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Hip Axis Length Variation: Its correlation to anthropometric measurements in women from three ethnic groups

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Abstract

Introduction—Hip axis length (HAL) has been reported to be an independent predictor of hip fracture. Significant ethnic differences in HAL have been noted, but no direct comparison has been made between African-American, Mexican-American, and non-Hispanic white women using the same protocol.

Methods—We compared 157 non-Hispanic white women from the Rancho Bernardo Study, 292 women from the Health Assessment Study of African-American Women, and 210 women from the Skeletal Health of Mexican-American Women Project. A standardized questionnaire was used to obtain medical history; height, weight, waist girth, and hip girth were measured; and percent body fat and HAL were obtained using dual energy x-ray absorptiometry. All HAL comparisons were adjusted for maximum hip girth to control for differences in size magnification by fan-beam absorptiometry.

Results—Though there were ethnic differences in the unadjusted HAL measurement, after adjusting for hip circumference, there were no residual differences in HAL by ethnicity: 10.7 cm in Mexican-American women vs. 10.8 in non-Hispanic white women and African-American women (p=0.61)

Conclusions—There were no ethnic differences in HAL in women from the 3 ethnic groups. Differences in fracture risk among these groups cannot be explained by ethnic differences in HAL.

Keywords

ethnic differences; hip axis length; hip fracture; women; hip geometry

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Introduction

Hip fractures are an important cause of morbidity and mortality in older women. Although low bone mineral density (BMD) at the hip is the most commonly used predictor of hip fracture, hip axis length (HAL) has been shown to predict hip fracture independent of age and BMD (1-6). Boonen and associates (4) reported that HAL had greater sensitivity and specificity than BMD for predicting fracture risk. All three studies (1,3,4) that reported associations of age, body size and body composition with HAL, found that only height was positively correlated with HAL. Other studies reported a lower hip fracture rate with shorter HAL suggesting that HAL might be associated with the large variation in hip fracture rates across countries (2,7). Faulkner and colleagues (1,8) hypothesized that a longer HAL may cause the greater trochanter to protrude further beyond the pelvis, creating a vulnerable target for impact from a fall.

The purpose of the present study was to determine the effect of height and other anthropometric measurements on HAL among African-American, Mexican-American, and non-Hispanic white women. Identical protocols were used to search for possible differences among these three ethnic groups. It is known that rates of hip fractures vary in these groups, being highest in non-Hispanic white women, intermediate in Mexican-American or Hispanic women, and lowest in African-American women.

Methods

Women studied were community-dwelling, ambulatory, San Diego residents from three ethnic groups. African-American women (n=292), aged 51−80 years, were volunteers in the Health Assessment Study of African-American Women (HASAAW) recruited between October 1992 and January 1996 via focused marketing efforts targeting community-based organizations, university employee programs, civic groups, businesses, personal networks, and churches. Mexican-American women (n=210), aged 46−84 years, were volunteers recruited from July 1995 to July 1996 from church groups, participant referrals, newsletters, and clinics that serve Hispanics. Three-quarters of these women were born in Mexico and the rest in the United States; in this paper all are referred to as Mexican American. The women born in Mexico had lived an average of 28 years in the U.S., and the majority had immigrated as adults. Overall, independent of birthplace, these Mexican-American women had lived an average of 36 years in the U.S. Non-Hispanic white women (n=157), aged 37−87 years, were members of a geographically defined community-based cohort, the Rancho Bernardo Study, and were studied between February 1992 and November 1996.

All participants completed a standardized questionnaire on medical history; their height, weight, and waist and hip girths were measured; and their percent body fat and hip geometry (HAL) ascertained. For the Mexican-American cohort, questionnaires and informed consent documents were translated into Spanish and administered by a Mexican-born, native Spanish-speaking female interviewer. Participants were allowed to choose either the Spanish or English version of the self-administered portion of the questionnaire.

Physical measurements

Height (cm) was determined by a stadiometer to the nearest 0.1 cm, and weight was assessed using a regularly calibrated scale to the nearest 0.1 kg. Body mass index (BMI) was calculated as weight (kg) divided by height (m^2) Circumference measurements (waist girth, iliac crest girth, and maximum hip girth) were measured in centimeters at the trunk bending point (used as the measure of waist girth), at the iliac crest, and at the maximum hip circumference using a cloth measuring tape. Because measurements of hip circumference may reflect differences in hip girdle characteristics and surrounding soft tissue mass among women with similar body types (8,9), measurements at both the iliac crest and maximum hip circumference were used

to assess HAL associations with hip circumference. Waist to hip ratio was calculated as the waist girth divided by maximum hip circumference in cm, multiplied by 100. Participants in each ethnic group had body size measurements made by trained personnel, with participants wearing light clothing and no shoes.

Femoral geometry

HAL was measured at the right hip (unless there was hip surgery) using dual energy x-ray absorptiometry (DXA) fan-beam mode (Hologic QDR-2000, Waltham, MA.) One hip has been shown to be representative of HAL at both hips.(10,11) The manufacturer's lower extremity positioning tool was used to standardize femoral positioning during DXA scanning, to avoid femoral positioning variations that can distort HAL measurements(12). All HAL data were obtained using a standard software program provided by the manufacturer, in which the distance along the femoral neck axis from the base of the greater trochanter to the inner pelvic brim is measured directly from the conventional DXA scan.

Because we were not able to directly correct for the magnification error associated with the fan beam DXA(13) we adjusted HAL comparisons for hip size; adjusting for maximal hip girth should control for fan-beam magnification differences between women, since the magnification is proportional to the distance of the femoral neck from the scan table, and this distance is proportional to maximal hip girth. If hip fracture risk in women with larger HAL results predominantly from protrusion of the greater trochanter beyond the pelvis, then it is important to control for inter-individual differences in pelvis width. Adjusting for maximum hip girth also achieves this control.

Other measurements

Body fat was estimated from whole body DXA, which distinguishes body composition by the different X-ray attenuation properties of fat, lean soft tissue, and bone. Each component was expressed as a percent of total body composition (14).

Scans were standardized daily against a phantom, with a precision error of 1%. Precision errors for fat mass and total percent body fat were approximately 1.2% or less. All scans were administered by certified bone density technologists.

Statistical Analysis

A generalized linear model was used to compare unadjusted and age-adjusted mean values for body size variables across ethnic groups using SPSS (version 12) (15). Data were age-adjusted to control for age differences between ethnic groups. A similar model was used to compare HAL between ethnic groups adjusted by each one of the anthropometrical measurements. A p-value of ≤ 0.05 was used for tests of statistical significance and 95% confidence intervals were calculated for all means.

Results

The 659 women evaluated for HAL and anthropometric measurements included: 157 non-Hispanic whites (mean age 53.9, 95% Cl 52.9−55.0); 210 Mexican Americans (mean age 63.4, 95% Cl 62.4−64.3); and 292 African Americans (mean age 60.5, 95% Cl 58.7−61.3). Non-Hispanic white women were significantly younger than either group of ethnic minority women.

Age-adjusted body measurements for non-Hispanic white, Mexican-American, and African-American women are compared in Table 1. On average, Mexican-American women were significantly shorter (155.5 cm) than non-Hispanic white (163.0 cm) and African-American women (162.2 cm). The average weight in non-Hispanic whites (66.3 kg) was significantly

lower compared to African-American women (79.5 kg); Mexican-American women (70.0 kg) were of intermediate weight. Body mass index was significantly greater in African Americans (30.3 kg/m^2) compared with non-Hispanic whites (25.0 kg/m^2), again with intermediate values for Mexican Americans (29.0 kg/m^2). Percent body fat was greater in African-American (37.3) and Mexican-American women (37.0) than in non-Hispanic white women (34.0). Iliac crest girth in the African-American (88.7 cm) and Mexican-American (88.7 cm) women was significantly higher than in non-Hispanic whites (78.0 cm) ($p>0.001$). Maximum hip girth was greatest in the Mexican Americans (108.3 cm) followed by African Americans (106.9 cm) and non-Hispanic whites (102.1 cm). Central adiposity assessed by waist to hip ratio was significantly greater in the Mexican Americans (0.87) than in African Americans and non-Hispanic whites (0.82).

Table 2 shows hip axis length values adjusted for maximum hip girth were almost identical for each ethnic group: African-American women (10.8 cm), non-Hispanic white (10.8 cm), and Mexican-American women (10.7 cm). No significant differences were found among the groups ($p=0.61$). Because height, weight, and other anthropometric measurements are associated with ethnicity, we adjusted the HAL for these covariates. Differences were found in height-adjusted HAL and percent of body fat-adjusted HAL, but these results are difficult to interpret given that they were not adjusted for maximal hip girth and might reflect a magnification error, since Mexican-American and African-American women had significant differences in some of the anthropometric measurements.

Discussion

In previous studies of HAL and body size parameters in African-American, Asian, Mexican-American and other Hispanic, and non-Hispanic white women, aged 50 and older (2,3,8,16), HAL was reported to be longest in non-Hispanic white women, followed in decreasing order by African-American and Mexican-American women (2,3,16). This previously reported pattern of HAL ethnic differences was not observed in the present study where HAL adjusted measurements were similar in the three ethnic groups. Two studies have reported HAL measurements in Hispanics and Mexican Americans: Wang and colleagues (8) studied a young (9 to 29 years old) population of 103 non-Hispanic whites, 115 non-Hispanic blacks, 102 Hispanics (Mexican Americans among other Hispanics in this sample), and 103 Asians; they reported that mean HAL was longer in non-Hispanic white than Asian or Hispanic girls at all stages of puberty. In another study, HAL in 152 postmenopausal Mexican-American women (52 to 84 years) was similar to that of African Americans or Asian Americans, and significantly shorter than for non-Hispanic whites (3).

In the present study HAL measurements were similar within the three ethnic groups, in contrast with the results of other studies where Mexican Americans showed a shorter or similar HAL to that of African Americans. The explanations for this discrepancy with published studies could be related to several factors, such as inclusion or exclusion of covariates like height (3), or factors related to acculturation of Mexican Americans or their geographical sites of origin within Mexico. Northern Mexican women are taller and heavier and have greater bone density than central or southern Mexican women (17). Unfortunately, we have no information regarding the birth site locations of the Mexican-American women in our study. Because only two other studies have reported HAL in adult Mexican Americans to date, and with contradictory results, further research on Mexicans living in the U.S. and Mexicans living in Mexico is needed.

Although is clear that the three different ethnic groups had differences in anthropometric measurements as seen in Table 1, these differences had no impact in HAL length. Technical reasons might also explain some differences, because different equipment and techniques were

used to measure HAL in different studies across different populations (e.g., print-outs vs. software buildup of HAL measurements, as well as different generations of Lunar and Hologic bone scanners). In the present study, all women were analyzed using the same model DXA scanner.

Among the ethnic groups studied here, based on published reports, the lowest risk of hip fracture is in African Americans, and the highest risk in non-Hispanic whites(18). Shorter HAL is reported for African Americans and longer HAL for white Caucasians(2). An intermediate rate of hip fractures has been found in Asians and Mexicans(19) HAL has been reported to be shorter in Asian populations, and no data regarding HAL in Mexicans living in Mexico have been published. It is plausible that extra hip padding and shorter height may lower risk of fractures despite the HAL measurements. However, it has been reported recently that Hispanics living in the U.S. have the same risk of hip fractures as non-Hispanic whites (18), and that the risk of hip fractures has increased in Hispanics living in the U.S.; the reason for this increment in this minority group is not clear yet. The term Hispanics is a broad ethnic categorization with no distinction of ethnic background. Is not clear how many of the Hispanic individuals in the previous studies were Mexican Americans (20). It is difficult to hypothesize that these changes in the prevalence of hip fracture are due to HAL; the present cross-sectional study provides no information on fractures. The migration of Mexican Americans might not reflect genetic background. It seems likely that other environmental or life-style factors account for differences in Mexican immigrants to the United States.

Hip fracture rates increase in association with low BMI and low percent body fat in non-Hispanic white women (9), and rates are lower in African-American women who tend to have a higher BMI and percent body fat (21). Decreased hip fracture rates in African-American women, versus non-Hispanic whites (22-24), have been postulated to be in part due to increased BMI and adiposity (22), reflecting either increased estrogen production in fat cells (25) or increased bone mineral mass in weight-bearing bones (26). BMD has not been shown to correlate with HAL (2).

Mikhail and colleagues (16) found no significant height differences between premenopausal African-American and non-Hispanic white women, but African-American women were heavier than non-Hispanic whites. In the present study, body size measurements (weight, body mass index, percent body fat) were highest in African-American, intermediate in Mexican-American, and lowest in non-Hispanic white women, corroborating the data observed in the Mikhail study.

There are some limitations to our study. The measurements of HAL and adjustments made may make comparisons with other studies problematic. It is possible that adjusting for maximum hip girth is an over-adjustment for magnification differences. As in other studies of U.S. ethnic minority groups, participants were volunteers, not a representative sample. Volunteers tend to be better educated and healthier than the general population. Selection bias could have occurred if women with a personal or family history of fractures were more likely to participate; this bias should have been minimized because women were recruited to the present study for general health, not osteoporosis.

In conclusion, this study showed there were no ethnic differences in HAL among the groups of non-Hispanic white, Mexican-American, and African-American women. Differences in the risk of hip fracture probably involve other risk factors. Anthropometric differences among groups are present, and might play a bigger role than HAL in the occurrence of fracture in different ethnic groups.

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Table 1

Age and body size measurements by ethnic group (body size measurements are "age-adjusted").

Variables	Non-Hispanic White N=157		Mexican American N=210		African American N= 292	
	mean	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**
Age (years)	53.9	(53.0−54.8)	63.4***	(62.4−64.3)	60.5***	(59.7−61.3)
Height (cm)	163.0	(161.9−164.2)	155.5***	(154.6−156.5)	162.2*	(161.4−163.0)
Weight (Kg)	66.3	(63.7−68.8)	70.0***	(67.9−72.1)	79.5***	(77.8−81.2)
BMI (Kg/m^2)	25.0	(24.0−25.9)	29.0***	(28.2−29.7)	30.3***	(29.6−30.9)
% Body fat (DXA)	34.0	(32.8−35.3)	37.0***	(36.0−38.0)	37.3***	(36.5−38.2)
Iliac Crest Girth (cm)	78.0	(76.0−80.1)	88.7***	(87.0−90.4)	88.7***	(87.3−90.1)
Max. Hip Girth (cm)	102.1	(100.4−103.8)	108.3***	(106.9−109.7)	106.9***	(105.7−108.0)
Waist- Hip Ratio:	0.82	(0.81−0.83)	0.87***	(0.86−0.88)	0.82*	(0.81−0.83)

* $p < 0.01$ Reference group Mexican Americans vs. African Americans

*** $p < 0.001$ Reference group non Hispanic whites vs. Mexican Americans and African Americans.

Table 2

Hip axis length values with adjustments for body size measurements by ethnic group.

Variables	Non-Hispanic White n=157		Mexican American N=210		African American n= 292	
	Mean	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**
Max. Hip Girth (cm)-adjusted HAL	10.8	(10.7−10.9)	10.7	(10.6−10.8)	10.8	(10.7−10.9)
Height - adjusted HAL	10.6	(10.5−10.7)	10.9*	(10.8−11.0)	10.7++	(10.7−10.8)
Weight - adjusted HAL	10.8	(10.7−10.9)	10.7	(10.6−10.8)	10.7	(10.7−10.8)
BMI - adjusted HAL	10.7	(10.6−10.8)	10.7	(10.6−10.8)	10.8	(10.7−10.9)
% Body fat - adjusted HAL	10.7	(10.6−10.8)	10.7	(10.6−10.8)	10.8++	(10.8−10.9)
Iliac girth - adjusted HAL	10.7	(10.6−10.9)	10.7	(10.6−10.8)	10.8	(10.7−10.9)
Waist - Hip Ratio:-adjusted HAL	10.8	(10.6−10.9)	10.7	(10.6−10.8)	10.8	(10.7−10.9)

*p< 0.05 reference group non-Hispanic white vs. Mexican American and African American

++p< 0.05 reference group Mexican American vs. African American