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Original Research

Characteristics of Adult Flatfoot in the United States

Naohiro Shibuya, DPM, MS, FACFAS [1], Daniel C. Jupiter, PhD [2], Louis J. Ciliberti, DPM, MS [3], Vincent VanBuren, PhD [4], Javier La Fontaine, DPM, MS, FACFAS [5]

[1] *Associate Professor, Department of Surgery, Texas A&M Health Science Center, College of Medicine, Temple, TX; Staff, Central Texas Veterans Health Care System, Scott and White Health Care System; Diplomat, American Board of Podiatric Surgery*
[2] *Research Scientist, Department of Surgery, Scott and White Health Care System, Temple, TX*
[3] *Second Year Podiatric Medicine and Surgery Resident, Scott and White Memorial Hospital, Texas A&M Health Science Center, College of Medicine, Temple, TX*
[4] *Assistant Professor, Department of Systems Biology and Translational Medicine, Texas A&M Health Science Center, College of Medicine, Temple, TX*
[5] *Associate Professor, Department of Surgery, Texas A&M Health Science Center, College of Medicine, Temple, TX; Chief, Section of Podiatry, Central Texas Veterans Health Care System, Scott and White Health Care System; Diplomat, American Board of Podiatric Surgery*

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ABSTRACT

Many factors have been suggested to cause flatfoot deformity. The purpose of this study was to identify risk factors for flatfoot deformity, which itself can be a causative factor for other foot and ankle pathologies. The *National Health Interview Survey (Podiatry Supplement)* from 1990 was analyzed to determine associations of various demographic factors and other foot and ankle pathologies with self-reported flatfoot deformity. We found statistically significant ($P \leq .05$) associations of flatfoot with age, male gender, BMI, white-collar occupation, veteran status, bunion, hammertoe, calluses, arthritis, and poor health. Treatment and prevention of flatfoot may have an effect on an individual's overall health and occurrence of other foot and ankle pathologies.

Commonly, flatfoot is defined as a foot with an absent or abnormally low arch height as measured during weight-bearing stance. Because of genetic, racial, and morphologic differences, not all flatfeet are symptomatic (1). Many argue that most asymptomatic flatfeet do not need any treatment (2–5); however, there are many proposed consequences of neglected flatfeet (6–10). Staheli (3) stated that flatfeet were normal or physiological in infants, children, and some adults. On the other hand, some have hypothesized that in many cases flatfeet in children lead to disability in adulthood (7, 9, 11, 12).

Flatfoot can also be acquired in adulthood. In the adult-acquired condition, patients typically present with an insidious onset of vague pain in the medial foot and behind the medial malleolus along the course of the tibialis posterior tendon (13). As the condition progresses, these patients have more complaints related to loss of function and changes in the shape of the foot. In the late stages, rigidity, arthritic changes, and ankle valgus may also be observed.

In adulthood, the tibialis posterior tendon should maintain its integrity between the medial malleolus and navicular tuberosity. When the tendon is elongated, the plantar structures such as the spring ligament stretch excessively, leading to joint subluxation. A cross-sectional study in 24 subjects with tibialis posterior tendon abnormality and 48 sex- and age-matched controls showed that advanced tibialis posterior tendon pathology was statistically significantly associated with adult-acquired flatfoot deformity and spring ligament pathology (14). As the pathology progresses, the medial arch collapses. This leads to compensation of the foot by forefoot supinatus and calcaneal valgus, resulting in the deformity of pes planovalgus (15). An ankle equinus may also present as either a primary deforming force or a secondary adaptation in such patients.

In adults with pathologic flatfoot, conservative management options are somewhat limited as compared with the management options available for children. Depending on the child's age and skeletal maturity, plaster casting, splints, muscle training, orthosis, and shoes can be used effectively (16). On the other hand, adults with pathologic flatfeet may use orthoses, braces, and shoe modifications, but with limited beneficial results in many cases (17). In those patients who do not respond to conservative management, surgical intervention may be necessary.

Today, prevention is considered to play a major role in reducing high health care costs in the United States, and identification of risk factors for a disease is essential for the development of effective disease prevention programs. The purpose of this investigation was to identify clinical and demographic factors associated with flatfoot

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Address correspondence to Naohiro Shibuya, DPM, MS, FACFAS, Texas A&M Health Science Center, College of Medicine, Department of Surgery, 1901 Veterans Memorial Drive, Temple, TX 76502.
E-mail address: naohiroshibuya@gmail.com (N. Shibuya).

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deformity in the United States, using previously released national cross-sectional data. We hypothesized that not only can some of the known links between foot pathologies be confirmed, but that some hitherto unexplored variables are also associated with flatfoot deformity.

Patients and Methods

The *National Health Interview Survey, 1990 (Podiatry Supplement)* was used for this report of secondary data analysis (18). The data were collected by the US Department of Health and Human Services National Center for Health Statistics, and distributed by the Inter-university Consortium for Political and Social Research (Ann Arbor, MI). The data were collected by survey and all information was self-reported; and, in fact, pathologies could have been self-diagnosed. We considered and analyzed the information as prevalence data. The original data were collected from noninstitutionalized civilians of the 50 states and the District of Columbia, and measured 90 variables including respondents' demographics, podiatric conditions, and type of health care professionals sought for treatment of pedal problems. From the original set of variables, we selected items that we thought were clinically important and relevant to flatfoot deformity and its care. We considered flatfoot to be our dependent variable, and "flatfoot" was one of the variables contained in the original dataset. Each participant answering the original questionnaire was asked if he or she had "flatfoot," without being given a specific definition of the condition; as such, the presence of flatfoot was self-reported. We also considered, after filtering, the following independent variables in the analyses: gender (male or female), race (see Table 1 for the specific categories), financial status (above or below the poverty line), age (0–99), health status (defined later in this paragraph), industry (defined later in this paragraph), veteran status (defined later in this paragraph), body mass index (BMI, computed from survey weight and height data as BMI = 703[weight in pounds]/[height in inches $]^2$), bunion deformity (present or not present), callus formation (present or not present), hammertoe deformity (present or not present), and the presence of arthritis (yes or no). We excluded from the analyses a number of variables, based on a priori bivariate analyses. For example, even though regional differences (Northwest, Midwest, South, and West) in foot pathologies may be clinically interesting, such differences were excluded because the variable did not produce a significant association (odds ratio) with flatfoot in the regression model, nor did it affect the overall regression model. Further, geographic demographics may have changed radically in the 20 years since the original study. Health status and industry data were dichotomized into broader categories to simplify interpretation of the results and to make results clinically more relevant for broader readership. Specifically, health status in the original survey was stratified as excellent, very good, good, fair, and poor. For the purposes of this analysis, we further collapsed health status into 2 broader categories: "healthy" (excellent, very good, good) and "not healthy" (fair, poor). Industries were categorized in the original survey as agriculture, mining, construction, manufacturing, public utilities, wholesale, retail, finance, repair, personal services, entertainment, professional services, public administration, not working, and armed forces. For the purposes of this analysis, we collapsed industries into "blue collar" (agriculture, mining, construction, manufacturing, public utilities, repair, and armed service) and "white collar" (all other industries).

Statistical Analyses

The data were analyzed to determine the relative risk (RR) and odds ratio (OR) for the occurrence of flatfoot between strata of variables of interest while controlling for potential confounders: age; race; gender; financial status; health status; veteran status; industry; presence of callus, hammertoe, bunion, or arthritis; and BMI. When the 95% confidence intervals (CIs) of those RRs and ORs did not include 1, we considered the association to be statistically significant. Additional hypothesis tests for association were also undertaken when we felt that it was clinically or statistically indicated. Moreover, from the original data (N = 119,631 records), we removed the records for those respondents 17 years of age or younger (n = 33,243), those whose race was unknown (n = 571), those whose financial status was unknown (n = 8094), those whose veteran status was unknown (n = 891), those whose health status was unknown (n = 196), those whose industry was unknown (n = 973), those whose height was unknown (n = 247), those whose weight was unknown (n = 694), and those who did not respond to questions regarding the foot deformities examined in our study (n = 1). Individuals 17 years or younger were removed in an effort to minimize masking effects of veteran status and occupation on flatfoot deformity and to focus on adult flatfoot deformity.

Because most of the analyzed data were nominal and age was not normally distributed, nonparametric tests were used for comparisons of age distributions (Mann-Whitney *U*). Deviance from normality of the ages of respondents was assessed using the Kolmogorov-Smirnov test. Contingency tables were checked for deviance from independence using a chi-squared test with a Yates correction for continuity. Furthermore, the Woolf test was used to determine whether ORs were consistent across strata (eg, the OR of occurrence of flatfoot between genders, stratified by race). ORs and RRs of diseases were originally computed directly from contingency tables. Then logistic regression was used to obtain 95% CIs for, and estimates of, ORs for flatfoot between strata for each variable while controlling for the other covariates. In particular, the coefficient for each variable, and its CI, were the model OR and 95% CI. As flatfoot pathology was rare (occurring in < 10% of respondents), the RR in these models was estimated with ORs (for clarity, in the case of very rare diseases, the formulas for OR and RR yield very similar results, and one often uses the OR as a proxy for RR).

All of the statistical analyses were carried out by the coauthors (D.C.J., N.S.), using the R statistical package (R, Developmental, Core, Team, R: A Language and Environment for Statistical Computing 2009, http://www.R-project.org). Furthermore, in this report, *t* tests and their nonparametric equivalents, as well as all proportions, were derived from the raw data; and ORs presented are those derived from the logistic regression models.

Table 1
The frequency of each race and the proportions of men in each race category, 74,721 respondents

	Aleut	Asian	Black	White	Other	Multiple
All	532	1,747	9,393	62,061	939	49
Proportion of total	0.007	0.023	0.126	0.831	0.013	<0.001
Men	259	841	3,868	29,717	472	25
Women	273	906	5,525	32,344	467	24
Proportion Men	0.487	0.481	0.412	0.479	0.503	0.510

Results

After filtering, our study encompassed 74,721 respondents: 35,182 (47%) men and 39,539 (53%) women. The mean age of respondents was 43.8 ± 17.37 (SD) years; that for females was 44.3 ± 17.81 years, whereas that for males was 43.2 ± 16.85 years, and this difference was statistically significant (Mann-Whitney $P < .001$). Age was non-normally distributed for males and females, and for the population as a whole. Seven "races" were included in the study, and a breakdown of frequency counts and the proportion of males in each race are provided in Table 1. We also noted oversampling of female African Americans (African American gender breakdown versus all other races combined, χ^2 test, $P < .001$).

Veterans comprised 16.02% of the population. Only 1.39% of females were veterans whereas 32.47% of males were veterans. The mean age of veterans was 52.53 ± 14.43 years, whereas that for nonveterans was 42.08 ± 17.38 years, and this difference was statistically significant (Mann-Whitney $P < .001$). We noted that male veterans were significantly older than female veterans (Mann-Whitney $P < .001$), and that the opposite relationship held among nonveterans. The proportion of veterans by race also varied significantly (χ^2 test, $P < .001$). Further, Mann-Whitney tests revealed that the ages of veterans and nonveterans within each race were significantly different ($P < .05$) (Table 2).

Flatfoot by gender

The proportions of people with flatfoot stratified by gender are presented in Table 3. The χ^2 test indicated that gender was not a significant factor for flatfoot deformity, until we controlled for all of the other covariates, where gender was observed to have a statistically significant association with flatfoot (OR = 1.23, 95% CI = 1.10–1.39, $P < .001$).

Flatfoot by age

Those with or without flatfoot had mean ages of 45.40 ± 17.76 and 43.70 ± 17.36 years, respectively, and this difference was statistically significant (Mann-Whitney $P < .001$). The mean age of males with flatfoot was 44.20 ± 17.16 years, whereas that for males without flatfoot was 43.14 ± 16.85 years, and this difference was not statistically significant. The mean age of females with flatfoot was 46.44 ± 18.23, whereas that for females without flatfoot was 44.22 ± 17.79

Table 2
The distribution of men, women, and different races in the veteran population, 74721 respondents

	Non-veteran	Veteran	Proportion Veteran	Mean Age: Veteran	Mean Age: Non-veteran	Mann-Whitney P Value
All	62,746	11,975	0.160	52.53	42.08	< .001
Men	23,758	11,424	0.325	52.86	38.51	< .001
Women	38,988	551	0.014	45.62	44.25	.056
Aleutian	451	81	0.152	48.36	38.00	< .001
Asian	1,665	82	0.047	49.76	38.91	< .001
Black	8,246	1,147	0.121	49.67	41.44	< .001
White	51,465	10,596	0.171	52.95	42.41	< .001
Other	882	57	0.061	42.02	36.63	.002
Multiple	37	12	0.245	52.58	39.43	.015

years, and this difference was statistically significant (Mann-Whitney $P < .001$). The difference between the mean ages of males and females with flatfoot was statistically significant (Mann-Whitney $P = .016$); and the difference in ages between males and females without flatfoot was also significant (Mann-Whitney $P < .001$). These findings were indicative of sex confounding the influence of age on flatfoot, with females being older than males and those with flatfoot being older than those without flatfoot. After adjusting for covariates, however, age became a statistically significant factor in regard to the occurrence of flatfoot (OR = 0.99, 95% CI = 0.99–0.99), indicating that increased age decreases the risk of having flatfoot, when all of the other covariate indicators were held constant.

Flatfoot by race

The proportions of flatfoot by race are presented in Table 4. The χ^2 tests revealed a statistically significant difference in the occurrence of flatfoot based on the race of the individual. Specifically, African Americans had a higher prevalence of flatfoot sufferers (proportion = 0.032) as compared with the rest of the populace (proportion = 0.021) ($P < .001$).

Flatfoot by poverty

We looked at the influence of poverty on flatfoot, and made some basic demographic observations. The proportions of poor in the various races were significantly different (χ^2 $P < .001$) (Table 5). When each race was compared against all of the other races grouped together, black individuals displayed a significantly higher prevalence of poverty (proportion of 0.245 versus 0.076), as did Aleuts (0.256 versus 0.096), whereas white individuals displayed a lower prevalence of poverty (0.072 versus 0.222) (all 3 noted comparisons, χ^2 $P < .001$). Furthermore, males and females had significantly different proportions of individuals classified as poor (χ^2 $P < .001$) (Table 6), and veterans were less likely to be poor than nonveterans (χ^2 $P < .001$) (Table 7). Woolf tests revealed that the ORs of occurrence of flatfoot in the poor versus the affluent were consistent across the strata of race, gender, and veteran status. In other words, even though poverty varied by race, gender, and veteran status, it had a consistent relationship with the occurrence of flatfoot.

Table 3
The proportions of flatfoot sufferers in the entire population, and stratified by gender, 74,721 respondents

	No Flatfoot	Flatfoot	Proportion of Flatfoot	OR	RR
All	73,046	1675	0.022		
Men	34,385	797	0.023	1.02	1.02
Women	38,661	878	0.022	0.98	0.98

OR, odds ratio; RR, relative risk.

Table 4
The proportions of flatfoot sufferers by race, 74,721 respondents

	No Flatfoot	Flatfoot	Proportion of Flatfoot
Aleutian	522	10	0.019
Asian	1728	19	0.011
Black	9089	304	0.032
White	60,734	1327	0.021
Other	926	13	0.014
Multiple	47	2	0.041

The proportions of flatfoot by poverty status are presented in Table 8, where it can be seen that χ^2 tests revealed significant differences ($P < .001$). The OR/RR of having flatfoot for the poor versus the affluent is 1.40/1.38. In the regression analyses, poverty became a nonsignificant factor (model OR = 1.12, 95% CI = 0.96–1.31, $P = .148$), in contrast to the results seen with the χ^2 test.

Looking for a possible cause, we found that there was an inter-variable association of poverty and health status (χ^2 $P < .001$). Also, the Spearman correlation coefficient between poverty and health status was 0.137 ($P < .001$). This strong relationship, and the even greater significance of health status with the occurrence of flatfoot, suggests that controlling for health removes the influence of financial status, and that health may confound the effects of financial status. Indeed, whereas Woolf tests indicated homogeneity of ORs for financial status and health status stratified by the other, the Mantel-Haenszel OR for flatfoot in poor versus affluent, stratified by health status, was only 1.21. Further, while a χ^2 test of the association of flatfoot and financial status was significant ($P = .022$) among the unhealthy, it was not significant among the healthy ($P = .231$).

Flatfoot by veteran status

The proportions of flatfoot by veteran status are presented in Table 9. The OR and RR of having flatfoot for veterans over nonveterans were 1.21 and 1.20, respectively. For male veterans, the corresponding numbers were 1.24 and 1.24. For female veterans, the corresponding results were 1.32 and 1.31. A Woolf test revealed homogeneity of ORs for occurrence of flatfoot in veterans versus nonveterans, stratified by gender. Veteran status was significant, as was male veteran (χ^2 $P < .01$), but female veteran status was not, and this was likely attributable to a relatively small number of female veterans. After adjusting for the other variables, veteran status remained significant (OR = 1.25, 95% CI = 1.07–1.44, $P = .004$) in the regression model.

Flatfoot by health status

The proportions of flatfoot by health status are presented in Table 10. A χ^2 test revealed a significant relationship between health status and the occurrence of flatfoot ($P < .001$). The OR and RR of having flatfoot in unhealthy individuals versus those categorized as healthy were 2.19 and 2.14, respectively. Furthermore, 10.53% of males were categorized as unhealthy, whereas 12.76% of females were unhealthy, and this difference was statistically significant (χ^2 $P < .001$). The

Table 5
The proportions of affluence and poverty in each race, 74,721 respondents

	Affluent	Poor	Proportion of Poor
Aleutian	396	136	0.256
Asian	1543	204	0.117
Black	7096	2297	0.245
White	57,581	4480	0.072
Other	776	163	0.174
Multiple	42	7	0.143

Table 6
The proportions of affluence and poverty in the entire population, and stratified by gender, 74,721 respondents

	Affluent	Poor	Proportion of Poor
Male	32,540	2642	0.075
Female	34,894	4645	0.117
All	67,434	7287	0.098

African American population had a significantly higher proportion (0.192) of unhealthy individuals (χ^2 $P < .001$) as compared with the rest of the population (0.106). Further, 13.85% of veterans were unhealthy, whereas 11.30% of nonveterans were unhealthy, and this difference was also statistically significant (χ^2 $P < .001$). Woolf's test revealed homogeneity of ORs for occurrence of flatfoot in healthy versus unhealthy individuals, stratified by race, gender, and veteran status. Indeed, the ORs and RRs of flatfoot in unhealthy versus healthy individuals in nonveterans were 2.33 and 2.27, respectively; and in veterans the values were 1.62 and 1.60, respectively. In males, the OR and RR were 1.76 and 1.73, respectively; and in females the values were 2.57 and 2.50, respectively. This suggested strong effect modification by gender and veteran status on the impact of general health on flatfoot deformity. In all cases, however, the general trend of unhealthy individuals being more prone to flatfoot was preserved.

Flatfoot by industry

In regard to the influence of industry category on flatfoot, the χ^2 test indicated a significant difference ($P < .001$) wherein white-collar workers were more likely to have flatfoot (Table 11).

Flatfoot by BMI

The average BMI of the entire population was 25.10 $\pm$ 4.73. Veterans had a statistically significantly higher BMI in comparison with nonveterans: 26.11 $\pm$ 3.94 versus 24.91 $\pm$ 4.84 (t test, $P < .001$). Males had a significantly higher BMI than did females: 25.75 $\pm$ 4.07 versus 24.52 $\pm$ 5.18 (t test, $P < .001$). There was a statistically significant Pearson correlation (coefficient = 0.124, $P < .001$) between BMI and age. An analysis of variance (ANOVA) also revealed that BMI varied with race ($P < .001$). BMI in those with flatfoot was 26.52 $\pm$ 5.42, in those without was 25.07 $\pm$ 4.71, and this difference was statistically significant (t test and Wilcoxon test $P < .001$). This last relationship, wherein those with flatfoot also displayed a greater BMI, held up when we restricted attention to male, female, veteran, and nonveteran individuals with flatfoot versus those without flatfoot; and the regression analyses revealed a model OR = 1.04 (95% CI = 1.03–1.05).

Other foot pathologies by flatfoot

Of those who suffer from flatfoot, 339 participants in the survey also suffered from pedal calluses, 132 suffered from hammertoe deformity, 187 suffered from bunion deformity, and 156 suffered from arthritis. Model ORs and 95% CIs of flatfoot risk ratios for other foot pathologies as well as the rest of the variables are listed in Table 12. All of the foot pathologies analyzed in this study had a statistically significant association with flatfoot after adjusting for the other covariates.

Table 7
The proportions of affluence and poverty stratified by veteran status, 74,721 respondents

	Affluent	Poor	Proportion of Poor
Non-veteran	55,957	6789	0.108
Veteran	11,477	498	0.042

Table 8
The proportions of flatfoot sufferers stratified by financial status, 74,721 respondents

	No Flatfoot	Flatfoot	Proportion of Flatfoot
Above poverty	65,977	1457	0.022
Below poverty	7,069	218	0.030

Discussion

The national survey that we analyzed here has been analyzed previously by multiple authors (19, 20). For this study, we focused on flatfoot and attempted to identify its risk factors while adjusting for other relevant covariates. As a result, we found that male gender was a significant factor associated with flatfoot deformity. A preponderance of males in the veteran population may be a part of the reason for this. Veteran status was also significantly associated with flatfoot deformity. Because of high incidence of foot problems in new recruits, the government has been using pre-enlistment screening processes, investigations of training programs, a proper shoe-fitting program, and attempts at early detection and treatment of foot problems (21–27). There have been changes in military boot design and training programs in recent years. Newer recruits benefit from more protective and supportive boots and training programs. It should also be noted that the National Health Interview Survey was conducted before the Desert Storm campaigns.

Although age was a statistically significant factor, we did not think it had any clinical importance (OR = 0.99, 95% CI = 0.99–0.99). Pfeiffer et al (2) showed reduction in prevalence of flatfoot in children as they age from 3 to 6 years in Austria. Many of the asymptomatic pediatric flatfeet are thought to achieve structural normalcy in that period (10, 28, 29). In contrast, intuitively, the prevalence of adult-acquired flatfoot should increase with age. It should be noted that the survey that we used for the data analyzed in this article did not distinguish between different types of flatfoot deformities. For this reason, it could have included congenital, iatrogenic, and trauma-induced flatfeet, which may not have had any relationship with age. Therefore, the nature of the survey could have masked the effect of age on adult-acquired flatfoot. The lack of a clinically significant association between age and flatfoot in this study may also be attributable to inactivity, or at least less weight-bearing activity, in the older population, resulting in less weight-bearing stress on the foot. It is interesting to note that Sachithanandam and Joseph (30) observed a similar finding in their study that looked at objectively measuring flatfeet in an Indian population. In that study, the proportion of flatfeet in skeletally mature subjects did not differ significantly between different age groups. Evaluating women older than 40 years in

Table 9
The proportions of flatfoot sufferers stratified both by veteran status and gender, 74,721 respondents

	No Flatfoot	Flatfoot	Proportion of Flatfoot
Male			
Non-veteran	23,258	500	0.021
Veteran	11,127	297	0.026
Female			
Non-veteran	38,126	862	0.022
Veteran	535	16	0.029
All			
Non-veteran	61,384	1362	0.022
Veteran	11,662	313	0.026

Table 10
The proportions of flatfoot sufferers stratified by health status, 74,721 respondents

	No Flatfoot	Flatfoot	Proportion of Flatfoot
Healthy	64,665	1305	0.0198
Not Healthy	8381	370	0.042

England, Hohls-Gatzoulis et al (31) also did not find age to be a significant factor for developing tibialis posterior dysfunction.

BMI, which was closely related to age, also showed a statistically significant association with flatfoot, although the OR of 1.04 indicated that the clinical importance of this association could be trivial. In a pediatric population, Pfeiffer et al (2) found that weight was a significant factor in the occurrence of flatfoot in children between 3 to 6 years of age. Chen et al (32) also noted that obesity was associated with flatfoot in Taiwanese children between 5 and 13 years old. A similar result was found in preschool children in Australia (33). Interestingly, in Turkish adolescents, weight and height were not significant factors related to the occurrence of flatfoot (6). Arangio et al (34) found significantly higher BMI in an adult-acquired flatfoot group compared with a control group without flatfoot. However, the precise meaning of the association was not described, as they did not stratify their analyses on the other variables (in fact, the mean age of the adult-acquired flatfoot group was 51.1 years, whereas that of the control group was 36.7 years). Otsuka et al (35) found a linear correlation between prevalence of flatfoot and BMI in Japanese women older than 60 years, whereas they did not observe such a relationship in men. Moreover, their subjects were mostly blue-collar workers, mainly in the farming industry. Furthermore, the mean BMI for males in their study was 22.3 and that for females was 22.9, and most of their subjects had a BMI between18.5 and 25.0. In our study, veteran status and male gender were statistically significantly associated with flatfoot, and it should be noted that these factors also related to a higher BMI than in nonveterans and females. For this reason, we believe that BMI may be a confounder (significantly associated with the outcome in reality, as well as with another independent variable in the sample, thereby masking the causal effects of the other variable) for the occurrence of flatfoot, rather than a direct causative factor.

We found that African Americans were more prone to flatfoot deformity than other races, whereas Asian Americans were significantly less likely to have flatfeet. In a study published by Stewart in 1970 (36), 98.3% of flatfeet were observed in Congoids (East and West Africans) in a population of 8476 Nigerians that also included Caucasoids, Mongoloids, and mixed racial persons. In that study, moreover, several indices were used to measure the arch height in individuals using lateral weight-bearing plain radiographs. The results showed consistently lower arch height in Congoids, followed by Caucasoids. Mixed races and Mongoloids (which consisted of Chinese and Japanese) consistently had higher arch indices than others. Interestingly, these findings are very similar to what we observed in the current study. In contrast, Igbigbi and Masamati (37) showed that the arch index was significantly higher in Malawians compared with Caucasian Americans. The same authors found that the prevalence of flatfoot in Kenyans was twice that of Tanzanians (38). Combined, these studies display coherence, and speak to the causal relationship between racial background and the prevalence of flatfoot deformity. Abdel-Fattah et al (39) found a strong association (OR = 8.06, 95% CI = 4.55–15.25) between family history and the prevalence of flatfoot in a cross-sectional study of 516 Saudi Arabian army recruits aged 18 to 21 years.

Table 11
The proportions of flatfoot sufferers stratified by industrial backgrounds, 74,721 respondents

	No Flatfoot	Flatfoot	Proportion of Flatfoot
White Collar	51,367	1255	0.024
Blue Collar	21,679	420	0.019

Table 12
Logistic regression model odds ratios (OR), 95% confidence intervals (CI), and *P* values for each covariate examined while controlling for all other covariates, 74,721 respondents

	OR	CI Low	CI High	*P* Value
Male sex	1.23	1.10	1.39	<.001
Age	0.99	0.99	0.99	<.001
African American race	1.27	1.11	1.46	<.001
Asian American race	0.61	0.39	0.97	.035
Multiple race	0.63	0.37	1.11	.114
Aleut American race	0.78	0.41	1.47	.437
Other race	2.23	0.54	9.24	.269
Below poverty	1.12	0.96	1.31	.148
Veteran status (+)	1.25	1.07	1.44	.004
Health status (healthy)	0.62	0.54	0.71	<.001
Blue collar industry	0.82	0.73	0.92	.001
Body mass index	1.04	1.03	1.05	<.001
Callus	3.52	3.09	4.01	<.001
Hammertoe	2.90	2.33	3.62	<.001
Bunion	2.76	2.29	3.32	<.001
Arthritis	2.59	2.12	3.16	<.001

We also noted that poverty became nonsignificant after adjusting for the other covariates; although we found that poverty was closely associated with poor health status, which was a significant factor for predicting flatfoot. Therefore, poverty's relation to health status partially mediated its effects. Alakija (9) studied Nigerian school children of different social backgrounds and suggested that the prevalence of flatfoot was partly attributable to an inability to afford well-fitted shoes. In contrast, others have suggested that wearing shoes in early childhood was associated with the occurrence of flatfoot (11, 30, 39).

Interestingly, blue-collar workers in our study had a lower prevalence of flatfoot. This would contradict the common knowledge that overuse or strenuous activities causes flatfoot. However, it has been documented that prolonged weight bearing is unlikely to cause flatfoot (30).

All the foot pathologies analyzed in the current study were statistically significantly associated with flatfoot with high ORs and tight CIs. People with calluses were 3.5 times as likely to have flatfeet, and those with bunion or hammertoe deformities are also approximately 3 times more likely to have flatfeet. Arthritis was also a significant risk factor for flatfoot (OR = 2.5). This is consistent with the well-accepted theory that forefoot instability can be caused by a pronated foot, which contributes to the formation of bunion and hammertoe deformities. Also, such malalignment can cause arthritis and biomechanical skin lesions.

The major weakness of this secondary data analysis is that all the foot pathologies are self-reported. Lesser accessibility to health care professionals may falsely reduce the prevalence of the pathologies noted. This may bias against our result that people who were unhealthy (or below poverty) were more likely to have flatfoot. On the other hand, those in poverty may have had a larger number of untreated cases that could have shown up more frequently in the survey. We believe disparity in prevalence of flatfoot in various epidemiological studies comes from inconsistency in regard to the definition of flatfoot, age groups, and the universe in which each study was conducted. It should again be remarked that the survey we used was conducted in the United States and flatfoot was self-reported. Also, it should be noted that we excluded those who were 17 years of age or younger. This may have resulted in oversampling of adult-acquired flatfeet. Although these procedures can be weaknesses of the study, they were likely to have had several effects: (1) we probably left out more asymptomatic flatfeet because people were less likely to report deformity if asymptomatic, (2) it is likely that our results provide relevant information for clinicians who practice in the United States, and (3) we were likely to have left out those physiological pediatric flatfeet that would not have manifested in adulthood. For these reasons, we believe that the results of this investigation provide relevant information for those who encounter symptomatic adult flatfeet in the United States, as long as the user understands the potential limitations related to diversity in an individual's perception of health problems, race, religion, and language in the United States.

In conclusion, we undertook a secondary analysis of previously procured national cross-sectional data. As this was a cross-sectional study, causal relationships could not be determined. However, we may able to suggest that prevention or treatment of flatfeet may reduce the incidence of calluses, bunion, hammertoe, and arthritis. We can also possibly infer that people with flatfeet are more likely to be unhealthy. Therefore, prevention or treatment of flatfeet may also have a role in the improvement of the overall health of an individual.

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