Ambulatory Activity and Body Mass Index in White and Non-White Older Adults

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Background: The purpose of this study was to examine the extent to which physical activity (PA) is related to obesity in older adults when accounting for race/ethnicity. Methods: Cross-sectional data were collected on 214 older adults (72.3 ± 8.9 y; body mass index [BMI] 28.9 ± 6.0; 151 females; 96 non-White). Measures of body height and mass were collected; BMI was calculated. PA was assessed via an electronic pedometer worn for seven consecutive days. Results: “White” subjects accumulated 5036 ± 286 steps/d. “Non-White” subjects accumulated significantly fewer steps/d (3671 ± 253 steps/d; z = –3.45, P = 0.001). Race/ethnicity, income, age, gender, and steps/d accounted for 27.4% (P < 0.001) of the variance in BMI, with steps/d accounting for 21.2% (P < 0.001). The most influential factor in this model was PA level (β = –0.510), followed by age (β = –0.220), and finally gender being the least influential, but still a significant factor (β = 0.168). Conclusion: Although race/ethnicity and income have been associated with obesity levels, this study shows that older adults who accumulate more ambulatory activity tend to have healthier levels of BMI irrespective of race/ethnicity or income.

Key Words: steps, physical activity, pedometer, obesity, ethnicity

Racial/ethnic disparities exist in prevalence rates of obesity. Epidemiological research has demonstrated that obesity levels tend to be higher in minority populations such as African Americans and Hispanics.1-4 A number of current theories attempt to explain this phenomenon, including a dissimilarity in resting metabolism,5-10 differing socioeconomic factors,11-13 genetic variation,12,14 cultural attitudes toward obesity and body image,15 and level of physical activity (PA).16-20 Although research has shown these factors contribute to, or are related to higher levels of obesity, the majority of these factors, with the exception of PA level, are not easily altered. Therefore, PA is a likely tool to assist in the prevention and treatment of obesity.
Low levels of PA may increase the likelihood of overweight and obesity by gradually creating and sustaining an energy surplus. Population-based research relying on self-reported PA has shown that Black/African American, American Indian, Alaska native and Hispanic/Latino individuals participate in less intentional exercise compared with White individuals. Similarly, studies employing objectively determined total daily walking levels (via electronic pedometer) have demonstrated that “non-White” adults engage in less total walking on a daily basis compared with “White” adults. Specifically, Tudor-Locke et al. showed White subjects walked 1836 more steps/d, or just under one additional mile (assuming 2000 steps/mile) than African American subjects. Another study using similar technology found comparable results with White subjects accumulating 6051 steps/d and Black subjects accumulating 1363 fewer steps/d. Collectively, it is not clear whether this difference in PA can account for the difference in obesity level equally for different racial/ethnic groups.

Research has demonstrated a significant negative relationship between the amount of walking performed and body mass index (BMI) of adults, with those individuals accumulating more steps/d having lower BMI levels ($r = -0.401$ for both genders, $r = -0.417$, for women only). In addition to correlational data, research has shown a significant mean difference between the number of steps accumulated by a normal BMI group (mean ± standard deviation: 7029 ± 3857 steps/d) and an obese group (mean ± standard deviation: 4618 ± 3359 steps/d) of adults. Research has not examined how race/ethnicity impacts this relationship between PA and obesity level.

After the age of 55 y, the negative side effects of being overweight or obese do not subside. In fact, being overweight or obese can exacerbate current health challenges and increase the likelihood of developing a chronic disease for which an older individual may already be at risk. Self-reported obesity has been associated with lower health perception and poorer physical functioning in older adults ($\geq 65$ y). Individuals over the age of 65 y, irrespective of race/ethnicity, have been shown to be less active than their younger counterparts, with older adults taking an average of 3766 ± 2805 steps/d (mean ± standard deviation) less than younger individuals. Although there is evidence to support a negative relationship between walking and BMI in a general adult population, little is known about this relationship in adults over the age of 55 y. Therefore, it is important to evaluate the relationship between obesity and PA in this sub-group of the population.

Furthermore, although research has focused on the relationship between race/ethnicity and obesity, race/ethnicity and PA, and obesity and PA, there is a paucity of knowledge between the inter-relationships between race/ethnicity, obesity, and PA. In addition, little information is known about this relationship in older adults from various racial/ethnic backgrounds. Therefore the purpose of this study is to examine the relationship between race/ethnicity, obesity, and PA in adults age 55 y or older. Specifically, we examined the extent to which PA affects obesity, when accounting for race/ethnicity. To test these questions, height, mass, BMI, and 7-d pedometer monitoring were assessed in a group of older adults age 55 y or older. Given the high prevalence of obesity and physical inactivity in the older adult population, identifying variables that contribute to obesity and the racial/ethnic disparity in obesity is an important research priority.
Research Design and Methods

Subjects

Two-hundred and fourteen adults age 55 y or older (63 males, 151 females; 72.3 ± 8.9 y; age range 55 to 94 y), free of any disease or condition that may affect PA levels, volunteered for participation in this study. Subjects were recruited by posted flyers at local senior centers, churches, and other public places, as well as by word of mouth. Each subject read and signed an informed consent document approved by the university institutional review board prior to participation. Subjects were excluded from the study if they had any limitations to walking or had any condition or disease that would put them at risk while walking.

Study Design

All subjects underwent baseline anthropometric assessments including height and mass. After the initial assessment, volunteers were asked to wear a sealed pedometer for a consecutive 7-d period. Subjects were asked not to open the sealed pedometer and therefore did not record daily steps. Following the 7-d PA monitoring period, subjects returned the pedometer and total steps taken during the 7-d period were recorded by the researcher.

Measurements

Information on race/ethnicity, occupation, and income was collected via self-report questionnaire. Individuals were asked to classify themselves as “White,” “American Indian,” “Asian,” “Black/African American,” “Hispanic,” or “Native Hawaiian/Pacific Islander.” There were no subjects that self-reported being Native Hawaiian/Pacific Islander. Individual’s self-reported income was collected in eight categories (< $5,000; $5,000 to $9,999; $10,000 to $14,999; $15,000 to $19,999; $20,000 to $29,999; $30,000 to $39,999; $40,000 to $49,999; and > $50,000). Only 171 subjects provided information on income. The majority of the population was retired, therefore occupation was not used in statistical assessments.

Body mass and height were measured with minimal clothing and no shoes. Body mass was measured to the nearest 0.01 kg using a physician’s balance beam scale (Continental Scale Corp., Bridgeview, IL) and height was measured to the nearest 0.1 cm using a stadiometer (Continental Scale Corp.). Body mass index (BMI) was calculated according to the formula body mass (kg) divided by height squared (m$^2$). For all analysis based on categorization of BMI, BMI for the White, Black/African American, American Indian, and Hispanic subjects was classified according to the NHLBI Obesity Education Initiative Expert Panel on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults, where normal BMI = 18.5 to 24.9, overweight: BMI = 25 to 29.9, and obese: BMI = greater than or equal to 30. For all analysis based on categorization of BMI, the BMI of the Asian subjects was categorized according to the Western Pacific Region of the World Health Organization, where normal BMI = 18.5 to 22.9, overweight: BMI = 23.0 to 24.9, and obese: BMI
greater than or equal to 25. The differing categorization scheme for BMI of Asian subjects was based on research finding that the relationship between BMI and body composition is different for Asians versus non-Asians, with Asians having higher body fat and visceral fat at a lower BMI compared with non-Asians.26, 27

**Pedometer Assessment**

Electronic pedometers (model SW-200, Yamax Corp., Tokyo, Japan) were used to count steps for a consecutive 7-d monitoring period. Previous research has shown the Yamax pedometer to be a valid and reliable method of recording steps in individuals of varying body sizes.28-30 Validity of pedometers has not been assessed specifically in older adults. However, before each monitoring period, individualized pedometer calibrations were completed to assess the functional status of each pedometer. The pedometer calibration included taking 20 steps at each subject’s normal walking speed and then comparing the steps counted by the pedometer with manually tallied steps. Pedometer counts ranging from 19 to 21 were deemed acceptable. Subjects were instructed to place the pedometer on the right side of the body on a belt or the waistband of the individual’s clothing, on the anterior midline of the thigh, immediately upon waking in the morning. Pedometers were worn during all waking hours, except when bathing or swimming, and removed just before going to sleep at night. Subjects were asked not to open the pedometer and therefore were not able to see the amount of steps taken each day and did not record daily steps taken. At the end of the 7-d assessment period, each subject returned their pedometer and a researcher recorded total steps taken for the 7-d period. Subjects were categorized into steps/d quartiles (quartile 1: ≤ 2401 steps/d (n = 14 males, n = 39 females), quartile 2: 2402 to 3707 steps/d (n = 16 males, n = 36 females), quartile 3: 3708 to 5741 steps/d (n = 15 males, n = 38 females), quartile 4: ≥ 5742 steps/d (n = 18 males, n = 34 females), based on average steps/d, with an even number of subjects in each quartile.

**Statistical Analysis**

Descriptive statistics were run on all variables. Variables listed in Table 1 are expressed as mean ± standard deviation; all other data are reported as mean ± standard error. Normality of data was assessed using histograms and tests of skew. Because some racial/ethnic groups had a limited sample, the subjects were dichotomized into two groups: White (including only those individuals who self-reported their race/ethnicity being “White”) and non-White (including only those individuals who self-reported their race/ethnicity being “American Indian,” “Asian,” “Black/African American,” or “Hispanic”). Mann-Whitney tests were conducted to compare accumulated steps/d, as a continuous variable, between White and non-White subjects, and to compare BMI values, as a continuous variable, between White and non-White subjects. Hierarchical regression was performed on normalized data (BMI and steps/d were transformed by square root to normalize the distribution) to explore the contribution of steps/d, as a continuous variable, to BMI, as a continuous variable, while controlling for race/ethnicity, gender, income and age. Finally, Kruskall-Wallis analysis was performed to detect differences in BMI level as a continuous variable across quartiles of activity and differences in
steps/d as a continuous variable across BMI categories. Analyses were performed using SPSS version 12.0 for Windows (SPSS, Inc., Chicago, IL), and the alpha level was set at 0.05.

## Results

Subject characteristics are displayed in Table 1. Fifty-five percent of the study population was White, 4% were Black/African American, 17% were Asian, 17% were Hispanic, and 7% were American Indian. Most subjects were women (71%), lived with someone (53%), were not married (55%), did not smoke (93%), and earned less than $20,000/y (82%) (data not shown).

### Pedometer Determined Steps/d

All subjects combined accumulated 4424 ± 199 steps/d, with a range of 878 to 14,158 steps/d (Figure 1). Median steps/d accumulated was 3656. After dichotomizing the entire sample into racial/ethnic categories, the individuals who classified themselves as “White” accumulated an average of 5036 ± 3106 steps/d, with a range of 878 to 14,102 steps/d and median steps/d accumulated were 4199. Individuals classifying themselves as non-White accumulated significantly less \((z = -3.45, P = 0.001)\) steps/d with an average of 3671 ± 2481 steps/d and a range of 943 to 14,158 steps/d and 3100 steps/d as a median. Further analysis of the non-White category showed American Indian subjects accumulated 3104 ± 4091 steps/d (median: 2699 steps/d), Asian subjects accumulated 3994 ± 370 steps/d (median: 3333 steps/d), Hispanic subjects accumulated an average of 3830 ± 491 steps/d (median: 3155 steps/d), and Black/African American subjects accumulated an average of 2549 ± 809 steps/d (median: 1710 steps/d).

### Body Mass Index

When examining the entire sample, 54 subjects (25%) were classified as normal BMI, 25, 26 85 of the subjects (40%) were classified as overweight, 25, 26 and 75 (35%) were classified as obese. 25, 26 The average BMI for the entire sample was 28.9 ± 0.4. When examining the White group, 33% \((n = 39)\) of individuals were classified as having a normal BMI, 36% \((n = 42)\) were classified as overweight, and 31% \((n = 37)\) were classified as obese. In the non-White group, 15.6% \((n = 15)\)
individuals were classified as having a normal BMI, 44.8% \((n = 43)\) were classified as overweight, and 39.6% \((n = 38)\) were classified as obese. The average BMI for the non-White group \((29.6 ± 0.7)\) was not significantly different than the White group \((28.3 ± 0.5; z = –1.575, P = 0.115)\). Further examination of the non-White group shows the American Indian subjects \((n = 15)\) had an average BMI of 36.7, the Asian/Hmong group \((n = 36)\) had an average BMI of 26.7, the Hispanic group \((n = 37)\) had an average BMI of 29.5, and the Black/African American group \((n = 8)\) had an average BMI of 29.6.

**Relationship Between Body Mass Index and Steps per Day by Race/Ethnicity**

For the group as a whole, a significant difference was present in the number of steps/d taken by normal BMI, overweight, and obese individuals \((\chi^2 = 48.6, P < 0.001)\). Individuals in the normal BMI group took an average of 6769 ± 471 steps/d. Subjects in the overweight group took an average of 4166 ± 261 steps/d. Finally, subjects in the obese BMI category accumulated an average of 3027 ± 210 steps/d.

Hierarchical regression analysis was performed on transformed data to determine the contribution of steps/d to BMI after controlling for race/ethnicity, income, age, and gender (Table 2). Gender was included in the model because a significant gender difference in BMI \((z = –2.15, P = 0.031)\) was present in this study population, with females having a higher BMI. Race/ethnicity, income level, age, gender, and steps/d accounted for 27.4% \((P < 0.001)\) of the variance in BMI, with steps/d significantly accounting for 21.2% \((P < 0.001)\) of the variance in BMI after
Table 2  Summary of Hierarchical Regression Analysis for Variables Predicting Body Mass Index (N = 171)

<table>
<thead>
<tr>
<th>Variable</th>
<th>$R^2$</th>
<th>$R^2$Δ</th>
<th>$F$Δ</th>
<th>Sig $F_\Delta$</th>
<th>$B$</th>
<th>SE $B$</th>
<th>$\beta$</th>
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<tr>
<td>Step 1</td>
<td>0.000</td>
<td>0.000</td>
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<td>0.803</td>
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<td>0.362</td>
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<td>-0.019</td>
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<td>Step 2</td>
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<tr>
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<td>Step 3</td>
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<td>0.007</td>
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<td>0.268</td>
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<td>0.427</td>
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<td>Income level</td>
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<tr>
<td>Step 4</td>
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<td>0.040</td>
<td>7.16</td>
<td>0.008</td>
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<td>0.420</td>
<td>-0.076</td>
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<td>Income level</td>
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<tr>
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<td>-0.091</td>
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<tr>
<td>Gender</td>
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<td>Step 5</td>
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<td>0.371</td>
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<td>0.371</td>
<td>-0.098</td>
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<td>Income level</td>
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<tr>
<td>Age</td>
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<td>0.049</td>
<td>-0.220*</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>2.28</td>
<td>0.912</td>
<td>0.168*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steps/d</td>
<td>-0.001</td>
<td>0.000</td>
<td>-0.510*</td>
<td></td>
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</tbody>
</table>

*p < 0.05

Table 3  Body Mass Index (kg/m²) by Race/Ethnicity and Steps/d Quartiles

<table>
<thead>
<tr>
<th>Race/Ethnicity</th>
<th>Quartile 1: (\leq 2339) steps/d</th>
<th>Quartile 2: 2340-3656 steps/d</th>
<th>Quartile 3: 3657-5663 steps/d</th>
<th>Quartile 4: (\geq 5664) steps/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>All * (N = 214)</td>
<td>33.5 ± 1.0 (n = 54)</td>
<td>28.7 ± 0.7 (n = 53)</td>
<td>27.7 ± 0.6 (n = 55)</td>
<td>25.5 ± 0.5 (n = 52)</td>
</tr>
<tr>
<td>White * (n = 118)</td>
<td>33.0 ± 1.2 (n = 25)</td>
<td>28.6 ± 1.1 (n = 23)</td>
<td>27.7 ± 0.8 (n = 31)</td>
<td>25.7 ± 0.6 (n = 39)</td>
</tr>
<tr>
<td>Non-White * (n = 96)</td>
<td>34.0 ± 1.5 (n = 29)</td>
<td>28.8 ± 0.9 (n = 30)</td>
<td>27.7 ± 0.8 (n = 24)</td>
<td>24.9 ± 1.2 (n = 13)</td>
</tr>
<tr>
<td>American Indian (n = 15)</td>
<td>46.8 ± 2.5 (n = 5)</td>
<td>32.7 ± 2.9 (n = 5)</td>
<td>30.7 ± 0.6 (n = 4)</td>
<td>30.1 (n = 1)</td>
</tr>
<tr>
<td>Asian (n = 36)</td>
<td>30.3 ± 2.1 (n = 6)</td>
<td>26.1 ± 0.8 (n = 15)</td>
<td>28.0 ± 1.3 (n = 9)</td>
<td>22.2 ± 1.0 (n = 6)</td>
</tr>
<tr>
<td>Hispanic (n = 37)</td>
<td>31.9 ± 1.7 (n = 13)</td>
<td>32.1 ± 1.6 (n = 8)</td>
<td>26.2 ± 1.3 (n = 11)</td>
<td>26.0 ± 2.0 (n = 5)</td>
</tr>
<tr>
<td>Black/African American (n = 8)</td>
<td>31.2 ± 1.9 (n = 5)</td>
<td>25.3 ± 0.6 (n = 2)</td>
<td>30.5 (n = 0)</td>
<td>30.5 (n = 1)</td>
</tr>
</tbody>
</table>

Values are means ± SD. *p < 0.05, significant difference across groups.
the effects of race/ethnicity, income, age, and gender were statistically controlled. Age, gender, and steps/d level made a statistically significant contribution to the variance in BMI. The most influential factor in this model was steps/d (β = -0.510), followed by age (β = -0.220), and finally gender being the least influential, but still significant, factor (β = 0.168).

Table 3 displays the average BMI data for each step quartile and racial/ethnic category. There was a significant difference in BMI across step quartiles for the entire sample ($\chi^2 = 49.0$, $P < 0.001$), for the White group ($\chi^2 = 25.5$, $P < 0.001$), and for the non-White group ($\chi^2 = 19.5$, $P < 0.001$). For the entire sample, White group and non-White group, the lowest activity level had the highest BMI, and the highest activity level had the lowest BMI.

Discussion

Population-based research has linked race/ethnicity with obesity levels. Specifically, African American women, and Hispanic men and women tend to have higher BMIs than their White counterparts. Researchers have proposed many explanations for the difference, including differences in resting metabolism, socioeconomic factors, genetic susceptibility, cultural attitudes towards obesity and body image, and level of PA. The primary outcome of this study showed that in this multi-ethnic, older adult sample, accumulated PA, in the form of steps/d, is more influential on BMI than race/ethnicity, income, age, or gender. This has important implications considering the obesity epidemic facing this nation. If individuals, regardless of their race/ethnicity, are more physically active on a daily basis, lower rates of obesity are possible. Therefore, higher PA levels may decrease the health burden that obesity places on people of all ages, genders, or races/ethnicities.

Data from this study show that non-White older adults that participated in this study took 1365 fewer steps/d than did the White subjects. These data support published research showing lower accumulated activity in non-White adults compared with White adults. Population-based research has shown African American and Hispanic individuals tend to engage in less PA than their White counterparts. Tudor-Locke et. al. demonstrated that non-White individuals, age 18 y to over 65 y living in Sumter County, SC accumulated significantly fewer (1218 steps/d) steps/d than their White counterparts. Bennett et al. showed that in low-income housing residents, age 18 y to over 70 y, race was not significantly associated with daily steps, however, only 8% of the study population was White.

Our data supports published literature that shows an inverse relationship between BMI and accumulated walking. Cross sectional results of this study show that despite racial/ethnic background, those individuals who walked more had lower BMIs and vice versa. More specifically, mean BMIs were the highest, classifying subjects as “obese,” in the White and non-White groups that accumulated the least amount of daily activity (≤ 2339 steps/d). At higher activity levels, mean BMI level was lower, with those individuals in the highest PA quartile (≥ 5664 steps/d) having a BMI 8 kg/m² lower than the individuals in the lowest PA quartile. Thompson et. al. established a negative relationship between BMI and steps/d ($r = -0.417$, $P < 0.001$) in a group of Caucasian, pre- and post-menopausal middle-aged women (average age 50.3 y). Women participating in Thompson et al.’s study included a
wide range of BMIs and activity levels with BMIs ranging from 18.3 to 53.3 and steps/d ranging from 3407 to 16,729. A similar relationship was seen in a group of 182 middle-aged (mean age 43 y) employees working in moderately or highly sedentary jobs. BMI and steps/d were negatively related ($r = -0.401$, $P < 0.001$) in this group of employees. BMI levels classified these employees, on average, as overweight (female: 29.4; male: 29.9). In addition, on average, the female employees in the Chan et al. study took 7230 steps/d and the males took 8265 steps/d. The current study extends the literature base to include older adults, a population that is understudied in this area. In our sample of older adults (age range 55 to 94 y), BMIs ranged from 18.0 to 52.8, and steps/d ranged from 878 to 14,158, showing a wide range of BMIs and activity levels. Despite the much older sample, a strong inverse relationship between BMI and steps/d ($r = -0.506$, $P < 0.001$, data not shown) was displayed similar to previous literature in younger populations. This suggests that even as individuals age, if they remain active, they are less likely to be overweight or obese.

Population-based research has linked race/ethnicity with obesity levels. Specifically, African American women, and Hispanic men and women tend to have higher BMIs than their White counterparts. Socioeconomic factors including education and income have been thought to contribute to the difference in overweight and obesity between races/ethnicities. Interestingly, neither race nor income level significantly contributed to BMI levels in this study. Our results are supported by research showing that after statistically controlling for socioeconomic factors, differences in obesity between racial/ethnic groups remained. Further, in our sample of older adults, age, gender, and daily steps significantly contributed to BMI, with daily steps accounting for 21.2% of the variance in BMI. Therefore, although socioeconomic factors and race/ethnicity have been shown to contribute to or be related to obesity, the results of this study show that daily steps is a much stronger contributor to obesity than race/ethnicity or income. This has important implications considering the obesity epidemic facing the US and the world. Increasing PA levels may decrease the health burden that obesity places on older adults of various races/ethnicities and incomes.

Due to the design of this study, causation cannot be inferred. In general, individuals who are overweight or obese tend to have poorer health, quality of life, physical functioning, and physical well-being. Therefore, it cannot be determined from this study whether overweight and obese individuals took fewer steps/d because they were overweight/obese or they were overweight or obese because they took fewer steps/d. Additional limitations include sample size within racial/ethnic sub-groups and the measure of obesity used in this study. The sample size in each racial/ethnic group was not equal with small sample sizes in certain racial/ethnic groups, not allowing further meaningful statistical analysis between specific racial/ethnic groups. Body mass index was used as an estimate of overweight and obesity in this sample. Although this is a common measure of overweight and obesity, it does have limitations. BMI only takes into account body mass and body height; it does not account for composition of the body. In the older adult population, the composition of the body can be altered, including bone loss, hydration issues, sarcopenia, and accumulation of additional body fat. Further studies should evaluate the interrelationships of body composition, fat distribution, ethnicity, and PA in older adults. Finally, data on other chronic diseases was not collected and individuals with limitations to walking were excluded from participation in this study.
In conclusion, this data suggests that regardless of race/ethnicity, PA can have a strong influence on the level of obesity in older adults. These results highlight the importance of PA and the public health need to promote increasing PA levels within all cultures, as higher PA in any culture may aid in reducing obesity levels.

Acknowledgments

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