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ETHNIC DIFFERENCES IN THE CONSISTENCY OF ACCURACY OF PERCEIVED EXERTION

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KATHERINE SWEATT

EXERCISE PHYSIOLOGY

ABSTRACT

Objective It has been previously found previously overweight women who over-perceived their exertion during a submaximal task gained more weight during the following year and reported lower vitality, poorer mental health, and poorer dietary control when compared to those who under-perceived exertion. Therefore, we investigated the effect of diet-induced weight loss on accuracy of perceived exertion (APE), and examined whether any changes persist one year following a weight loss intervention in premenopausal, previously overweight, African American (AA) and European American (EA) women. *Design* formerly overweight women (n=102, age 20-44 yrs) completed a weight loss program to achieve a normal body weight (BMI <25). Submaximal aerobic exercise task was performed while measures of physiological and perceived exertion (Borg's 6-20 RPE Scale) were recorded prior to, immediately following, and approximately one year after weight loss. *Results* APE_z was significantly greater than zero at baseline and at 1-year follow-up for EA women (0.347 ± 0.88 $p < 0.05$ and 0.525 ± 0.92 , $p < 0.01$ respectively) and was significantly less than zero at 1-year

follow-up for AA (-0.366 ± 1.1 , $p < .010$). EA women had lower physiological effort at baseline and 1-year follow-up states (-0.238 ± 0.66 $p < 0.05$; and, -0.266 ± 0.84 $p < 0.05$ respectively). AA women had higher physiological effort, at 1-year follow-up state (0.207 ± 0.61 , $p < 0.010$). *Conclusion* EA women tended to overperceive despite lower physiological effort compared to AA women. AA women tended to underperceive, despite having higher physiological effort than EA women. Physiologic effort and perceived exertion contributed independently to the racial differences, and APE may be a trait evaluation before planning an exercise intervention.

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Keywords: perceived exertion, accuracy of perceived exertion, weight loss

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LIST OF ABBREVIATIONS

AA	African American
ANOVA	Analysis of Variance
APE	Accuracy of Perceived Exertion
APE _Z	Accuracy of Perceived Exertion z-score
BMI	Body Mass Index
DXA	Dual X-ray Absorptiometry
EA	European American
GCRC	General Clinic Research Center
HR	Heart Rate
kg	kilogram
Kj	kilo joule
m ²	square meter
RER	Respiratory Exchange Ratio
RPE	Rate of Perceived Exertion
RPE _Z	Rate of Perceived Exertion z-score
RQ	Respiratory Quotient
SES	Socioeconomic Status
VE	Ventilation
VO ₂	Oxygen consumption
VO _{2max}	Maximum oxygen consumption
VT	Ventilatory Threshold

INTRODUCTION

Obesity continues to be a problem in the United States and is associated with adverse health [1,2]. The difficulty in healthy weight maintenance after a weight loss intervention is well documented as weight regain is common [1,3-9]. Daily physical activity has been consistently shown to be an important component in maintaining a healthy lifestyle and body weight [10-12]. However, the majority of Americans do not participate in enough physical activity [13,14]. Therefore, it is important to identify potential factors that influence participation in physical activity.

Previous studies have found that those who perceive exercise effort to be harder than their physiologic effort would predict are less physically active [17-19]. Generally, people are more inclined to do things that make them feel better and are less inclined to participate in activities that make them feel worse [15,16]. Lovell et al., using the Exercise Benefits/Barriers Scale, determined that physical exertion was the largest perceived barrier to partaking in daily physical activity among non-exercising university women. A consistent concern was that physical activity is “fatiguing and hard work” [20].

Perceived exertion refers to the act of detecting and interpreting sensations from the body during exercise [21] and is commonly measured with Borg’s rating scale of perceived exertion (RPE) [21, Skinner, Borg). Borg depicts RPE as a psychophysiological model, integrating both physiological and psychological constructs

[21]. The RPE scale correlates with physiological measures of exertion including heart rate (HR), ventilation rate, oxygen uptake (VO_2), blood lactate concentration, and respiratory exchange ratio (RER) during standardized tasks and the relationship tends to increase with exercise intensity [21, 22,]. Perceived exertion is influenced not only by physiologic feedback, but an interaction of physiologic and psychological stimuli such as mood, previous experience of a task, affective responses, and knowledge of time and/or distance to completion [23, 24]. Accordingly, it is probable that perceived exertion in overweight individuals is not merely a consequence of physiologic effort, but psychological constructs as well [17, 18, 25, 26].

It is logical that practicing an activity improves the ability to perceive exertion level accurately. Indeed, research has shown that when RPE is used to regulate exercise intensity, practice improves the ability to reproduce a given RPE [27, 28]. As expected, RPE itself increases as intensity increases due to amplification of physiological cues of exertion such as increased HR, breathing rate, and muscle fatigue [29, 30, 31].

Ekkekakis and colleagues proposed the dual mode model suggesting that intensities at and above the ventilatory threshold (VT), physiological parameters become heightened and drive the conscious determination of perception of exertion. On the other hand, intensities below the VT are likely driven by psychological influences because physiological influences are not heightened [29, 32, 33]. In the current study, RPE was evaluated during moderate intensity exercise; therefore psychological factors may play a significant role in the accuracy of RPE, or accuracy of perceived exertion (APE). APE during exercise has not been thoroughly investigated, particularly accompanied by changes in body weight.

Our group has recently found discrepancies in the APE in a homogenous population of weight-reduced, obesity-prone women. Brock et al. evaluated physiologic and perceptual measures of exertion and found that those who over-perceived their exertion during a submaximal task gained more weight during the following year (Brock). Importantly, evaluation was performed during a weight-reduced state with all BMIs between 23 and 25 kg/m². Considering that over-perception is associated with reduced levels of physical activity [19] and higher weight regain after weight loss intervention [17], it is plausible that an underlying psychological attribute, independent of an individual's weight and physiologic response, reduces engagement in physical activity and thereby jeopardizes long-term weight maintenance. To further add to this observation, Chandler-Laney examined associations of APE with psychological variables in the same group of women as used in the Brock et al. study [18]. Those women who over-perceived exertion reported lower vitality, poorer mental health, and poorer dietary control when compared to those who under-perceived exertion.

Evidence suggests that as weight gain occurs, it becomes a barrier to physical activity [34]. Ekkekakis et al. observed the effects of chosen exercise intensity versus 10% higher than chosen intensity in overweight and normal-weight women. There was no difference in chosen intensity between overweight and normal weight women but overweight women reported higher RPE. At intensity 10% higher than chosen, overweight women had significantly diminished pleasure compared to normal-weight controls [25]. The dual mode model proposed by Rejeski suggests that at low to moderate intensities, psychological factors have a stronger influence on RPE than physiological factors [25, 29, 32, 33]. RPE of overweight women may be influenced by

psychological variables such as poor mental health, self-efficacy, and lower affective responses to physical activity causing lower APE. Therefore, weight loss may improve APE 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 [19]. Elite male AA endurance runners have been found to perform at a higher percent of their VO₂max than EA runners [35]. Weston also showed AA runners were 5% more economical (use less energy) while performing at race pace. This indicates AA may operate at a higher physiological output with less perceived exertion. Hunter also demonstrated that typically-sedentary AA women are more economical while performing daily physical activities [19]. Together, these data suggest that African Americans may under-perceive exercise exertion while having lower aerobic capacity. In addition, AA have lower physical activity and higher incidence of obesity [36, 37,38, 39], are less likely to achieve weight loss goals, and are more likely to regain weight during long-term follow-up [36, 37, 40].

The purpose of this study was to determine the effect of diet-induced weight loss on APE, and to examine whether any changes persist one year following the weight loss intervention in premenopausal, previously overweight, AA and EA women. We hypothesize that APE will improve (approach zero Z-score units) with weight loss. Because AA are more economical in locomotion, we hypothesize that they will tend to under-perceive exertion compared to EA.

METHODS

Participants

Participants included AA and EA, premenopausal women between the ages of 20 and 46 years. Participants were recruited to have a BMI between 27-30 kg/m² with a family history of obesity (BMI>27 kg/m²) in at least one first-degree relative. Participants were placed into one of three groups: diet only, diet plus aerobic exercise, or diet plus resistance exercise. Participants were nonsmokers, reported regular menses, and had normal glucose tolerance as assessed by an oral glucose tolerance test. 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/m². Prior to the intervention and immediately following weight loss, women underwent 4-week supervised weight maintenance periods during which they were weighed 3–5 times per week. For the last 2 weeks of this period, 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 GCRC 3 days prior to exercise testing. Exercise

testing included submaximal and maximal tasks during which physiological and perceptual responses to exercise were evaluated. 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).

VO₂max

Maximal oxygen consumption (VO₂max) was determined during a maximal modified Bruce graded treadmill protocol (Hellerstein). 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 Sormedics 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 VO₂ max.²⁰ All subjects achieved at least two criteria for VO₂ max.

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.

Rate of Perceived Exertion

Exercise difficulty was measured using Borg's rating scale of perceived exertion [41]. Participants were asked to rate their perceived exertion at the third and fourth minutes of the submaximal walking task on a 6-20 point scale which was anchored by.....

Physiological Exertion

Three variables were used to evaluate the physiological response to the submaximal walk test: Heart Rate (HR); Ventilation (VE); and Respiratory Exchange Ratio (RER).

Relative physiological effort during the submaximal walk was found by pooling the three variables. Each was converted to a z-score by dividing the difference between the recorded value minus the mean by the standard deviation ($\text{HR} - \text{mean HR} / \text{standard deviation}$). The z-scores for the three variables were then averaged to obtain the composite physiological score for the relative measure of physiological stress during the 3 mph walk test. Difference between composite physiological z-score and RPE z-score represents the difference z-score [17].

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 [18]. Therefore, positive values reflect overperception or exertion, and negative values reflect underperception of exertion.

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

STATISTICAL ANALYSIS

Body composition and exercise variables for EA and AA were computed at baseline. A three by two (time x race) repeated measures ANOVA was used to analyze time by race interactions in heart rate, ventilation, respiratory quotient, and RPE over time. A three (time: baseline, weight-reduced, 1-yr follow-up) by two (race: EA vs AA) repeated measures ANOVA was conducted to analyze race by time interactions in physiological effort (using the composite physiologic z-score), and perceptual effort (z-score), and APE. 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 are shown in Table 1. There were no significant differences between races with the exception of percent body fat. AA had $42.6 \pm 0.47\%$ body fat compared to $44.5 \pm 0.48\%$ 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 and all had to

reduce to a BMI below 25. Average weight regain at the 1-yr follow-up did not differ between races (5.068 ± 0.48 kg for EA and 5.852 ± 0.47 kg for AA). Differences in percent body fat between races did not significantly affect APE (not shown). African American women had more lean mass compared to European American women, however this did not affect APE, weight loss, or weight regain.

Table 1: Descriptive Characteristics

N=102	AA	EA	P
Age (years)	34.7 \pm 6.1	35 \pm 6.7	0.77
Height (m)	164.6 \pm .79	166.6 \pm 1.1	0.13
BW(kg)	76.4 \pm .70	78.4 \pm 1.28	0.16
BMI	28.2 \pm .16	28.1 \pm .2	0.64
Body Fat Percent	42.6 \pm .47	44.5 \pm .48	0.008*
VO_{2max}	27.5 \pm .4	28.4 \pm .6	0.06
HR_{submax}	121.1 \pm 1.9	120 \pm 2.1	0.68
VO_{2submax}	11.8 \pm 1.3	12.1 \pm 1.5	0.29
VE_{submax}	25.0 \pm .6	25.1 \pm .6	0.97
RQ_{submax}	0.8 \pm 0.01	0.81 \pm 0.01	0.43
RPE_{submax}	9.73 \pm 2.0	9.98 \pm 1.8	

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); VO_{2max}: maximum oxygen consumption ($\text{mL}/\text{kg}/\text{min}$); HR: Heart Rate; *Significance at $p < 0.05$.

Figure 1 represents changes by race in physiological variables (HR, Ve, and RQ) and RPE over time during the submaximal walking task. The figure was constructed using absolute values in order to illustrate changes in these variables across time points. Statistical analysis of these changes were conducted on the z-scores of the composite physiological effort and RPE (discussed below)

Repeated measures ANOVA indicated no time effect in APE_z (Figure 2). There was a main effect for race as EA overestimated and AA underestimated APE ($p < 0.05$).

There was also a race by time interaction ($p<0.05$) shown in Figure 2. Post hoc analysis indicate EA women overperceived exertion, as APE_z was significantly greater than zero at baseline and at 1-year follow-up (0.347 ± 0.88 $p<0.05$ and 0.525 ± 0.92 , $p<0.01$ respectively). APE_z for AA women was significantly less than zero at 1-year follow-up (-0.366 ± 1.1 , $p<0.010$). It is important to point out that the interaction affect, i.e. AA decreasing APE_z and EA increasing APE_z masked the main effect of time. That is, APE changed with weight status, but this change was in different directions for AA and EA women.

Repeated measures ANOVA of physiological effort show no main effect of time. The main effect of race approached significance ($p=0.065$). There was a significant race by time interaction shown in Figure 3. The composite physiological exertion_z for EA women was significantly less than zero, indicating lower physiological effort at baseline and 1-year follow-up (-0.238 ± 0.66 $p<0.05$; and, -0.266 ± 0.84 $p<0.05$ respectively). The composite physiological exertion_z for AA women was significantly greater than zero, indicating higher physiological effort at 1-year follow-up (0.207 ± 0.61 , $p<0.010$).

Figure 4 shows a significant race effect and race by time interaction for RPE ($p<0.05$ and $p<0.05$, respectively). EA tended to have a high RPE while AA tended to have a low RPE. EA reported RPE_z significantly greater than zero at 1-year follow-up (0.259 ± 0.86 , $p<0.05$)

The Pearson correlation coefficient between APE_z at baseline and at the weight reduced state was 0.39 ($p<0.01$); between the weight reduced state and the 1-year follow-

up was 0.34 ($p < 0.01$), and between baseline and the 1-year follow-up was 0.44 ($p < 0.01$; data not shown).

DISCUSSION

The purpose of this study was to determine the effect of diet induced weight loss on APE, both immediately after weight loss and at 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 at the 1-year follow-up (significantly higher than zero), but estimated APE better in the weight-reduced state. On the other hand, the average APE of AA women closely approximated zero (indicating RPE was not different from physiological effort) in the baseline and weight-reduced states, and was significantly underestimated at the 1-year follow-up. The stronger correlation between the overweight state and one year follow-up (after subjects had regained some of their previously lost weight) suggests that estimates of effort may be affected by weight status. Differences between AA and EA in physiological effort and RPE contribute to the racial differences in APE. AA women had a lower RPE but had a higher physiological effort, while EA women had a higher RPE but a lower physiological effort. Together with the finding that accuracy of perceived exertion remains fairly consistent across time irrespective of weight change, the fact that EA remained over-estimators of exertion, while AA accurately or under-estimated exertion, implies that accuracy in estimation of exertion may be an inherent trait that is not influenced by current weight status.

Ethnic Differences

AA subjects have lower aerobic capacity than EA subjects. This has been reported in AA children [42], male middle distance runners [35], and premenopausal sedentary AA women compared to their EA counterparts [19]. In our study, AA women tended to have lower VO₂max than EA women ($p = 0.06$), however, reported lower RPE during the 3 mph walk. Despite lower aerobic capacity, AA show increased exercise economy (use less energy) than EA. This has also been reported in male middle distance runners [35] and premenopausal sedentary AA women [19]. A significant racial difference in exercise economy may contribute to racial differences in APE. Despite the finding of lower perceived effort among AA compared to EA, AAs have lower physical activity and higher incidence of obesity [36, 37, 38, 39] are less likely to achieve weight loss goals, and are more likely to regain weight during long-term follow-up [36, 38, 40]. Together, these findings suggest that accurate perception of exertion may not be an important determinant of whether AA engage in physical activity. Further investigation into psychological factors influencing perceived exertion specific to AA women is warranted.

The Influence of Psychological Factors

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. Rejeski proposed a model in which the influence of psychological variables on RPE as a function of intensity was described. At submaximal exertion levels, perception is dominated by cognitive factors including personality, self-efficacy, mood, and affective responses, among others. Once certain intensity is reached, though, the power of sensory

cues due to heightened physiological variables (HR, \dot{V}_E , RER) and metabolic changes overrides psychological determinants in producing perceived exertion [30, 31].

Many studies also show affective responses (pleasure and displeasure) are associated with exercise at various intensities. There is evidence that a link exists between perceived exertion and affective responses [33, 43, 44]. 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 as physiological parameters become heightened and drive the conscious determination of perception of exertion [32]. 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 was 9.28 and 9.72 for AA and EA respectively, well below the 12 to 14 normally associated with VT [23]. Importantly, 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. Such factors may require specific intervention in order to retain a successful weight loss program in obesity prone women.

Conflicting with the dual-mode model, Welch et al reported declines in affective responses at intensities below the VT in sedentary women at baseline, revealing that even moderate-intensity exercise elicits premature negative responses [43]. 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 merits further research.

Affective responses have also been shown to predict future participation in physical activity [42, 45]. 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 [15, 16]. 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, and this association was found to be significant in predicting future participation in physical activity [44]. The prediction no longer existed when controlling for RPE, suggesting that RPE and affect are linked and play an important role in mediating participation in physical activity. Recalling findings by Brock et al., that obesity-prone women who over-perceive 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. Due to the emphasis of moderate-intensity physical activity in maintaining optimal health and weight status, additional research determining the extent to which APE and affective responses predict the likelihood of physical activity participation in obesity-prone individuals is warranted.

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 [24]. 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. It may be that this mechanism is altered and perception of exertion is inaccurate before the bout of exercise even begins.

Conclusions

The accuracy of perceived exertion during a 4 minute, 3 mph submaximal walk task was consistent and the tendency to over- or underperceive exertion was not 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. Physiologic efficiency and perceived exertion contributed independently to the racial differences. 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 [17], and those who over-perceive also report lower vitality, poorer mental health, and poorer dietary control [18]. 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. Due to differences between AA and EA women in physiological efficiency and perceived exertion, weight loss and physical activity strategies may need to be race-specific. Further investigation into racial differences in

physiological and psychological constructs in determining perceived exertion is necessary.

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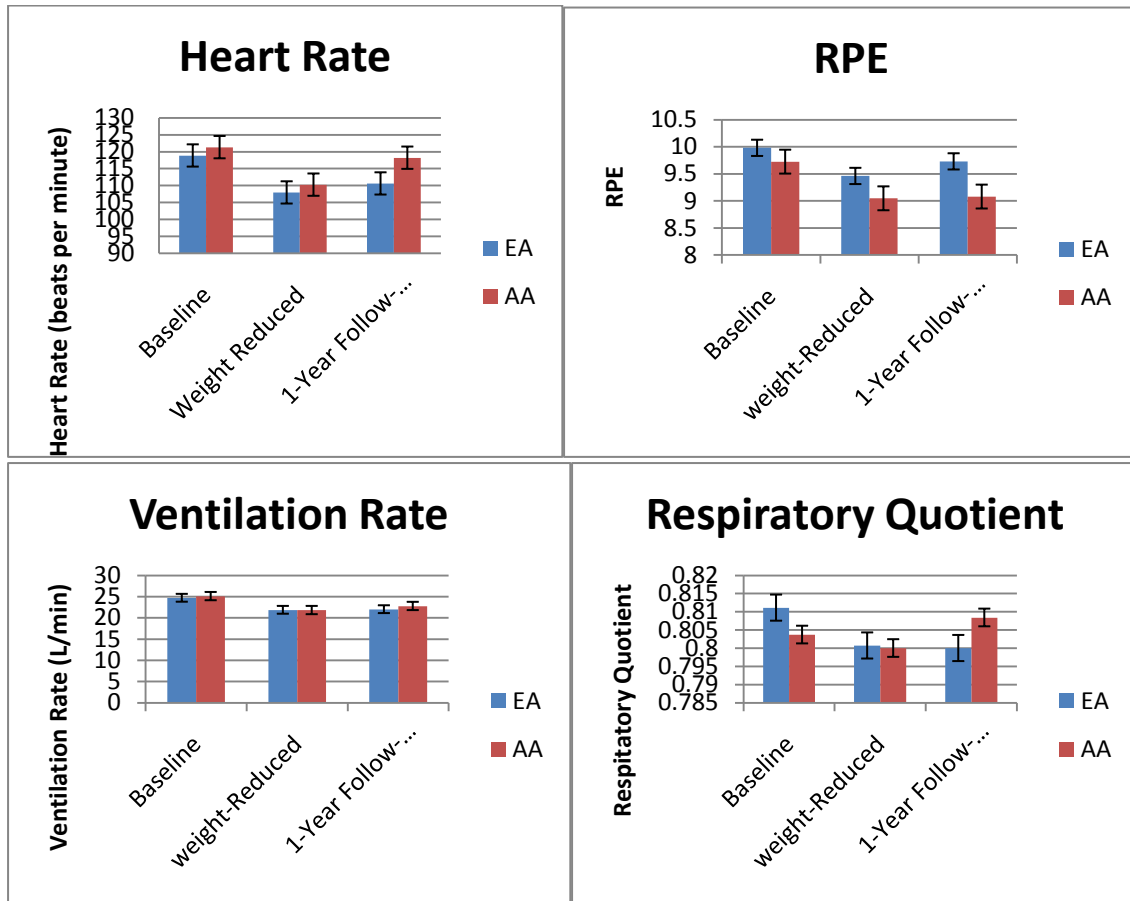


Figure 1 Changes in Physiological Variables and RPE Over Time
Absolute values for HR, Ve, RQ and RPE reported by race over time.

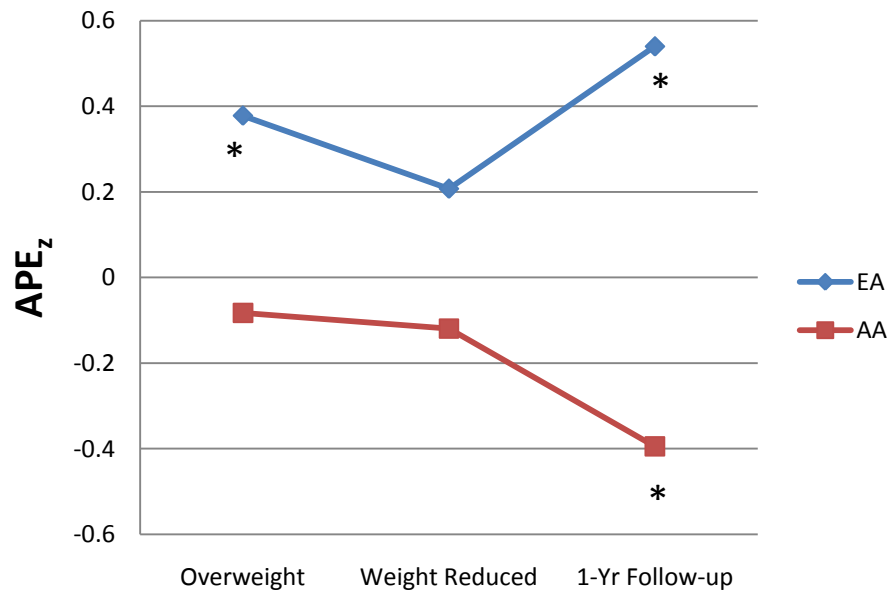


Figure 2: Accuracy of Perceived Exertion

There was no main effect of time in APE_z . There was a significant main effect of race ($p=.039$) and race by time interaction ($p<0.05$). Post hoc analysis of within race differences revealed APE_z was significantly greater than zero at baseline and 1-year follow-up states for EA women ($p<0.01$ at baseline and $p<0.001$ at 1-yr follow-up). APE_z was significantly less than zero at 1-year follow-up for AA women ($p<0.01$).

APE_z =Accuracy of Perceived Exertion in z-score units

*Significant difference from zero.

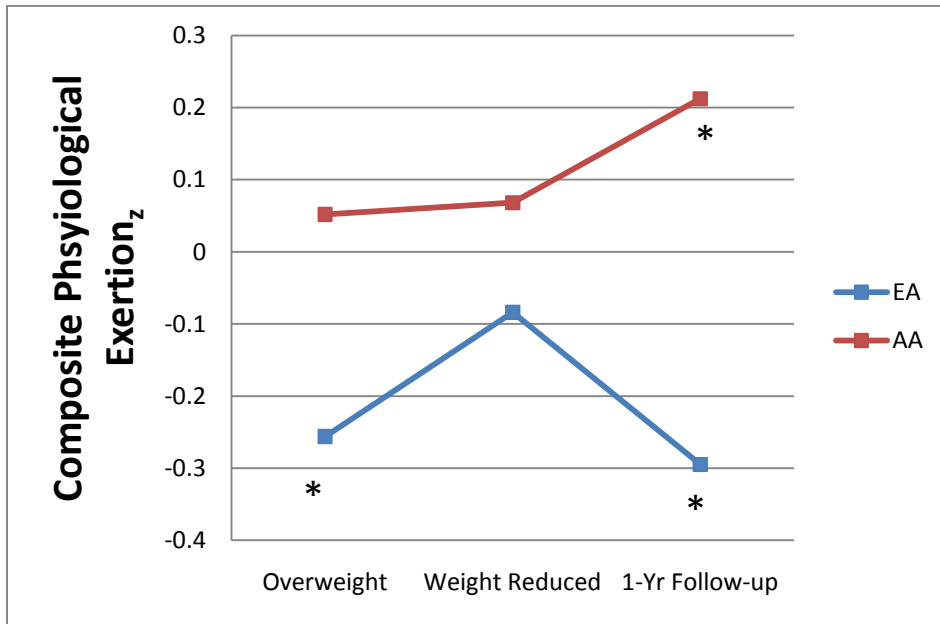


Figure 3: Physiological effort

There was no time effect in composite physiological exertion_z. Race approaches significance (.065). Post hoc analysis indicate EA women show significantly less composite physiological exertion_z from zero at baseline and 1-year follow-up ($p<0.05$ and $p<0.05$ respectively). AA women show significantly greater composite physiological exertion_z at 1-year follow-up ($p<0.01$).

*Significant difference from zero. Composite physiological exertion_z = composite physiological exertion z-score

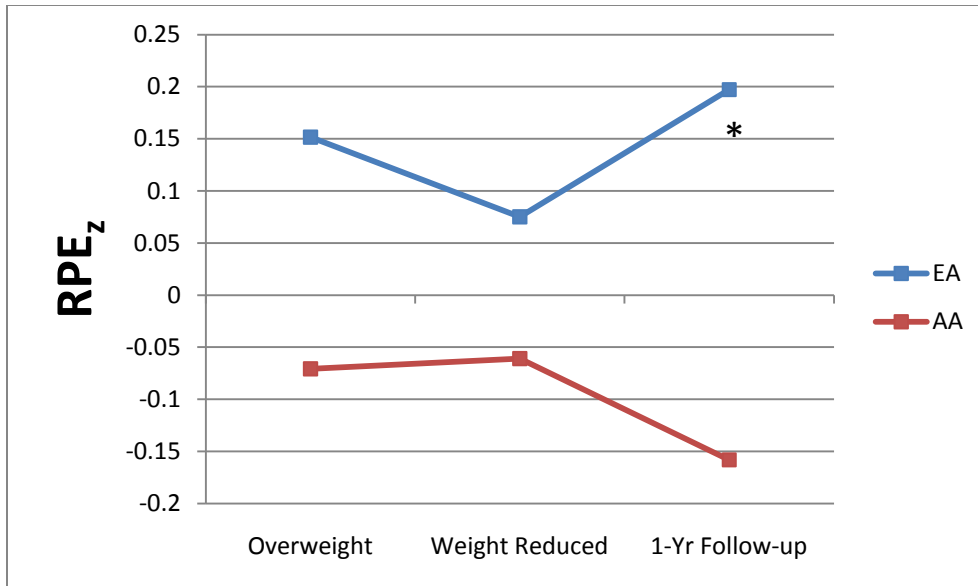


Figure 4: Rate of Perceived Exertion

There was a significant main effect of race and race by time interaction for RPE_z ($p < 0.05$ and 0.01 , respectively). EA tended to over-perceive, while AA tended to under-perceive. EA reported RPE_z significantly greater than zero at 1-year follow-up ($p < 0.05$).

*Significant difference from zero. RPE_z = rate of perceived exertion z-score

Perceived Exertion, Participation in Physical Activity, and Weight Loss Maintenance

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A LITERATURE REVIEW

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INTRODUCTION

The prevalence of overweight and obesity is increasing in the United States and other industrialized countries (Mokdad). Despite consistent findings indicating that daily physical activity is important in maintaining a healthy body weight and a healthy lifestyle, physical inactivity remains one of the most challenging current public health concerns (Booth, Anderson, Grief, Weiss).

The lack of success in maintaining a healthy weight status after a weight loss intervention is well documented (Booth, Grodstein, Van Baak, Wadden, Weinsier Wing 2001, 2005). On average, participants regain about half of weight lost within one year of the intervention and approximately 80% of participants will regain all of weight lost within 3-5 years after the intervention (Byrne). Physical activity is important in maintaining weight loss over time (Barnes, Chaput, Wing). A qualitative study by Byrne et al. determined that those who regained weight after a weight loss intervention were less physically active and less adherent to diet control (Byrne). Identification of reasons for lack of engagement in adequate physical activity may therefore lead to potential strategies to increase physical activity for weight maintenance.

Recent research has focused on issues impacting physical activity and barriers to healthy active living. Variations in perceptions associated with physical activity among individuals are likely to impact the decision to be physically active (Lovell, Hall).

Perceived of exertion refers to the detection and interpretation of sensations experienced

by an individual during exercise and is commonly measured by Borg's rating scale of perceived exertion (RPE) (Borg, Bruce and Noble). The RPE scale is a psychophysiological model integrating two broad groups of information into one conceptual model, namely physiological and psychological factors. It relates to physiological variables such as ventilations rate (V_e), heart rate (HR), respiratory rate, oxygen uptake (VO_2), and blood lactate among others (Chen, Robertson and Noble). RPE is also related to psychological variables including personality factors, situational factors, and affective responses. Psychological variables have a greater impact on RPE at lower intensities and become less influential as intensity increases (Robertson and Noble, Hall). Perceived exertion represents the final conscious configuration of physical exertion which varies between individuals. RPE likely influences one's inclination to participate in physical activity, and subsequently, the ability to maintain healthy weight status.

Our group has recently found discrepancies in the accuracy of perceived exertion (APE) in a population of weight-reduced, obesity-prone African American (AA) and European American (EA) women. Physiological variables including RQ, HR, and V_e were analyzed during a 4 minute, 3mph walking task. RPE was obtained during the last 30 seconds of the walk. Each was converted to a z-score and the physiological variables were averaged to constitute a composite physiological score. To determine accuracy of perceived exertion, the composite z-score was subtracted from the RPE z-score. Brock et al. found that those who over-perceived their exertion gained more weight during the following year, independent of race (Brock). To further add to this observation, Chandler-Laney compared APE with psychological variables in the same group of

women as used in the Brock et al. study. Those women who over-perceived exertion reported lower vitality, poorer mental health, and poorer dietary control when compared to those who under-perceived exertion. It is likely that over-perception is associated with reduced levels of physical activity (Hunter 2004 Aerobic Fitness), contributing to higher weight regain after weight loss intervention (Brock).

We also found AA women tend to under-perceive and EA women to over-perceive RPE during a 3mph walking task (Unpublished). Differences between AA and EA in physiological effort and RPE contribute to the racial differences in APE. AA women had a lower RPE but had a higher physiological effort, while EA women had a higher RPE but a lower physiological effort. Therefore, it is plausible that an underlying psychological attribute, independent of an individual's weight and physiologic response, reduces engagement in physical activity and thereby contributed to long-term weight maintenance, and this may vary between races.

Inaccuracy of perceived exertion may therefore be a trait and barrier to participation in physical activity worth evaluation before planning an exercise intervention in both AA and EA women. A specialized and individualized program may produce more success in long-term healthy weight maintenance. Due to differences between AA and EA women in physiological efficiency and perceived exertion, weight loss and physical activity strategies may need to be race-specific.

The purpose of this review is to discuss physiological and psychological aspects of perceived exertion and racial differences that may contribute to accuracy of perceived exertion. Theories that integrate psychological and physiological constructs of perceived

exertion, exercise adherence related to perceived exertion, and effects of weight status on perceived exertion will be covered.

1. Physiological Factors of Perceived Exertion

Perceived exertion refers to detecting and interpreting sensations arising from the body during physical exercise (Noble and Roberson p. 4). The most widely used instrument is Borg's 15-point rating scale of perceived exertion (RPE). The RPE scale is used as an indicator of intensity level. Relations between perceived exertion and physiological variables have been identified, though no single variable directly and consistently relates to perceived exertion (Chen, Eston 2007). It is important to understand the underlying physiological and psychological processes influencing perceived exertion in order to apply perceived exertion in a clinical setting. The intensity of perceptual signals of exertion is mediated by physiological responses during exercise (Noble and Roberson, Perceived Exertion p. 105). According to Noble and Roberson (Perceived Exertion), three mediators exist, composing the psychophysiological model of perceived exertion; respiratory-metabolic mediators, peripheral mediators, and nonspecific mediators (Noble and Robertson). Changes in these mediators are thought to be monitored during exercise by the brain and regulated to prevent any factor from causing harm.

1.1 Respiratory-Metabolic Mediators

Respiratory-metabolic mediators include ventilator drive (V_e), oxygen consumption (VO_2), carbon dioxide excretion (VCO_2), Heart rate (HR), and blood pressure (Noble and Robertson). An independent relationship between each respiratory-metabolic mediator

and perceived exertion has been found under a variety of performance and environmental conditions. The relationship becomes stronger at higher metabolic rates due to increased exercise intensity (Noble and Robertson, Hall, Ekkekakis). Therefore, at low to moderate intensities, respiratory-metabolic mediators do not have as strong of an influence on RPE, as they do at high intensities.

1.2 Peripheral Mediators

Peripheral mediators refer to physiological events in active muscles and joints. Lactic acid production, contractile properties of fast and slow-twitch skeletal muscle fibers, muscle blood flow, and energy substrate status are thought to mediate the intensity of peripheral perceptions of exertion. Robertson et al. (1986) used NaHCO_3 ingestion to alter blood pH responses during leg and arm exercise at relative metabolic rates ranging from 20-60% of VO_2max . Shifts in blood pH during high intensity exercise (80% VO_2max) mediated peripheral perceptions of exertion in active muscle. However, at intensities below 80% VO_2max , ratings of perceived exertion were not affected by changes in blood pH suggesting a threshold effect (Rejeski). This is consistent with Rejeski's theory that as increases in physiological sensations occurs due to increasing exercise intensity, the relationship between perceived exertion and physiological constructs also increases.

A relationship between muscle fiber-type distribution may influence perceived exertion, though evidence is conflicting. Increased perceived exertion has been reported in fast-twitch dominant muscles, possibly because of the increased production of lactic acid and faster onset of muscle fatigue (Noble and Robertson). Muscle blood flow is

occluded by auscultation causing increased sensations of exertion(Noble and Robertson). When exercise intensity is high and muscular tension is at a high percent of maximal voluntary contraction, portions of the vascular bed are occluded elevating peripheral vascular resistance. This causes fatigue in the active muscle and increases perceived exertion.

Energy substrate status mediates perceived exertion as well (Noble and Robertson). Depletion of carbohydrate fuel sources triggers muscular fatigue. Horstman et al. (1979) suggests that the decision to terminate prolonged exercise is linked to mechanisms that regulate carbohydrate metabolism during exercise (Noakes). Findings suggest carbohydrate metabolism during exercise influences perceived exertion only above the lactate threshold.

Noakes and colleagues propose that RPE is not only the direct result of afferent sensory input, but is influenced by muscle glycogen status. RPE increases more rapidly in a glycogen-depleted state (Baldwin 2003), therefore Noakes suggests that the rate of RPE reflects glycogen depletion rate during exercise. Furthermore, taking duration into account, pace is set based upon muscle glycogen status and anticipated end-point (Noakes 2004, Tucker).

1.3 Nonspecific Mediators

Nonspecific mediators are those that are not linked directly to respiratory-metabolic or peripheral sensations of perceived exertion. Nonspecific mediators are hormonal regulation, temperature regulation (Crewe), and pain reactivity. Following the

common theme of physiological mediators of perceived exertion, as nonspecific mediators intensify with increasing exercise intensity, the correlations with RPE increase (Noble and Robertson). Catecholamine (CAT) secretion (epinephrine and norepinephrine) may influence perceived exertion metabolically and/or psychologically in nature. Metabolically, CAT secretion during prolonged exercise regulates blood glucose levels. At power outputs lower than the lactate influx, CAT secretion is minimal. However, at intensities greater than 50% of $\text{VO}_{2\text{max}}$, CAT secretion is increased markedly and parallels a fall in muscle glycogen and blood glucose, reflecting fatigue. Circulating CAT has a psychological effect that may influence perceived exertion. This hormone is secreted in response to emotional stress and unpleasant sensations which accompany high-intensity exercise. Therefore, CAT secretion in response to exercise, especially high intensity exercise, may influence perceived exertion in both a metabolic and psychological origin (Noble and Robertson).

Crewe et al. studied the influence of ambient temperature on RPE and found a significant correlation between RPE and rectal temperature, which increased linearly with exercise duration (Crewe). They suggest the brain may be able to subconsciously set a rate of increase of RPE based on duration of the exercise bout, heat condition, and intensity therefore reaching volitional fatigue before excessive rise in body temperature (Crewe).

In summary, correlations between physiological mediators and perceived exertion get stronger as intensity increases. It can be surmised that perceived exertion during low to moderate intensity exercise is mediated primarily by psychological factors resulting in more interindividual variation. At intensities low to moderate intensities, RPE is likely

subject to influence by numerous psychological variables such as personality, mood, feelings toward exercise, previous experience of exercise, and many others, which may in turn affect APE.

2. Psychological Aspects of Perceived Exertion

Physiological sensations account for 50%-80% of the variance in perception of exertion (Noble and Robertson p 172). Therefore, inter-individual variations in perception of exertion must involve psychological inputs as well as physiological. Psychological factors influencing RPE are described as situational and dispositional. Situational factors refer to environmental influences rather than personal characteristics. Dispositional factors are those embedded in one's personality that might affect perception, personality for example (Noble and Robertson pg. 172).

2.1 Situational Factors

Situational factors that influence RPE include expected duration of exercise, social influence of a cofactor (such as a tester or competitor), self presentation, and timing of evaluation.

2.1a Expected Duration

Rejeski et al. (1980) was the first to suggest that one's expected duration of an exercise bout modifies RPE. In 1996 Hans-Volkhart Ulmer proposed the theory of teleoanticipation in which the brain regulates exercise intensity in response to sensory feedback from multiple systems in the body and fatigue is "conscious sensations of subconscious interpretation of subconscious regulatory processes in the brain (Crewe,

Noakes, St. Claire-Gobson).” In a study by Crewe, participants performed five cycling trials at varying temperatures and intensities. Findings revealed that RPE increased linearly with time during exercise at a fixed intensity and the rate of RPE increase predicts the duration of exercise to exhaustion at a constant load. From this observation, the conclusion can be drawn that the brain takes into account expected duration and power output in producing RPE. Coquart et al. found that athletes had lower RPE during a running test when endpoint was unknown compared to the test with a known running distance (Coquart), suggesting knowledge of running length influenced the ratings of perceived exertion. Time to fatigue can be predicted at the onset of exercise because termination of exercise is congruent to maximal RPE. Ulmer suggests that the conscious increase in RPE at increased intensity and/or near completion of the exercise bout is a subconscious strategy by which the brain prevents catastrophic failure in maintaining homeostasis (Ulmer, Crewe, St. Claire-Gibson 2004, Noakes 2005).

Baden et al. studied the effects of (i) known duration of 20 minutes, (ii) unknown duration, and (iii) deceived duration where participants were told they were to perform a 10 minute run at 75% VO_2max then informed to run an additional 10 minutes. In the deceived trial, RPE increased significantly between minute 10 and 11 compared to the other two trials. This supports Ulmer’s theory of teleoanticipation. The brain prepares the body for an exercise bout at a certain intensity with a known duration with perceived exertion increasing linearly. When this system is tricked, as in Baden’s study, RPE significantly increased when exercise duration went just one minute past what was expected.

2.1b Social Influence of a Cofactor

Social influence may have an impact on RPE. RPE tends to be lower when exercising in the presence of other people than when exercising alone at low to moderate exercise intensities. However, at high intensity, RPE is not affected by social influence likely because physiological cues become more powerful (Hardy, Hall, Prestholt 1986).

2.1c Timing of RPE Evaluation

Depending on when RPE is evaluated (before, during, or after exercise) may have an impact on accuracy of perceived exertion (Kilpatrick). The assessment of RPE after an exercise is commonly referred to as a session RPE in which the global experience of the exercise is qualified (Day, Foster). The session RPE has been designated a valid method in assessing an exercise bout as a whole (Day, Foster), however, one study found RPE assessed post-exercise tended to reflect only the end of the exercise bout instead of the bout as a whole (Kilpatrick). Kilpatrick et al. found that RPE assessment before a bout of exercise was higher than RPE during or after the bout (Kilpatrick). This is in concert with pain perceptions in which one overperceives anticipated pain stimuli (Arntz). This may be important in exercise adherence as exercise may be perceived as hard or painful, therefore one is less likely to participate. Predicted RPE may therefore be used as a determinant of adherence to exercise in some populations.

2.1d Self-Presentation

Self-presentation refers to the degree which one values presenting oneself in a socially desirable manner. It can take the form of audience pleasing, self-construction (the attempt to build one's cognitive and affective representation of one's own identity),

or the motive to impress others in general. High self-constructors have been shown to rate RPE lower than low self-constructors. Wright et al. (Wright 2005) studied the relation of physical self-efficacy and motivational responses toward physical activity in urban high school students. They found positive relationships among perceived physical ability, physical self-presentation, confidence, effort, and enjoyment. This indicated that those who had higher perceived physical ability were likely to have higher perceptions of self-presentation, more enjoyment of physical activity, and work harder in physical activity. It is logical to conclude that high self-presentation is linked to lower RPE during physical activity due to higher perceived physical ability, confidence, and enjoyment during physical activity. According to these results, physical self-efficacy seems to be a strong predictor of motivation in physical activity (Wright 2005).

Situational factors may be important in APE and subsequently participation in adherence to exercise. Implementing such strategies as increasing self-efficacy, strategies for coping with cofactor presence in a positive manner, increasing self-presentation, and finding the best exercises and intensity that is not too strenuous but results in appropriate calorie burn for weight maintenance may be beneficial for some exercisers.

2.2 Dispositional Factors

Dispositional factors are psychological traits identified to have an influence on RPE and include external or internal locus of control, associative or dissociative cognitive style, affective responses (pleasure vs. displeasure) introversion-extroversion, and self-efficacy among others.

2.2a Locus of Control

Those with an internal locus of control believe their behavior influences outcomes whereas those with an external locus of control attribute outcomes to external forces such as fate or other people (Noble and Robertson). Therefore, those with external locus of control tend to give higher RPE, believing they are working harder than they actually are when intensity is manipulated (Kohl and Shea 1988- Noble and Robertson pg 180). Few studies have reported consistent results supporting Kohl and Shea's findings. Chandler-Laney et al. found that women with an external locus of control had a higher RPE but lower physiological output during a 4minute 3mph treadmill walk (Chandler-Laney). These women also tended to gain more weight in one year following a weight loss intervention. Hassm'en and Koivula found similar results in which women with an external locus of control have higher RPE but lower heart rate while performing a cycling task (Hassm'en). Further research is necessary to establish a link between APE and locus of control in predicting weight maintenance and physical activity participation.

2.2b Association or Dissociation

Attention focus is the manipulation of sensory cues (internal or external) to control conscious awareness. Associational attention focus is characterized by focus on bodily sensations- respiration, temperature, and muscular fatigue specifically- necessary for optimal performance (Lind). Dissociation, on the other hand, is actively blocking out sensations of pain or discomfort related to physical exertion (Lind). Pennebaker and Lightner found participants to have greater enjoyment and satisfaction during a bout of exercise performed while listening to street sounds (external focus) than while listening

to breathing sounds (internal focus) (Pennebaker). These findings led to the hypothesis that an individual's exercise experience depends on whether an internal or external attention focus is maintained (Pennebaker).

Evidence also suggests dissociation at low intensities and association at higher intensities, as physiological sensations become stronger (Lind). In a study comparing experienced marathon runners to recreational runners, Schomer (1986) found that associative strategy was related to intensity. As intensity increased, so did association (or attention). Experienced marathoners trained at a higher intensity, therefore had higher proportions of associative thinking while running. The recreational runners were found to use a dissociation strategy, deflecting physiological sensory cues as a form of distraction from exercise. As perceived effort increased, so did associative thinking as well as intensity (Schomer).

To improve adherence to physical activity recommendations among recreational exercisers, the method of dissociation may be more beneficial. During a bout of exercise, the brain is constantly shifting attention focus between associative and dissociative thoughts (Schomer, Antonini-Philippe Moran). More specifically, dissociative thinking early in the exercise and progressing to more associative thoughts as the bout nears completion. This may be due to an increase in physiological sensations also causing RPE to increase. It is possible that a link exists between progression of exercise duration, intensity, increased association, and RPE.

2.2d Self-Efficacy

Self-efficacy refers to the belief one has in their ability to successfully produce a desired result. Efficacy is an important determinant of behavior, thought patterns, and affective reactions in situations perceived to be challenging (Bozoian, Ekkekakis 1999). It is theorized that those with high self-efficacy during exercise will have lower perceived exertion than those with low self-efficacy (Noble Robertson). Hall et al. proposed that the relationship between RPE and self-efficacy varies in magnitude with exercise intensity. They found that at and below the VT, there was a consistent significant negative correlation between RPE and self-efficacy. Above the VT, there was a consistent absence of significant correlation (Hall 2005). Self-efficacy may, therefore, be an important psychological factor in APE and exercise adherence. Further research investigating the effects of high versus low self efficacy in relation to APE and the inclination to engage in physical activity is needed.

2.2e Extraversion-Intraversion

Eysenck's theory of personality suggests that extraversion is closely related to positive affect. He argues that extraverts have a low level of basal arousal therefore reduce intensity of incoming stimulation, whereas introverts amplify incoming stimulation because of their high level of basal arousal (Eysenck). Hall et al. evaluated aspects of personality in relation to RPE and exercise intensity. Extraversion, neuroticism, behavioral activation, and behavioral inhibition were analyzed at 20% below, equivalent to, and 10% above ventilator threshold. They found extraversion to be consistently negatively correlated with RPE at all intensities (Hall 2005). This is supported by the personality theory which states that extroverts seek higher levels of sensory stimulation. Extroversion may therefore have lower RPE during low to moderate

physical activity when physiological cues of exertion are minimal and psychological cues dominate. As intensity increases, though, extroversion or introversion likely has less of an impact on RPE because physiological cues take over in producing RPE more accurately.

2.2f Behavioral Activation or Inhibition

In the same study as above, Hall et al. found a positive correlation between behavioral inhibition, but not activation, at all intensities using the Behavioral Inhibition (BIS) and Behavioral Activation Systems (BAS) scales. Behavioral inhibition refers to the inhibition to move towards one's goals and is associated with sensitivity to punishment and negative affect (Hall 2005).

Exercise recommendations for individuals based on dispositional factors may be result in a formula for successful exercise adherence and weight maintenance. Further research of specific dispositional factors at various intensities is necessary to determine barriers to adherence to exercise, and possibly successful healthy weight maintenance.

3. Theories Integrating Physiological and Psychological Constructs in Producing RPE

3.1 Dual-Mode Model

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 as physiological

parameters become heightened and drive the conscious determination of perception of exertion (Ekkekakis 2003). At and above the VT heart rate, respiration rate, muscle fatigue, and lactic acid production among other physiological variables intensify.

Rejeski's model took intensity of exercise into account. When physiological demands of exercise are submaximal- below the VT, psychological factors dominate RPE. When exercise intensity increases, the sensory input from physiological factors dominate RPE (Rejeski). The level at which the shift from heightened psychological input to physiological input in determining RPE has not been discovered and likely varies from individual to individual due to tolerance threshold. One assumption is that the relationship between physiological and psychological variables with RPE change systematically as a function of exercise intensity (Hall, Rejeski). This theory holds that psychological variables are correlated with RPE but, as exercise intensity increases, the correlation weakens (Hall, Rejeski). Individuals that tend to over-perceive may be more sensitive to increases in physiological sensations before those who perceive more accurately or tend to under-perceive physical exertion. Therefore, individualized cognitive strategies for exercise adherence may benefit those who tend to over-perceive exertion. Association and dissociation strategies may be an appropriate application in order to maintain adherence to and extend the intensity and/or duration of low to moderate exercise when psychological factors are the primary influence on RPE (Lind).

3.2 Teleoanticipation

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 [24]. 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. It may be that this mechanism is altered and perception of exertion is inaccurate before the bout of exercise even begins.

4. RPE and Exercise Adherence

According to the National Institutes of Health Development Panel on Physical Activity and Cardiovascular Health, “moderate intensity physical activities are more likely to be continued than are high intensity activities (NIH).” As far as the relationship between exercise intensity and adherence, exercise must be “pleasant enough” to compete with other pleasurable options available to the exerciser (Ekkekakis, Hall). Current ACSM guidelines recommend at least 30 minutes of moderate physical activity five days per week. As far as the relationship between exercise intensity and adherence, exercise must be “pleasant enough” to compete with other pleasurable options available to the exerciser (Ekkekakis, Hall). Pollock proposed “people participate in programs they enjoy. Lower-intensity effort makes programs more enjoyable (Pollock).” Healthy People 2010 suggests that “each person should recognize that starting out slowly with an activity that is enjoyable...is central to the adoption and maintenance of physical activity behavior.”

A study by Ekkekakis et al. found that intensity of 15 minute treadmill exercise influenced the affective responses during exercise in young adults. When intensity exceeded that of the VT, there was significant decrease in positive affective responses (Ekkekakis 2008). Higher intensity exercise, therefore, reduces pleasure which could negatively affect adherence. Ekkekakis also observed the influence of intensity on affective responses in overweight women. Results indicated that at an intensity just 10% above self-selected intensity, led to a significant decrease in pleasure. This suggests that enjoyment and intrinsic motivation for physical activity may reduce adherence over time (Ekkekakis 2005).

5. Racial Differences

African American (AA) women have lower rates of physical activity than all other race groups with the exception of Mexican American Women (Banks-Wallace, Adamas-Campbell, King). Compared with European American women (EA), AA have a 2-fold higher prevalence of type II diabetes, hypertension, and stroke and a 2.7-fold higher risk of overall mortality (Becker, Nies). External, environmental barriers to physical activity differ between AA and EA women. According to a study by Neis et al. utilizing focus groups to identify barriers to physical activity among AA women, lack of social support, need for childcare, unsafe environment, concerns of hair care, and lack of home space were among the top concerns preventing physical activity in AA women (Neis 1999).

On the other hand, research has revealed differences in physiological and psychological aspects of physical activity between AA and EA women. Many studies

have found AA subjects to have lower aerobic capacity than EA subjects. This has been shown in AA children (Trowbridge, Pivarnik), women (Hunter 2000), and male middle distance runners (Weston 2000). AA male middle distance runners use less energy while running (Weston) and Hunter et al. found AA women to use less energy while performing a battery of tasks such as walking at 3mph, climbing stairs, and riding a bike (Hunter 2000). Our group has recently found AA women tend to under-perceive RPE during a 3mph walking task. This is likely in part due to increased economy. Therefore, RPE mediated exercise prescription may not be an effective intervention for weight maintenance in AA women. Further research focusing on improving the exercise behavior and success in weight maintenance of AA women is necessary.

6. Influence of Weight Status on RPE

Evidence suggests that as weight gain occurs, it becomes a barrier to physical activity [34]. Ekkekakis et al. observed the effects of chosen exercise intensity versus 10% higher than chosen intensity in overweight and normal-weight women. There was no difference in chosen intensity between overweight and normal weight women but overweight women reported higher RPE. At intensity 10% higher than chosen, overweight women had significantly diminished pleasure compared to normal-weight controls [25]. The dual mode model proposed by Rejeski suggests that at low to moderate intensities, psychological factors have a stronger influence on RPE than physiological factors [25, 29, 32, 33]. RPE of overweight women may be influenced by psychological variables such as poor mental health, self-efficacy, and lower affective

responses to physical activity causing lower APE. Therefore, weight loss may improve APE in previously overweight, sedentary women.

7. on Weight Status: Weight Loss and Weight Loss Maintenance

Exercise is not only a way to burn calories as commonly perceived, rather it is important in maintaining healthy body weight (Chaput). Exercise contributes to improvement in energy and macronutrient regulation and to regulation of global body homeostasis (Tremblay). Therefore, exercise should be performed on a regular basis. From a physiological standpoint, when a sedentary person begins an exercise program, regulation of metabolism brought on by the exercise stimulus occurs at many levels including an influx of key enzymes, increased cellular sensitivity to regulatory hormones, facilitation of substrate membrane transportation, and many others. With sedentary behavior, the body must compensate for the lack of the exercise stimulus on regulation of metabolism. Thus, fat gain and associated health complications ensue. With fat gain, maintenance of energy metabolism requires the overuse of regulatory hormones occurs, such as hyperinsulinemia, in order to control energy intake and expenditure (Chaput). How successfully exercise contributes to healthy weight maintenance depends on energy cost of the exercise bout and the extent to which post exercise energy metabolism is altered. Therefore, appropriate exercise duration, intensity, frequency, and type, as well as nutrition, for sufficient amount of calorie burn should be the goal of an exercise intervention.

Discussion

The purpose of this review was to discuss previous studies on the topics of perceived exertion, participation in physical activity, and weight loss maintenance. The objectives were to relate these factors to our group's recent findings of inaccuracy of perceived exertion and weight regain.

It seems a chain link between APE, exercise intensity, adherence to sufficient exercise, psychological factors and weight loss maintenance may exist. This follows Ekkekakis and Hall's intensity-affect-adherence model (Ekkekakis 2008) and applies it to long-term weight loss maintenance. Consistent evidence shows an increasing relationship between exercise intensity, physiological variables such as HR, \dot{V}_E , and RQ and APE. As intensity increases to and above that of the ventilator threshold, noticeable physiological changes begin occur and perceived exertion of those sensations increase. Therefore, RPE increases. Affective responses become less positive with increase in intensity and psychological factors such as association, self-efficacy, and extroversion play less of a role in determining RPE due to competition with physiological factors.

Current ACSM recommendation hold that adults should partake in a minimum of 30 minutes of moderate aerobic exercise 5 days per week, or 20 minutes of vigorous intensity exercise on 3 days per week (Haskell). For example, 30 minutes of brisk walking 5 days of the week will meet minimum recommendations. Because moderate aerobic physical activity is performed under the ventilator threshold, psychological factors influence RPE more than physiological factors because increases in physiological factors does not occur due to lower intensity. APE may therefore vary much more at this intensity. It is possible that APE varies much more at moderate intensity. Those who tend to over-perceive, particularly EA women, may exhibit less adherence rates than

those who more accurately or even under-perceive exertion level. Consistent with the hedonic treadmill theory, we tend to partake in activities we enjoy and are less likely to adhere to activities that are not enjoyable (Brickman, Diener). Because exercise is important in maintaining healthy weight, negative affective responses to even moderate physical activity can therefore affect adherence to adequate intensity and duration of exercise. Subsequently, it may be necessary to identify one's APE before weight loss.

Special considerations may be necessary when selecting mode, intensity, and duration of exercise. Finding exercises that one likes and associates positive affective responses with may be key in maintaining adherence and healthy weight status. Thus, a chain based on accuracy of perceived exertion linking exercise intensity, affect, adherence, and healthy weight maintenance seems to exist.

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Form 4: IRB Approval Form
Identification and Certification of Research
Projects Involving Human Subjects

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The Assurance number is FWA00005960 and it expires on September 29, 2013. The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56.

Principal Investigator: SWEATT, SARAH KATHERINE

Co-Investigator(s):

Protocol Number: **X101124003**

Protocol Title: *Ethnic Differences in Reproducibility of Accuracy of Perceived Exertion in Weight Loss and Weight Gain*

The IRB reviewed and approved the above named project on 12/7/10. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This Project will be subject to Annual continuing review as provided in that Assurance.

This project received EXPEDITED review.

IRB Approval Date: 12-7-10

Date IRB Approval Issued: 12/7/10

Marilyn Doss

Marilyn Doss, M.A.

Vice Chair of the Institutional Review
Board for Human Use (IRB)

Investigators please note:

The IRB approved consent form used in the study must contain the IRB approval date and expiration date.

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.