Racial differences in the response of cardiorespiratory fitness to aerobic exercise training in Caucasian and African American postmenopausal women

Damon L. Swift,1 Neil M. Johannsen,1 Carl J. Lavie,1,4 Conrad P. Earnest,6 William D. Johnson,2 Steven N. Blair,5 Timothy S. Church,1 and Robert L. Newton, Jr.3

1Department of Preventive Medicine, Pennington Biomedical Research Center, Baton Rouge, Louisiana; 2Department of Population Science, Pennington Biomedical Research Center, Baton Rouge, Louisiana; 3Department of Physical Activity and Ethnic Minority Health, Pennington Biomedical Research Center, Baton Rouge, Louisiana; 4Department of Cardiovascular Diseases, John Ochsner Heart and Vascular Institute, Ochsner Clinical School, The University of Queensland School of Medicine, New Orleans, Louisiana; 6Departments of Exercise Science and Epidemiology and Biostatistics, University of South Carolina, Columbia, South Carolina; and 5Department for Health, University of Bath, Bath, United Kingdom

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Swift DL, Johannsen NM, Lavie CJ, Earnest CP, Johnson WD, Blair SN, Church TS, Newton RL Jr. Racial differences in the response of cardiorespiratory fitness to aerobic exercise training in Caucasian and African American postmenopausal women. J Appl Physiol 114: 1375–1382, 2013. First published March 7, 2013; doi:10.1152/japplphysiol.01077.2012.—African American (AA) women have lower CRF at baseline, but a similar increase in CRF following aerobic exercise training compared with Caucasian American (CA) women. However, little data exist that evaluate racial differences in the change in CRF following aerobic exercise training. CA (n = 264) and AA (n = 122) postmenopausal women from the Dose-Response to Exercise in Women study were randomized to 4, 8, and 12 kcal·kg body wt−1·wk−1 (KKW) of aerobic training or the control group for 6 mo. CRF was evaluated using a cycle ergometer. A greater increase in relative CRF was observed in CA compared with AA women in the 4 (CA: 1.00 vs. AA: 0.35 ml O2·kg−1·min−1, P = 0.034), 8 (CA: 1.59 vs. AA: 0.82 ml O2·kg−1·min−1, P = 0.041), and 12 (CA: 1.98 vs. AA: 0.50 ml O2·kg−1·min−1, P = 0.001) KKW groups. Similar effects were found in absolute CRF, with the exception of the 4-KKW (CA: 0.04 vs. AA: 0.02 l O2·min−1, P = 0.147) group. However, in categorical analyses, the percentages of women who improved in both relative (>0 ml O2·kg−1·min−1) and absolute (>0 l O2·min−1) CRF were not significantly different for CA and AA women in all exercise groups (all P > 0.05). AA postmenopausal women, in general, had an attenuated increase in CRF (both relative and absolute) following exercise training, but had similar response rates compared with CA women. Future studies should investigate the physiologic mechanisms responsible for this attenuated response.

race; exercise training; African American; cardiorespiratory fitness

RACIAL HEALTH DISPARITIES are an important public health problem (23). African American (AA) women have a higher risk of cardiovascular disease (CVD), stroke, and mortality compared with Caucasian American (CA) women (21, 23). Higher levels of cardiorespiratory fitness (CRF) are associated with reduced risk of CVD and mortality (4, 14, 20), and recent data suggest that AA women have lower CRF levels compared with their CA counterparts (11, 17, 18, 28, 31). Specifically, the Coronary Artery Risk Development in Young Adults (CARDIA) study (30) found that CRF from a maximal exercise test was higher in CA women compared with AA women. Similar findings have been reported in another epidemiological study (28), larger clinical studies (18, 31), and smaller studies in a variety of subject populations [adults (31), women (11, 17), type 2 diabetes (9)]. Thus lower CRF may contribute to CVD disparities between CA and AA women; however, racial differences in CRF have not been evaluated specifically in postmenopausal women.

CRF is inversely associated with all-cause mortality in CA and AA adults (16), and increasing CRF levels are associated with reduced risk of CVD (3). Aerobic exercise training has a well-documented effect for improving CRF, which occurs in both CA and AA individuals (8, 31). Thus increasing levels of CRF should reduce CVD risk, regardless of race. However, little data exist evaluating racial differences in the improvement of CRF as a result of aerobic exercise training between CA and AA adults.

Data from the Health, Risk Factors, Exercise Training and Genetics Family (HERITAGE) study suggest that although mean CRF [expressed in changes in maximal oxygen consumption (VO2)] increased following 20 wk of cycle ergometer training to a greater extent in CA (5.5 ml O2·kg−1·min−1) compared with AA (4.9 ml O2·kg−1·min−1) adults, no differences were observed in mean percent change in both groups (CA: 17.5%; AA: 18.7%). Since no racial differences were additionally observed in absolute CRF or in CRF corrected for lean mass, the authors concluded that race had no major effect on the change in CRF following aerobic training (31). It is important to note that in HERITAGE study’s sample included both men and women and had a wide age range (17-65 yr) (5). Thus, to our knowledge, no studies have evaluated racial differences in the response to CRF following aerobic training, specifically in postmenopausal women. This has clinical importance, as postmenopausal women have a higher risk of CVD compared with premenopausal women (13).

The purpose of the present study is to determine if there are differences between CA and AA postmenopausal women in 1) baseline CRF and 2) changes in CRF following 6 mo of aerobic exercise training in the Dose-Response to Exercise in Women (DREW) trial. We hypothesized, based on the data presented above, that AA postmenopausal women would have lower CRF at baseline, but a similar increase in CRF following training compared with CA women.
METHODS

Design and Participants

The full design (25) and primary outcomes (7) for the DREW trial have been published. DREW was a randomized, controlled trial evaluating the dose response of CRF with increasingly higher doses of energy expenditure in sedentary, postmenopausal women with elevated blood pressure (BP). The protocol was reviewed and approved annually by The Cooper Institute Institutional Review Board and subsequently approved by Pennington Biomedical Research Center for continued analysis. Written, informed consent was obtained from all participants prior to screening. Women recruited for this study were overweight or obese and had elevated systolic BP. Notable exclusion criteria included the presence of significant CVD, conditions contraindicated for exercise training, elevated LDL, and significant weight loss in the previous year (25).

A consort diagram for the present study is shown in Fig. 1. We excluded women who were not CA or AA (n = 27), had low (<75%) exercise-training adherence (n = 10), did not complete the trial (n = 40), or had missing exercise testing data (n = 1). Thus 264 CA and 122 AA postmenopausal women were in the analytical sample.

Maximal Exercise Testing

Testing was performed using an Excalibur Sport electronically braked cycle ergometer (Lode, Groningen, the Netherlands). Participants cycled at 30 W for 2 min and then 50 W for 4 min, followed by increases of 20 W every 2 min until they could no longer maintain a pedal cadence of 50 revolutions/min. Respiratory gases were measured using a TrueMax 2400 metabolic measurement cart (ParvoMedics, Sandy, UT). CRF measures were calculated in relative (ml O₂·kg⁻¹·min⁻¹) and absolute VO₂ peak (l O₂/min). Two fitness tests were performed on different days at baseline, and two tests were performed at follow-up. The average value for the two tests at each time point was used in the analyses, unless only one of the two tests was completed at baseline or follow-up, in which case, we used the single value. At baseline, 96% of participants completed both exercise tests. At follow-up, 95% of participants completed both exercise tests. The coefficient of variation for repeated measures of CRF (l/min) at baseline and follow-up were 5.2% and 4.7%, respectively.

Baseline Physical Activity

Baseline physical activity level was measured using an Eagle AE1620 (Accusplit, Livermore, CA) pedometer over the course of 1 wk prior to randomization.

Resting BP

Resting BP was evaluated with an automated BP unit (Colin Medical Instruments, San Antonio, TX) with the participant in the supine position.

Anthropometric Measures

Weight was measured using an electronic scale (Siemens Medical Solutions, Malvern, PA). Waist circumference was obtained following the guidelines of the Airlie Conference (22). Body mass index was calculated by dividing weight (kg) by height (m) squared.

Participant Randomization

Following baseline testing, participants were randomized to the 4-, 8-, or 12-kcal·kg body wt⁻¹·wk⁻¹ (KKW) or the nonexercise control group (25). The final analysis included 84 participants from the control group, 130 from the 4-KKW group, 81 from the 8-KKW group, and 91 from the 12-KKW group. The larger sample size in the 4-KKW group reflects a design feature of DREW that provided sufficient statistical power for detecting smaller anticipated changes compared with the 8- and 12-KKW groups following exercise training (25).

Fig. 1. Consort diagram. DREW, Dose-Response to Exercise in Women trial; KKW, kcal·kg body wt⁻¹·wk⁻¹; AA, African American; CA, Caucasian American; VO₂, maximal oxygen consumption.
Exercise Training

We determined that the exercise-training energy expenditure for women in the DREW age range, associated with meeting the consensus public health guidelines, was ~8 KKW (25). Based on this, we also determined the energy expenditure at 50% below (4 KKW) and 50% above (12 KKW) consensus public health guidelines. All groups expended 4 KKW during the 1st wk. Participants assigned to the 4-KKW treatment arm continued to expend 4 KKW for 6 mo. All of the other groups increased their energy expenditure by 1 KKW/wk until they reached the exercise dose required for their group (i.e., 8 KKW, 12 KKW). Aerobic training was performed on semirecumbent cycle ergometers and treadmills, and all sessions were supervised directly by study staff. Women in the exercise groups participated in three or four sessions/wk for 6 mo at a heart rate associated with 50% of peak VO2. Exercise training adherence was excellent in CA (99.2%) and AA (99.0%) participants. Participants in the nonexercise control group were asked to not alter their habitual physical activity level during the study.

Dietary Changes

Food frequency questionnaires were collected at baseline and follow-up in DREW to monitor dietary changes. No significant dietary changes were found following exercise training, which is reported in the DREW main outcomes paper (25).

Blinding

Separate intervention and assessment teams were maintained, and assessment staff members were blinded to the randomization of study participants.

Statistical Procedure

Statistical analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC). Descriptive data were tabulated as means (SD) or frequencies (percent) as appropriate.

Baseline characteristics. An ANOVA was performed to evaluate the significance of the racial difference in each baseline characteristic. Baseline differences between CA and AA women were found for age and maximum mean respiratory exchange ratio (RER) value from baseline exercise testing. Therefore, differences in baseline CRF between CA and AA were adjusted further for those variables.

Racial differences in the change in weight, RER, and maximum heart rate following training. An analysis of covariance (ANCOVA) was used to evaluate the change in weight, RER, and maximum heart rate following exercise training with adjustment for baseline value. Adjusted means were reported as least squares means and 95% confidence intervals.

Evaluation for racial differences in the change in CRF. Changes in CRF (assessed by VO2 peak) following exercise training between CA and AA postmenopausal women were compared in relative (ml O2·kg⁻¹·min⁻¹) and absolute terms (l/min): 1) across dose of exercise; 2) in exercisers only adjusted for exercise dose (total caloric energy expenditure during training sessions); and 3) in exercisers only adjusted for exercise dose in those that achieved a RER value >1.05 at baseline and follow-up. All linear statistical models were analyzed to compare baseline fitness and 6-mo changes in fitness with adjustment for covariates (age, baseline value, and maximum mean RER from baseline exercise test). Adjusted means were reported as least squares means and 95% confidence intervals. Statistical significance was defined as P ≤ 0.05.

Categorical analysis for change in CRF. Women with change in relative CRF > 0 ml O2·kg⁻¹·min⁻¹ following exercise training were classified as relative CRF responders, and those with change in relative CRF ≤ 0 ml O2·kg⁻¹·min⁻¹ were classified as relative CRF nonresponders. Similarly, those with change in absolute CRF > 0.1 O2/min following exercise training were classified as absolute CRF responders, and those with change in absolute CRF ≤ 0.1 O2/min following exercise training were classified as absolute CRF nonresponders. A general linear model was used to compare CA with AA women with respect to the percent of responders in each study group in the entire study sample (n = 386).

Dose response to fitness. Multiple linear regression analysis was used to test the significance of the trend of increasing CRF with higher doses of exercise (4 KKW, 8 KKW, and 12 KKW) for AA and CA participants. These analyses were performed only in the exercise groups.

Variance for change in CRF. In exercisers only, linear regression models were used to estimate the percent of total variance for change in peak VO2 (relative and absolute) that may be attributed to race. Variables entered into the model included: exercise-training dose, age, baseline fitness, and race. Furthermore, within each training dose (4, 8, or 12 KKW) age, baseline fitness, and race were entered into regression models and analyzed analogously.

RESULTS

Baseline characteristics are summarized by race and exercise-training dose in Table 1. AA women were generally younger, had higher body weight, fasting glucose, and diastolic BP but lower waist circumference and hemoglobin values compared with CA women. The mean difference between races was not significant for systolic BP or baseline steps/day (all P > 0.05). No significant differences were observed in baseline characteristics across exercise groups or within either race group. Approximately 23% of women (both CA and AA) were taking antihypertensive medication, and 50% of CA and 32% of AA were taking hormone-replacement therapy.

Baseline Fitness

Baseline maximal exercise tests revealed that compared with AA women, CA women, on average, had significantly higher relative CRF and maximum RER, but the racial differences in absolute CRF and maximum heart rate were not statistically significant. After adjustment for both age and maximum RER, AA women had significantly lower relative and absolute CRF compared with CA women (Table 2).

Weight, RER, and Maximum Heart Rate Outcomes

No significant race differences were observed in the change of weight, maximum RER, or maximum heart rate following exercise training (Table 3).

Cardiorespiratory Fitness

Mean changes in relative and absolute CRF following exercise training are shown by race in Fig. 2. CA women, on average, experienced significantly greater changes than AA women for relative VO2 peak in the 4-KKW (CA: 1.00 vs. AA: 0.35 ml O2·kg⁻¹·min⁻¹, P = 0.034), 8-KKW (CA: 1.59 vs. AA: 0.82 ml O2·kg⁻¹·min⁻¹, P = 0.041), and 12-KKW (CA: 1.98 vs. AA: 0.50 ml O2·kg⁻¹·min⁻¹, P = 0.001) groups. The race difference in mean change for relative VO2 peak approached statistical significance (P = 0.065) in the control group, with a larger decline occurring in AA women. The race differences did not vary significantly (P = 0.390) across exercise-training doses, indicating an absence of significant race by exercise-training dose interaction, whereas CA women demonstrated a more favorable main-effect change in relative VO2 peak after exercise training (P < 0.001).
CA women, on average, had a greater absolute VO2 peak in the 8-KKW (CA: 0.10 vs. AA: 0.04 l·O2/min, P = 0.031) and the 12-KKW (CA: 0.15 vs. AA: 0.04 l·O2/min, P = 0.003) groups but not in the 4-KKW (CA: 0.04 AA: 0.02, l O2/min, P = 0.147) group. The race difference for the change in absolute VO2 peak in the control group was not significant (P = 0.155). A significant main effect was observed for race (P = 0.001), with no significant race by exercise-training dose interaction (P = 0.486).

**CRF (Adjusted for Exercise Dose)**

As shown in Fig. 3, CA women experienced greater improvements compared with AA women in relative and absolute CRF following exercise training (P < 0.05). Similar results were found when the analyses were restricted to women who had obtained a maximum RER value >1.05 at baseline and follow-up from exercise testing (n = 276).

**Categorical Analysis for CRF**

No significant race differences were observed in the percentage of participants who increased relative CRF within the control (45.9 vs. 43.5%, P = 0.822), 4-KKW (69.9 vs. 57.4%, P = 0.121), 8-KKW (86.8 vs. 82.1%, P = 0.651), and 12-KKW (85.1 vs. 75.0%, P = 0.336) groups. Similarly, race differences in the percentage of women who increased absolute CRF did not differ significantly within the control (37.7% vs. 39.6%, P = 0.121).

### Table 1. Baseline characteristics stratified by race

<table>
<thead>
<tr>
<th></th>
<th>Caucasian</th>
<th>Control (n = 61)</th>
<th>4 KKW (n = 83)</th>
<th>8 KKW (n = 53)</th>
<th>12 KKW (n = 67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>58.3 (6.3)*</td>
<td>57.8 (6.1)</td>
<td>59.5 (6.3)</td>
<td>58.1 (6.3)</td>
<td>57.5 (6.5)</td>
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<tr>
<td>Weight (kg)</td>
<td>83.4 (11.6)*</td>
<td>85.7 (12.9)</td>
<td>82.5 (10.9)</td>
<td>85.1 (12.9)</td>
<td>81.2 (10.5)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>31.4 (3.9)</td>
<td>32.2 (4.3)</td>
<td>31.1 (3.4)</td>
<td>32.0 (4.2)</td>
<td>30.7 (3.7)</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>101.8 (11.7)*</td>
<td>104.5 (12.5)</td>
<td>100.1 (10.3)</td>
<td>103.6 (10.3)</td>
<td>100.2 (13.1)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>140.0 (12.9)</td>
<td>141.9 (11.8)</td>
<td>139.7 (11.9)</td>
<td>140.2 (14.8)</td>
<td>138.5 (13.5)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>80.0 (8.6)*</td>
<td>80.2 (8.1)</td>
<td>79.5 (9.6)</td>
<td>80.3 (8.1)</td>
<td>80.1 (8.2)</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>95.1 (9.4)*</td>
<td>94.6 (13.1)</td>
<td>95.0 (7.9)</td>
<td>95.1 (7.5)</td>
<td>95.7 (8.3)</td>
</tr>
<tr>
<td>Hemoglobin (g/dl)</td>
<td>13.2 (0.9)*</td>
<td>13.2 (0.8)</td>
<td>13.2 (0.8)</td>
<td>13.3 (1.0)</td>
<td>13.1 (0.8)</td>
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<tr>
<td>Baseline physical activity (steps/day)</td>
<td>4,930.4 (1,759.5)</td>
<td>5,101 (1,685.9)</td>
<td>4,824.3 (1,886.0)</td>
<td>4,706.7 (1,634.5)</td>
<td>5,082.1 (1,769.4)</td>
</tr>
<tr>
<td>RER (VCO₂/VO₂)</td>
<td>1.15 (0.07)*</td>
<td>1.13 (0.06)</td>
<td>1.15 (0.07)</td>
<td>1.14 (0.07)</td>
<td>1.16 (0.07)</td>
</tr>
<tr>
<td>Maximum heart rate (beats/min)</td>
<td>151.8 (16.4)</td>
<td>151.7 (15.2)</td>
<td>150.2 (17.8)</td>
<td>152.4 (16.3)</td>
<td>152.9 (16.2)</td>
</tr>
<tr>
<td>Percentage of age-predicted maximum heart rate (%)</td>
<td>90.7 (9.2)</td>
<td>90.6 (9.0)</td>
<td>90.3 (9.8)</td>
<td>91.0 (9.0)</td>
<td>91.1 (8.9)</td>
</tr>
<tr>
<td>Exercise test max RER value &gt;1.05 (%)</td>
<td>92.1% (243)*</td>
<td>93.4 (57)</td>
<td>90.4 (75)</td>
<td>92.5 (49)</td>
<td>92.6 (62)</td>
</tr>
</tbody>
</table>

#### African American

<table>
<thead>
<tr>
<th></th>
<th>All (n = 122)</th>
<th>Control (n = 23)</th>
<th>4 KKW (n = 28)</th>
<th>8 KKW (n = 28)</th>
<th>12 KKW (n = 24)</th>
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</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>54.8 (5.9)</td>
<td>55.6 (5.2)</td>
<td>55.4 (6.1)</td>
<td>54.3 (6.8)</td>
<td>53.4 (5.0)</td>
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<tr>
<td>Weight (kg)</td>
<td>85.9 (11.9)</td>
<td>87.1 (10.7)</td>
<td>84.2 (13.0)</td>
<td>85.8 (11.1)</td>
<td>86.4 (11.5)</td>
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<tr>
<td>Body mass index (kg/m²)</td>
<td>32.2 (3.6)</td>
<td>32.4 (3.0)</td>
<td>31.7 (4.0)</td>
<td>32.8 (3.7)</td>
<td>32.3 (3.0)</td>
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<tr>
<td>Waist circumference (cm)</td>
<td>98.5 (11.2)</td>
<td>98.3 (10.6)</td>
<td>98.7 (12.2)</td>
<td>99.6 (12.6)</td>
<td>97.0 (8.3)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>138.8 (12.7)</td>
<td>140.0 (11.3)</td>
<td>139.0 (14.8)</td>
<td>137.6 (11.1)</td>
<td>138.9 (11.8)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>83.2 (8.2)</td>
<td>82.1 (8.1)</td>
<td>83.4 (7.8)</td>
<td>82.9 (7.9)</td>
<td>84.1 (9.7)</td>
</tr>
<tr>
<td>Glucose (mg/dl)</td>
<td>92.8 (10.8)</td>
<td>95.8 (13.9)</td>
<td>91.5 (9.3)</td>
<td>92.3 (11.8)</td>
<td>93.3 (9.3)</td>
</tr>
<tr>
<td>Hemoglobin (g/dl)</td>
<td>12.6 (0.9)</td>
<td>12.8 (0.6)</td>
<td>12.6 (1.0)</td>
<td>12.5 (0.8)</td>
<td>12.6 (1.0)</td>
</tr>
<tr>
<td>Baseline physical activity (steps/day)</td>
<td>5,087.4 (1,921.6)</td>
<td>5,205.6 (1,412.0)</td>
<td>4,873.8 (1,822.5)</td>
<td>5,281.6 (2,177.6)</td>
<td>5,139.2 (2,260.9)</td>
</tr>
</tbody>
</table>

### Table 2. Evaluation of differences in baseline CRF between Caucasian and African American participants

<table>
<thead>
<tr>
<th></th>
<th>Caucasian</th>
<th>African American</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative CRF (ml·kg⁻¹·min⁻¹)</td>
<td>15.7 (CI: 15.5–16.1)</td>
<td>15.1 (CI: 14.4–15.4)</td>
<td>0.015</td>
</tr>
<tr>
<td>Model adjusted for age</td>
<td>15.9 (CI: 15.9–16.2)</td>
<td>14.7 (CI: 14.3–15.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Model adjusted for age and maximum RER value</td>
<td>15.8 (CI:15.5–16.1)</td>
<td>15.0 (CI:14.6–15.5)</td>
<td>0.011</td>
</tr>
<tr>
<td>Absolute cardiorespiratory fitness (l/min)</td>
<td>1.31 (CI: 1.28–1.34)</td>
<td>1.28 (CI: 1.23–1.34)</td>
<td>0.24</td>
</tr>
<tr>
<td>Model adjusted for age</td>
<td>1.33 (CI: 1.30–1.36)</td>
<td>1.24 (CI: 1.20–1.28)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Model adjusted for age and maximum RER value</td>
<td>1.33 (CI:1.30–1.35)</td>
<td>1.25 (CI:1.21–1.29)</td>
<td>0.003</td>
</tr>
</tbody>
</table>

CRF, cardiorespiratory fitness; CI, confidence interval.
Table 3. Change in weight, RER, and maximum heart rate following exercise training in Caucasian and African American women

<table>
<thead>
<tr>
<th></th>
<th>Caucasian</th>
<th>Control (n = 61)</th>
<th>4 KKW (n = 83)</th>
<th>8 KKW (n = 53)</th>
<th>12 KKW (n = 67)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Weight (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>−1.5 (CI: −2.4, −0.6)</td>
<td>−1.8 (CI: −2.6, −1.1)</td>
<td>−1.8 (CI: −2.7, −0.8)</td>
<td>−1.6 (CI: −2.5, −0.8)</td>
</tr>
<tr>
<td>Δ RER (VCO2/VO2)</td>
<td></td>
<td>−0.005 (CI: −0.013, 0.003)</td>
<td>−0.006 (CI: −0.013, 0.001)</td>
<td>−0.004 (CI: −0.013, 0.004)</td>
<td>−0.003 (CI: −0.011, 0.004)</td>
</tr>
<tr>
<td>Δ Maximum heart rate (beats/min)</td>
<td></td>
<td>−3.3 (CI: −5.5, −1.1)</td>
<td>−1.3 (CI: −3.2, 0.7)</td>
<td>−0.6 (CI: −3.0, 1.9)</td>
<td>−0.3 (CI: −2.4, 1.8)</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>African American</th>
<th>Control (n = 23)</th>
<th>4 KKW (n = 28)</th>
<th>8 KKW (n = 28)</th>
<th>12 KKW (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ Weight (kg)</td>
<td></td>
<td>−0.5 (CI: −2.0, 0.9)</td>
<td>−0.7 (CI: −1.7, 0.3)</td>
<td>−2.0 (CI: −3.3, −0.7)</td>
<td>−1.3 (CI: −2.7, 0.1)</td>
</tr>
<tr>
<td>Δ RER (VCO2/VO2)</td>
<td></td>
<td>−0.011 (CI: −0.024, 0.003)</td>
<td>−0.000 (CI: −0.010, 0.009)</td>
<td>−0.016 (CI: −0.028, −0.004)</td>
<td>−0.013 (CI: −0.026, 0.000)</td>
</tr>
<tr>
<td>Δ Maximum heart rate (beats/min)</td>
<td></td>
<td>−3.5 (CI: −7.2, 0.1)</td>
<td>−0.2 (CI: −2.8, 2.4)</td>
<td>0.1 (CI: −3.3, 3.4)</td>
<td>−2.2 (CI: −6.0, 1.5)</td>
</tr>
</tbody>
</table>

Δ, change. Results are reported as adjusted least squares means with 95% CIs.

30.4%, $P = 0.519$), 4-KKW (60.2 vs. 51.1%, $P = 0.276$), 8-KKW (75.4 vs. 78.6%, $P = 0.773$), and 12-KKW (82.1 vs. 70.8%, $P = 0.305$) groups.

Dose Response to CRF

Significant trends were observed for increasing CRF with higher exercise dose in relative fitness ($P$-trend $<$ 0.001) and absolute ($P$-trend $<$ 0.001) for CA women. In AA participants, no significant trend was observed for higher exercise dose and increasing CRF in either relative ($P$-trend $= 0.62$) or absolute ($P$-trend $= 0.46$) fitness. We excluded controls in this analysis, because the decrease in fitness in the AA control participants could lead to a spurious interpretation.

Percent Variance in the Change in CRF Explained by Race

The results of linear regression models (step-wise elimination) to determine the percent variance of CRF, explained by participant race, found that the coefficient of partial determination (partial $r^2$) for race for the change in relative and absolute CRF in all exercisers was 3.8% and 3.6%, respectively. For change in relative CRF, the partial $r^2$ for race was 1.6%, 7.2%, and 8.5% in the 4-KKW, 8-KKW, and 12-KKW groups, respectively. For change in absolute CRF, the partial $r^2$ for race was 4.3% and 5.1% in the 8-KKW and 12-KKW groups, respectively, but was not significant in the 4-KKW group.

DISCUSSION

The primary findings of the present paper were: 1) at baseline, AA postmenopausal women had lower levels of CRF compared with CA women; 2) despite improvements in CRF in both CA and AA women, the overall magnitude of the response was generally greater in CA women; this relationship was evident after adjustment for potential confounders, such as age, baseline CRF level, and maximal RER from exercise testing; and 3) the percentage of responders to aerobic exercise training was similar in CA and AA participants, suggesting that exercise training is beneficial regardless of race. Our findings have clinical implications, as higher CRF reduces CVD and diabetes risk (2, 29), both of which are more prevalent in AA women (10, 21).

Our finding of lower baseline levels of CRF in AA compared with CA postmenopausal women is supported by large epidemiology studies (28, 30). The CARDIA study ($n = 4,968$) found that CRF [expressed as maximal estimated metabolic equivalents (METS) from exercise testing] was lower in young (18–30 yr) AA (9.4 METS) compared with CA (11.1 METS) women (30). Similarly, the Action for Health in Diabetes (Look AHEAD) study ($n = 5,145$) found that CRF was lower in AA (6.7 METS) compared with CA (7.3 METS) overweight and obese adults with type 2 diabetes (28). In our study, postmenopausal AA women had lower CRF, despite the fact that they were, on average, nearly 4 yr younger and had similar pedometer-determined physical activity levels at baseline compared with CA participants. Therefore, it is plausible that lower CRF in AA postmenopausal women...
may contribute to the racial disparities in risk of developing CVD and type 2 diabetes.

Following the 6 mo of aerobic training, postmenopausal AA women generally demonstrated an attenuated improvement in CRF compared with CA women, despite similar adherence to training regimens and adjustment for potential confounding factors. When CRF was expressed in relative terms, this racial difference was found in all exercise groups following the intervention. Similarly, when CRF was expressed in absolute terms, AA women demonstrated a lower change in CRF in the 8-KKW and 12-KKW groups compared with CA participants. When all exercise groups were combined, and statistical models were adjusted for the dose of exercise training, AA women demonstrated an attenuated improvement in CRF (both relative and absolute) compared with CA women following exercise training. According to Mora et al. (24), who evaluated the effect of CRF on mortality and CVD outcomes, a 1-MET increase in CRF was associated with a 17% reduction in 20-yr cardiovascular mortality risk in women. When CRF values are converted to METS, the racial difference in the change in fitness observed following exercise training at the various doses in the present study corresponds to a range of an approximate 3–7.2% reduction in cardiovascular mortality. Although the racial differences in the change in CRF observed in the present study are not large in magnitude, they may have some clinical impact, especially at higher exercise doses. In addition, the dose response of greater change in CRF with higher exercise dose was observed in CA women but not in AA women.

The HERITAGE Family Study found an attenuated improvement in relative CRF in AA (n = 198) compared with CA (n = 435), but racial differences in absolute CRF following 20 wk of aerobic training were not statistically significant. Nevertheless, the investigators concluded that race explained a small fraction of the variability in response of absolute CRF (~1%) (6). In the present study, along with finding significant differences in absolute CRF between CA and AA participants, race explained ~3.6% of the total variability in absolute CRF response among exercisers, with a greater influence within the higher exercise-training doses (8 KKW: 4.3%; 12 KKW: 5.1%). Differences in findings in absolute CRF between HERITAGE and DREW could be due to differences in study design (i.e., aerobic training intensity, study length, and exercise session duration). The age range and gender composition of both studies may also play a role, as HERITAGE included both men and women over a wide age range (17–65 yr), whereas DREW included postmenopausal women only. Additionally, 20% (n = 118) of The HERITAGE Family Study was composed of older adults (age ≥50 yr), of which only 13% (n = 15) were AA (31). Our data expand the findings of The HERITAGE Family Study by evaluating racial differences in CRF, specifically in postmenopausal women, which may be clinically significant, given the markedly increased CVD risk following menopause (13).

A potential mechanism that may explain the racial differences in CRF could be higher proportion of type 1 muscle fibers observed in CA compared with AA individuals (1a, 32). Since type 1 muscle fibers are more oxidative than type 2 (32), this may contribute to the observed racial differences in baseline CRF and changes in CRF following exercise training. It could be speculated that another potential mechanism could be the lower hemoglobin levels in AAs compared with CA indi-
viduals, which have been shown in adolescents (27) and premenopausal women (12) and in the present study (Table 1). However, although lower hemoglobin levels could reduce oxygen transport to active musculature during aerobic exercise, the small differences observed in our study are unlikely to be clinically significant. Additionally, when baseline hemoglobin was included in our statistical models, it was not a significant covariate and did not alter our findings (data not shown).

Strengths of the present study are that DREW was a large, dose-response, randomized, controlled trial, and the training intervention was controlled for caloric energy expenditure. Additionally, CRF was measured twice at both baseline and follow-up with good reproducibility. Racial differences were evaluated at three doses of exercise training with similar exercise-training adherence between CA and AA women. Notable limitations are that the DREW study was not originally designed to specifically evaluate racial differences in CRF, there was a larger sample of CA compared with AA participants, and CRF values are not corrected for lean mass [since fat mass contributes little to oxygen uptake during exercise (19)]. Furthermore, it is possible that other results could be found with different exercise training intensities/modalities or in other subject populations.

In conclusion, the results of the present study suggest that AA postmenopausal women have lower CRF at baseline and an attenuated response to 6 mo of exercise training compared with CA women. However, it should be emphasized that although we found a racial difference in the magnitude of the change in CRF, the percentage of responders (increased CRF categorically) to exercise training was similar in both CA and AA women. Clinicians should strongly encourage adherence to exercise training in both CA and AA postmenopausal women due to the inverse relationship of CRF with CVD risk (15) and the increased risk of CVD following menopause (13). Future studies should evaluate whether racial differences exist in the response to CRF between CA and AA individuals in a prospective exercise-training study specifically designed to evaluate ethnic differences and investigate the physiologic mechanisms responsible for the attenuated response in AA individuals.

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Present address of C. P. Earnest: Dept. for Health, University of Bath, Bath, BA2 7AY, UK.

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DISCLOSURES

The authors have no conflict of interest to declare on the subject matter of the present paper.

AUTHOR CONTRIBUTIONS


REFERENCES


