Maximal aerobic capacity across age in healthy Hispanic and Caucasian women

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Schiller, Brian C., Yoli G. Casas, Christopher A. Desouza, and Douglas R. Seals. Maximal aerobic capacity across age in healthy Hispanic and Caucasian women. J Appl Physiol 91: 1048–1054, 2001.—We tested the hypothesis that the age-related decline in maximal aerobic capacity, as measured by maximal oxygen uptake (V\text{\textsubscript{\text{02}}} max), is greater in Hispanic than in Caucasian women. We studied 146 healthy sedentary women aged 20–75 yr: 53 Hispanic (primarily of Mexican descent) and 93 Caucasian (non-Hispanic white). The groups did not differ in mean age, body mass, percent body fat, estimated physical activity-related energy expenditure, or education-based socioeconomic status (SES). During maximal exercise, respiratory exchange ratio, rating of perceived exertion, and percent predicted maximal heart rate were similar across age and ethnicity, suggesting equivalent maximum voluntary efforts in all subjects. V\text{\textsubscript{\text{02}}} max (ml·kg\textsuperscript{-1}·min\textsuperscript{-1}) was inversely related to age (P < 0.01) in Caucasian (r = −0.68) and Hispanic (r = −0.61) women. The absolute rate of decline in V\text{\textsubscript{\text{02}}} max with age was the same in the two groups (−0.31 ml·kg\textsuperscript{-1}·min\textsuperscript{-1}·yr\textsuperscript{-1}). The relative rate of decline (% from age 25 yr) also was similar in the Caucasian (−9.0%) and Hispanic (−9.2%) women. When subjects of all ages were pooled, mean levels of V\text{\textsubscript{\text{02}}} max were similar in the two groups (−28 ml·kg\textsuperscript{-1}·min\textsuperscript{-1}). These results, the first to our knowledge in Hispanics, indicate that mean levels of V\text{\textsubscript{\text{02}}} max, as well as the rate of decline in V\text{\textsubscript{\text{02}}} max with age, are similar in healthy sedentary Hispanic and Caucasian women of similar SES. Thus it does not appear that Hispanic ethnicity per se modulates maximal aerobic capacity in this population.

Maximal aerobic capacity, as assessed by maximal oxygen uptake (V\text{\textsubscript{\text{02}}} max), declines with advancing age in healthy men and women (2, 6, 9, 12, 30). This decline contributes to a reduction in physical functional capacity, resulting in older individuals working closer to maximal effort when performing a particular submaximal task (3). Eventually, reductions in physical functional capacity with age lead to increased disability, loss of independence, and reduced quality of life (18, 34). Moreover, maximal aerobic capacity is an independent risk factor for all-cause and cardiovascular disease mortality (4, 5), the prevalence of which increases markedly with age (1, 10).

Hispanics are the fastest growing segment of the US population and by the year 2020 will constitute our largest minority group (32). As a consequence, the greatest percent growth in older adults in the future will be in the Hispanic population. Recent evidence suggests that age-related reductions in physical functional capacity and increases in functional disability, as measured by physical performance tasks, may be greater in Hispanics than Caucasians (7, 15, 16, 26, 28), particularly in women (13). It also is noteworthy that after 60 yr of age, Hispanic women are at a greater risk of premature mortality compared with non-Hispanic white women (19). Whether the age-associated declines in maximal aerobic capacity are greater in Hispanic women and, therefore, could contribute to their greater functional disability and premature mortality with age is unknown.

Accordingly, the primary experimental objective of the present investigation was to test this working hypothesis. To determine whether any group differences observed in the decline in maximal aerobic capacity with age could be attributed to Hispanic ethnicity per se, subjects of similar socioeconomic status (SES) were studied because SES is independently and positively related to functional capacity and disease risk (28, 36).

METHODS

Subjects. We studied 146 healthy sedentary women aged 20–75 yr: 53 Hispanic and 93 Caucasian. The Hispanic women studied constituted all of the healthy available subjects of sufficiently high SES in the region who could be recruited. Subjects were recruited from churches, community centers, newspaper advertisements, and posted flyers primarily from the greater Boulder County, Colorado area. Ethnicity was determined by asking subjects to which ethnic group they belonged. Those who stated “Caucasian, white, or non-Hispanic white” were considered Caucasian and those who chose “Mexican/Mexican-American, Central American,
or South American" were considered Hispanic as described by Winkleby et al. (35). Hispanic women also volunteered that they or their parents or grandparents were born in Mexico, Central, or South America. Ninety percent of the Hispanic subjects were of Mexican descent.

All subjects were healthy as assessed by medical history. Subjects 50 yr of age and older were further evaluated for clinical evidence of cardiopulmonary disease with a physical examination and electrocardiograms during rest and maximal exercise. Subjects were nonsmokers and were not using any regular medications that could influence maximal aerobic capacity. The nature, purpose, and risks of the study were explained to each subject in English or Spanish, as needed, before written informed consent was obtained. The experimental protocol was approved by the Human Research Committee at the University of Colorado at Boulder.

Measurements. \( \dot{V}O_2 \) \( \text{max} \) was determined during continuous incremental treadmill exercise using on-line computer-assisted, open-circuit spirometry as described in detail previously (11, 29, 30).Expired air volume was measured with a turbine (model VMM-2, Interface Associates, Laguna Niguel, CA) previously calibrated against a 7-liter syringe (Hans Rudolph, Kansas City, MO). Gas fractions were analyzed with a mass spectrometer (model MGA-1100, Perkin-Elmer, Pomona, CA). Before each trial, the mass spectrometer was calibrated with standard gases of known concentrations. After a 6- to 10-min warm-up period, each subject walked at a comfortable speed that corresponded to \( \sim 70\% \) of age-predicted maximal heart rate. Heart rate was monitored via a five-lead electrocardiogram. Treadmill grade was increased 2.5\% every 2 min until volitional exhaustion. At the end of each stage, subjects were asked to rate perceived effort using the Borg scale (6–20). Each treadmill test lasted between 8 and 12 min. Maximal heart rate was defined as the highest value recorded during exercise. To ensure that subjects gave a maximal voluntary effort, at least three of the following criteria were met: 1) voluntary exhaustion (unable to continue walking); 2) a respiratory exchange ratio of at least 1.10; 3) achievement of age-predicted maximal heart rate; and 4) rating of perceived exertion \( \geq 18 \) units (20). No subjects had to be retested for failing to meet these criteria.

Body mass was measured to the nearest 0.1 kg with a physician’s balance scale (Detecto, Webb City, MO). In all 146 subjects, body fat percent was estimated from the sum of five-site skinfold measurements with a Lange caliper (22). Fat-free mass (FFM; kg) was calculated from percent body fat and body mass using the two-compartment model. In addition, body composition was measured in all of the Hispanic subjects \( (n=53) \) and a subgroup of Caucasian subjects \( (n=56) \) using dual-energy X-ray absorptiometry (DXA; DXA-IQ, Lunar Radiation, Madison, WI; software version 4.1), which became available after the initial cohort of Caucasian women had been studied. The values for \( \dot{V}O_2 \) \( \text{max} \) expressed per kilogram of body mass, and normalized for kg of FFM and as the relative change. The latter was defined as the mean percent change in \( \dot{V}O_2 \) \( \text{max} \) per decade of age starting with the initial decade of age through the last decade of age in the group, as described previously by our laboratory (12, 30). Multivariate analysis of variance was used to determine differences in the dependent variables among age groups and between ethnic groups. Analysis of group differences in \( \dot{V}O_2 \) \( \text{max} \) expressed per unit kilogram of body mass or FFM using the ratio method (ANOVA) and using analysis of covariance in which body mass and FFM served as covariates (23, 31) provided similar results; thus only the more traditional ratio-based values are presented below. Simple regression analyses and partial correlation coefficients were used to determine the relations among the dependent variables. Multiple-regression analyses were used to identify independent determinants for the age-related declines in \( \dot{V}O_2 \) \( \text{max} \). The slopes and intercepts of regression lines between groups were compared using analysis of covariance. Data are expressed as means \( \pm \) SE. The level of statistical significance was set at \( P<0.05 \) for all analyses.

RESULTS

Subject characteristics: relation to age. Selected subject characteristics are shown in Table 1. In the Caucasian women, no significant relations were observed between age and height, SES, FFM, or physical activity-related energy expenditure; however, body mass and percent body fat increased \( (P<0.01) \) with advancing age. In the Hispanic women, only percent body fat was positively related to age \( (P<0.05) \).

Maximal exercise responses: relation to age. Mean values per decade of age obtained during maximal exercise are presented in Table 2. In both groups, heart rate as a percentage of age-predicted maximum, peak respiratory exchange ratio, and rating of perceived exertion at \( \dot{V}O_2 \) \( \text{max} \) were not different across age, indicating similar maximal voluntary efforts. \( \dot{V}O_2 \) \( \text{max} \) declined with advancing decades of age in both groups regardless of manner of expression \( (P<0.01) \). Maximal heart rate also declined with age \( (P<0.01) \).

Rate of decline in \( \dot{V}O_2 \) \( \text{max} \) with age. Figure 1 shows the individual subject data for \( \dot{V}O_2 \) \( \text{max} \) across age in the two groups. \( \dot{V}O_2 \) \( \text{max} \) \( (\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}) \) was inversely related to age in both the Caucasian \( (r=-0.68) \) and the Hispanic \( (r=-0.61) \) women \( (P<0.001) \); the mean absolute rates of decline were similar in the two groups \( (-0.31 \text{ml} \cdot \text{kg}^{-1} \cdot \text{yr}^{-1}) \) (Fig. 2A). The relative (% rates of decline in \( \dot{V}O_2 \) \( \text{max} \) from mean levels at age \(-25 \) yr also were similar in the Caucasian \( (-9.0\% \text{/decade}) \) and Hispanic \( (-9.2\% \text{/decade}) \) women (Fig. 2B). There also were no differences in either the absolute or the relative rates of decline between the two groups when \( \dot{V}O_2 \) \( \text{max} \) was expressed in liters per minute or per unit FFM \( (\text{ml} \cdot \text{kg FFM}^{-1} \cdot \text{min}^{-1}) \) (data not shown). In addi-
tion, there were no differences between the groups in either the slope or the intercept for all regression models of the rate of decline in maximal aerobic capacity with age.

Rate of decline in maximal heart rate with age. Both groups demonstrated an inverse relation between maximal heart rate and age (Caucasian, \( r = -0.66 \); Hispanic, \( r = -0.75 \); both \( P < 0.01 \); Fig. 3). The slopes of the age-related declines in maximal heart rate were not different (\( P = 0.90 \)) in the Caucasian (\(-0.62\) beats-min\(^{-1}\)-yr\(^{-1}\)) and Hispanic (\(-0.75\) beats-min\(^{-1}\)-yr\(^{-1}\)) women.

<table>
<thead>
<tr>
<th>Variable</th>
<th>20–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>&gt;60</th>
<th>( r ) With Age</th>
<th>Pooled Mean Value</th>
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<tr>
<td>( n )</td>
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<td>14</td>
<td>21</td>
<td>26</td>
<td>18</td>
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<td>54±1</td>
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<tr>
<td>Height, cm</td>
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<td>164±2</td>
<td>163±2</td>
<td>167±1</td>
<td>161±1</td>
<td>NS</td>
<td>164±1</td>
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<td>SES, yr education</td>
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<td>18±1</td>
<td>16±1</td>
<td>16±1</td>
<td>14±1</td>
<td>NS</td>
<td>16±1</td>
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<td>Body mass, kg</td>
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<td>66±2</td>
<td>67±2</td>
<td>72±3</td>
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<td>Body fat, %</td>
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<td>34±1</td>
<td>34±1</td>
<td>36±1</td>
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<td>FFM, kg</td>
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<td>45±1</td>
<td>42±1</td>
<td>43±1</td>
<td>46±1</td>
<td>NS</td>
<td>44±1</td>
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<td>EPAEE, kcal·kg(^{-1})·day(^{-1})</td>
<td>35±1</td>
<td>36±1</td>
<td>35±1</td>
<td>34±1</td>
<td>34±1</td>
<td>NS</td>
<td>35±1</td>
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</tbody>
</table>

### Subject characteristics: relation to ethnicity

Mean values for age, SES, body mass, body fat percent, and estimated energy expenditure were not different between groups. The Hispanic women were shorter and had a slightly smaller FFM (\( P < 0.05 \)) (Table 1).

### Maximal exercise responses: relation to ethnicity

Mean values are presented in Table 2. Heart rate as a percentage of age-predicted maximum, peak respiratory exchange ratio, and rating of perceived exertion at \( V_{\text{O}}_{2}\) max were not different in the two groups, indicating similar maximal voluntary efforts (Table 2). Mean values for \( V_{\text{O}}_{2}\) max (Fig. 4) were similar in the pooled

### Table 2. Age group and pooled mean responses to maximal exercise across age

<table>
<thead>
<tr>
<th>Variable</th>
<th>20–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>&gt;60</th>
<th>( r ) With Age</th>
<th>Pooled Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{\text{O}}_{2}) max, l/min</td>
<td>2.1±0.1</td>
<td>2.1±0.1</td>
<td>1.8±0.1</td>
<td>1.8±0.1</td>
<td>1.5±0.1</td>
<td>-0.61*</td>
<td></td>
</tr>
<tr>
<td>( V_{\text{O}}_{2}) max, ml·kg(^{-1})·min(^{-1})</td>
<td>34.2±1.4</td>
<td>33.4±1.5</td>
<td>28.0±1.0</td>
<td>26.2±1.0</td>
<td>21.5±1.1</td>
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</tr>
<tr>
<td>( V_{\text{O}}_{2}) max, ml·FPM(^{-1})·min(^{-1})</td>
<td>46.1±1.3</td>
<td>47.5±1.6</td>
<td>43.6±1.8</td>
<td>40.5±1.1</td>
<td>33.8±1.3</td>
<td>-0.58*</td>
<td></td>
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<tr>
<td>%HR max</td>
<td>192±3</td>
<td>186±2</td>
<td>180±2</td>
<td>174±2</td>
<td>167±2</td>
<td>-0.70*</td>
<td>179±1</td>
</tr>
<tr>
<td>%RER max</td>
<td>101±2</td>
<td>101±1</td>
<td>102±1</td>
<td>103±1</td>
<td>103±2</td>
<td>NS</td>
<td>102±1</td>
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<tr>
<td>RPE max</td>
<td>1.1±0.02</td>
<td>1.17±0.02</td>
<td>1.20±0.01</td>
<td>1.18±0.01</td>
<td>1.16±0.02</td>
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<tr>
<td>( V_{\text{E}}) max, l/min</td>
<td>63.5±3.2</td>
<td>66.4±2.6</td>
<td>64.2±2.8</td>
<td>66.0±3.6</td>
<td>52.9±5.3</td>
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<td>63.2±1.7</td>
</tr>
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### Hispanic subjects

<table>
<thead>
<tr>
<th>Variable</th>
<th>20–29</th>
<th>30–39</th>
<th>40–49</th>
<th>50–59</th>
<th>&gt;60</th>
<th>( r ) With Age</th>
<th>Pooled Mean Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{\text{O}}_{2}) max, l/min</td>
<td>2.1±0.1</td>
<td>1.9±0.1</td>
<td>1.7±0.1</td>
<td>1.6±0.1</td>
<td>1.5±0.1</td>
<td>-0.60*</td>
<td></td>
</tr>
<tr>
<td>( V_{\text{O}}_{2}) max, ml·kg(^{-1})·min(^{-1})</td>
<td>34.0±2.2</td>
<td>30.3±1.6</td>
<td>26.8±0.8</td>
<td>25.5±1.5</td>
<td>20.7±1.3</td>
<td>-0.61*</td>
<td></td>
</tr>
<tr>
<td>( V_{\text{O}}_{2}) max, ml·FPM(^{-1})·min(^{-1})</td>
<td>49.9±2.5</td>
<td>43.1±2.3</td>
<td>42.1±1.4</td>
<td>40.3±1.8</td>
<td>34.3±1.9</td>
<td>-0.53*</td>
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<tr>
<td>%HR max</td>
<td>196±2</td>
<td>185±2</td>
<td>181±2</td>
<td>173±3</td>
<td>165±6</td>
<td>-0.75*</td>
<td>181±2</td>
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<tr>
<td>%RER max</td>
<td>103±1</td>
<td>100±1</td>
<td>102±1</td>
<td>101±2</td>
<td>101±3</td>
<td>NS</td>
<td>102±1</td>
</tr>
<tr>
<td>RPE max</td>
<td>1.19±0.01</td>
<td>1.20±0.02</td>
<td>1.18±0.02</td>
<td>1.19±0.02</td>
<td>1.18±0.02</td>
<td>NS</td>
<td>1.19±0.01</td>
</tr>
<tr>
<td>( V_{\text{E}}) max, l/min</td>
<td>19.0±0.3</td>
<td>19.4±0.2</td>
<td>19.0±0.3</td>
<td>19.0±0.4</td>
<td>19.6±0.2</td>
<td>NS</td>
<td>19.2±0.1</td>
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<tr>
<td>( V_{\text{E}}) max, l/min</td>
<td>63.3±3.8</td>
<td>67.3±3.0</td>
<td>56.1±5.6</td>
<td>57.0±3.2</td>
<td>54.0±7.0</td>
<td>NS</td>
<td>60.5±1.8</td>
</tr>
</tbody>
</table>

Values are means ± SE; \( V_{\text{O}}_{2}\) max, maximal oxygen uptake; \%HR max, maximal heart rate; RER max, maximal respiratory exchange ratio; RPE max, maximal rating of perceived exertion; \( V_{\text{E}}\) max, maximal ventilation in STPD units; FFM, fat-free mass; bpm, beats per minute. *\( P < 0.01 \).
groups of Hispanic and Caucasian women regardless of manner of expression. Absolute levels of maximal heart rate also were similar in the two groups.

Correlates of the age-related decline in \( \dot{V}O_2 \) max. Table 3 shows the significant independent predictor variables of the age-related reductions in \( \dot{V}O_2 \) max normalized for body mass in the two groups as determined by multiple-regression analysis. Variables of physiological interest entered into the multiple regression model included age, body mass, FFM, estimated physical activity, and maximal heart rate. Age and FFM were the significant independent predictors in the Caucasian group (both \( P < 0.01 \)). FFM was the only significant independent predictor in the Hispanic group (\( P = 0.01 \)).

DISCUSSION

There are at least three new and, we believe, significant findings from the present investigation. First, among healthy sedentary women aged 20–75 yr of similar SES, Hispanic (primarily of Mexican descent) ethnicity per se is not obviously associated with greater age-related declines in maximal aerobic capacity when compared with Caucasians. Second, mean levels of maximal aerobic capacity are not lower in healthy sedentary Hispanic compared with Caucasian women. Third, the age-related declines in maximal heart rate are not different in Hispanic and Caucasian women. To our knowledge, the present results represent the first data on maximal aerobic capacity and its associated physiological correlates in Hispanics.

Our working hypothesis of augmented declines in maximal aerobic capacity with age in Hispanic women was based on three previous sets of, albeit indirect, observations. The first was that Hispanic adults in general, and Hispanic women in particular, have been reported to experience greater reductions in physical functional capacity with age than their Caucasian peers (7, 13, 15, 16, 26, 28). Because maximal aerobic capacity is known to be an important determinant of physical functional capacity (3), it follows that Hispanic adults may undergo greater reductions in \( \dot{V}O_2 \) max with age than Caucasians. The second observation is
that, within Mexican-American women, leisure-time physical activity levels decline with advancing age and that older Mexican-American women have the lowest levels of leisure-time physical activity among any majority or minority group (8). Jackson et al. (23) have shown that declines in leisure-time physical activity levels are strongly associated with age-related reductions in maximal aerobic capacity among healthy women. Third, Hispanic women demonstrate a greater prevalence of overweight and obesity compared with Caucasian women (14, 17, 35). Because greater increases in body mass and fatness with age are linked to greater age-related declines in VO₂max among healthy women (23, 31), the high prevalence of obesity reported previously in Hispanic women would, in itself, act to lower maximal aerobic capacity.

In contrast to our hypothesis, the results of the present cross-sectional study indicate that both the absolute and relative rates of decline in maximal aerobic capacity were similar in our healthy Hispanic and Caucasian women. These findings were independent of the expression of VO₂max used for comparison. Both the absolute (−0.31 ml·kg⁻¹·min⁻¹·yr⁻¹) and relative (−9% decrease per decade from mean levels at age 25 yr) rates of decline were similar to the values reported by our laboratory in earlier meta-analysis and laboratory-based investigations of VO₂max and age in healthy women (12, 30), and to the results of others (6). In addition, mean levels of VO₂max in the pooled ethnic groups were almost identical. Thus, taken together, these results fail to indicate any obvious association between Hispanic ethnicity per se and maximal aerobic capacity among healthy adult women.

This lack of association likely is due, at least in part, to the absence of differences in the physiological and behavioral factors described above that are known to influence VO₂max in healthy women. For example, estimated habitual physical activity did not decline with age in either group, nor were mean levels different in the Hispanic compared with the Caucasian women. The absence of any significant differences in estimated physical activity levels with age or ethnicity in the present study most likely was due to the fact that the women were all of similarly high SES. SES is directly related to leisure-time activity levels (25).

There are several experimental considerations that should be mentioned. First, we used a cross-sectional, rather than a longitudinal, study design. It has been suggested that these two approaches may provide different results when used to determine age-related declines in VO₂max (6). However, as our laboratory has found previously (12, 30), investigations in which both study designs were employed in the same study sample(s) have demonstrated similar mean rates of decline with age using these different approaches. Second, our subject samples consisted only of healthy women. If women with clinically documented disease (e.g., severe obesity, the prevalence of which is higher in Hispanic women) had been included, our results may have been different. Third, although our overall subject number (n) of ~150 women represents a relatively large study sample for a laboratory-based physiological investigation, it nevertheless is a small subject sample from an epidemiological perspective, particularly considering the limited number of Hispanic subjects in general (n = 53) and in certain age intervals. In this regard, it

<table>
<thead>
<tr>
<th>Group</th>
<th>Predictor 1</th>
<th>Predictor 2</th>
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<tbody>
<tr>
<td>Caucasian</td>
<td>Age*</td>
<td>Fat-free mass*</td>
</tr>
<tr>
<td>Hispanic</td>
<td>Fat-free mass*</td>
<td></td>
</tr>
</tbody>
</table>

* *P ≤ 0.01.*
should be noted that we were limited by the availability of Hispanic women of sufficiently high SES to compare with the regional Caucasian population of women (controls). Thus the reader should be aware of the possibility of type II errors, particularly in the context of age-related changes in our Hispanic women. Fourth, the Hispanic women studied here were primarily (~90%) of Mexican-American descent. As such, our findings cannot be generalized to Hispanic women of other descent. Fifth, as mentioned previously, SES is directly related to measures of functional capacity and disability (28). Therefore, although the exact relation between SES and maximal aerobic capacity has not been determined, it is possible (even likely) that our results would have been different had we not studied Hispanic and Caucasian women of similar SES.

The present findings have important implications for gerontology and geriatric medicine. Age-associated reductions in physical functional capacity result in increased disability, dependence on family and others for care, and costs of health services, as well as reduced quality of life. Current projections indicate marked increases in the number of US adults >65 yr of age in the near future, greatly exacerbating these present problems. Physical functional capacity has been reported to be reduced and functional disability increased in older Hispanic adults, particularly women (13). Because Hispanics are our fastest growing minority population (32), it is important to determine the physiological factors contributing to age-related disability in this group. The present findings indicate that Hispanic ethnicity per se (i.e., cultural and/or genetic predisposition) is not obviously associated with greater declines in maximal aerobic capacity with age or with mean levels. Thus this factor does not appear to contribute directly to ethnicity-related differences in physical functional capacity.

In conclusion, these results, the first to our knowledge in Hispanics, do not support the hypothesis that the rate of decline in maximal aerobic capacity with age is greater in healthy sedentary Hispanic women than in Caucasian women of similar SES. Thus it does not appear that Hispanic ethnicity per se modulates maximal aerobic capacity, an important determinant of physical functional capacity, in this population.

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