

Study reference	Reason
[32]	Not radiographic diagnosis
[8]	Review article with no new data
[12]	Review article with no new data
[6]	Review article with no new data
[24]	Not related to primary hip OA
[52]	Not related to primary hip OA
[45]	Review article with no new data
[53]	Review article with no new data
[17]	Results not reported as prevalence
[16]	Results not reported as prevalence
[25]	Not radiographic diagnosis
[4]	Review article with no new data

OA = osteoarthritis.

Appendix 2. Study design, population, number of participants, and type of radiographs for the 23 included studies

Study reference	Design	Population	Participants	Radiographs	Comments
[49]	Prospective cohort	Males and females aged 55 years or older	Baseline: n = 6450; followup (mean, 6.6 years); n = 3585	Hip	Related to Rotterdam Study
[1]	Cross-sectional	Adult population aged 19 years or older in urban, suburban, and rural areas	n = 8740	Pelvis	Related to ESORDIG Study
[48]	Prospective cohort	Males and females aged 55 years or older	Baseline: n = 6450; followup (mean, 6.6 years); n = 3585	Hip	Related to Rotterdam Study
[30]	Cross-sectional	Randomly selected white adults	n = 3568	Pelvis	Related to Copenhagen City Heart Study
[31]	Cross-sectional	Participants with musculoskeletal questionnaire score greater than 4/50 (cases) or less than 3/50 (controls)	n = 3807	Hip	Related to Copenhagen City Heart Study
[47]	Prospective cohort	Males and females aged 55 years or older	Baseline: n = 6450; followup (mean, 6.6 years); n = 3585	Pelvis	Related to Rotterdam Study
[43]	Cross-sectional	(1) BOA (males and females aged 60 years or older); results compared to: (2) NHANES I (elderly white men and women); and (3) SOF (females aged 65 years or older)	BOA: n = 1492; NHANES I: n = 314; SOF: n = 7998; Total: n = 9804	Pelvis	Results from three studies

Appendix 2. continued

Study reference	Design	Population	Participants	Radiographs	Comments
[26]	Review article	Summarizes older estimates of prevalence from: Croft, 1990; Danielsson, 1966; Danielsson, 1984; Forsberg, 1992; Hoaglund, 1973; Jörring, 1980; Lawrence, 1954; Lawrence, 1958; Lawrence, 1960; Lawrence, 1961; Lawrence, 1962; Lawrence, 1963; Lawrence, 1964; Lawrence, 1970; Lindberg, 1993; Muller, 1970; Ota, 1965; Petersen, 1941; Pogrund, 1982; Solomon, 1976; Steffensen, 1941; Tepper, 1971			
[27]	Cross-sectional	Patients aged 35 years or older at three hospitals	n = 1501	Colon	Study also reported in 26
[29]	Cross-sectional	(1) Patients aged 20–79 years at one hospital in France; (2) similar study was also conducted at a hospital in Japan	France: n = 401; Japan: n = 782; Total: n = 1183	Intravenous urography	
[28]	Cross-sectional	Patients aged 35 years or older at three hospitals	n = 1517	Colon	Study also reported in 26
[55]	Cross-sectional	(1) Males and females aged 60–75 years in Britain; (2) males and females aged 60–79 years in Japan	Britain: n = 1498; Japan: n = 198; Total: n = 1696	Intravenous urography	
[44]	Prospective cohort	Males and females aged 55 years or older	n = 2895	Hip	Related to Rotterdam Study
[19]	Cross-sectional	General adult population aged 25–74 years	n = 3448	Pelvis	Related to NHANES I
[9]	Cross-sectional	Patients aged 40 years or older in: (1) 1987–1995; (2) 1956–1962 and 1975–1982	1987–1995: n = 4121; 1956–1962 and 1975–1982: n = 7930; Total: n = 12,051	Colon	
[36]	Review article	Provides additional data on prevalence by gender and method of diagnosis for older estimates summarized in 26			
[5]	Prospective cohort	Males and females aged 55 years or older	n = 1211	Pelvis	Related to Rotterdam Study
[3]	Case-control	Population aged 45 years or older: (1) cases had hip pain; (2) controls had no hip pain	Cases: n = 56; Controls: n = 147; Total: n = 203	Pelvis	
[54]	Cross-sectional	General adult population aged 45 years or older	n = 6585	Pelvis	Related to EPOZ Study
[23]	Cross-sectional	Pima Indian males and females aged 45 years or older	n = 755	Pelvis	
[38]	Review article	Summarizes older estimates of prevalence from: Maurer, 1979			Related to NHANES I
[22]	Prospective cohort	Rural black and white adults aged 45 years or older	n = 3200		Related to Johnston County OA Project Study published as abstract only; results as reported in 37
[7]	Cross-sectional	Men and women older than 45 years	n = 610	Hip	Related to ESPSHEP conducted by WHO

BOA = Beijing Osteoarthritis Study; EPOZ = Epidemiologic Prevention Study of Zoetermeer; ESORDIG = Epidemiological Study of Rheumatic Diseases in Greece; ESPSPHEP = Epidemiological Study of Physical, Social, and Psychological Health of Elderly People; NHANES = National Health and Nutrition Examination Survey; SOF = Study of Osteoporotic Fractures; WHO = World Health Organization.

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