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Factors Associated with Hallux Valgus in a Community-Based Cross-Sectional Study of Adults with and without Osteoarthritis

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Abstract

Objective—To determine whether hallux valgus (HV) was associated with potential risk factors including foot pain in a large, bi-racial cohort of older men and women.

Methods—We conducted a cross-sectional analysis of cohort members of the Johnston County Osteoarthritis Project of whom 1,502 had complete clinical and demographic data available (mean age 68 years, mean body mass index [BMI] 31.3 kg/m^2, 68% women, 30% African American). The presence of HV was assessed visually using a validated examination. Multivariate logistic regression models with generalized estimating equations for the total sample and for each sex and race subgroup were used to examine the effect of age, BMI, foot pain, pes planus, and knee or hip radiographic osteoarthritis (OA) on HV.

Results—HV was present in 64% of the total sample (African American men=69%, African American women=70%, Caucasian men=54%, Caucasian women=65%). The association between HV and foot pain was elevated but not statistically significant (adjusted odds ratio [aOR] 1.21, 95% confidence interval 0.99, 1.47). Women, African American, older individuals, and those with pes planus or knee/hip OA had significantly higher odds of HV (aORs 1.17–1.48). Participants

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with higher BMI had lower odds of HV compared to those with normal BMI (aORs 0.54–0.72). Overall, patterns of associations were similar across subgroups.

Conclusion—HV was associated with female sex, African American race, older age, pes planus, and knee/hip OA and inversely associated with higher BMI. Early prevention and intervention approaches may be needed in high-risk groups; longitudinal studies would inform these approaches.

Keywords

hallux valgus; pes planus; foot pain; epidemiology

Hallux valgus (HV) is a common deformity of the foot characterized by the progressive subluxation and medial bony enlargement of the first metatarsophalangeal joint.[1] HV is a major attributable factor to orthopedic foot and ankle surgery each year,[2] and is also associated with functional disability, foot pain, impaired balance, and high risk falls in older adults.[3–7] Previous large studies in adults 65+ years of age[4,8,9] and in clinic samples[4,10] have reported the following factors associated with HV. HV has been shown to be more common in women than men[8,9] and in African Americans than Caucasians.[8,11] Also, the prevalence of HV was higher in individuals with older age,[4,8–10] but associations between HV and body mass index (BMI)[7,9,12,13] were inconsistent and appeared to vary by sex.[8,9] With the pes planus foot, forces during standing and walking may be directed more medially to the first ray, contributing to disorders of the medial foot such as HV and metatarsalgia;[14] however, reports of the link between HV and pes planus differ.[9,15] HV has been shown to be associated with osteoarthritis (OA) of the first metatarsophalangeal joint.[16] Since OA may be a multiple joint condition, HV and OA at other lower body joint sites may be related, particularly if there are biomechanical mechanisms at play, but this relationship previously has not been explored. Other related factors include wearing shoes with high heels and structural foot attributes such as long first metatarsals, round metatarsal heads and pronated foot posture.[9,17] Identifying adults with HV earlier in the life course may aid in preventing later functional limitations, such as impaired balance in older populations.

The overall objective of the present study was to examine potential factors related to HV in the study sample and by sex and race in a large, community-based study of African American and Caucasian men and women 50+ years of age. Inconsistences in the existing literature of factors potentially related to HV (as described above) may be explained by sex and race differences. The present study has two main purposes: 1) to determine whether HV is associated with foot pain and if this relationship differs by sex and race, and 2) to examine sex- and race-specific associations of age, BMI, pes planus, and presence of knee or hip OA with HV. We hypothesized that: 1) foot pain would be more commonly reported in individuals with HV compared to those without HV regardless of sex or race, 2) HV would be associated with female sex, African American race, greater age, greater BMI, pes planus, and the presence of knee/hip OA, and 3) associations of HV with age, BMI, pes planus, and knee/hip OA would not vary by sex or race.

METHODS

Study Participants

Participants in the present cross-sectional study were members of the population-based Johnston County Osteoarthritis Project. The parent study is an ongoing, prospective study of OA in African American and Caucasian residents in a rural North Carolina county, and full details of identification and recruitment of participants has been described by Jordan et al.[18] In summary, the cohort included individuals from rural areas and African Americans were oversampled from Johnston County because the parent study aimed to compare OA by race. Six townships out of a total of 17 townships in Johnston County were selected because they had the largest proportion of African American residents and were surrounded by rural areas. Using streets as the main unit for sampling, streets were stratified (based on criteria of urban vs. rural streets and streets with Caucasian, mixed ethnicity, or African American residents,) and selected using simple random sampling. Civilian, non-institutionalized adults 45+ years old from these streets were invited to participate, and those who agreed completed informed consent and were enrolled from 1991 to 1997.[18] Additional Johnston County residents 45+ years old were enrolled from 2003 to 2004, and participants from both recruitment phases were included in the present study. Clinical examinations were completed for all participants from both recruitment phases who returned for a follow-up visit conducted between 2006 and 2010, by which time participants had aged to at least 50 years. Both the Institutional Review Boards of the University of North Carolina and of the Centers for Disease Control and Prevention in Atlanta, Georgia have approved the Johnston County Osteoarthritis Project.

Foot Assessment

Presence of foot disorders, including HV, was determined by two trained examiners using a validated foot examination.[19,20] A laminated foot diagram with two lines intersecting at 15° was used to determine the presence of HV. Participants stood on the diagram with the medial edge of their foot against one line and their first metatarsophalangeal joint at the apex of the two lines. If the great toe had a lateral angulation more than the 15° on the diagram, HV was recorded as present; otherwise, HV was defined as absent. Both feet were assessed separately. The interrater reliability for the HV measure was excellent for the left foot (kappa 0.84, 95% confidence interval [CI] 0.73, 0.96) and good for the right foot (kappa 0.71, 95% CI 0.57, 0.92). The presence of foot pain was determined based on an affirmative response to the questions: “On most days, do you have pain, aching or stiffness in your [right/left] foot?”

Pes Planus

Plantar pressure data were collected with a Tekscan Matscan System (Tekscan Inc, Boston, MA) at a sampling frequency of 40 Hz. The MatScan system has demonstrated moderate to good reliability.[21] Scans were completed during standing (bipedal relaxed stance), and foot structure was assessed using the Modified Arch Index (MAI).[22] To determine the MAI, the maximum peak pressure image of the foot in standing was used, and the foot, excluding the toes, was divided into anterior, middle, and posterior thirds. The MAI was calculated as the ratio of the area of the middle third of the foot to the whole foot area. MAI cutoff values were set *a priori* based on data from the Framingham Foot Study, which defined the lowest 20% of values in that cohort as representative of a cavus (high arch) foot type and those in the highest 20% as a planus (flat; MAI ≥0.164) foot type.[23] Using these values from the Framingham study, we created a 2-category variable in the present study in which planus was defined as values ≥0.164 and values <0.164 were considered the referent category.

Other Factors

The following variables were collected at time of HV assessment and included in our analyses as previous work in the literature identified them as likely to be related to HV: age (in 10 year increments from age 50); BMI (calculated as weight in kilograms/height in meters squared [kg/m^2] and categorized as <25, 25–30, 30–35, and 35+ kg/m^2); sex, race (African American or Caucasian), and the presence of knee or hip radiographic OA. HV may be a component of 1st metatarsophalangeal joint OA,[24] but foot radiographs were not available at this data collection time point. We selected knee/hip OA to examine the association of HV with lower extremity OA.

Height without shoes was measured in inches using a calibrated stadiometer and converted to meters, and weight was measured in pounds using a balance beam scale and converted to kilograms. Bilateral posteroanterior fixed-flexion radiography of the knees in weight bearing was completed by all participants. Supine anteroposterior pelvic radiographs were acquired for women who were 50+ years of age and for all men. A single muscuoloskeletal radiologist with high reliability (weighted kappa for interrater reliability 0.9; kappa for intrarater reliability 0.9)[25] rated all knee and hip radiographs using the Kellgren-Lawrence (K-L) radiographic atlas[18]. K-L grade of 0–1 was defined as the absence of OA, while a K-L grade of 2–4 or the presence of a total joint replacement for treatment of OA was considered to be OA. If a participant had OA in at least one knee or hip, he or she was categorized as having knee/hip OA.

Analysis

Frequencies of categorical variables and means (and standard deviations) for continuous variables were calculated for the study sample and for subgroups by sex and race (African American men, African American women, Caucasian men, and Caucasian women). A multivariate logistic regression model was used for the study sample to examine associations between HV and sex, race, age, BMI, foot pain, pes planus, and presence of knee/ hip OA, controlling for all other factors. Analyses were foot-based so that examinations of HV, foot pain, and pes planus were all within the same foot, and generalized estimating equations were used to account for correlated data within an individual. For each subgroup, separate multivariate regression models were used to examine associations between HV and age, BMI, foot pain, pes planus, and presence of knee/ hip OA. Effect measure modification was assessed between sex, race, age, BMI, foot pain, pes planus, and presence of knee/ hip OA and was considered statistically significant for p-values <0.10. Because results showed associations of HV with age and BMI that required further investigation, post hoc analyses were conducted to: 1) calculate frequencies and means of all variables described above by age group (<65 and 65+ years) and by BMI group (<25, 25–<30, 30–<35, and 35+ kg/m^2), and 2) estimate associations of HV with all other variables by age group and by BMI group, using multivariate regression models in similar manner as described above. All statistical computations were computed using SAS version 9.2 (SAS Institute, Cary, NC).

RESULTS

Of the 1,695 participants with clinical foot exam data, 4 were excluded because of lower extremity amputation, 61 participants did not have foot pain data, 27 did not have radiographic knee or hip OA data (4 of these were excluded for inflammatory arthropathy or other non OA conditions), and 101 were missing valid MAI data for both feet, leaving 1,502 participants with available data for analyses (Figure 1). Of these participants, 12 only had complete data for one limb (5 were missing pes planus data for one foot, 6 were missing OA data for one limb, and 1 was missing pain data for one foot). As shown in Table 1,67.8% of participants were women and 30.4% were African American. At the time of HV assessment, the mean age was 68.4 years (standard deviation [SD] = 8.9 years, range 50–95 years), and the mean BMI was 31.3 kg/m^2 (SD = 6.9). The frequency of pes planus and foot pain was 39.6% and 27.0%, respectively, and the presence of OA in at least one knee or hip was common at 66.4%. Generally, the means or distributions were similar across subgroups (see Table 1) with the following exceptions: mean BMI and the frequency of knee/hip OA was higher in African American women than in other subgroups, HV occurred less often in Caucasian men compared to other subgroups, and pes planus was more common in African Americans than Caucasians. Compared to the 1502 participants with available data, the 193 participants not included in analyses were more likely to be slightly older (70.2 vs. 68.4 years), to be African American (37.5% vs. 30.4%), to have HV (68.8% vs. 63.8%), to have radiographic knee or hip OA (73.9% vs. 66.4%), and to have foot pain (35.9% vs. 27.0%).

Table 2 shows participant variables by age (<65 and 65+ years of age) and BMI categories (<25, 25–<30, 30–<35, and 35 kg/m^2). Compared to older participants (65+ years), participants who were younger than 65 years were more likely to be African American, have pes planus, and had less radiographic OA of the knee and hip. For BMI categories, 72% of participants with a normal BMI of <25 kg/m^2 had HV, while 61–64% of participants with BMIs in the overweight (25 – <30 kg/m^2), obese (30–<35 kg/m^2) and very obese categories (35+ kg/m^2) have HV. Compared to participants with normal BMI, participants with higher BMIs were more likely to be African American, have pes planus, report foot pain, and have radiographic knee or hip OA.

The only statistically significant interaction between variables was that of sex and race (p=0.07). Each adjusted odds ratio (aOR) and 95% confidence interval (CI) calculated from the multivariate logistic regressions models are shown in Table 3 for the study sample and by each subgroup. In the study sample, the association between HV and foot pain was elevated but not statistically significant (adjusted odds ratio [aOR] 1.21, 95% confidence interval 0.99, 1.47). Sex, race, age, pes planus, and knee/hip OA were significantly and positively associated with HV (Table 2). Greater BMI lowered the odds of HV, and results were statistically significant for BMI 25–30 and >35 kg/m2 compared to the referent (Table 3). There were no statistically significant interactions between factors in models for the study sample or for each subgroup.

Across subgroups, patterns of associations were generally similar to each other and to those of the study sample, although many were not statistically significant (Table 3). When foot pain were present, the odds of HV were higher among African American women (aOR 1.60, 95% CI 1.01, 2.55) and Caucasian men (aOR 1.48, 95% CI 1.02, 2.13), but no associations were observed among African American men (aOR 0.92, 95% CI 0.68, 1.25) and Caucasian women (aOR 1.01, 95% CI 0.75, 1.34). The aORs for the association between older age and HV were between 1.17 and 1.49 and were statistically significant for all subgroups except African American men. A BMI of 25–30 kg/m^2 compared to a BMI <25 kg/m^2 was inversely associated with HV among African American men (aOR 0.31, 95% CI 0.10, 0.99), as was a BMI >35 kg/m^2 compared to a BMI <25 kg/m^2 among Caucasian women (aOR 0.59, 95% CI 0.37, 0.94). This inverse association between BMI and HV was observed in other BMI categories and in other subgroups, but was not statistically significant. When pes planus or knee/hip OA was present, the odds of HV were generally higher across subgroups with a borderline statistically significant association for pes planus and HV in African American women (aOR 1.40, 95% CI 0.99, 1.97).

Overall, estimates by age group and by BMI group were comparable. When participants were African American or when pes planus was present, the odds of HV were somewhat higher among adults 65+ years compared to those < 65 years (Table 4). African American race was strongly associated with HV when BMI was lower, with estimates decreasing with greater BMI (Table 4).

DISCUSSION

In this community-based study of older adults, HV was common overall and in each sex and race subgroup. HV and foot pain were associated in African American women and Caucasian men but not in other subgroups. Additionally, HV was associated with female sex, African American race, older age, and knee/hip OA and inversely associated with higher BMI, and these associations were fairly consistent across subgroups.

Our first hypothesis that foot pain would be associated with HV was partially supported; there was an association, but it differed by sex and race. HV is known to be more common in women than men,[8,9] and women also report more foot pain.[9] Prior research demonstrated that a greater proportion of African Americans had HV than Caucasians,[8,11] but foot pain proportions by race have not been reported in large cohort studies. Dunn et al.[8] demonstrated that ankle pain was more common in African Americans than Caucasians (17.5% vs. 12.2%), and, in light of these results, a similar difference may exist for foot pain. Consideration of longitudinal aspects of HV and foot pain is important, and future studies might be able to address other important factors to better understand racial and gender differences in HV and foot pain.

Our second hypothesis was supported for associations between HV and female sex, African American race, older age, pes planus, and knee/hip OA when controlling for all other variables. The reported associations between HV and female sex, African American race, and older age agree with other published work.[4,8–10] Differences in these associations by age group were minimal, even when other age category definitions were examined (data not shown). Since participants in this study were 50+ years old, early factors that may be related to later HV development were not easily identifiable, and future studies should include younger individuals and employ longitudinal analytic methods. The association between HV and radiographic knee/hip OA may represent lower extremity OA, although radiographic examination of the first metatarsophalangeal joint is needed to confirm this finding.[4] Hallux valgus may represent a tendency for bone formation in certain adults or may occur with or as a result of OA of the first metatarsophalangeal joint and would likely be associated with OA at other joint sites.[4] Radiographic first metatarsophalangeal joint OA was associated with radiographic knee and hand OA in the Clearwater Osteoarthritis Study.[26]

The second hypothesis was not supported for BMI, which demonstrated an inverse association with HV. Similar to the present study, the Framingham Foot Study reported this same association in their sample of over 3000 participants, regardless of sex.[13] Furthermore, the MOBILIZE Boston Study reported less frequent HV with a higher BMI in women, but the association was positive among men in their cohort.[9] The results for men may differ between the two studies because a BMI of more than 25 kg/m^2 was more common in the Johnston County Osteoarthritis Project (89%) than in the MOBILIZE Boston Study (68%). We explored whether this inverse association may be driven by difficulty with detecting HV with increasing obesity. Radiographic assessment of HV, which is less prone to ascertainment bias, may confirm this HV-BMI association, but this measure was not available in our study, nor are we aware of any other large cohort studies that have reported on an inverse relations of radiographic HV and BMI. If ascertainment of HV were biased in the present study, one would expect to see a steady decline in the proportion with HV for each increasing category of BMI (e.g., the greater the adiposity at the foot, the harder to detect HV). The sharp contrast in the proportion with HV in the normal weight vs. overweight category (72% vs. 62%) with a fairly steady proportion with HV across overweight, obese, and very obese categories suggests that there may be factors other than a measurement issue. Although we do not know what those differences might be, future work should address novel risk factors. Some thoughts might include the contribution of genetics, especially genes related to both obesity and HV. Also, shoes may play a role. Perhaps normal weight individuals, compared to those who are overweight or obese, are more likely to wear narrower shoes or high heeled shoes, known factors associated with foot deformities. More insight might be provided by a prospective study of changes in BMI with HV or onset of HV.

The high proportion of participants with HV in the present study (64%) differs from estimates in a 2010 systematic review (36% of older adults).[1] Nix et al.[1] emphasized in the Discussion section of their paper that most studies in their systematic review did not clearly state the definition of HV. Few studies used a quantifiable method of measuring HV on clinical exam, and perhaps, without a consistent angular definition, only the more extreme HV cases were reported. Some studies used self-report of bunion or HV, and if these terms were not well-understood by respondents, reporting of the condition may not be accurate. An unclear definition of HV across many studies could have contributed to an under-estimation of the prevalence of HV. The advantage of our study was the consistent angular definition (15 degrees) and the consistent measurement method (using a foot mat). Characteristics of our cohort also may have contributed to the high proportion with HV;

nearly 1/3 of the sample was African American and 2/3 were women, both significant risk factors for HV. Furthermore, knee/hip radiographic OA occurred in 2/3 of participants, and a high occurrence of HV would be expected, too, since HV is linked to first metatarsophalangeal joint OA.

This study has several strengths, particularly that it was community-based, included large numbers of African American and Caucasian men and women, and included individuals who were somewhat younger (50+ years) than previous similar studies, which tended to examine adults 60+. Additionally, the study included a validated foot exam and quantitative, biomechanical measures of foot structure. Also, two foot pressure measures were obtained per participant for each foot and an average of the values obtained was used to approximate representative foot structure measures for each participant. Analyses were foot-based and included available data for both feet per participant, and statistical methods were used to account for correlated data within a participant. This study has several limitations. The cross-sectional design of this study does not allow for the temporal examination of the associations of hallux valgus with other variables. Potentially, occupational demands, changes in body composition and/or weight changes, footwear constrictions or poor shoe fit across adulthood may affect HV and foot pain. The foot pain question used in this study asked about pain in the foot but was not specific to region of the foot, and the presence of first metatarsophalangeal joint pain was not known. Future work in this cohort will collect site-specific foot pain. Furthermore, the presence and angulation of HV was not measured by radiograph (thought by some to be a "gold standard");[27] however, the clinical measure used in this study for determining the presence or absence of HV previously has been validated and was conducted by trained examiners. Participants with inflammatory arthritis or gout identified on hip or knee radiographs were removed from analyses, but potentially some participants may have had these conditions in their feet. No radiographs or clinical assessments were collected to confirm the presence of these rheumatologic diseases. However, these conditions are uncommon in the general population and may have had little effect on the estimates calculated in this population-based study. Future research in the area of HV risk factors should examine gout and inflammatory arthritis in the foot with validated measures.

In summary, HV was associated with female sex, African American race, older age, pes planus, and knee/hip OA and inversely associated with higher BMI in this population study. The inverse association with higher BMI requires further examination to explain this relationship (though also seen in other cohorts as noted above) and to determine if other factors, such as shoe type and shoe width, or altered gait in higher BMI, contribute to this finding. Additionally, longitudinal studies are needed to clarify the temporality of the associations reported in this study and the possible onset of foot pain related to the deviation of the hallux. Future investigations would add to our understanding if they examined shoe wear, occupational factors, weight changes across adulthood, genetic, and first metatarsophalangeal OA to inform early intervention approaches.

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SIGNIFICANCE AND INNOVATION

- This study is the first to report HV by sex- and race- subgroups (African American men, African American women, Caucasian men, Caucasian women), showing that hallux valgus is remarkably common across all subgroups in adults 50+ years of age, with the highest occurrence among African American women and lowest occurrence among Caucasian men.
- Hallux valgus was associated with the biomechanical risk factor of pes planus and the presence of knee or hip osteoarthritis, suggesting that groups with these risk factors may require targeted preventative approaches.
- Foot pain (pain, aching, and stiffness) was associated with HV only among Caucasian men and African American women.
- This study confirmed an inverse association of hallux valgus with body mass index that has been described in two other large cohort studies; genetics and improper shoe wear should be explored as risk factors for HV among those with normal body weight.

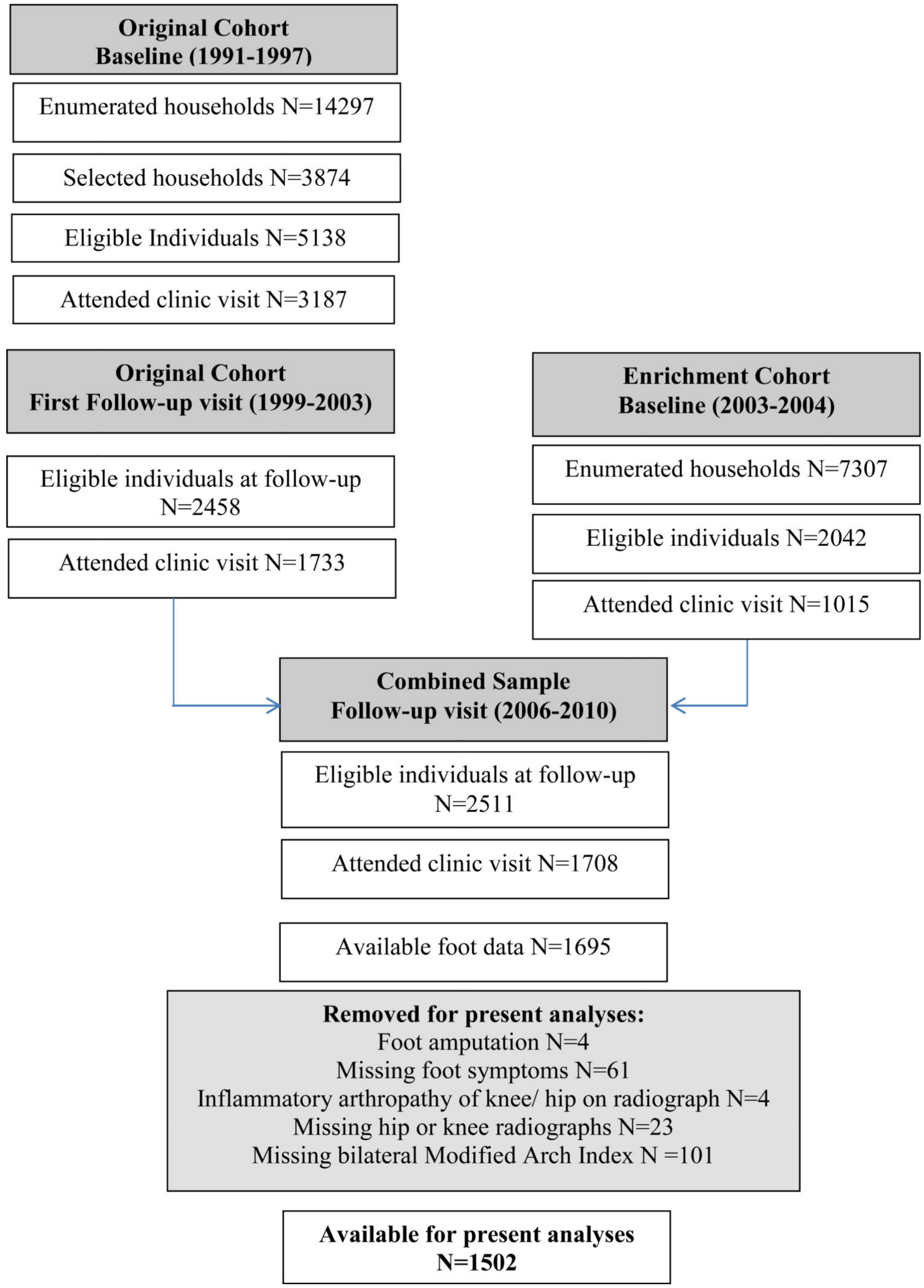

Figure 1.

Johnston County Osteoarthritis Project participants available for analyses.

Table 1

Distributions of Hallux Valgus, Participant Characteristics, and Clinical Factors: Total Sample and by Race and Sex.*

		Subsamples, by race and sex			
		African American		Caucasian	
	Study Sample N=1,502	Men n=125 (8.3%)	Women n=331 (22.0%)	Men n=358 (23.8%)	Women n=688 (45.8%)
Hallux Valgus, n (%)	958 (63.8)	86 (68.8)	232 (70.1)	194 (54.2)	446 (64.8)
Age, mean years (SD)	68.4 (8.9)	66.2 (8.6)	67.5 (9.1)	68.9 (8.6)	68.9 (8.9)
Body Mass Index, mean kg/m^2(SD)	31.3 (6.9)	30.6 (7.0)	34.0 (8.1)	30.9 (5.4)	30.4 (6.5)
Women, n (%)	1019 (67.8)	--	--	--	--
African American, n (%)	456 (30.4)	--	--	--	--
Pes Planus, n (%)	595 (39.6)	83 (66.4)	234 (70.7)	78 (21.8)	200 (29.1)
Foot pain, n (%)	406 (27.0)	20 (16.0)	92 (27.8)	78 (21.8)	216 (31.4)
Knee or Hip osteoarthritis*, n (%)	997 (66.4)	77 (61.6)	239 (72.2)	229 (64.0)	452 (65.7)

* All measures collected at time of hallux valgus assessment

Table 2

Distributions of Hallux Valgus, Participant Characteristics, and Clinical Factors in Subsamples, by Age and by Body Mass Index (BMI).

	Age (years)		BMI (kg/m^2)			
	<65 n=618 (41.1%)	**≥ 65 n=884 (58.9%)**	**<25 n=218 (14.5%)**	**25–<30 n=508 (33.8%)**	**30–<35 n=395 (26.3%)**	**35+ n=381 (25.4%)**
Hallux Valgus, n (%)	353 (57.1)	605 (68.4)	157 (72.0)	317 (62.4)	252 (63.8)	232 (60.9)
Age, mean years (SD)	--	--	71.1 (9.9)	70.0 (9.1)	67.3 (8.0)	65.7 (7.9)
BMI, mean kg/m^2(SD)	32.8 (7.6)	30.3 (6.1)	--	--	--	--
Women, n (%)	410 (66.3)	609 (68.9)	167 (76.6)	316 (62.2)	255 (64.6)	281 (73.8)
African American, n (%)	209 (33.8)	247 (27.9)	54 (24.8)	117 (23.0)	126 (31.9)	159 (41.7)
Pes Planus, n (%)	274 (44.3)	321 (36.3)	39 (17.9)	105 (20.7)	168 (42.5)	283 (74.3)
Foot pain, n (%)	173 (28.0)	233 (26.4)	39 (17.9)	116 (22.8)	118 (29.9)	133 (34.9)
Knee or Hip osteoarthritis, n (%)	330 (53.4)	667 (75.5)	130 (59.6)	319 (62.8)	255 (64.6)	293 (76.9)

Table 3

Multivariate Logistic Regression Models of Factors Associated with Hallux Valgus, adjusted for all other variables.

		Subsamples, by race and sex			
		African American		Caucasian	
	Study Sample (feet=2,992) OR (95% CI)*	Men (feet=247) OR (95% CI)	Women (feet=659) OR (95% CI)	Men (feet=712) OR (95% CI)	Women (feet=1,374) OR (95% CI)
Sex (referent=men)	1.30 (1.05, 1.60)	--	--	--	--
Race (referent=Caucasian)	1.48 (1.18, 1.84)	--	--	--	--
Age (10 year increment)	1.25 (1.12, 1.40)	1.49 (0.97,2.29)	1.37 (1.06, 1.76)	1.31 (1.03, 1.67)	1.17 (1.00, 1.36)
BMI* <25 kg/m^2 (referent)	1.00	1.00	1.00	1.00	1.00
BMI 25–30 kg/m^2	0.69 (0.50, 0.94)	0.31 (0.10, 0.99)	0.81 (0.32, 2.02)	0.77 (0.37, 1.59)	0.75 (0.50, 1.13)
BMI 30–35 kg/m^2	0.72 (0.50, 0.99)	0.81 (0.25, 2.68)	0.54 (0.22, 1.33)	0.73 (0.34, 1.53)	0.88 (0.55, 1.39)
BMI >35 kg/m^2	0.54 (0.38, 0.76)	0.34 (0.10, 1.20)	0.44 (0.18, 1.10)	0.76 (0.34, 1.70)	0.59 (0.37, 0.94)
Foot pain	1.21 (0.99, 1.47)	0.92 (0.68, 1.25)	1.60 (1.01, 2.55)	1.48 (1.02, 2.13)	1.01 (0.75, 1.34)
Pes Planus	1.22(1.03, 1.44)	1.01 (0.62, 1.66)	1.40 (0.99, 1.97)	1.10 (0.81, 1.51)	1.22 (0.95, 1.57)
Knee or Hip osteoarthritis	1.17 (1.03, 1.33)	1.09 (0.62, 1.91)	1.29 (0.95, 1.74)	1.20 (0.95, 1.52)	1.12 (0.94, 1.35)

* OR= odds ratio, 95% CI = 95% confidence interval, BMI = body mass index.

Table 4

Multivariate Logistic Regression Models of Factors Associated with Hallux Valgus by Age and Body Mass Index (BMI)

	Age Group (years)		BMI Group (kg/m^2)			
	<65 (feet=1231) OR (95% CI)*	65+ (feet=1761) OR (95% CI)	<25 (feet = 435_ OR (95% CI)	25–<30 (feet = 1013_ OR (95% CI)	30–<35 (feet = 787)_ OR (95% CI)	35+ (feet =_757) OR (95% CI)
Sex (referent=men)	1.32 (0.96, 1.87)	1.27 (0.96, 1.68)	1.34 (0.70, 2.51)	1.49 (1.06, 2.10)	1.29 (0.87, 1.92)	1.13 (0.73, 1.76)
Race (referent=Caucasian)	1.38 (0.97, 1.88)	1.55 (1.14, 2.10)	2.02 (1.00, 4.10)	1.46 (0.95, 2.23)	1.54 (1.21, 1.95)	1.31 (0.87, 1.96)
BMI <25 kg/m^2 (referent)	1.00	1.00	--	--	--	--
BMI 25–30 kg/m^2	0.61 (0.37, 1.03)	0.72 (0.48, 1.06)	--	--	--	--
BMI 30–35 kg/m^2	0.52 (0.31, 0.89)	0.87 (0.51, 1.34)	--	--	--	--
BMI >35 kg/m^2	0.52 (0.30, 0.89)	0.51 (0.33, 0.80)	--	--	--	--
Foot pain	1.12 (0.83, 1.51)	1.27 (0.97, 1.65)	0.73 (0.39, 1.35)	1.31 (0.89, 1.91)	1.26 (0.92, 1.71)	1.26 (0.89, 1.77)
Pes Planus	1.18(0.91, 1.53)	1.25(1.01, 1.56)	1.20 (0.67, 2.14)	1.18 (0.83, 1.67)	1.31 (0.97, 1.77)	1.18 (0.90, 1.54)
Knee or Hip Osteoarthritis*	1.20 (0.98, 1.46)	1.15 (0.97, 1.36)	0.86 (0.61, 1.23)	1.19 (0.98, 1.45)	1.37 (1.05, 1.79)	1.13 (0.87, 1.47)

* OR= odds ratio, 95% CI = 95% confidence interval.