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Foot osteoarthritis frequency and associated factors in a community-based cross-sectional study of White and African American adults

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Abstract

Objective.—Few studies have explored foot osteoarthritis (OA) in the general population. The purpose of this study was to determine the frequency of foot OA and identify associated factors in a cross-sectional analysis of a large community-based cohort.

Methods.—Data were from the 2013–2015 study visit of the Johnston County OA Project. Radiographic OA (rOA) of the foot was defined using the La Trobe radiographic atlas (2 osteophytes or joint space narrowing in at least one of five joints). Symptomatic OA (sxAO) of the foot was defined as foot rOA with pain, aching, or stiffness in the same foot. At the foot-level, separate logistic regression models with generalized estimating equations to account for intra-person correlations were performed to examine associations of foot rOA or sxAO with age, body mass index (BMI), sex, race, educational attainment, and previous foot injury.

Results.—Of 864 participants with available data (mean age 71 years, mean BMI 30 kg/m², 68% women, 33% African American, 13% <12 years of schooling), 22% had foot rOA, 20% had foot symptoms, and 5% had foot sxAO. Radiographic, but not symptomatic, foot OA was more

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common in African Americans than Whites. Participants with obesity, compared to normal weight, had over 2 times the odds of rOA and over 5 times the odds of sxOA in adjusted models.

Conclusion.—Foot rOA and foot symptoms were common in the sample, but both conditions simultaneously (i.e., sxOA) occurred infrequently. Notably, obesity was linked with foot sxOA, perhaps implicating metabolic or mechanical influences.

Keywords

osteoarthritis; foot; joint pain; epidemiologic study

Osteoarthritis (OA) is a painful disease and a leading cause of disability (1) that affects an estimated 90 million adults in the United States (2). Although studies have evaluated lower limb OA at the knee and hip, few have focused on foot radiographic OA (rOA). First metatarsophalangeal joint rOA, a common joint site for OA in the foot, ranges from a prevalence of 6.3% in rural African women 40+ years old (3) to 42% in adults 62-94 years old residing in a retirement village in Australia (4). Even less is known regarding the prevalence of foot rOA with symptoms (foot symptomatic OA [sxOA]). Only one cohort study of community-dwelling adults 50+ years old has examined prevalence of foot sxOA: the Clinical Assessment Study of the Foot (CASF) of 5109 adults registered with four general practices in North Staffordshire, United Kingdom. In CASF, only participants reporting foot pain during the last 12 months completed foot radiography (560 participants), and the estimated frequency of sxOA overall was 16.7%, with 7.8% having sxOA of the first metatarsophalangeal joint (6). Older age, female sex, obesity, socioeconomic status, and history of joint injury are commonly associated with OA at the knee and hip, and results from CASF suggest that these factors may also be related to foot sxOA (5,6). No studies have considered whether radiographic and symptomatic foot OA differ by race.

To enhance our understanding of foot OA in populations, we used data from a large community-based bi-racial cohort in which participants completed radiography of the foot, regardless of presence of foot pain, to determine: 1) the frequency of foot rOA and sxOA, and 2) factors potentially associated with foot OA.

MATERIALS AND METHODS

Study Participants.

Participants were from the Johnston County OA Project (JoCoOA), a community-based cohort study of individuals with and without OA (7). Non-institutionalized White and African-American residents aged 45 years or older were recruited from six communities within Johnston County, North Carolina. Because the parent study was designed to examine racial differences in OA development and progression longitudinally, African-Americans were oversampled to allow for such comparisons (approximately one-third of the sample). For the present study, data were obtained from individuals who attended the 2013-2015 study visit of the JoCoOA. At this study visit, all participants were at least 55 years of age. This study was approved by the Institutional Review Boards of the University of North Carolina School at Chapel Hill and the Centers for Disease Control and Prevention. All participants provided written informed consent prior to data collection.

Foot Osteoarthritis and Symptoms.

Standardized weight-bearing anteroposterior and lateral radiographic images of the foot were obtained. Based on the La Trobe radiographic atlas (4,8), osteophytes and joint space narrowing were graded by an expert musculoskeletal radiologist (JBR) for the 1st metatarsophalangeal joint, 1st & 2nd cuneo-metatarsal joints, navicular-1st cuneiform joint, and talo-navicular joint. Foot radiographic OA (rOA) was defined as a score of 2 or more for osteophytes or joint space narrowing in at least one of the 5 joint sites. Presence of general foot symptoms was assessed by an affirmative response to the question: “On most days of any one month in the last 12 months did you have pain, aching or stiffness in your [left/right] foot?” Symptomatic OA (sxA) was defined as foot rOA and general foot symptoms in the same foot.

Demographic and Clinical Characteristics.

Because race, age, sex, BMI, history of injury, and socioeconomic status (e.g., education) are key factors associated with OA (9), these variables were selected as covariates in analyses. Race, age, sex, and educational attainment were collected via self-report, with race (African-American/White), sex (men/women), and education (<12 vs. 12+ years of schooling) defined as dichotomous variables. For these analyses, age was a continuous variable. Height was measured using a calibrated stadiometer, and weight was measured using a balance-beam scale. Both measures were taken without shoes. Body mass index (BMI) was calculated as weight in kg/(height in m)². BMI was categorized as obese (30+ kg/m²), overweight (25-<30 kg/m²), and normal weight (<25 kg/m²) for analyses. History of foot injury was obtained via questionnaire consisting of two questions: “Has a doctor ever told you that you broke or fractured your [right/left] foot?” and “Other than a fracture, have you injured your [right/left] foot enough to require a cane, cast, or crutch for two weeks or longer?” History of foot injury was defined as an affirmative response to at least one of these questions and was determined separately for each foot.

Analysis.

Means and standard deviations for continuous variables, and frequencies and percentages for categorical variables, were calculated for demographic and clinical characteristics. At the level of the foot (rather than the participant), separate logistic regression models with generalized estimating equations (GEE; to account for intra-person correlations of the two foot [right/left] observations per participant) were performed to examine discrete associations (odds ratios [OR]) of foot rOA or sxA with age, BMI, sex, race, education, and history of foot injury. The presence or absence of foot injury was linked to the same side [right/left] as the foot examined in analyses. Next, multiple logistic regression models with GEE were performed for foot rOA or sxA outcomes adjusting for the above factors. All statistical analyses were completed using SAS System Software 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Study Participants.

Data were obtained from 908 individuals who attended the 2013-2015 study visit of the JoCoOA. Foot radiographs were not available for 44 participants. These participants without foot radiographs were slightly older with higher BMIs and were more likely to be men, African American, and have foot pain. Of the 864 participants with available data, the mean age was 71 ± 8 years and the mean BMI was 31 ± 6 kg/m². Over 2/3 of participants were women (68%), 33% were African American, 13% had <12 years of education, 22% had foot rOA, 20% had foot symptoms, 5% had sxOA, and 4% reported prior foot injury. Among those with foot rOA, 27% had foot symptoms, compared to 19% without foot rOA. The 864 participants contributed 1,728 feet for foot-specific analyses. One individual was missing foot symptoms data, and thus, 863 participants had available data for the foot sxOA analyses. Two participants were missing foot injury data, and three were missing education data.

Factors Associated with Foot OA.

After adjusting for age, sex, race, education, and injury, compared to those who without obesity, individuals with obesity (BMI ≥ 30) had 2.3 times the odds of having foot rOA (Table 1). Additionally, older age was associated with foot rOA (Table 1), after adjusting for BMI, sex, race, education, and injury. In unadjusted analyses, African Americans had 46% higher odds of having foot rOA compared to Whites (OR =1.46, 95% confidence interval [CI] 1.06, 2.03); this association was slightly attenuated after adjustment for covariates (adjusted OR [aOR]=1.39, 95% CI 0.99, 1.97, Table 1).

Despite small numbers for foot sxOA contributing to imprecise estimates (N=46), similar to the analyses of foot rOA, after adjusting for age, sex, race, education, and injury, individuals with obesity had more than 5 times the odds of having foot sxOA compared to participants who were normal weight (aOR=5.13, 95% CI 1.49, 17.7, Table 2). The odds of foot sxOA by race were not statistically different in either unadjusted or adjusted models. Education of <12 years was associated with foot sxOA in unadjusted models (aOR=2.15, 95% CI 1.04, 4.45); this association was attenuated after adjustment (aOR=1.92, 95% CI 0.86, 4.35, Table 2). The odds of foot sxOA were much higher among those with foot injury than without foot injury, although results were not statistically significant (aOR=3.18, 95% CI 0.76, 13.3) .

DISCUSSION

To our knowledge, this is the first bi-racial community-based study of middle-to-older aged adults to examine the frequency of foot OA. Results of this study suggest that obesity may be linked to foot OA, and that foot rOA may be more common among African Americans than Whites.

In this study, foot rOA was common in older adults, with 1 out of 5 older adults having foot rOA, which fits within the range of frequencies of foot rOA in older adults (5-43%) reported in previous studies (3,10,11). Foot sxOA was less frequent, affecting 1 out of 20 individuals. These results suggest a lower frequency than previously stated in the literature, with CASF

reporting 12% sxOA at the midfoot (5), 7.8% sxOA at the first metatarsophalangeal joint (6), and 16.7% overall (6). The present study and CASF used different source populations, recruitment approaches, and definitions of foot sxOA, which may have contributed to the differences in the estimates of sxOA occurrence.

Presence of foot symptoms in the present study (20%) corresponds to previous reports. In a population based survey in the Netherlands, 20% of people aged 65 years or older reported non-traumatic foot complaints, the majority of which involved pain (12). A population-based study from Australia reported that 17% of all adults had foot pain (13), and the Framingham Foot Study reported 22% had foot pain on most days (14). The frequency of foot symptoms in this study represents a public health concern, not dissimilar to knee pain (regardless of knee OA status), as anatomical pain often indicates an underlying musculoskeletal condition that interferes with daily activities. Thus, further work is necessary to evaluate the impact of foot symptoms upon mobility and other physical functioning in the community. Even after adjusting for age, obesity, smoking, and symptoms of depression, the Framingham Foot Study found that men with foot pain had twice the odds of having limited mobility (aOR = 2.0, 95% CI 1.14, 3.50) and women with foot pain had nearly 60% greater odds of having mobility limitations (aOR=1.59, 95% CI 1.03, 2.46) (14).

Similar to the knee (9) and ankle (15), the present study showed that obesity was linked to OA at the foot, and our results are consistent with findings from CASF that demonstrated an association between sxOA of the midfoot and obesity (5). The present analysis does not suggest the direction of the obesity-foot OA association, but longitudinal analyses could advance the understanding of obesity as a mechanical or metabolic factor for foot OA and pain, which ultimately could guide interventions.

Although several studies have reported foot OA frequency, to our knowledge, this is the first study to examine frequency of foot OA in a cohort including African Americans, allowing for comparisons of foot OA by race. Notably, African Americans had 40% higher odds of foot rOA than Whites, even after adjusting for covariates. The lack of racial differences for foot sxOA in our study may be due to the small numbers of persons with foot sxOA, and remains of interest for future studies as sxOA is considered to be a more clinically relevant outcome than rOA.

In adjusted models, older age was associated with foot rOA. Estimates for foot rOA and sxOA were higher, but not statistically significant, for women vs. men and those with foot injury vs. without injury. Education was not associated with foot rOA, but estimates for foot sxOA were higher for those with <12 years vs. 12+years of schooling. Overall, these results were consistent with prior literature, in that foot OA, as seen with knee and hip OA, is more common with older age, female sex, lower educational attainment, and injury history (5,6,9). The anatomical and biomechanical complexity of the foot, with 26 bones and 33 joints, may lead to differences in factors associated with foot OA compared to those observed for large, weight-bearing joints like the knee or hip.

There are several limitations to this study. Because of the cross-sectional design, the direction of associations cannot be determined. Therefore, it is unknown if obesity resulted

in foot OA or if foot OA led to obesity. Longitudinal analyses of the relationship between OA risk factors and foot OA may help in examining directionality of associations, how those associations may change with age, and how demographic and clinical factors relate to progression of foot OA. Additionally, this sample consisted primarily of older adults, so results may not be generalizable to younger adults. Also, JoCoOA participants who were not able to return for the 2013-2015 clinic visit were generally older and in poorer health than those who attended, and thus our sample may not fully represent an older adult population. For these analyses, we defined foot symptoms using a question that did not specify a location within the foot. This approach for defining symptoms was suitable for our purpose of examining foot sxOA in general, but future investigations of sxOA at specific joints of the foot, such as the five joint sites included in the La Trobe Atlas, will require matching the region of symptoms to the specific location of joint pathology. The assessment of foot OA based only on radiographic features of osteophytes and joint space narrowing is a further limitation because it does not capture the multiple tissues involved in OA that may be observed with other imaging techniques.

In conclusion, foot rOA and the presence of pain, aching, or stiffness in the foot were common, occurring in 1 out of 5 older adults. However, foot sxOA was less frequent in this community-based bi-racial cohort than reported by other studies. In addition, obesity increased the odds for foot OA, suggesting that weight may be an important component of strategies for managing foot OA, especially for individuals with sxOA.

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SIGNIFICANCE AND INNOVATIONS

- This is the first large community-based study to examine the frequency of foot OA in a sample that includes African American and White older adults.
- Both radiographic OA and symptoms of the foot are common in older adults.
- Radiographic foot OA may be more common in African Americans than Whites, but there were no differences in symptomatic foot OA by race.
- Obesity is associated with radiographic and symptomatic foot OA. Given the frequency of foot rOA, foot symptoms, and higher BMI in older persons, further work on patterns and inter-relations of these elements is warranted.

Table 1.

Unadjusted and adjusted associations of JoCo participant characteristics with foot radiographic osteoarthritis (odds ratios (OR) and 95% confidence intervals (CI)).

Characteristic	Overall N=864	Foot rOA N=191 (22.1%)	No Foot rOA N=673 (77.9%)	OR* (95% CI)	Adjusted OR** (95% CI)
Age: years, mean (SD)	71.2 (7.6)	72.1 (7.9)	70.9 (7.4)	1.02 (0.99, 1.04)	1.03 (1.01, 1.06)
BMI: 30 kg/m ² , n/N (%)	435/864 (50.3)	118/191 (61.8)	317/673 (47.1)	2.18 (1.31, 3.65)	2.27 (1.34, 3.86)
BMI: 25-<30 kg/m ² , n/N (%)	296/864 (34.3)	52/191 (27.2)	244/673 (36.3)	1.28 (0.73, 2.24)	1.39 (0.78, 2.46)
BMI: <25 kg/m ² , n/N (%)	133/864 (15.4)	21/191 (11.0)	112/673 (16.6)	referent	referent
Women, n/N (%)	589/864 (68.2)	134/191 (70.2)	455/673 (67.6)	1.21 (0.86, 1.70)	1.14 (0.80, 1.62)
Men, n/N (%)	275/864 (31.8)	57/191 (29.8)	218/673 (32.4)	referent	Referent
African American, n/N (%)	289/864 (33.4)	78/191 (40.8)	211/673 (31.4)	1.46 (1.06, 2.03)	1.39 (0.99, 1.97)
White, n/N (%)	575/864 (66.6)	113/191 (59.2)	462/673 (68.6)	referent	Referent
<12 years education, n/N (%)	114/861 (13.2)	31/191 (16.2)	83/670 (12.4)	1.27 (0.83, 1.95)	1.06 (0.68, 1.66)
12+ years education, n/N (%)	747/861 (86.8)	160/191 (83.8)	587/670 (87.6)	referent	referent
Foot injury, n/N (%)	33/862 (3.8)	9/190 (4.7)	24/672 (3.6)	1.34 (0.53, 3.40)	1.55 (0.59, 4.06)
No foot injury, n/N (%)	829/862 (96.2)	181/190 (95.3)	648/672 (96.4)	referent	referent

rOA = radiographic osteoarthritis

* adjusted only for intra-person correlation using generalized estimating equations

** adjusted for intra-person correlation and all other listed covariates

Table 2.

Unadjusted and adjusted associations of JoCo participant characteristics with foot symptomatic osteoarthritis (odds ratios (OR) and 95% confidence intervals (CI)).

Characteristic	Overall N=863	Foot sxOA N=46 (5.3%)	No Foot sxOA N=817 (94.7%)	OR* (95% CI)	Adjusted OR** (95% CI)
Age: years, mean (SD)	71.2 (7.6)	71.0 (7.1)	71.2 (7.6)	1.01 (0.97, 1.05)	1.02 (0.97, 1.07)
Obese, n/N (%)	435/863 (50.4)	34/46 (73.9)	401/817 (49.1)	4.60 (1.40, 15.1)	5.13 (1.49, 17.7)
Overweight, n/N (%)	296/863 (34.3)	9/46 (19.6)	287/817 (35.1)	1.64 (0.44, 6.18)	1.81 (0.44, 7.53)
Normal Weight, n/N (%)	132/863 (15.3)	3/46 (6.5)	129/817 (15.8)	referent	referent
Women, n/N (%)	588/863 (68.1)	35/46 (76.1)	553/817 (67.7)	1.49 (0.72, 3.06)	1.47 (0.66, 3.30)
Men, n/N (%)	275/863 (31.9)	11/46 (23.9)	264/817 (32.3)	referent	referent
African American, n/N (%)	289/863 (33.5)	15/46 (32.6)	274/817 (33.5)	0.97 (0.50, 1.88)	0.76 (0.37, 1.68)
White, n/N (%)	574/863 (66.5)	31/46 (67.4)	543/817 (66.5)	referent	Referent
<12 years education, n/N (%)	114/860 (13.3)	11/46 (23.9)	103/814 (12.7)	2.15 (1.04, 4.45)	1.93 (0.86, 4.35)
12+ years education, n/N (%)	746/860 (86.7)	35/46 (76.1)	711/814 (87.3)	referent	referent
Foot injury, n/N (%)	33/861 (3.8)	4/46 (8.7)	29/815 (3.6)	2.82 (0.72, 11.1)	3.18 (0.76, 13.3)
No foot injury, n/N (%)	828/861 (96.2)	42/46 (91.3)	786/815 (96.4)	referent	referent

sxOA = symptomatic osteoarthritis

* adjusted only for intra-person correlation using generalized estimating equations

** adjusted for intra-person correlation and all other listed covariates