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Ethnic differences in the consistency and accuracy of perceived exertion

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Abstract

Objectives—This study investigated the effect of weight loss and weight regain on accuracy of perceived exertion (APE) in previously overweight African American (AA) and European American (EA) women.

Methods—Formerly overweight women (n=102, age 20–44 yrs) completed a weight loss program to achieve BMI <25kg/m^2. Physiological variable of exertion and rating of perceived exertion (RPE, Borg's 6–20 Scale) were recorded during submaximal aerobic exercise prior to, immediately following, and approximately one year after weight loss. APE was defined as the composite score of physiological variables (heart rate, ventilation rate, and respiratory exchange ratio) minus RPE.

Results—APE was significantly different from the composite score of physiological variables at baseline and at 1-year follow-up for EA women (0.347±0.88 $p<0.05$ and 0.53±0.92, $p<0.01$ respectively) and at 1-year follow-up for AA (−0.37±1.1, $p<.01$). EA women had lower physiological effort at baseline and 1-year follow-up states (−0.24±0.66 $p<0.05$; and, −0.27±0.84 $p<0.05$ respectively). AA women had higher physiological effort, at 1-year follow-up state (0.21±0.61, $p<0.01$).

Conclusions—Physiologic effort and perceived exertion contributed independently to the racial differences in APE, and APE may be an important trait to evaluate before planning an exercise intervention.

Keywords

weight loss; physical activity; rate of perceived exertion; exercise

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BACKGROUND

Obesity is a chief risk factor for cardiovascular disease and is associated with metabolic perturbations such as insulin resistance, dyslipidemia, and metabolic syndrome ("Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in

Adults--The Evidence Report. National Institutes of Health," 1998; Khaodhiar, McCowen, & Blackburn, 1999; "Methods for voluntary weight loss and control. NIH Technology Assessment Conference Panel. Consensus Development Conference, 30 March to 1 April 1992," 1993; Ogden, Carroll, Kit, & Flegal, 2013). While weight loss has been shown to improve health, achieving and maintaining a healthy weight, particularly after weight loss, is difficult as weight regain is common (Anderson, Konz, Frederich, & Wood, 2001; Byrne, Cooper, & Fairburn, 2003; "Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health," 1998; Wing & Phelan, 2005). Daily physical activity (PA) has been consistently shown to be an important component in maintaining a healthy lifestyle and body weight (van Baak et al., 2003; Weinsier et al., 2002; Weiss, Galuska, Kettel Khan, Gillespie, & Serdula, 2007). However, the majority of Americans do not meet PA recommendations (Booth & Lees, 2006; Carlson, Fulton, Schoenborn, & Loustalot, 2010; Chaput et al., 2011). Therefore, it is important to identify potential factors that influence participation in PA.

Evidence suggests that the physical difficulty that accompanies PA is a possible barrier to PA. Lovell et al. 2010, using the Exercise Benefits/Barriers Scale, determined that physical exertion was the largest perceived barrier to partaking in daily PA among non-exercising university women. A consistent concern was that PA is “fatiguing and hard work” (Lovell, El Ansari, & Parker, 2010). Similarly, using Borg’s rating scale of perceived exertion (RPE) (Borg, 1982) during a submaximal exercise task, we have previously shown that women who perceived exercise effort to be harder than their physiologic effort were less physically active in their daily life (Brock et al., 2010; Hunter, Weinsier, Zuckerman, & Darnell, 2004). In addition, those who over-perceived their physical effort gained more weight one year following a supervised weight loss intervention. Over-perceivers also reported lower vitality, poorer mental health, and poorer dietary control when compared to those who under-perceived exertion (Chandler-Laney et al., 2010). Furthermore, it has been shown that over-perception is associated with reduced levels of physical activity (Hunter et al., 2004). These findings suggest that the accuracy of perceived exertion (APE) may influence psychological health, weight loss maintenance, and likelihood of participation in physical activity. Moreover, APE may be influenced by these factors, specifically weight status. The effect of weight loss and weight regain on APE has not been investigated particularly in previously overweight, sedentary women.

The current study consists of a biracial African American (AA) and European American (EA) sample. There are many known physiological differences between AA and EA. AA women have significantly lower aerobic capacity on a maximal treadmill test (Hunter et al., 2004). Elite male AA endurance runners perform at a higher percent of their VO_2max than EA runners (Trowbridge et al., 1997). In addition, AA runners were shown to be 5% more economical (use less energy) than EA while performing at race pace (Weston, Mbambo, & Myburgh, 2000). Coincidently, Hunter et al. 2004 also demonstrated that typically sedentary AA women are more economical while performing daily physical activities compared to EA women (Hunter et al., 2004). Therefore, AA are more economical, however, they experience more physiological stress (higher heart rate for the same task despite being more economical). This is most likely a function of the lower aerobic fitness found in the AA women. Together, these data suggest that AAs may under-perceive exercise exertion while having lower aerobic capacity. In addition, AAs have low physical activity and higher incidence of obesity (Banks-Wallace & Conn, 2002; Gordon-Larsen, Adair, & Popkin, 2003; Kumanyika, Obarzanek, Stevens, Hebert, & Whelton, 1991; Lee & Im, 2010), are less likely to achieve weight loss goals, and are more likely to regain weight during long-term follow-up (Banks-Wallace & Conn, 2002; Barnes et al., 2007; Gordon-Larsen, Adair, & Popkin, 2002; Gordon-Larsen, McMurray, & Popkin, 2000).

The purpose of this study was to determine the effects of weight loss and weight regain on APE in previously overweight AA and EA women. We hypothesize that APE will improve with weight loss and that there will be racial differences in APE due to physiological differences in aerobic capacity and exercise economy between AA and EA.

METHODS

Participants

Participants included AA and EA premenopausal women between the ages of 20 and 46 years, with a BMI between 27–30 kg/m^2 and a family history of obesity (BMI>27 kg/m^2) in at least one first-degree relative. Participants were nonsmokers, reported regular menses, and had normal glucose tolerance as assessed by an oral glucose tolerance test. Procedures followed were in accordance with the ethical standards of the institution committee on human experimentation. Before participating in the study, all participants provided informed consent. The protocol was approved by the Institutional Review Board and Human Services Regulation of Human Research Subjects.

Procedure

All participants underwent a weight-loss intervention in which they were provided with a 3347.2 KJ/day diet until achieving a BMI < 25 kg/m^2. Prior to the intervention and immediately following weight loss, women underwent a 4-week supervised weight maintenance period during which they were weighed 3–5 times per week. For the last 2 weeks of these two periods, participants were provided with a control diet (20%–22% kJ from fat, 18%–22% kJ from protein, 58%–62% KJ from carbohydrate) from the General Clinical Research Center (GCRC) kitchen. In order to further control for potential environmental confounders that may affect participant performance during the exercise tests, subjects were admitted to the General Clinical Research Center 3 days prior to exercise testing. Exercise testing included submaximal and maximal tasks during which physiological and perceptual responses to exercise were evaluated prior to, following, and approximately one year following weight loss intervention. Body composition was also measured prior to, following, and approximately one-year after the weight loss intervention. Since metabolism may be affected by menstrual cycle, all testing was performed in the follicular phase of the menstrual cycle (within 10 days of menses).

Dual-energy X-ray absorptiometry (DXA)—Percent fat was determined by DXA (DPX-L, Lunar Radiation Corp., Madison, WI, USA). The scans were analyzed using the Adult Software (Version 1.33).

VO_2max—Maximal oxygen consumption (VO_2max) was determined during a maximal modified Bruce graded treadmill protocol (Hellerstein & Franklin, 1984). Heart rate was measured using a POLAR Vantage XL heart rate monitor (Gays Mills, WI, USA). Oxygen consumption and carbon dioxide production were measured continuously via open circuit spirometry, and analyzed using a Sensormedics metabolic cart (Model #2900, Yoma Linda, CA, USA). Prior to each test, the gas analyzers were calibrated with certified gases of known standard concentrations. Standard criteria for heart rate, respiratory quotient, and plateauing were used to ensure achievement of VO_2 max. All subjects achieved at least two criteria for VO_2max.

Submaximal Walk Test—Level walking was performed at 3 miles per hour and 0% grade for 4 minutes on a treadmill (Quinton Instruments, Seattle, WA). Submaximal oxygen uptake (VO_2), heart rate, and rate of perceived exertion (RPE) were obtained in the steady state, during the third and fourth minutes. Average VO_2 for the third and fourth minutes was considered metabolic economy (work output relative to oxygen uptake or energy expended).

Rate of Perceived Exertion—Exercise difficulty was measured using Borg's rating scale of perceived exertion (Borg, 1982). Participants were asked to rate their perceived exertion at the third and fourth minutes of the submaximal walking task.

Composite Physiological Exertion—The physiological response to the submaximal aerobic exercise test was evaluated by three variables commonly measured during exercise: Heart Rate (HR), Ventilation (VE), and Respiratory Exchange Ratio (RER) (Brock et al., 2010). Relative physiological effort during the submaximal walk was calculated by dividing the absolute submaximal values by maximal values obtained during the VO_{2max} test such that $\%HR_{max}$=submaximal HR/HR_{max}; $\%VE_{max}$=submaximal VE/VE_{max}; and $\%RER_{max}$= submaximal RER/RER_{max}. Each physiological effort variable was then converted to a z-score by dividing the difference between the recorded value minus the mean by the standard deviation (%effort/ standard deviation). To obtain a composite relative measure of physiological stress during the 3 mph walk test, the average of the z-scores for $\%HR_{max}$, $\%VE_{max}$, and $\%RER_{max}$ was calculated. The composite physiological effort score did not include $\%VO_{2max}$ because it is known to affect each of the other variables, thus would be redundant (Gamberale, 1972; Robertson, 1982; Skinner, Hutsler, Bergsteinova, & Buskirk, 1973) Difference between composite physiological z-score and RPE z-score represents the difference z-score.

Accuracy of Perceived Exertion—The composite physiological exertion z-score was subtracted from the RPE z-score (RPE_z) to quantify the degree of accuracy in perceived exertion (Chandler-Laney et al., 2010). Therefore, positive values reflect over perception or exertion, and negative values reflect under perception of exertion.

$$\text{Accuracy of perceived exertion } (\text{APE}_z)=\text{RPE}_z-\text{composite physiological exertion}_z.$$

Statistical Analysis

Body composition and exercise variables for EA and AA were computed at baseline. A three (time: baseline, following weight loss, and approximately one-year after the weight loss intervention) by two (race: EA vs AA) ANOVA with repeated measures over time was conducted to analyze race by time interactions in physiological effort (using the composite physiologic z-score) and perceptual effort (z-score), and APE. Paired t-test analysis was used to assess differences between time points by race. A three by two (time x race) ANOVA with repeated measures was used to analyze time by race interactions in heart rate, ventilation, respiratory quotient, and RPE over time. One-sample t-tests were conducted to examine specific *post hoc* contrasts using Bonferroni adjustments. Simple Pearson correlations were performed to examine the consistency in APE.

RESULTS

Body composition and exercise variables for AA and EA at baseline, weight-reduced, and 1-year follow-up are shown in Table 1. There were significant differences between races for percent body fat, maximal RPE and maximal RQ. AA had 42.6±0.47% body fat compared to 44.5±0.48% in EA at baseline (p<0.01). As expected, there was no significant difference between races in weight loss because all women were recruited at a BMI between 27 and 30 kg/m^2 and all had to reduce to a BMI below 25 kg/m^2. Average weight regain at the 1-yr follow-up did not differ between races (5.07 ± 0.48 kg for EA and 5.85 0.47 kg for AA) (Fig. 1). Differences in percent body fat between races did not significantly affect APE.

Fig. 2 represents changes in APE_z by race over time during the submaximal walking task. Repeated measures ANOVA indicated no time effect in APE_z. There was a significant main effect of race and race by time interaction (p<0.05). Paired t-test analysis indicate EA women over perceived exertion, as APE_z was significantly greater than zero at baseline and at 1-year follow-up (0.345 ± 0.88 p<0.05 and 0.523 ± 0.92, p<0.01 respectively). APE_z for AA women was significantly less than zero at 1-year follow-up (−0.367 ± 1.1, p<0.01).

Repeated measures ANOVA of physiological effort show no main effect of time. Main effect of race approached significance (p=0.067). There was a significant race by time interaction as shown in Fig. 3. Composite physiological $exertion_z$ for EA women was significantly less than zero, having lower physiological effort, at baseline and 1-year follow-up states (−0.234 ± 0.66 p<0.05; and, −0.267 ± 0.84 p<0.05, respectively). Composite physiological $exertion_z$ for AA women was significantly greater than zero, having higher physiological effort, at 1-year follow-up (0.201 0.61, p<0.01).

Changes in $RPE_{z,}$ by race over time is shown in Fig. 4. There was no time effect or race by time interaction, however there was a trend for an increase in RPE over time in EA and a decrease in RPE over time in AA.

Figs. 5–9 represent changes in HR, VE, RQ, and RPE, respectively, by race over time during the submaximal walking task. Figures were constructed using absolute values in order to compare across time points. There was a significant between race difference at the 1-year follow-up visit in submaximal HR, RQ, and RPE. Fig. 10 represents maximal VO_2 over time by race.

Pearson correlation between APE_z at baseline and weight reduced state was 0.39 ($p<0.01$), between weight reduced and 1-year follow-up was 0.34 ($p<0.01$), and between baseline and 1-year follow-up was 0.44 ($p<0.01$).

DISCUSSION

The purpose of this study was to determine the effect of diet induced weight loss on APE immediately after weight loss and one year following weight loss in premenopausal, overweight, AA and EA women. The main findings were that APE during the submaximal walking task differed for EA and AA women, and changed with weight status, but in different directions. Specifically, EA women significantly overestimated APE at baseline and 1-year follow-up states, but APE was better in the weight-reduced state. On the other hand, APE of AA women was better than that of EA women in the baseline and weight-reduced states, and was significantly underestimated at the 1-year follow-up. Further, physiological effort and RPE contributed to the racial differences in APE such that AA women had a lower RPE but had a higher physiological effort, while EA women had a higher RPE but a lower physiological effort. These findings suggest that accuracy in estimation of exertion is influenced by body weight and race.

Physiological factors, rather than psychological factors, may explain the tendency for AA to under perceive exertion compared to EA. Studies show AA subjects have lower aerobic capacity than EA subjects do (Hunter et al., 2004; Trowbridge et al., 1997; Weston et al., 2000). Despite lower aerobic capacity, AA show increased exercise economy (use less energy) than EA. This has also been reported in male middle distance runners (Weston et al., 2000) and premenopausal sedentary AA women (Hunter et al., 2004). In our study, AA women tended to have lower VO_2max than EA women ($p = 0.06$), however, reported lower RPE during the 3 mph walk. A significant racial difference in exercise economy may contribute to racial differences in APE. Although AA report lower perceived effort compared to EA, AAs have lower PA and higher incidence of obesity (Banks-Wallace & Conn, 2002; Gordon-Larsen et al., 2002, 2003; Kumanyika et al., 1991; Lee & Im, 2010), are less likely to achieve weight loss goals, and are more likely to regain weight during long-term follow-up (Banks-Wallace & Conn, 2002; Barnes et al., 2007). Together, these findings suggest that accurate perception of exertion may not be an important determinant of whether AA engage in physical activity. Further investigation with respect to psychological factors that influence perceived exertion in AA women is needed.

It is likely that perceived exertion, in the current study, was influenced by psychological more than physiological factors due to the low intensity of the 3mph walk task used. This suggests that the influence of psychological variables on RPE is a function of intensity. Psychological variables influence APE the most at lower intensities, but as intensity increases physiological factors manifest (feeling of HR increase, sweating, increased breathing rate, etc.), and override psychological factors influencing APE (St Clair Gibson et al., 2003). At submaximal exertion levels, perception is dominated by cognitive factors including personality, self-efficacy, mood, and affective responses, and many others. Once a certain intensity is reached, though, the power of sensory cues due to heightened physiological variables (HR, Ve, RER) and metabolic changes prevail over psychological determinants in producing perceived exertion (Bruce J. Noble, 1996; Hetzler et al., 1991).

Many studies report affective responses (pleasure and displeasure) are associated with exercise at various intensities. Though evaluation of affective responses were beyond the scope of the current study, there is evidence that a link exists between perceived exertion and affective responses (Ekkekakis & Petruzzello, 1999; Welch, Hulley, & Beauchamp, 2010). Ekkekakis et al. proposed the dual-mode model, similar to that proposed by Rejeski, which holds that affective responses are likely to be driven by cognitive appraisals (how an individual views a situation) during exercise under the ventilatory threshold (VT). At and above the VT, cognitive appraisals become less significant due to heightened physiological parameters that drive the conscious determination of perception of exertion (Ekkekakis, Hall, & Petruzzello, 2008). In the current study, psychological influences are a likely explanation for the inaccuracy in perceived exertion in our 3mph walk task as the average RPE in overweight, weight-reduced, and approximately 1-year following weight loss was between 8–10 for both AA and EA. This is below the RPE reflective of VT (12–14) (St Clair Gibson et al., 2006). There was a significant within race difference for both AA and EA women in submaximal RPE at the weight-reduced measure compared to baseline as both races accurately predicted RPE compared to physiological variables. This parallels significant changes in body weight, percent fat, and increase in fitness indicated by increased VO_{2max}. This suggests improved fitness and body composition may improve accuracy of perceived exertion, particularly for EA women in our study who over-perceived RPE in the overweight state. Measures approximately 1-year following weight loss indicated increased VO_{2max} compared to baseline in both races. Additionally, AA women significantly improved VO_{2max} at the 1-year follow-up compared to the weight-reduced measure. This occurred despite a significant increase in body weight. There was no within race change in submaximal RPE 1-year following weight loss, however there was a significant between race difference such that EA submaximal RPE was significantly higher than AA women. Interestingly, EA women had lower submaximal RQ and percent body fat 1-year following weight loss compared to AA women. APE decreased 1-year following the weight loss intervention for both races. Because all physiological variables during the submaximal walk were below that of the VT, psychological factors may have more influence on perceived exertion than that of physiological variables. However, our findings suggest that, due to physiological differences between AA and EA women, the psychological factors influencing RPE may differ by race. Further investigation is necessary to determine which psychological factors may influence APE and whether those factors remain significant throughout changes in weight and fitness status.

Results indicate that EA women over-perceived exertion and AA women under-perceived exertion compared to physiological variables during a submaximal walking task despite similar fitness levels, particularly in an overweight state. These findings may be particularly important for implementing an aerobic exercise training program for overweight and obese individuals. RPE scales and other forms of perceived exertion are commonly used as exercise intensity guides for individuals (Eston, Lamb, Parfitt, & King, 2005; Skinner et al., 1973). Inaccurate perceived exertion level may reflect too high or too low exercise intensity and suboptimal results, particularly for obesity-prone EA women. For example, our findings suggest that EA women may over-perceive exertion and reduce exercise intensity during an aerobic exercise program, thus not progress at a desired rate. This may lead to poor exercise adherence, decreased free-living physical activity, poor mental health, and increased weight regain following weight loss (Brock et al., 2010; Chandler-Laney et al., 2010). In our study, AA women under-perceived exertion, which may suggest overtraining. However, studies have reported AAs to have low physical activity and higher incidence of obesity (Banks-Wallace & Conn, 2002; Gordon-Larsen et al., 2003; Kumanyika et al., 1991; Lee & Im, 2010), are less likely to achieve weight loss goals, and are more likely to regain weight during long-term follow-up (Banks-Wallace & Conn, 2002; Barnes et al., 2007; Gordon-Larsen et al., 2002; Gordon-Larsen et al., 2000). Thus strategies for weight loss maintenance and exercise adherence may differ by race. Further investigation is needed to determine whether racial differences in perceived exertion influence health and body composition outcomes of an exercise program.

Conflicting with the dual-mode model, Welch et al., 2010 reported declines in affective responses at intensities below the VT in sedentary women from baseline, revealing that even moderate-intensity exercise elicits premature negative responses. Though affect was not measured in the current study, it is plausible that EA obesity-prone women experience negative affective responses during exercise below the VT reflective of their tendency to over-perceive exertion. AA women, on the other hand, tend to under perceive and may not elicit negative affective responses until intensity is at or above the VT. The association between race, affective responses, and APE, and the reproducibility of such relationships, in obesity prone women are unclear.

Affective responses have been shown to predict future participation in physical activity (Eston et al., 2005; Trowbridge et al., 1997). Findings correspond with the hedonic theory stating that, in general, people are more inclined to partake in activities that make them feel better and are less inclined to participate in activities that make them feel worse (McGraw, Larsen, Kahneman, & Schkade, 2010). Williams et al. found in a sedentary population that those who reported more positive affective responses to moderate-intensity exercise at baseline recorded more minutes of physical activity 6 and 12 months later. As expected, there was a negative association between RPE and affective response. This association was found to be significant in predicting future participation in physical activity (Williams et al., 2008). The prediction no longer existed when controlling for RPE, suggesting that RPE and affect are linked, thus playing an important role in mediating participation in physical activity. Recalling findings by Brock et al., that obesity-prone women who over-perceive level of exertion are more likely to gain weight, those who over-perceive may also be less likely to participate in physical activity because of inflated perception of effort (Brock et al., 2010). Due to the emphasis of moderate-intensity physical activity in maintaining optimal health and weight status, the extent to which APE and affective responses predict the likelihood of physical activity participation in obesity-prone individuals is not known.

Ulmer proposed the theory of teleoanticipation which holds that fatigue is not only a physical event but is a conscious sensation felt as a result of subconscious regulatory process in the brain, in place to ensure homeostasis is maintained during exercise (Ulmer, 1996). Before the beginning of the exercise bout, the brain sends efferent information to different organs and physiological systems in order to generate appropriate power output and metabolic rates. Once the exercise bout has begun, afferent input in response to the onset of exercise sends information to the pacing centers in the brain and subsequent adjustments in power output are made. Thus, power output is continuously modified throughout a bout of exercise. This mechanism may be altered, such as by weight status and race, which may have contributed to inaccuracy in perceived of exertion before the bout of exercise even began in obesity prone participants in this study.

The accuracy of perceived exertion during a 4 minute, 3 mph submaximal walk task was affected by weight change in EA and AA obesity-prone, premenopausal women. European American women tended to over-perceive while AA women tended to under-perceive exertion level. Accuracy was comparable at similar weight status (baseline and 1-year follow-up). Previous findings by our group revealed that over-perception is associated with more weight gain within one year of weight loss (Brock et al., 2010), and those who over-perceive also report lower vitality, poorer mental health, and poorer dietary control (Chandler-Laney et al., 2010). Inaccuracy of perceived exertion may therefore be a trait and barrier to participation in physical activity worth evaluation before planning an exercise intervention. A specialized and individualized program may produce more success in long-term healthy weight maintenance. Further investigation into racial differences in physiological and psychological constructs in determining perceived exertion is necessary.

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GRH conceived and designed the study and aided in data analysis and interpretation of the data. SKS drafted all sections of the manuscript. All authors critically read the manuscript for intellectual content and approved the final version to be published. The authors declare they have no competing interests.

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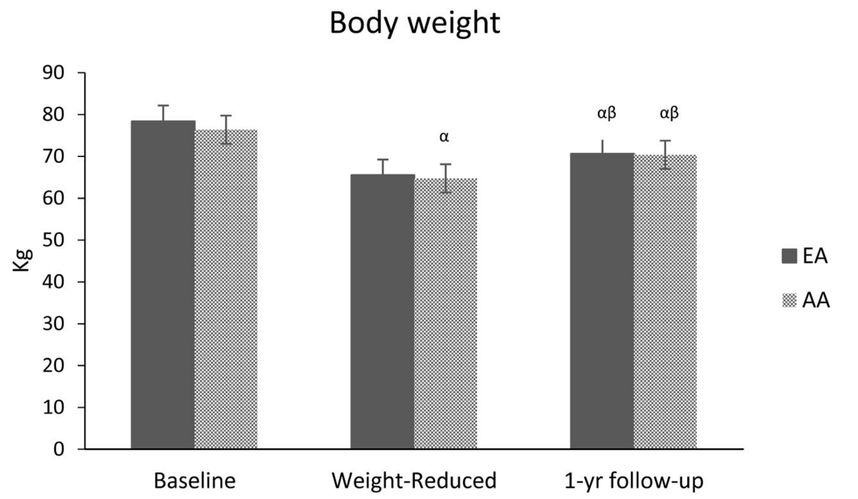

Figure 1.

Body weight by race. EA European American; AA African American; Kg kilograms. $^{\alpha}$within race difference compared to baseline; p<0.05; $^{\beta}$ within race difference between weight-reduced and 1-yr follow-up measures; p<0.05.

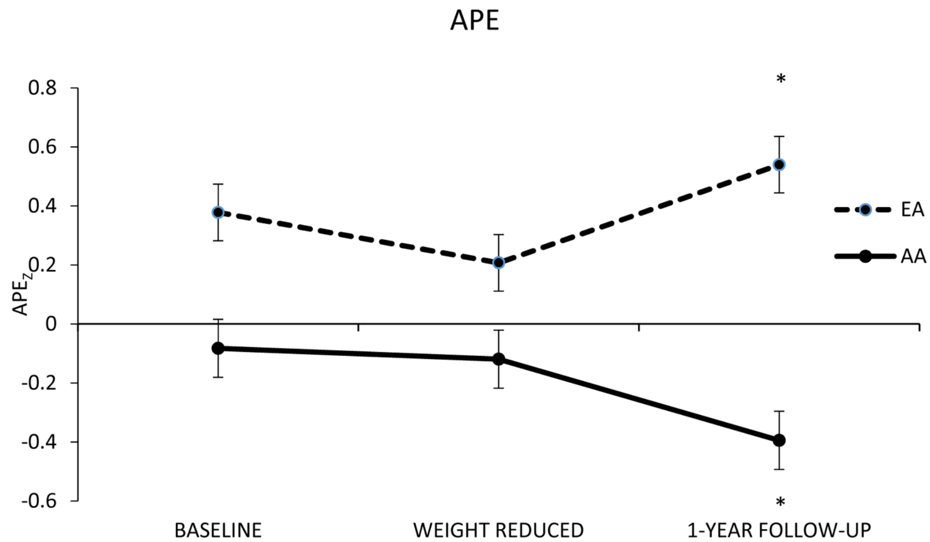

Figure 2.

Changes in submaximal accuracy of perceived exertion over time by race. APE_Z: accuracy of perceived exertion z-score. EA: European American; AA: African American. *indicates significant difference from zero; $p<0.05$

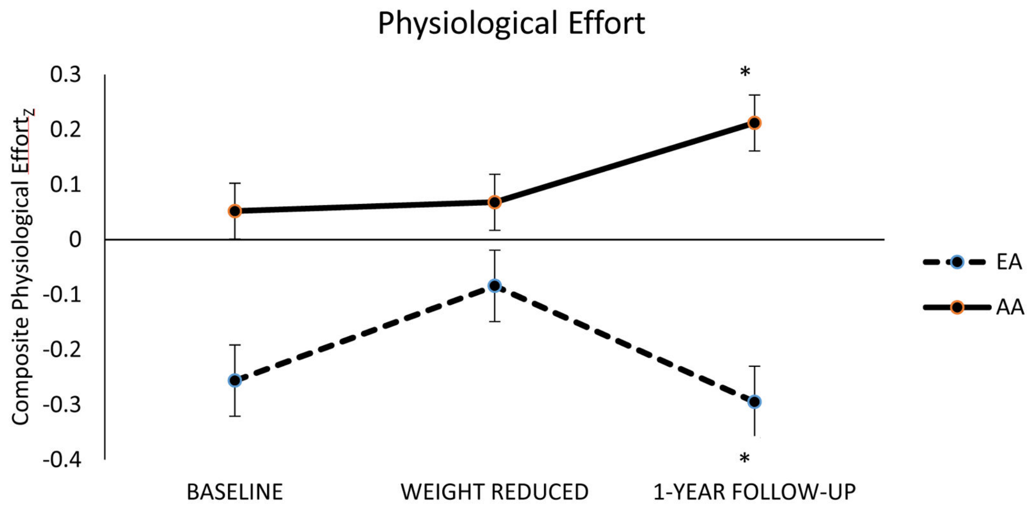

Figure 3.

Changes in submaximal physiological effort by race. EA European American; AA African American. *indicates significant difference from zero; $p<0.05$

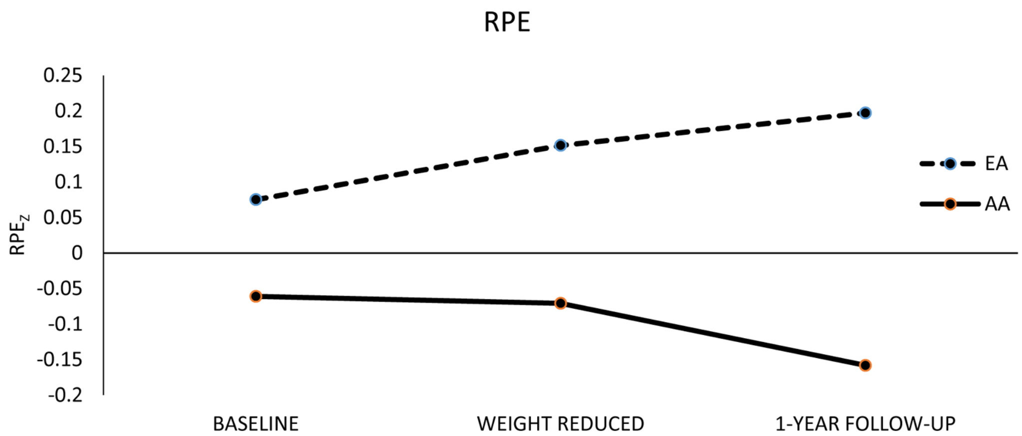

Figure 4.

Changes in submaximal rating of perceived exertion over time by race. RPE_z: rating of perceived exertion z-score. EA: European American; AA: African American.

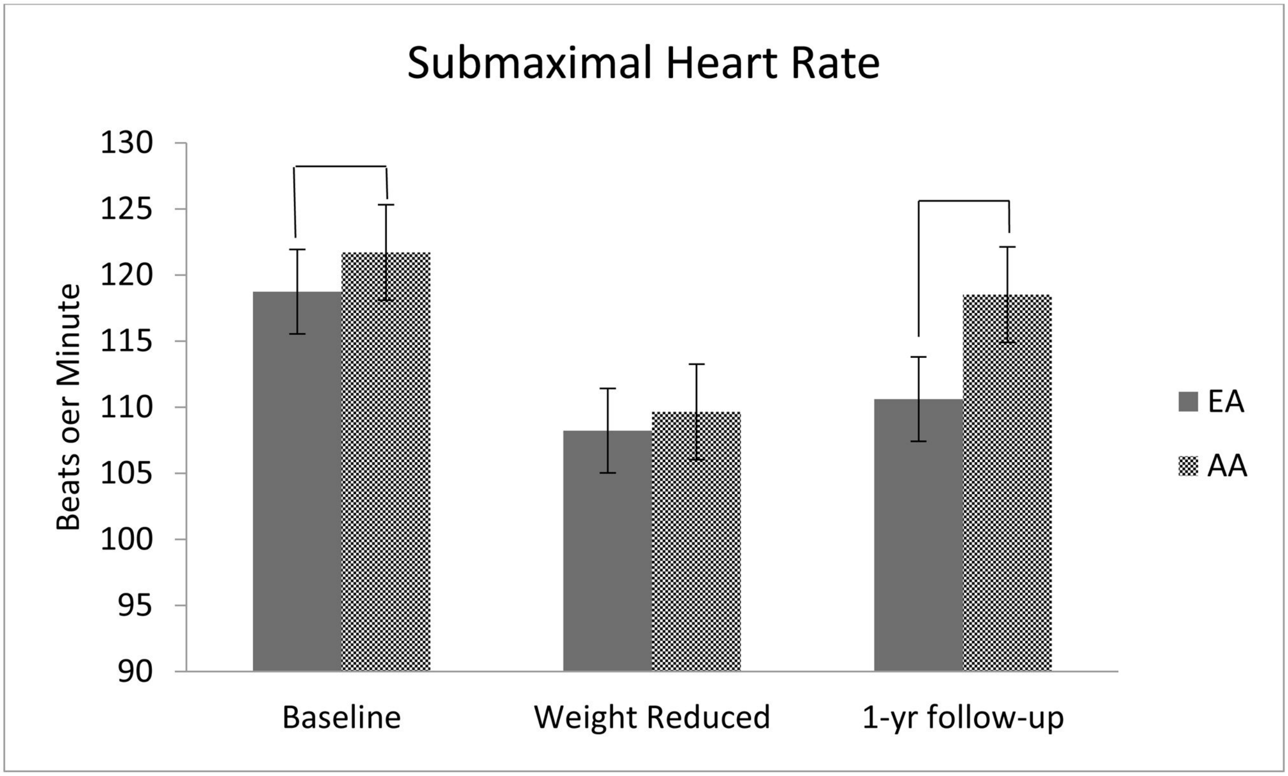

Figure 5.
Absolute values for heart rate during submaximal exercise by race. EA European American; AA African American. *p<0.05

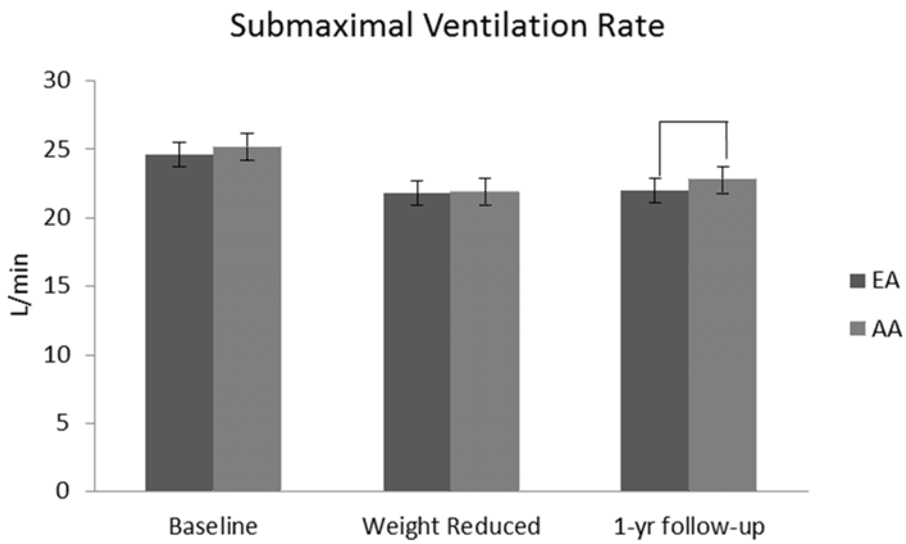

Figure 6.
Absolute values for ventilation rate during submaximal exercise by race. EA European American; AA African American. *p<0.05

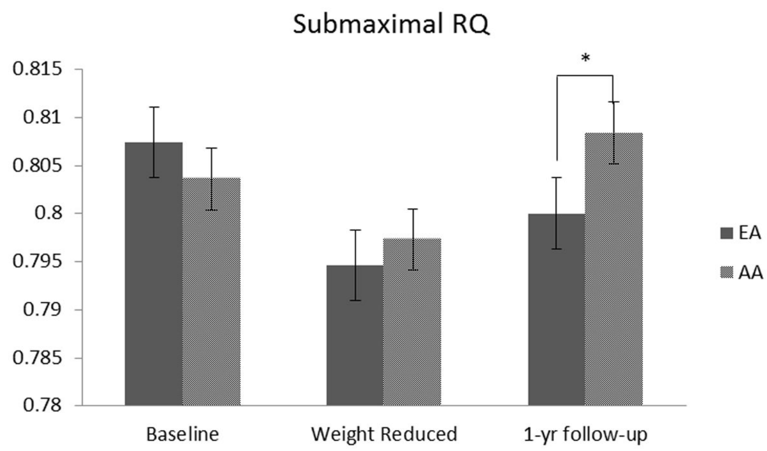

Figure 7.
Absolute values for RQ (respiratory quotient) during submaximal exercise by race. EA European American; AA African American. *p<0.05

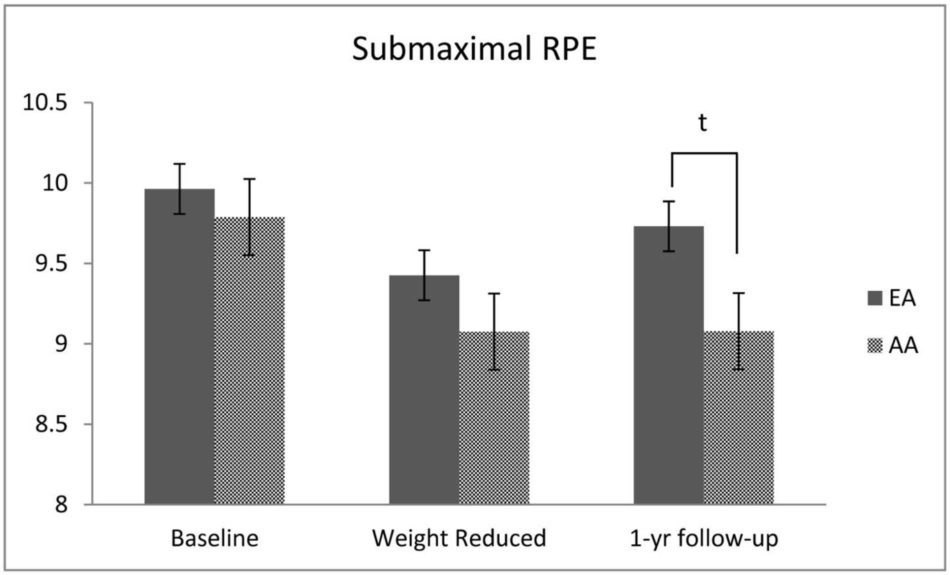

Figure 8.

Absolute values for rating of perceived exertion during submaximal exercise by race. EA European American; AA African American. $^{t}p<0.10$

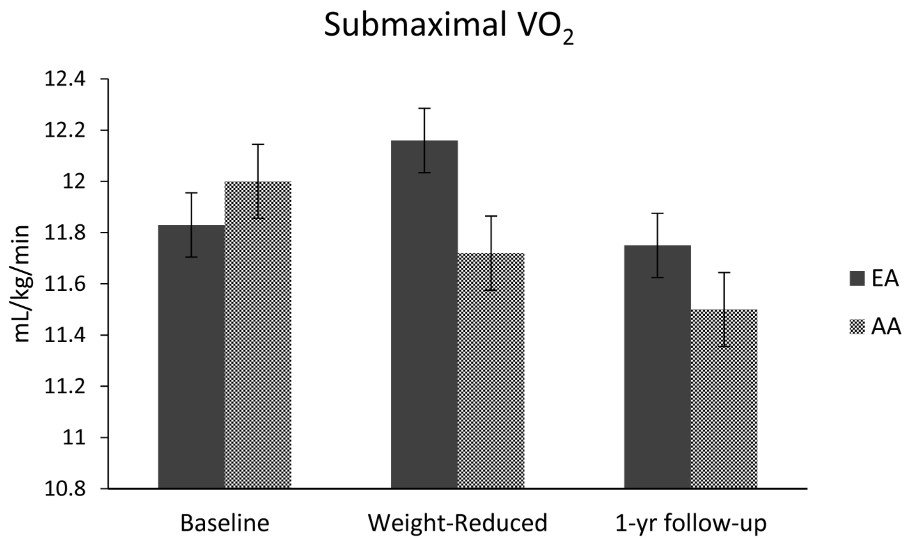

Figure 9.

Absolute values for VO_2 during submaximal exercise by race. EA European American; AA African American

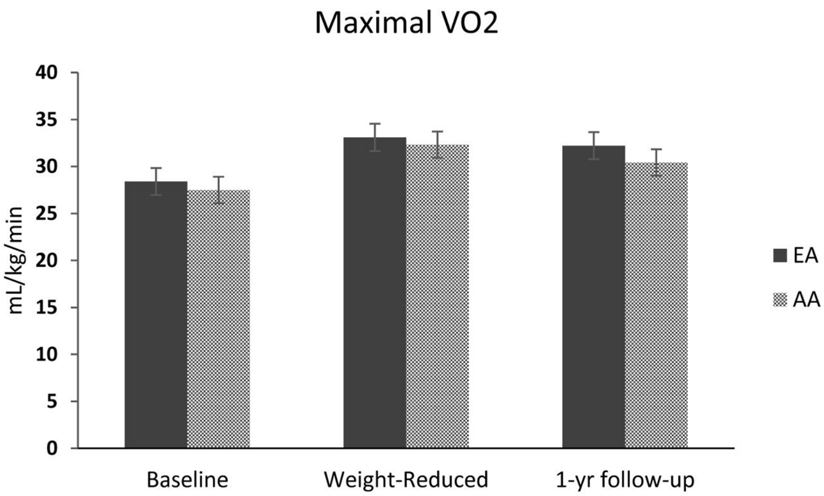

Figure 10.

Absolute values for VO_2 during maximal exercise by race. EA European American; AA African American

Table 1

Outcomes at baseline, with weight loss, and approximately 1-year following weight loss

	Baseline		Weight reduced		1-yr follow-up	
	AA	**EA**	**AA**	**EA**	**AA**	**EA**
Age (years)	34.7±6.1	35±6.7				
BW(kg)	76.4±.70	78.4±1.28	64.73±4.9 $^{\alpha}$	65.54±8.2 $^{\alpha}$	70.39±7.0 $^{\alpha\ \beta}$	70.64±9.8 $^{\alpha\beta}$
BMI	28.20±1.1	27.96±1.36	23.97±0.9 $^{\alpha}$	23.75±1.2 $^{\alpha}$	26.01±1.9 $^{\alpha\ \beta}$	25.36±2.2 $^{\alpha\beta}$
% Body fat	42.6±.47	44.5±.48 *	31.78±4.7 $^{\alpha}$	34.32±4.4 $^{*\ \alpha}$	37.48±5.21 $^{\alpha\ \beta}$	38.72±5.8 $^{\alpha\ \beta}$
HR_{submax}	121.48±15.4	119.76±13.9	110.85±16.8 $^{\alpha}$	108.05±16.7 $^{\alpha}$	118.61±13.8 $^{\beta}$	110.76±15.3 $^{*\ \alpha}$
$VO_{2submax}$	12.0±1.3	11.83±1.3	11.72±1.3	12.16±1.9	11.50±1.2	11.75±1.2
VE_{submax}	25.12±4.1	25.13±3.8	21.75±2.7	22.04±3.9	22.69±2.9 $^{\alpha}$	21.82±3.5 $^{\alpha}$
RQ_{submax}	0.8±0.01	0.81±.01	0.8±0.05	0.80±0.05	0.81±0.05	0.79±0.04 *
RPE_{submax}	9.71±2.0	10.18±1.8	8.88±2.0 $^{\alpha}$	9.44±1.7 $^{\alpha}$	8.94±1.9 $^{\alpha}$	9.76±1.6 ^{t}
HRmax	187.55±8.6	186.68±8.3	184.98±8.6 $^{\alpha}$	183.58±8.9 $^{\alpha}$	185.63±9.1 $^{\alpha}$	182.84±9.3 $^{\alpha}$
VO_{2max}	27.5±.4	28.4±.6	32.33±5.0 $^{\alpha}$	33.10±4.9 $^{\alpha}$	30.42±4.5 $^{\alpha\ \beta}$	32.22±5.5 $^{\alpha}$
VEmax	88.90±14.7	99.93±15.5	88.07±14.6	91.52±14.2	86.65±11.6	92.15±15.8
RQmax	1.26±0.1	1.31±0.1 *	1.25±0.09	1.27±0.1	1.22±0.09 $^{\alpha\ \beta}$	1.24±0.1
RPEmax	17.78±1.9	18.7±1.2 *	17.43±2.0	18.47±1.4 *	16.96±1.7 $^{\alpha}$	18.18±1.4 *

Submax reflects measured values during the standardized 3 mph submaximal walking test. EA: European American; AA: African American; BW: Body Weight; BMI: Body Mass Index (kg/m^2); VO2max: maximum oxygen consumption (mL/kg/min); HR: Heart Rate.

* indicates significant difference between race; $p<0.05$.

^{t} indicates between race differences $p<0.10$

$^{\alpha}$ indicates significant within race difference from baseline; $p<0.05$.

$^{\beta}$ indicates significant within race difference between weight-reduced and 1-yr follow-up measures; $p<0.05$.