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A cross-sectional analysis of radiographic ankle osteoarthritis frequency and associated factors: The Johnston County Osteoarthritis Project

Shahmeer Lateef, BS[1,2] **[UNC Medical Student]**, **Yvonne M. Golightly, PT, PhD**[1,3,4] **[UNC Assistant Professor of Epidemiology]**, **Jordan B. Renner, MD**[1,5] **[UNC Professor of Radiology and Allied Health Sciences]**, **Joanne M. Jordan, MD, MPH**[1,2,3,6] **[UNC Joseph P. Archie, Jr. Eminent Professor of Medicine, Chief of Division of Rheumatology, Allergy and Immunology, Director of Thurston Arthritis Research Center, Executive Associate Dean of Faculty Affairs and Leadership Development, Adjunct Professor of Epidemiology]**, and **Amanda E. Nelson, MD, MSCR**[1,2] **[UNC Assistant Professor of Medicine]**

[1]Thurston Arthritis Research Center, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[2]University of North Carolina at Chapel Hill School of Medicine

[3]Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[4]Injury Prevention Research Center University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[5]Department of Radiology, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

[6]Department of Orthopaedics, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

Abstract

Objective—As there are no epidemiologic data regarding the frequency of ankle OA in a general population, we sought to explore this disabling condition in a large, well-characterized community-based cohort of older individuals.

Methods—Cross-sectional data, including ankle radiographs, were from the most recent data collection (2013–5) of the Johnston County OA Project. Radiographic ankle OA (rAOA) was defined as a Kellgren-Lawrence Grade (KLG) of ≥ 2 on weight-bearing lateral and mortise radiographs. The presence of pain, aching, or stiffness in the ankles as well as history of ankle injury (limiting ability to walk for at least 2 days) were assessed. Chi-square statistics (categorical variables) and t-tests (continuous variables) were used to compare all participant characteristics by rAOA status. Joint-based logistic regression models with generalized estimating equations were used to examine associations of rAOA and covariates of interest (age, BMI, sex, race, ankle symptoms, and injury history).

RESPONSIBLE AUTHOR, REPRINTS AND CORRESPONDENCE: Amanda E. Nelson MD MSCR, 3300 Thurston Building, CB#7280, Chapel Hill, NC 27599, Phone (919)966-0553; Fax (919)966-1739, aenelson@med.unc.edu.

Results—Of 864 participants with available data, 68% were women, 34% were African American, with a mean age of 72 years and BMI of 31 kg/m^2. Nearly 7% of this sample had rAOA. Increasing age, high BMI, history of ankle injury, and presence of ankle symptoms were all independently associated with greater odds of having rAOA; no significant differences were seen by sex or race.

Conclusions—The frequency of rAOA was higher than estimates generally quoted in the literature. While injury was an important contributor, other factors such as age, BMI, and symptoms, were also significantly associated with rAOA.

INTRODUCTION

Osteoarthritis (OA) is the most common form of arthritis and is a leading cause of disability.(1) Although ankle OA is less commonly seen clinically than hip and knee OA,(2, 3) there are no community-based studies of the epidemiology of ankle OA to substantiate the widely quoted (4–6) 1% frequency of this condition. Most studies in ankle OA are of end-stage clinical populations, (5–7) which have also suggested that the etiology of ankle OA is almost always post-traumatic.(4, 8–10) This is in contrast to hip and knee OA, which are more often considered primary (although injury is an important risk factor); one study estimated that while 1.6% of hip and 9.8% of knee OA were post-traumatic, 79.5% of ankle OA was secondary to trauma.(11) The difference may be attributable at least in part to the unique anatomical and biomechanical characteristics of the ankle compared to hip and knee (e.g. smaller contact area, higher proteoglycan density, lower shear forces).(4, 12) Recently Kraus et al, identified radiographic ankle OA in 15% of individuals with symptomatic knee OA, yet less than 5% reported any prior injury or surgery,(13) suggesting that there may be a greater burden of ankle OA than currently appreciated, and that other risk factors typically associated with OA, such as obesity, may be contributing.

Regardless of cause, ankle OA can be a source of significant morbidity, as patients with end-stage ankle OA have a reduced quality of life and substantial functional limitations, equivalent to those reported by patients with end-stage hip OA, congestive heart failure, and end-stage kidney disease.(5, 9) Additionally, treatments for ankle OA are more limited than those for hip and knee given the poorer outcomes of surgical interventions for end-stage disease.(14)

In addition to the surprising lack of community-based epidemiologic studies of ankle OA, there has been minimal exploration into other potential contributors to this disabling condition. Therefore, in order to better understand characteristics associated with ankle OA, we examined its associations with factors (i.e. body mass index (BMI), sex, race, presence of ankle symptoms, and history of ankle injury) that may identify groups with a higher frequency of ankle OA in a large community-based cohort of older African American and white individuals.

METHODS

We utilized cross-sectional data from the Johnston County OA Project (JoCo OA), an ongoing community-based study of OA and its risk factors in Johnston County, North

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Carolina which has been previously described in detail.(15) The JoCo OA Project is a prospective, longitudinal cohort study in African American and white men and women ages at least 45 years of age, who were residents of 1 of 6 Johnston County townships for at least 1 year and capable of completing the study protocol. The JoCo OA Project has been continuously approved by the Institutional Review Boards of the University of North Carolina at Chapel Hill (92-0583) and the Centers for Disease Control and Prevention (Protocol #1820.0).

Standardized lateral and mortise views of the ankle were obtained in weight-bearing at the most recent data collection of the JoCo OA (2013–15) as described in a recent atlas (16); the tibiotalar joints were graded by an expert musculoskeletal radiologist (JBR) with excellent intra-rater reliability (kappa 0.91).(16) The Kellgren Lawrence grade (KLG) was modified for this purpose such that grade 0 indicated no radiographic findings of OA, grade 1 indicated “minute osteophytes of doubtful clinical significance”; grade 2 included definite osteophytes and mild joint space narrowing; grade 3 reflected the presence of definite osteophytes and moderate joint space narrowing, while grade 4 was the combination of definite osteophytes and severe joint space narrowing.(16) For these analyses, the presence of radiographic ankle OA (specifically tibiotalar OA) was defined as a KLG ≥ 2. We explored associations based on a KLG of 1 or more as well as osteophyte and joint space narrowing grades. Ankle symptoms were considered present based on 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 ankle?” History of ankle injury was self-reported based on an affirmative response to the question, “Have you ever injured your (right/left) ankle badly enough that it limited your ability to walk for at least 2 days?”

Two sets of analyses were conducted: 1) at the person-level to examine the associations of ankle OA and independent variables within participants, and 2) at the joint-level (left ankle, right ankle) for examination of these associations within the same joint. At the person-level, chi-square statistics for categorical variables and t-tests for continuous variables were used to compare all participant characteristics by the presence or absence of ankle OA. At the joint-based level, complete case analyses were conducted using logistic regression models with generalized estimating equations (GEE) to account for intra-person correlations. Separate logistic regression models with GEE were performed to examine the discrete associations of ankle OA with age, BMI, sex, race, ankle symptoms, and history of ankle injury (“unadjusted odds ratios”). Next, a multiple logistic regression model with GEE was conducted adjusting for all other factors (“adjusted odds ratios”). All models were run separately for each ankle OA definition (KLG 2 vs. <2 and KLG 1 vs. < 1).

RESULTS

Data for these analyses were from the third follow-up (T3) of the JoCo OA Project (2013–15). Over 2000 individuals were eligible for participation and were contacted. The main reasons for non-participation in this data collection were: moved away from the study area (n=295), became physically or mentally unable to participate (n=415), or inability to locate or contact (n=267), with other reasons as noted (Figure 1). A total of 908 individuals attended the study clinic visit at T3. Compared to the full cohort’s baseline characteristics, those who participated in T3 were younger at baseline (56 vs. 62 years) and had higher education levels (85% completed high school, vs. 58%), as expected. The proportions by sex, race, and BMI category were similar for participants and non-participants, with about 1/3 men, 1/3 African American, and 2/3 overweight or obese.

Data for radiographic OA, symptoms, and injuries of the ankle, as well as demographic and clinical characteristics, were available for 864 individuals, of whom 68% were women and about a third were African American, with a mean age of 72 years, and mean BMI of 31.0 kg/m^2 (Table 1). The 44 individuals without ankle radiographs were somewhat older and heavier, and were more likely to be male, African American, and symptomatic. Fifty-six of the 864 included participants had radiographic ankle OA defined as a KLG of 2 or more in at least one ankle, for a frequency of 6.5% in this sample. Those with radiographic ankle OA were on average slightly older, heavier, and were less often African American compared with those without ankle OA (Table 1). Those with ankle OA were also more likely to report prior injury and ankle symptoms, particularly involving both ankles.

The distribution of radiographic grades in the sample is shown in Table 2. More than half of the participants had a KLG of 1 in either the left or right ankle. More than 3% of the cohort had a KLG equal to 2 in either the left or right ankle, while less than 1% of the participants had a KLG of either 3 or 4 on their ankle radiographs. About 60% of ankle radiographs had an osteophyte grade of 1 or greater, while only 4% had joint space narrowing graded 1 or more.

Associations between radiographic ankle OA and covariates are shown in Table 3. In models adjusted only for intra-person correlation (between the two ankles of one participant), the odds of ankle OA were increased for older participants (although not statistically significant), those who were obese, and those reporting ankle symptoms or a history of ankle injury. When included in a model simultaneously, all of these covariates were found to be independently and statistically significantly associated with radiographic ankle OA. Individuals age 70 years or over had twice the odds of ankle OA compared to younger individuals. Obese participants had twice the odds of ankle OA compared with non-obese individuals. A history of ankle injury conferred 2 times higher odds of ankle OA, while self-reported ankle symptoms were associated with a 3-fold increase in the odds of ankle OA. No significant differences were seen by sex or race in either model (Table 3).

In an exploratory fashion, we also considered an outcome a KLG of 1 or more, which affected three-quarters (644/864) of participants. Compared with those who had KLG=0 in both ankles, those with KLG of 1 or more were slightly heavier and less often African American or female, and were more likely to report prior ankle injury (12.7 vs. 7.3%) and ankle symptoms (19.3 vs. 10.0%). In adjusted models (Table 4) the association with obesity was similar to the radiographic OA (KLG 2 or more) outcome. However, in contrast to the main analysis, there was no association with age, and significant differences were noted for both sex (women had about ½ the odds of having KLG 1 or more compared to men) and race (African Americans were 25% less likely to have KLG 1 or more). Again noted, while not as strong as for radiographic OA defined by a KLG of 2 or more, were statistically significant associations for ankle injury and ankle symptoms; comparisons are shown graphically in Figure 2.

DISCUSSION

We report a nearly 7% frequency of radiographic ankle OA (defined as a KLG ≥ 2) in this first community-based cohort study of older African American and white men and women. In this cross-sectional study, radiographic ankle OA was associated with older age, obesity, prior injury, and ankle symptoms. The frequency of a KLG ≥ 1 was very high in this sample and showed similar associations, although additional differences were seen by sex and race. There was a very low frequency of more severe changes in this cohort, with only 7 ankles having a KLG ≥ 3.

The risk of OA increases with age, but individuals with post-traumatic OA are often younger than those with primary OA. The association between age and radiographic ankle OA in the present study is consistent with what little information is available in the literature. In a cohort of end-stage ankle OA patients, those with primary OA were older (mean 65 years) compared with the post-traumatic OA group (mean 58 years, p=0.02).(6) Among individuals with symptomatic knee OA, those with any evidence of ankle abnormality by scintigraphy were slightly older than those with normal ankles (65.4 vs. 62.9 years, p=0.20).(13) Finally, in a study of organ donors, the severity of cartilage degeneration was associated with age, although this was more marked for the knee compared with the ankle.(17)

While the association between knee OA and obesity is well established, it is less clear for other sites, particularly the ankle. In a study of 1411 adults visiting a single orthopaedic foot and ankle specialist, the odds of having ankle or foot OA were increased by 50% in overweight/obese versus normal weight individuals, although this association was not statistically significant.(18) Another study of end-stage ankle OA patients in a tertiary care setting found no difference in BMI among those with post-traumatic, secondary, or primary OA.(6) Body habitus was not associated with the severity of ankle cartilage degeneration among organ donors.(17) The symptomatic knee cohort described by Kraus et al was obese on average (BMI 31.3 (6.7) kg/m^2), and compared to those with normal ankles, those with any ankle scintigraphic abnormality were significantly heavier (33.7 vs. 30.2 kg/m^2, p=0.0025).(13)

Our results support the known relationship between injury and OA at the ankle,(4, 6) with a somewhat smaller magnitude. In our cohort, 11% reported any injury, increasing to about 20% among those with radiographic ankle OA, with an adjusted odds ratio of about 2. In the study by Kraus et al, patients with symptomatic knee OA could identify prior ankle injury or surgery only 9% of the time, despite the high prevalence of ankle abnormalities and OA.(13) In contrast, in the clinical studies of end-stage ankle OA, ¾ or more of patients are often categorized as having post-traumatic OA.(6)

We also identified a cross-sectional association between ankle symptoms and the presence of radiographic ankle OA that is again in agreement with prior work,(9, 13) although this aspect is often not considered since the clinical cohorts tend to be of symptomatic end-stage patients and do not employ standard radiographic criteria.

Even though there were no significant differences by sex and race in the main analysis, the odds of having at least one ankle with a KLG ≥ 1 (versus both with KLG=0) were significantly lower among African Americans and women. There are no prior studies of radiographic ankle OA among African Americans, but difference in utilization of total ankle arthroplasty has been reported, with whites 4 times as likely to have this procedure compared to African Americans;(19) it is not known whether this is due to differences in prevalence or to racial disparities in utilization and access to care, as have been well-documented for other joint replacement procedures. Valderrabano et al reported a similar ratio of men and women with posttraumatic OA, although more men than women had primary OA (25 men vs. 11 women).(6) Kraus et al found no difference in the frequency of scintigraphic ankle abnormalities by sex.(13) Among healthy organ donors there was a trend toward delayed cartilage degeneration in women compared to men.(17)

This study has many strengths, including the use of data from a large and well-characterized community-based cohort which was not selected for foot or ankle issues, the inclusion of African American and white men and women, and the use of standardized, weight-bearing ankle radiographs read with high reliability by a single musculoskeletal radiologist with decades of experience. Although we provide the first epidemiologic data on the frequency of ankle OA in the community, our cohort is older (mean age 72 years, range 55–94 years), and our results may not be generalizable to younger populations. Another limitation is the lack of detailed data on the specifics of the ankle injuries, such as type and severity. The current analysis is cross-sectional, restricting our ability to make inferences about causality. However, this cross-sectional approach provides useful insights into the frequency of ankle OA and associated factors that: 1) support more clinical attention for this joint, especially among those with symptoms, prior injury, and obesity, and 2) will inform longitudinal assessments (the next phase of our work with future follow up in this cohort).

CONCLUSION

Ankle OA may be more common than previously thought. A better understanding, including longitudinal studies, of both traumatic and non-traumatic etiologies of ankle OA may allow for more effective preventive measures in at-risk individuals and therapeutic interventions earlier in the disease process for those with ankle OA.

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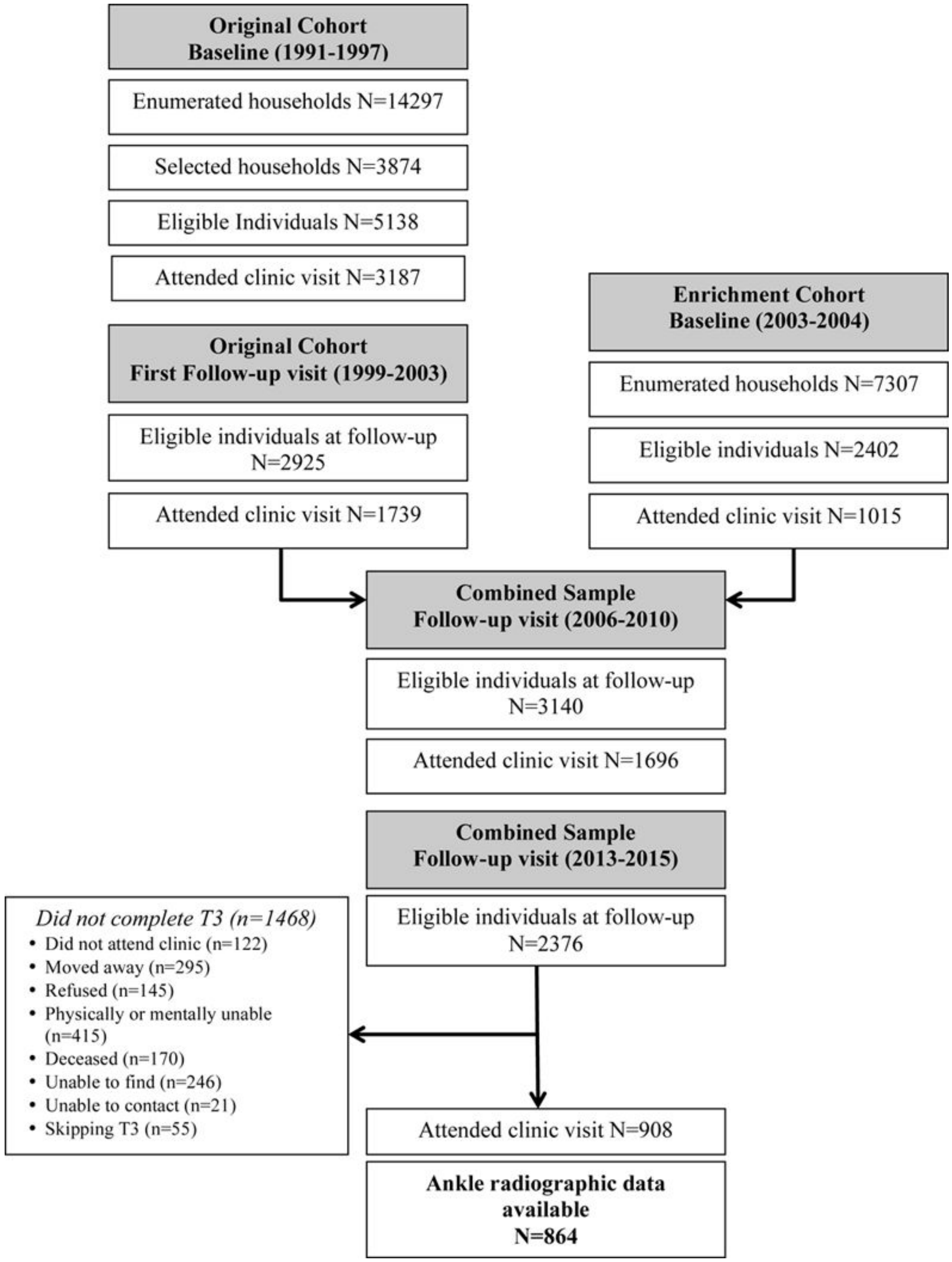

Figure 1.
Flow diagram of included participants

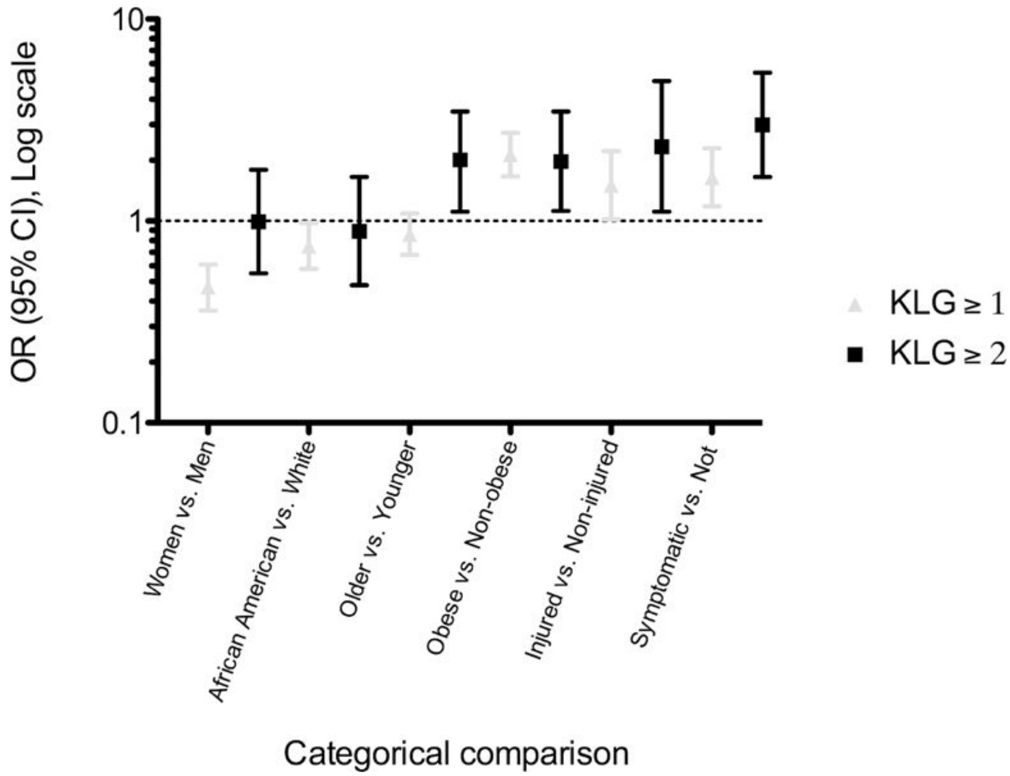

Figure 2.

Graphical representation of the Adjusted Odds Ratios and 95% Confidence Intervals from Tables 3 and 4, showing the consistency of the results for the outcomes of KLG 1 or more (gray triangles) and KLG 2 or more (black squares) for each category of comparison (x-axis) on the log 10 scale.

Table 1

Characteristics of participants overall and by KLG groupings

Participant Characteristics	Total Sample N=864	KLG≥2 in at least 1 ankle n=56	KLG<2 both ankles n=808
Age in years, mean (SD)	71.6 (7.6)	72.6 (7.3)	71.1 (7.6)
BMI in kg/m^2, mean (SD)	30.8 (6.4)	33.6 (6.69)	30.6 (6.3)
Women, n/N (%)	589/864 (68.2)	38/56 (66.1)	551/808 (68.2)
African American, n/N (%)	289/864 (33.5)	17/56 (30.4)	272/808(33.7)
History of ankle injury, n/N (%)	97/854 (11.4)	11/56 (19.6)	86/798(10.8)
Right ankle injury, n/N (%)	51/854 (6.0)	7/56 (12.5)	44/798 (5.5)
Left ankle injury, n/N (%)	33/854 (3.9)	1/56 (1.8)	32/798 (4.0)
Bilateral ankle injury, n/N (%)	13/854 (1.5)	3/56 (5.4)	10/798 (1.3)
Any ankle symptoms, n/N (%)	146/863 (16.9)	19/56 (33.9)	127/807 (15.7)
Right ankle symptoms, n/N (%)	31/863 (3.6)	2/56 (3.6)	29/807 (3.6)
Left ankle symptoms, n/N (%)	24/863 (2.8)	6/56 (10.7)	18/807 (2.2)
Bilateral ankle symptoms, n/N (%)	91/863 (10.5)	11/56 (19.6)	80/807 (9.9)

Table 2

Breakdown of sample by specific KL, osteophyte, and joint space narrowing grade

Radiographic Measure*	Grade	Left Ankle	Right Ankle
KLG	0	349/861 (40.5%)	326/863 (37.8%)
	1	479/861 (55.6%)	508/863 (58.9%)
	2	28/861 (3.3%)	27/863 (3.1%)
	3	3/861 (0.4%)	2/863 (0.2%)
	4	2/861 (0.2%)	0/863 (0.0%)
Osteophytes	0	348/864 (40.3%)	323/863 (37.4%)
	≥1	516/864 (59.7%)	540/863 (62.6%)
Joint Space Narrowing	0	828/864 (95.8%)	825/863 (95.6%)
	≥1	36/864 (4.2%)	38/863 (4.4%)

*864 participants with ankle X-rays; 1 missing right KL read; 3 missing left KL read

Table 3

Adjusted Odds Ratios and 95% Confidence Intervals (n=1702 ankles*) for associations between covariates and radiographic ankle OA (KLG 2 or more)

Characteristic	Odds Ratio[1] (95% Confidence Interval)	Adjusted Odds Ratio[2] (95% Confidence Interval)
Age ≥ 70 years	1.74 (0.98, 3.08)	2.01 (1.11, 3.48)†
Age < 70 years	referent	referent
BMI ≥ 30 kg/m^2	1.96 (1.10, 3.49)†	1.97 (1.12, 3.48)†
BMI < 30 kg/m^2	referent	referent
Women	1.06 (0.59, 1.88)	0.99 (0.55, 1.79)
Men	referent	referent
African-American	0.88 (0.48, 1.59)	0.89 (0.48, 1.65)
Caucasian	referent	referent
Ankle injury	2.54 (1.24, 5.22)†	2.33 (1.11, 4.92)†
No injury	referent	referent
Ankle symptoms	3.30 (1.84, 5.92)†	2.99 (1.65, 5.42)†
No ankle symptoms	referent	referent

*n=864 individuals/1728 ankles; missing data on injury (10 individuals/20 ankles), symptoms (1 individual/2 ankles), or KLG (4 ankles) results in 1702 ankles available for complete case analysis.

†statistically significant

Odds Ratio[1]: adjusted only for intra-person correlation using generalized estimating equations

Odds Ratio[2]: adjusted for intra-person correlation and all other listed covariates

Table 4

Adjusted Odds Ratios and 95% Confidence Intervals (n=1702 ankles*) for exploratory associations between covariates and KLG 1 or more

Characteristic	**Odds Ratio[1] (95% Confidence Interval)**	**Adjusted Odds Ratio[2] (95% Confidence Interval)**
Age ≥ 70 years	0.81 (0.64, 1.03)	0.86 (0.68, 1.09)
Age < 70 years	referent	referent
BMI ≥ 30 kg/m^2	2.00 (1.58, 2.52)†	2.13 (1.66, 2.73)†
BMI < 30 kg/m^2	referent	referent
Women	0.49 (0.38, 0.64)†	0.47 (0.36, 0.61)†
Men	referent	referent
African-American	0.83 (0.65, 1.06)	0.75 (0.58, 0.98)†
Caucasian	referent	referent
Ankle injury	1.57 (1.06, 2.31)†	1.50 (1.02, 2.22)†
No injury	referent	referent
Ankle symptoms	1.82 (1.32, 2.51)†	1.64 (1.18, 2.29)†
No ankle symptoms	referent	referent

*n=864 individuals/1728 ankles; missing data on injury (10 individuals/20 ankles), symptoms (1 individual/2 ankles), or KLG (4 ankles) results in 1702 ankles available for complete case analysis.

†statistically significant

Odds Ratio[1]: adjusted only for intra-person correlation using generalized estimating equations

Odds Ratio[2]: adjusted for intra-person correlation and all other listed covariates