Perceived exertion and pain during aerobic exercise differ by body mass index classification in college-aged women

Amanda J. Salacinski [1], Janelle C. Vaiden[2], Matthew Stults-Kolehmainen [3,4], Marilyn Looney [2]

[1] Department of Sports Medicine and Human Performance, Westfield State University, Westfield, MA, United States
[2] Department of Kinesiology and Physical Education, Northern Illinois University, DeKalb, IL, United States
[3] Division of Digestive Health, Yale New Haven Hospital, New Haven, CT, United States
[4] Department of Biobehavioral Sciences, Teachers College – Columbia University, New York, NY, United States

The authors declare no conflicts of interest.

The authors received no external funding for the research on which this article is based.

Send correspondence to:

Amanda J. Salacinski
Westfield State University
Department of Sports Medicine and Human Performance
215 Woodward
Westfield, MA 01085
Email: asalacinski@westfield.ma.edu
Phone: 413-572-8803

Co-Author Agreement: We the authors agree to the sharing of this preprint on SportRχiv.
All authors have read and approved this version of the manuscript.
This article was last modified on November 20, 2022.
This work is a preprint (has not been peer-reviewed yet).

Please cite as:
Salacinski, AJ, Vaiden, JC, Stults-Kolehmainen MA, Looney, M (2022). Perceived exertion and pain during aerobic exercise differ by body mass index classification in college-aged women. SportRχiv.

ABSTRACT

Purpose: The number of overweight or obese adults in the United States continues to increase. Many diseases are linked to obesity; consequently, there is great need for research to improve prevention and treatment of this condition. The purpose of this study was to compare OMNI ratings of perceived exertion (OMNI-RPE) among normal weight versus obese individuals across stages of an incremental aerobic fitness test. Secondary purposes included determining differences between groups for OMNI-muscle hurt (pain), heart rate (HR) and oxygen consumption (VO_2). **Methods:** Women 28.52(9.69) years of age of normal weight (BMI < 25 kg/m^2; n = 17) and obese status (BMI ≥ 30 kg/m^2; n = 12) completed two days of testing, including a modified Balke treadmill test. A 2 x 3 mixed model ANOVA (group x stage) was used to detect differences between normal weight and obese groups across all variables. **Results:** The obese group reported higher OMNI-RPE (p =.002), higher HR (p = 0.003) and significantly lower VO_2 (p =.027) than the normal weight group for all stages of the Modified Balke. No group x stage interactions were found for any variables with the exception of muscle pain (p < .004), which was higher for the obese group at higher test stages than the normal weight group. **Conclusion:** OMNI-RPE, pain, HR, and VO_2 data suggest that obese women have different physiological and perceptual responses than normal weight women at the same aerobic exercise intensity. Obese women perceive exercise as harder and more painful than normal weight women during an incremental treadmill test, which suggests the need for modified exercise recommendations for obese women. Further research is needed to determine if these differences explain reduced exercise participation for this population.

KEY WORDS

Rating of perceived exertion, pain, obesity, exercise, women

INRODUCTION

PARAGRAPH 1: The prevalence of being overweight or obese has dramatically increased in the past two decades. Nearly all segments of American society have demonstrated an increase in obesity, including children, adolescents and nearly 40% of adults from both sexes (Ogden et al., 2014). Obesity is recognized by the American Medical Association as a disease characterized by excessive amounts of body fat. (De Lorenzo et al., 2020). With this in mind, being overweight refers to those with increased amounts of body fat compared to standards based on height and weight - a transition zone between being normal weight and obese (24). These definitions have some overlap, but distinct cut-offs exist based on body mass index (BMI), which is calculated as body weight in kilograms divided by the square of height in meters . BMI is not accurate for all body types because it does not take into account muscle mass and body fat distribution varies considerably with race / ethnicity (Stults-Kolehmainen et al., 2012, 2013; Watson et al., 2019). However, when categorizing the general population, it has been deemed accurate (ACSM, 2021). Under current conventions, being overweight is 25.0-29.9, obesity is defined as having a BMI ≥ 30 and < 40, while morbid obesity is defined as BMI ≥ 40.

PARAGRAPH 2: Treatment for obesity particularly focuses on diet modification and exercise, but exercise prescription is challenging for overweight and obese populations. Yu et al. (2021) discusses that individuals who are overweight or obese have unmatched oxygen consumption and energy expenditure which are linked to insufficient exercise intensity. While exercise prescription guidelines recommend at least 150 minutes per week of moderate intensity cardiovascular activity, much more physical activity (PA) required in order to lose weight and maintain body mass after substantial weight loss. Unsurprisingly, these guidelines may be a barrier to progress as many overweight individuals find achieving them to be insurmountable, particularly when starting from a baseline of nearly no activity. Those who are overweight or obese are also highly likely to be very low in cardiovascular fitness. Furthermore, there is a plethora of data, starting with Wasseman and Whipp in 1975, indicating that the workload/VO2 relationship is shifted upwards in obese populations (de Souza e Silva et al., 2016; Heymsfield et al., 2005; Yu et al., 2021). In other words, for any given level of work, metabolic strain is greater for obese individuals, especially in moderate and vigorous exercise (Yu et al., 2021). Given these challenges, overweight and obese populations likely need exercise prescriptions that start at low workloads, progress slowly and have a high degree of personalization (ACSM, 2021). This indicates a need for a fresh look at how professionals prescribe exercise for individuals who are overweight or have obesity.

PARAGRAPH 3: Indeed, recent calls have been made to reform the approach for prescription and progression of exercise (Barreto, 2015; Du et al., 2019; Khanfir et al., 2022; Sparling et al., 2015; Yu et al., 2021). The American College of Sports Medicine (ACSM) has concluded that obese patients need a personalized exercise prescription, ideally from an exercise professional who can also monitor their progress in order for successful weight loss (ACSM, 2021). Guidance and monitoring will also enhance adherence to the exercise prescription, which is an important factor in determining a person's achievement of weight loss and the length of time lost weight is kept off.

PARAGRAPH 4: Continuation of exercise is also reinforced when it is associated with pleasurable affective responses. One key affective response specific to exercise is perceived exertion (effort sense). Exercise perceived as less effortful is usually rated as more pleasurable. For these and other reasons, rating of perceived exertion has been utilized as a method of prescribing exercise intensity. Interestingly, perception of exertion during submaximal exercise is positively associated with weight regain in formerly overweight individuals (Blair et al., 1985; Yu et al., 2021). Unfortunately, there is contrasting literature in regard to the association of weight status and perceptual responses during exercise with some data indicating that obesity has an influence on perceptual responses (Elsangedy et al., 2013; Yu et al., 2021) with other data refuting the effect (Mercier et al., 2010). This may be important not only for exercise prescription reasons, but also for aerobic capacity testing because RPE is one indicator of maximal performance. Thus, standard termination criteria may be inappropriate for overweight or obese individuals (ACSM, 2021). Consequently, the aim of this investigation was to observe perceptual responses during aerobic exercise testing and relate these to body weight classifications. We hypothesized that obese participants would have greater OMNI-RPE scores compared to normal weight participants at each stage completed of a Modified Balke treadmill test. Also, it was anticipated that obese participants would have different RER values, HR, oxygen consumption and muscle pain than the normal weight participants at each stage completed of a Modified Balke treadmill test.

METHODS

PARTICIPANTS

PARAGRAPH 5: Participants were recruited with flyers posted at a large Midwestern university in the United States. Thirty sedentary women (average age = 28.52, SD = 9.29) volunteered to participate in the current study, who then completed a medical history form before any testing began. Eligible participants: A) were female sex, B) had no health risks (e.g., cardiovascular disease or cardiovascular abnormalities) and no musculo-skeletal problems, and C) had been sedentary for the last 12-months. Sedentary condition was defined as not participating in physical exercise three or more days per week for the past 12 months (ACSM, 2021). All procedures were approved by the university Institutional Review Board, and all participants gave written consent for study participation.

INSTRUMENTATION AND TESTS

BMI

PARAGRAPH 6: BMI was calculated from height and weight measurements to determine weight classifications according to the CDC (1). The baseline testing of height and weight used a standardized stadiometer: a Seca 220 telescope height rod (Seca Corp, Hamburg, Germany). The participant was then asked to stand with her back facing the stadiometer, back of heels touching the wall and feet together. Next, the participant was asked to step on a Detecto Platform Balance Scale model T500E (A & A Scales, Prospect Park, NJ) for measurement of body mass. The scale was set to zero, and then the participant was asked to stand on the scale until a measure of weight in kilograms was recorded.

Waist Circumference

PARAGRAPH 7: The participant was asked to stand erect and breathe softly while holding her shirt high enough that the umbilicus was exposed. A Gulick II anthropometric tape (Lafayette Instrument Co., Lafayette, IN.) was placed horizontally around the waist at the midpoint between her lower rib and iliac crest. The measurement was read and recorded to the nearest centimeter.

Physical activity

PARAGRAPH 8: A seven-day physical activity recall developed for epidemiologic and health education was used. The physical activity recall has been shown to provide useful estimates of habitual physical activity for research in epidemiologic and health education studies (Blair et al., 1985).

Exertion

PARAGRAPH 9: OMNI Rating of Perceived Exertion (RPE) is a subjective way to monitor overall ratings of perceived exertion, similar to the Borg RPE scale from 6-20. The OMNI scale was developed in attempt to have a more accommodating or user-friendly scale for multiple age groups (Robertson et al., 2004). The scale ranges from 0-10 with descriptions of the intensity in words and pictures. The scale has been validated and is similar to the OMNI scale range used for pain. The OMNI-RPE scale has been validated in obese and non-obese participants (Jakicic et al., 1995; Utter et al., 2004).

Pain

PARAGRAPH 10: The OMNI Muscle hurt (Pain) was used to match the 0-10 range of the OMNI Scales for rating of perceived exertion. The Children's OMNI-Hurt Scale was developed and have displayed construct specific perceptual scales and have progressed to be measure pain in adults (Haile et al., 2015). The term hurt was used rather than pain because it is more commonly expressed to describe their nociceptive feelings (Haile et al., 2015); therefore, the OMNI-Hurt Scale was developed based on the principles of the OMNI RPE Scales. The scale contains numerical categories and construct specific verbal and pictorial descriptors just as the OMNI-RPE scale. Previous testing has indicated children could differentially rate the intensity of both muscle hurt and perceived exertion when measured during exercise (Haile et al., 2015).

6-MWT.

PARAGRAPH 11: Each participant completed a 6-minute walk (6-MWT) test on a treadmill no more than two days before the Modified Balke treadmill test was performed (ACSM, 2021). Participants were asked to give an OMNI-RPE and OMNI-muscle-hurt score while heart rate, VO_2, respiratory exchange ratio and blood pressure were recorded at each stage of the 6-MWT test. The purpose of this test is to exclude any participants that exhibit any musculoskeletal limitations or any signs and symptoms of cardiovascular disease. The total distance is recorded over a 6-minute period. Participants walked on a treadmill at a zero-grade incline with a self-selected speed while wearing an electronic heart rate monitor around their chest that transmits a signal to a wristwatch. OMNI-RPE and muscle-hurt scores are recorded for each minute of the test.

Modified Balk Treadmill Test

PARAGRAPH 12: The Modified Balke treadmill test starts at a zero grade and 53.6 meters per minute for the first minute in order for participants to begin at a comfortable walking pace on the treadmill. The speed is then increased to three miles per hour with a grade of zero for two-minutes. The grade is then increased by 2.5% points at the beginning of the following two-minute intervals. The speed is not increased during the rest of the test. This continues until each participant reaches 80% of her maximal heart rate, calculated by 206.9 – (0.67 * age) (ACSM, 2021) or indications of exercise termination arise as recommended from the American College of Sports Medicine (ACSM) (ACSM, 2021).

PROCEDURES

First session

PARAGRAPH 12: Participants were asked to eat no less than two hours prior to arriving for the first session and to dress in comfortable exercise clothing. After a briefing of the procedure, participants filled out a seven-day recall to verify physical activity exclusion criteria (Blair & Church, 2004). Participants were then measured for height, weight, waist and hip circumference, heart rate, and aerobic fitness determined by a six-minute walking test (6-MWT) at a self-selected pace. The 6-MWT familiarized the participants with treadmill walking, wearing a heart rate monitor, the OMNI-RPE scale and the OMNI-muscle hurt scale which were recorded at every minute of the test. The first meeting lasted 30 minutes. Participants then scheduled a date and time to return to the laboratory to complete a Modified Balke treadmill test no less than 48 hours after their first visit.

Second Session

PARAGRAPH 13: On arrival for the second visit, all participants were given the same HR monitor they wore on day one of testing and were asked to partake in a Modified Balke Graded Exercise test, according to ACSM guidelines (ACSM, 2021). A standard treadmill (Quinton Q65 Series 90 from Quinton Instruments in Seattle, WA) was used for testing, along with a Medical TrueOne Metabolic Measurement System (Consentius Tech, Sandy, UT). During the Modified Balke Test, an OMNI- RPE scale for walking/running was placed in front and within arm's reach for each participant to point at when directed to during testing protocol. A ten-point OMNI-muscle hurt scale was also administered following the OMNI-RPE scale. A BP cuff and sphygmomanometer (American Diagnostic Corp. 55 Commerce Drive, Hauppauge, NY 11788) were used to measure blood pressure the last 45 seconds of each stage of testing. HR was recorded during the last five seconds of each minute within each stage of testing and an OMNI-RPE and an OMNI-muscle hurt scale for aerobic exercise was used. During the Modified Balke test, RER and VO_2 were continuously recorded during the entire test. HR, BP, OMNI-RPE and pain scale were recorded immediately after walking stopped and every two minutes after for the following ten minutes after walking stopped. Each participant's second visit lasted approximately one hour.

ANALYTICAL METHODS

PARAGAPH 14: Descriptive statistics (mean and standard deviation) are reported in the results section for age, height, weight, waist circumference, BMI, VO_2, RER and 6-MWT distances. SPSS version 19.0 (IBM®) statistical software package was used to compute all statistical analyses. The mean OMNI-RPE score, HR, VO_2, pain scale and RER for the obese category of participants were compared separately to the means for the normal-weight category of participants during the same stage of the Modified Balke test using a two-way mixed model analysis of variance (ANOVA) (group by stage). When the spherecity assumption was not met the degrees of freedom were adjusted according to the Huyhn-Feldt method. All participants completed the first three stages of treadmill test; therefore, we compared participant groups on the first three stages. An alpha value of .05 was set to determine significance. The effect size (ES) is reported as partial eta squared. Post hoc dependent *t*-tests were calculated when stage main effect was significant. Correlation coefficients were calculated for RPE and BMI.

RESULTS

PARAGRAPH 15: Thirty female participants completed both testing sessions, although one subject was excluded from the statistical analysis due to her inability to anchor/use the OMNI-RPE scale properly. All participants completed through stage three of the sub-maximal Modified Balke treadmill test. Two normal weight participants completed only through stage three, eight participants completed through stage four, five participants completed through stage five and two participants completed through stage six. Six obese participants only completed the sub-maximal Modified Balke treadmill test through stage three, and six completed through stage four. Descriptive statistics (means (*M*) and standard deviations (*SD*)) for age, BMI, height, weight, waist to hip ratio, 6-MWT distance and age-predicted maximum HR for the participants are reported in Table 1.

Table 1. Participant Characteristics for Normal BMI (*n*=17) vs. Obese BMI (*n*=12)

Measure	Group	*M*	*SD*
Age(years)	Normal	30.41	10.28
	Obese	25.83	8.47
Height(cm)	Normal	168.20	5.16
	Obese	165.67	7.19
Weight(kg)	Normal	66.70	6.55
	Obese	92.30	7.57
W-H ratio	Normal	0.75	0.11
	Obese	0.76	0.22
Waist(cm)	Normal	77.10	5.80
	Obese	100.00	10.00
BMI(kg/m^2)	Normal	23.01	1.49
	Obese	33.73	3.71
6-MWT(m)	Normal	498.90	96.56
	Obese	466.71	80.47
Max HR(bpm)	Normal	185.88	7.06
	Obese	188.83	5.56

PARAGRAPH 16: Group means for normal weight participants (n = 17) and obese (n = 12) participants were compared for the Modified Balke treadmill test for OMNI-RPE, RER, HR, VO_2 and OMNI-muscle hurt, and are reported in Table 2. The means (*M*), standard deviations (*SD*) and 95% confidence intervals (CI) are reported in Table 2. The VO_{2max} calculated for the normal weight group was significantly higher 15.46 $\pm$ 1.66 ml/kg/min than the obese group 14.00 $\pm$ 1.66 ml/kg/min ($p=\leq 0.05$). There was significantly lower RPE and HR response reported for the normal group compared to the obese group, $p=\leq 0.05$.

Table 2. Modified Balke Test Results for Group Differences Between Normal BMI (*n*=17) vs. Obese BMI (*n*=12)

Measure	Group	*M*	*SD*	*CI*
RPE	Normal	2.51*	1.11	1.96 - 3.06
	Obese	3.92	1.11	3.26 - 4.58
RER	Normal	0.86	0.05	0.84 - 0.89
	Obese	0.89	0.05	0.86 - 0.92
Muscle-hurt	Normal	0.20	0.50	-0.05 - 0.45
	Obese	0.53	0.50	0.23 -0.83
HR(bpm)	Normal	120.67*	10.14	115.62 -125.71
	Obese	133.17	10.14	127.16 - 139.17
VO_2 (ml/kg/min)	Normal	15.46*	1.66	14.63 -16.29
	Obese	14.00	1.66	13.01 -14.99

Note. CI= 95% confidence interval; * groups differ, $p < .05$

PARAGRAPH 17: Group means for normal weight participants and obese participants were compared over the first three stages completed of the Modified Balke treadmill test for OMNI-RPE, RER, HR, VO_2 and OMNI-muscle hurt, and are reported in Table 3, and 4. The means (*M*), standard deviations (*SD*) and 95% confidence intervals (CI) are reported in Tables 2, 3 and 4 for the variables OMNI-RPE, RER, HR, VO_2 and OMNI-muscle hurt. A 2 x 3 (Group x Stage) mixed model ANOVA was performed for these variables.

Table 3. Modified Balke Test Results for Differences Between Stages (*n*=29)

Measure Stage		RPE*	RER*	MH*	HR*(bpm)	VO_2* (ml/kg/min)
	M	2.14	0.82	0.10	115.31	12.04
1	SD	1.01	0.08	0.32	9.82	2.78
	CI	1.76-2.52	0.79-0.85	-0.02-0.22	111.57-119.05	10.98-13.10
	M	2.99	0.88	0.33	125.46	14.53
2	SD	1.25	0.07	0.55	10.32	1.46
	CI	2.50-3.48	0.85-0.85	0.12-0.54	121.52-129.39	13.91-15.15
	M	4.52	0.92	0.66	139.99	17.61
3	SD	1.37	0.06	0.87	11.82	1.81
	CI	3.99-5.03	0.90-0.95	0.33-0.99	135.48-144.49	16.92-18.30

Note. CI=95% confidence interval, $^{*}p < .03$; each pairwise comparison between the stages was significant

Table 4. Modified Balke Results for Group by Stage Interaction: Normal BMI (*n*=17) and Obese BMI (*n*-12)

	Stage 1		Stage 2		Stage 3	
Measure	*M (SD)*	*CI*	*M (SD)*	*CI*	*M (SD)*	*CI*
RPE						
Normal	1.53 (0.98)	1.04-2.02	2.24 (1.27)	1.61-2.87	3.77 (1.35)	3.09-4.44
Obese	2.75 (0.99)	2.16-3.35	3.75 (1.27)	3.00- 4.50	5.25 (1.35)	4.45-6.10
RER						
Normal	0.82 (0.08)	0.78-0.86	0.85 (0.06)	0.82-0.88	0.91 (0.06)	0.88-0.94
Obese	0.82 (0.08)	0.78-0.87	0.90 (0.06)	0.86-0.94	0.93 (0.06)	0.90-0.98
Muscle-hurt*						
Normal	0.12(0.31)	0.04-2.76	0.24(0.54)	0.04-0.50	0.24 (0.86)	0.19-0.66
Obese	0.08(0.33)	0.10-0.27	0.42(0.54)	0.10-0.74	1.08 (0.86)	0.57-1.59
HR(bpm)						
Normal	110.12(9.67)	105.31-114.93	119.41(10.17)	114.35 124.47	132.47(11.64)	126.68-138.26
Obese	120.5 (8.6)	114.77-12623	131.5(10.17)	125.48 137.52	147.50(11.64)	140.61-154.39
VO_2 (ml/kg/min)						
Normal	13.12 (2.74)	11.75-14.48	15.06 (1.62)	14.26-15.86	18.20 (1.79)	17.31-19.09
Obese	10.97 (2.74)	9.35-12.59	14.00 (1.61)	13.04-14.96	17.02 (1.87)	15.96-18.07

Note. CI=95% confidence interval, * Significant group by stage interaction, p = .004.

RPE

PARARGRAPH 18: No group by stage interaction existed for RPE [$F(2, 54)=0.53$, $p=0.59$, *ES*=0.02, power=0.13] (Table 4). The obese group had a greater RPE than the normal weight group for all three stages [$F(1,27)=11.26$, $p=0.002$, *ES*=0.29, power= 0.90] (Table 2). The stage main effect for RPE was significant, [$F(2,54)=115.35$, $p\leq0.0005$, *ES*= 0.81, power= 1.0] (Table 3). Post hoc tests indicated RPE increased significantly from one stage to the next ($p=\leq.0005$). Refer to Figure 1 for differences between BMI means and OMNI-RPE means for each completed stage. Correlations for BMI with RPE at stages 1, 2, and 3 represented a small to moderate positive relationship ($r=0.49$, $p=0.007$; $r=0.46$, $p=0.012$; $r=0.40$, $p=0.034$, respectively).

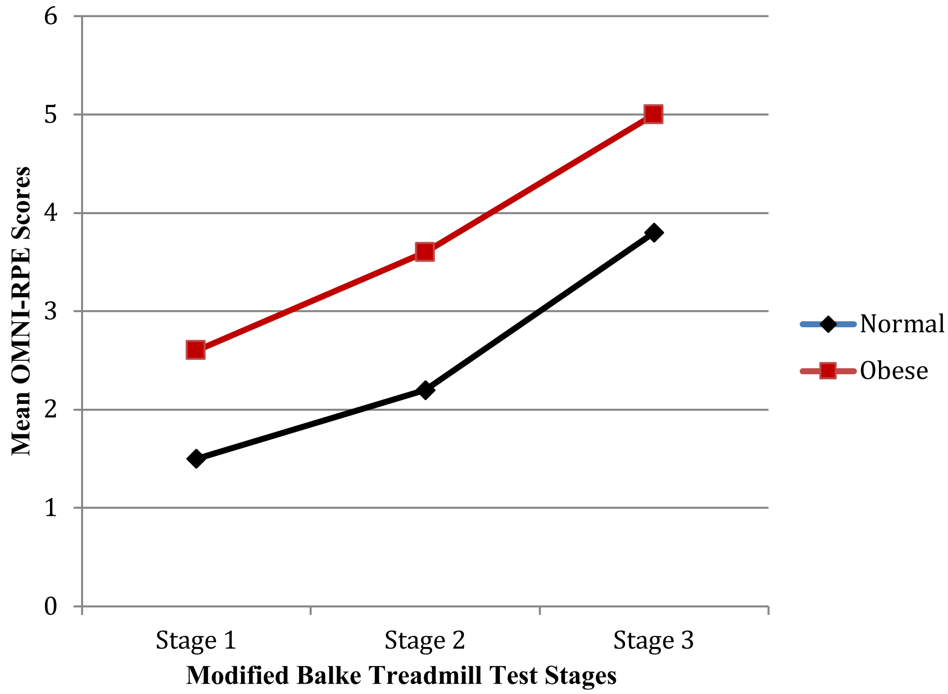

Figure 1**-** OMNI-RPE mean scores for the normal weight and obese participants during each stage of the Modified Balke Treadmill Test.

MUSCLE-HURT

PARAGRAPH 19: There was a group by stage interaction for muscle hurt (pain) [$F(1.40,37.78)=7.81$, $p=0.004$, $ES=0.30$, power= 0.96] (Table 4). Refer to Figure 2 for differences between the normal weight group and obese group for muscle hurt for each stage completed.

There was no significant difference between groups for muscle hurt [$F(1,27)=3.08$, $p=0.091$, $ES=0.22$, power= 0.86] (Table 2). The stage main effect was significant for muscle hurt [$F(1.40,37.78)=11.67$, $p\leq0.0005$, $ES=0.30$, power= 0.96] (Table 3). Post Hoc tests indicate muscle hurt increased from one stage to the next ($p=\leq.031$).

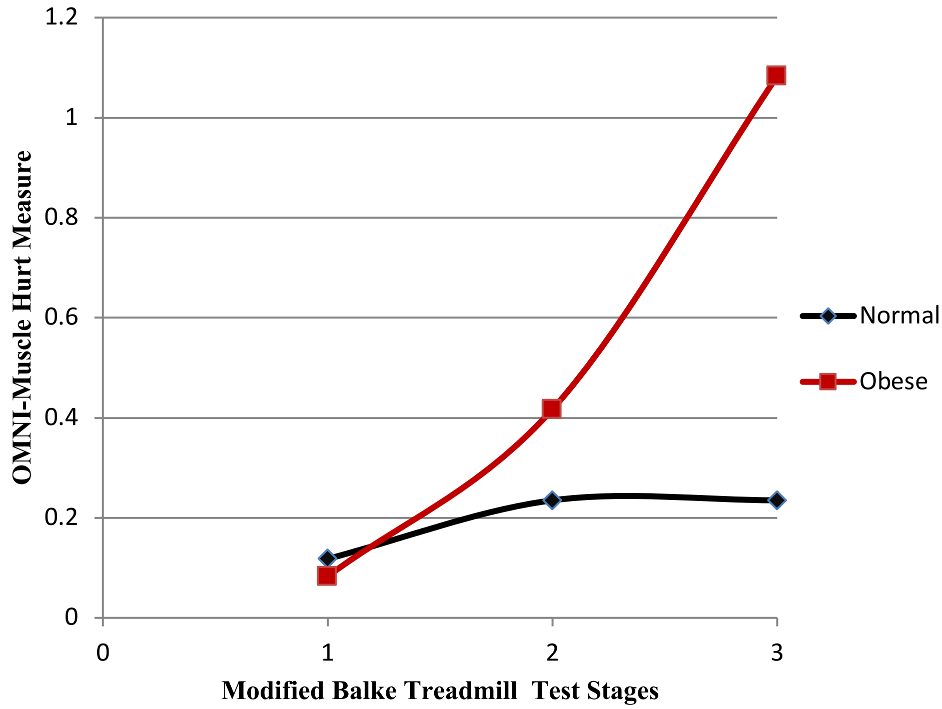

Figure 2- Mean Values of OMNI-muscle hurt measures during the Modified Balke Treadmill Test for the normal weight and obese group.

HEART RATE

PARAGRAPH 20: No group by stage interaction existed for heart rate [F(1.71, 46,23)=3.26, p=0.06, ES=0.11, power= 0.55] (Table 4). The obese group had greater values for heart rate than the normal group [F(1,27)=10.60, p=0.003, ES=0.28, power= 0.88] (Table 2). The stage main effect was significant for heart rate [F(1.71,46.23)=363.89, $p \leq 0.0005$, ES=0.93] (Table 3). Post Hoc tests indicate that heart rate increased from one stage to the next ($p = \leq .0005$).

VO_2

PARAGRAPH 21: No group by stage interaction existed for VO_2 [F(1.88,50.73)=1.0, p=0.37, ES=0.04, power=0.55] (Table 4). The normal group had greater values for VO_2 than the obese group [F(1,27)=5.56, p=0.03, ES=0.27, power=0.88] (Table 2). The stage main effect was significant for VO_2 [F(2, 54)=87.25, $p \leq 0.0005$, ES=0.76, power=1.0] (Table 3). Post Hoc tests indicate VO_2 increased from one stage to the next ($p = \leq .0005$).

RESPIRATORY EXCHANGE RATIO (RER)

PARAGRAPH 22: There was no group by stage interaction for RER [F(1.83,49.43)=1.42, p=0.25, ES=0.05, power=0.28] (Table 4). No significant difference between obese and normal group for RER [F(1,27)=1.86, p=0.18, ES=0.06, power=0.26] (Table 2). The stage main effect was significant for RER [F(1.83, 49.43)=26.53, $p \leq 0.0005$, ES=0.50, power=1.0] (Table 3). Post Hoc tests indicated RER increased significantly from one stage to the next ($p = \leq .004$).

DISCUSSION

PARAGRAPH 23: The purpose of this study was to investigate the differences in OMNI-RPE scores among normal-weight and obese women during exercise. A secondary purpose was to determine differences between groups for OMNI-muscle hurt (pain), RER, heart rate (HR) and oxygen consumption (VO_2) during exercise. Based on the work of past researchers examining obesity and subjective ratings of exertion (Ekkekakis et al., 2010; Utter et al., 2004; Yu et al., 2021), it was hypothesized that RPE would be greater during exercise in those women with a greater BMI. This prediction was supported by the current data. Those participants that had BMIs of 30 kg/m^2 or greater perceived their exertion to be greater than the normal weight group during stages 1-3 of the Modified Balke treadmill test. After the first stage, those with higher BMI also had greater pain ratings. Finally, there was a significant effect of BMI category on heart rate and submaximal VO_2 but no difference in respiratory exchange ratio (RER).

PARAGRAPH 24: These data seem to agree with results from several previous studies. Hulens and colleagues (2002) reported that RPE was significantly higher and VO_2 significantly lower in sedentary obese women. Huebschmann, et al. (2009) reported significantly higher RPE in those participants who were obese with Type 2 diabetes than a normal weight control group. Finally, Tompkins and colleagues tested obese individuals in a repeated measures design with Borg-RPE during a 6-MWT before they received gastric bypass surgery, three months post-surgery and again at six months post-surgery (Tompkins et al., 2008). After losing a substantial amount of weight these individuals reported lower RPE despite walking at a faster rate at three- and six-months post-surgery (Tompkins et al., 2008). Collectively, these datasets indicate that excess weight results in greater levels of exertion or effort sense during exercise.

PARAGRAPH 25: Not only do obese individuals have higher RPEs during exercise, it has been reported to be associated with higher dropout rates in exercise programs (Khanfir et al., 2022). To promote adherence, the ACSM recommends RPE used for prescribing exercise intensity and duration, that should be manipulated so that the intensity is low enough to allow a suitable duration to expend the recommended caloric energy (Khanfir et al., 2022). The ACSM also recommends a training frequency of five to seven weekly sessions of 45 to 60 min of moderate intensity (ACSM, 2021). The volume of exercise needed for weight loss is greater than that which is necessary to improve fitness (ACSM, 2021) and in this regard, 255 min of physical activity per week has been suggested for long-term weight loss and prevention of weight regaining (Jakicic et al., 2015). Significant weight loss is possible with aerobic exercise training without caloric restriction, requires a high volume, which may not be practical or sustainable (Jakicic et al., 2015; Khanfir et al., 2022). Therefore, exercise intensity is a crucial component of exercise prescription that may affect exercise adherence and may be related to how tolerable participants perceive the exercise. Again, higher exercise intensities have been shown to be associated with reduced exercise adherence in obese individuals (Khanfir et al., 2022). Jakicic et al., (2015) also reported maintenance of a sufficient dose of physical activity is challenging, and adherence is typically below the optimal level, which could impact weight loss outcomes.

PARAGRAPH 26: Many possible different factors could account for the exacerbated sensations of exertion in overweight individuals we observed, such as the decreased oxygen-carrying capacity, increased heart rate values and possibly psychological aversions from feeling inordinate physical stress, which agrees with previous researchers (Hills et al., 2006; Wang et al., 2013). We measured many of these to shed light on the effect. For instance, while there was no significant main effect of obesity status on muscle hurt (pain), there was also a significant interaction between exercise stage and group for muscle hurt. The results indicate that as intensity increased BMI groups did differ in muscle pain ratings. During stage one the normal and obese groups reported similar muscle hurt scores, but during stage two and stage three of the Modified Balke test the obese group reported higher muscular pain sensations (refer to Table 2 for stage and group means, Figure 2). The mean for stage two and stage three for the normal weight group did not increase or decrease, whereas the obese group's ratings between those stages doubled. It is interesting that the obese group rated RPE higher at all stages, but only in the second and third stage for muscle hurt, but it's important to consider that exertion and pain are distinct constructs with different physiological and psychological mechanisms (Hutchinson, 2021). Many individuals that are over-weight or obese have a negative feeling about their own exercise capacity (Sperandio et al., 2015), and the participants with obesity could have been compensating for their own negative feelings about exercise by initially rating their muscle hurt as higher. Normal weight participants could have appraised the exercise intensity in an opposite way; they could have been trying harder because they may have positive feelings about their exercise performance. It may be reasonable to expect then that at rest and low intensity work there may be no difference in affective responses between weight groups, but once intensity increases discomfort may be magnified.

PARAGRAPH 27: It's also possible that obese individuals had increased RPE due to perceptions of increased cardiovascular strain. The obese subject group had higher HR values at each stage of the Modified Balke treadmill test. The resting HR between participant groups was significantly different as well. In fact, people with larger amounts of fat have to work harder to move this additional mass (Heymsfield et al., 2005). Additionally, women with normal BMI values achieved significantly higher levels of relative oxygen consumption (i.e., expressed as ml of oxygen consumed per kilogram of body mass), meaning they had greater aerobic fitness. All of the participants of the current study were considered sedentary according to the criteria of the ACSM, not exercising at a moderate intensity more than three times a week for the past twelve months (ACSM, 2021). We can infer participants' fitness level from their 6-MWT test distance (Sperandio et al., 2015). The normal weight group did not appear to be any more fit than the obese group, as there was no significant difference in there 6-MWT, as shown in Table 1.0. This suggest that although we controlled for physical activity level, we did not control for fitness level, and while the two are largely overlapping constructs, they are somewhat independent. VO_2 has been found to be significantly higher in active obese women than sedentary obese women (Hulens et al., 2002; Jin et al., 2022), but was also significantly lower than in sedentary lean women. It is possible that aerobic fitness may have a stronger effect on RPE than Body Mass Index, or the two may interact (e.g., lean and fit individuals may have the lowest RPE for a given stage of work). In recent years, this has been a question of central focus, especially considering the fitness that some people have "metabolically healthy obesity" (MHO); in other words, are obese but don't have additional symptoms of cardiovascular and metabolic disease. For instance, Sui et al. (2007) reported that all-cause mortality was directly related to low-fitness levels regardless of fat-mass, and a lower risk of all-cause mortality was reported for fit obese individuals than unfit normal weight individuals (Barreto, 2015; Coquart et al., 2012; Khanfir et al., 2022).

PARAGRAPH 28: Even with the differences in RPE, heart rate and relative VO2, there was no significant difference between the two different groups of subjects for respiratory exchange ratio. RER indicates what substrate a person is most utilizing at rest or during physical activity. As exercise training increases a person's substrate utilization will reach the carbohydrate use (RER=1.0) period faster than an unfit person, as fatty acid oxidation is impaired in skeletal muscle of those who are obese (Khanfir et al., 2022). The results suggest that obese and normal weight women follow the same pattern of substrate use during an incremental treadmill exercise. Therefore, these data suggest that a difference in substrate utilization does not affect the subjective measure of perceived exertion. This is supported by a study conducted by Hulens and colleagues (2001) that reported no difference in substrate utilization during a submaximal incremental exercise test, although the researchers reported a significant difference in substrate utilization during a maximal exercise protocol. It's possible that one may not be able to see certain physiological differences between obese women and normal weight women until they reach higher levels of exercise intensity.

APPLICATION

PARAGRAPH 29: There are two main applications of this research: A) exercise prescription and B) enhancing affective responses to exercise to support exercise prescription compliance. The Office of the Surgeon General and the American College of Sports Medicine recommends that adults participate in at least 30 minutes of moderate physical activity on most days of the week (23), but recently basing prescriptions on these guidelines have come into question for obese participants due to the increased feelings of exertion and decreased adherence to moderate exercise. (Barreto, 2015; Coquart et al., 2012; Khanfir et al., 2022; Sparling et al., 2015), and individuals with low fitness have a difficult time achieving these recommendations, especially if starting from no exercise, which suggests a modified and more progressive approach is needed. Most relevantly to this study, it has been suggested that intensity standards could be quantified with RPE, which would be an effort of 5 to 6 on a 0 to 10 exertion scale, where 0 is sitting (rest) and 10 is the greatest effort possible, or 12-13 on a 6-20 RPE scale (Garber et al., 2011). Those with obesity feel like they are working harder, giving more effort and have more muscular pain during exercise, especially in later stages of work, than normal weight individuals, which means they will be working at a workload that may be less than optimal.

PARAGRAPH 30: Those experiencing aversive sensations to exercise likely also experience less pleasure and reward, thus one might assume that they would be less likely to exercise. This might explain why many obese or overweight individuals have a hard time complying with these physical activity recommendations. The predominant data indicates, however, that affect experienced during exercise is less important than after exercise. Specifically, the experience of aversions and pleasure after exercise predicts being active 6- and 12-months later (Williams et al., 2008), and we did not measure these exact sensations during recovery. Regardless, obese sedentary women, with similar characteristics to the current subjects, had a reduction in compliance to exercise programs and only a 10%

increase in their exercise intensity over a several week study (Ekkekakis et al., 2010). The results of the current study suggest that women with obesity may need a differentiated exercise plan to boost exercise compliance and thus effective weight management. For instance, work by Williams et al. (2008) and Ekkekakis et al. (2006), report that self-selected intensity may be important for exercise adherence in overweight women (Ekkekakis et al., 2006).

LIMITATIONS

PARAGRAPH 31: There were several limitations in the current research, necessitating additional research. First, we did not control for luteal phase of the menstrual cycle, where psychological responses may be impaired in the luteal phase (Prado et al., 2021), nor did we adjust for age, and these factors may have been limitations in the current research. Furthermore, we did not have equal group sizes. The data analysis was not sophisticated enough to incorporate all of the data from all stages, and future work should use linear-mixed modelling (LMM) analysis to do so. There is a need for future research to determine differences in exercise perceptions between non-obese and obese women at matched fitness levels (e.g., normal weight fit vs non-fit, obese but fit, non-fit). Session RPE is another topic of considerable concern that should be addressed (Haile et al., 2015) and "Peak versus end" RPE, which has implications for exercise participation (Hargreaves & Stych, 2013). Also, we did not look at mental health and self-perception factors. Hulens et al. (2002) reported that 22.6% of obese Australian adults felt "too fat" to exercise – that they weren't fit enough to get fit. According to these researchers (Hulens et al., 2002) poor psychological functioning and depression are more evident in obese individuals, and the experience of stress and depression weakens physical activity behavior (Stults-Kolehmainen & Sinha, 2014). Future studies should investigate whether higher ratings of exertion and pain actually impact future exercise behavior later in the day (a compensation effect reducing caloric expenditure (King et al., 2007), which falls in line with predictions of the WANT model (Stults-Kolehmainen et al., 2020). Finally, there should be more expansive familiarization techniques to ensure that all participants have a greater understanding of the exertion and muscle pain scales.

CONCLUSION

PARAGRAPH 32: The current data indicate that there are differences in physiological (HR, and VO_2) and subjective (OMNI-RPE, pain) responses between sedentary obese and normal weight women. Obese women perceive exercise as harder than normal weight women at all stages of an incremental treadmill test. They also experience exercise as more painful at later stages. These data suggest that exercise recommendations for obese women may need to be modified, particularly to avoid exercise compensation effects which could limit energy expenditure at later periods. Additionally, research is needed to determine if differences in affective responses during and after exercise in people with obesity predict exercise participation and adherence to weight management programming, particularly in line with the WANT model (Stults-Kolehmainen et al., 2020).

ACKNOWLEDGMENTS

No funding sources were used for this study. No companies, manufacturers, or outside organizations provided technical or equipment support. This article is based on the master's thesis from Janelle Vaiden.

CONFLICT OF INTEREST

No authors have a conflict of interest. No authors have professional relationships with any companies or manufacturers who will benefit from the results of the present study.

REFERENCES

ACSM. (2021). *ACSM Guidelines for Exercise Testing and Prescription* (11th ed.). Wolters Kluwer.

Barreto, P. d. S. (2015). Global health agenda on non-communicable diseases: Has WHO set a smart goal for physical activity? *BMJ*, *350*(jan20 7), h23–h23. https://doi.org/10.1136/bmj.h23

Blair, S. N., & Church, T. S. (2004). The Fitness, Obesity, and Health Equation: Is Physical Activity the Common Denominator? *JAMA*, *292*(10), 1232. https://doi.org/10.1001/jama.292.10.1232

Blair, S. N., Haskell, W. L., Ho, P., Paffenbarger, R. S., Vranizan, K. M., Farquhar, J. W., & Wood, P. D. (1985). ASSESSMENT OF HABITUAL PHYSICAL ACTIVITY BY A SEVEN-DAY RECALL IN A COMMUNITY SURVEY AND CONTROLLED EXPERIMENTS. *American Journal of Epidemiology*, *122*(5), 794–804. https://doi.org/10.1093/oxfordjournals.aje.a114163

Coquart, J.-B., Tourny-Chollet, C., Lemaître, F., Lemaire, C., Grosbois, J.-M., & Garcin, M. (2012). Relevance of the measure of perceived exertion for the rehabilitation of obese patients. *Annals of Physical and Rehabilitation Medicine*, *55*(9–10), 623–640. https://doi.org/10.1016/j.rehab.2012.07.003

De Lorenzo, A., Romano, L., Di Renzo, L., Di Lorenzo, N., Cenname, G., & Gualtieri, P. (2020). Obesity: A preventable, treatable, but relapsing disease. *Nutrition*, *71*, 110615. https://doi.org/10.1016/j.nut.2019.110615

de Souza e Silva, C. G., Franklin, B. A., & de Araújo, C. G. S. (2016). Influence of central obesity in estimating maximal oxygen uptake. *Clinics*, *71*(11), 629–634. https://doi.org/10.6061/clinics/2016(11)02

Du, Y., Liu, B., Sun, Y., Snetselaar, L. G., Wallace, R. B., & Bao, W. (2019). Trends in Adherence to the *Physical Activity Guidelines for Americans* for Aerobic Activity and Time Spent on Sedentary Behavior Among US Adults, 2007 to 2016. *JAMA Network Open*, *2*(7), e197597. https://doi.org/10.1001/jamanetworkopen.2019.7597

Ekkekakis, P., Lind, E., & Joens-Matre, R. R. (2006). Can Self-Reported Preference for Exercise Intensity Predict Physiologically Defined Self-Selected Exercise Intensity? *Research Quarterly for Exercise and Sport*, *77*(1), 81–90. https://doi.org/10.1080/02701367.2006.10599334

Ekkekakis, P., Lind, E., & Vazou, S. (2010). Affective Responses to Increasing Levels of Exercise Intensity in Normal-weight, Overweight, and Obese Middle-aged Women. *Obesity*, *18*(1), 79–85. https://doi.org/10.1038/oby.2009.204

Elsangedy, H. M., Krinski, K., Costa, E. C., Haile, L., Fonteles, A. I., Timossi, L. da S., & Gregorio da Silva, S. (2013). The rating of perceived exertion is not different at the ventilatory threshold in sedentary women with different body mass indices. *Journal of Exercise Science & Fitness*, *11*(2), 102–106. https://doi.org/10.1016/j.jesf.2013.11.002

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., Nieman, D. C., & Swain, D. P. (2011). Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise. *Medicine & Science in Sports & Exercise*, *43*(7), 1334–1359. https://doi.org/10.1249/MSS.0b013e318213fefb

Haile, L., Gallagher, M., & J. Robertson, R. (2015). *Perceived Exertion Laboratory Manual: From Standard Practice to Contemporary Application*. Springer New York. https://doi.org/10.1007/978-1-4939-1917-8

Hargreaves, E. A., & Stych, K. (2013). Exploring the peak and end rule of past affective episodes within the exercise context. *Psychology of Sport and Exercise*, *14*(2), 169–178. https://doi.org/10.1016/j.psychsport.2012.10.003

Heymsfield, S. B., Lohman, T. G., Wang, Z., & Going, S. B. (2005). *Human Body Composition* (2nd ed.). Human Kinetics.

Hills, A. P., Byrne, N. M., Wearing, S., & Armstrong, T. (2006). Validation of the intensity of walking for pleasure in obese adults. *Preventive Medicine*, *42*(1), 47–50. https://doi.org/10.1016/j.ypmed.2005.10.010

Hulens, M., Vansant, G., Claessens, A. L., Lysens, R., Muls, E., & Rzewnicki, R. (2002). Health-related quality of life in physically active and sedentary obese women. *American Journal of Human Biology*, *14*(6), 777–785. https://doi.org/10.1002/ajhb.10095

Hutchinson, J. C. (2021). Perceived Effort and Exertion. In *Essentials of exercise and sport psychology: An open access textbook* (pp. 294–315). Society for Transparency, Openness, and Replication in Kinesiology. https://doi.org/10.51224/B1013

Jakicic, J. M., Donnelly, J., Pronk, N., Jawad, A., & Jacobsen, D. (1995). Prescription of exercise intensity for the obese patient: The relationship between heart rate, VO2 and perceived exertion. *International Journal of Obesity and Related Metabolic Disorders: : Journal of the International Association for the Study of Obesity*, *19*(6), 382–387.

Jakicic, J. M., Rickman, A. D., Lang, W., Davis, K. K., Gibbs, B. B., Neiberg, R., & Marcus, M. D. (2015). Time-Based Physical Activity Interventions for Weight Loss: A Randomized Trial. *Medicine & Science in Sports & Exercise*, *47*(5), 1061–1069. https://doi.org/10.1249/MSS.0000000000000482

Jin, L., Zhu, X., & Xue, Q. (2022). *The Effect of Different Intensity Exercise on Energy Consumption and Metabolism Substrate in Obese Adult Women* [Preprint]. In Review. https://doi.org/10.21203/rs.3.rs-1671753/v1

Khanfir, M. A., Awicha, H. B., Masmoudi, L., Hmadou, F. B., Dardouri, W., Alardan, S., Nouira, S., & Zouch, M. (2022). Effects of Different Low-Intensity Exercise Types on Duration, Energy Expenditure and Perceived Exertion in Obese Individuals. *International Journal of Environmental Research and Public Health*, *19*(8), 4893. https://doi.org/10.3390/ijerph19084893

King, N. A., Caudwell, P., Hopkins, M., Byrne, N. M., Colley, R., Hills, A. P., Stubbs, J. R., & Blundell, J. E. (2007). Metabolic and Behavioral Compensatory Responses to Exercise Interventions: Barriers to Weight Loss*. *Obesity*, *15*(6), 1373–1383. https://doi.org/10.1038/oby.2007.164

Mercier, C.-S., Maïano, C., Nicol, C., Sepulcre, J., & Brisswalter, J. (2010). Étude des relations entre les valeurs d'anxiété, d'estime globale de soi et la perception de l'effort lors de l'exercice physique chez des adolescentes obèses et non obèses. *Science & Sports*, *25*(6), 323–326. https://doi.org/10.1016/j.scispo.2010.09.002

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2014). Prevalence of Childhood and Adult Obesity in the United States, 2011-2012. *JAMA*, *311*(8), 806. https://doi.org/10.1001/jama.2014.732

Prado, R. C. R., Silveira, R., Kilpatrick, M. W., Pires, F. O., & Asano, R. Y. (2021). The effect of menstrual cycle and exercise intensity on psychological and physiological responses in healthy eumenorrheic women. *Physiology & Behavior*, *232*, 113290. https://doi.org/10.1016/j.physbeh.2020.113290

Robertson, R. J., Goss, F. L., Dubé, J., Rutkowski, J., Dupain, M., Brennan, C., & Andreacci, J. (2004). Validation of the Adult OMNI Scale of Perceived Exertion for Cycle Ergometer Exercise: *Medicine & Science in Sports & Exercise*, *36*(1), 102–108. https://doi.org/10.1249/01.MSS.0000106169.35222.8B

Sparling, P. B., Howard, B. J., Dunstan, D. W., & Owen, N. (2015). Recommendations for physical activity in older adults. *BMJ*, *350*(jan20 6), h100–h100. https://doi.org/10.1136/bmj.h100

Sperandio, E. F., Arantes, R. L., Matheus, A. C., Silva, R. P., Lauria, V. T., Romiti, M., Gagliardi, A. R. T., & Dourado, V. Z. (2015). Intensity and physiological responses to the 6-minute walk test in middle-aged and older adults: A comparison with cardiopulmonary exercise testing. *Brazilian Journal of Medical and Biological Research*, *48*(4), 349–353. https://doi.org/10.1590/1414-431x20144235

Stults-Kolehmainen, M. A., Blacutt, M., Bartholomew, J. B., Gilson, T. A., Ash, G. I., McKee, P. C., & Sinha, R. (2020). Motivation States for Physical Activity and Sedentary Behavior: Desire, Urge, Wanting, and Craving. *Frontiers in Psychology*, *11*, 568390. https://doi.org/10.3389/fpsyg.2020.568390

Stults-Kolehmainen, M. A., & Sinha, R. (2014). The Effects of Stress on Physical Activity and Exercise. *Sports Medicine*, *44*(1), 81–121. https://doi.org/10.1007/s40279-013-0090-5

Stults-Kolehmainen, M. A., Stanforth, P. R., & Bartholomew, J. B. (2012). Fat in Android, Trunk, and Peripheral Regions Varies by Ethnicity and Race in College Aged Women. *Obesity*, *20*(3), 660–665. https://doi.org/10.1038/oby.2011.300

Stults-Kolehmainen, M. A., Stanforth, P. R., Bartholomew, J. B., Lu, T., Abolt, C. J., & Sinha, R. (2013). DXA estimates of fat in abdominal, trunk and hip regions varies by ethnicity in men. *Nutrition & Diabetes*, *3*(3), e64–e64. https://doi.org/10.1038/nutd.2013.5

Sui, X., LaMonte, M. J., Laditka, J. N., Hardin, J. W., Chase, N., Hooker, S. P., & Blair, S. N. (2007). Cardiorespiratory Fitness and Adiposity as Mortality Predictors in Older Adults. *JAMA*, *298*(21), 2507. https://doi.org/10.1001/jama.298.21.2507

Tompkins, J., Bosch, P. R., Chenowith, R., Tiede, J. L., & Swain, J. M. (2008). Changes in Functional Walking Distance and Health-Related Quality of Life After Gastric Bypass Surgery. *Physical Therapy*, *88*(8), 928–935. https://doi.org/10.2522/ptj.20070296

Utter, A. C., Robertson, R. J., Green, J. M., Suminski, R. R., Mcanulty, S. R., & Nieman, D. C. (2004). Validation of the Adult OMNI Scale of Perceived Exertion for Walking/Running Exercise: *Medicine & Science in Sports & Exercise*, *36*(10), 1776–1780. https://doi.org/10.1249/01.MSS.0000142310.97274.94

Wang, J., Sereika, S. M., Styn, M. A., & Burke, L. E. (2013). Factors associated with health-related quality of life among overweight or obese adults. *Journal of Clinical Nursing*, *22*(15–16), 2172–2182. https://doi.org/10.1111/jocn.12280

Watson, M. R., Stanforth, P. R., Talley, E. A., & Stults-Kolehmainen, M. A. (2019). Influence of Age, Ethnicity and Sex on Body Composition Thresholds for the Accumulation of Visceral Adipose Tissue in Adults. *American Journal of Sports Science*, *7*(3), 111. https://doi.org/10.11648/j.ajss.20190703.15

Williams, D. M., Dunsiger, S., Ciccolo, J. T., Lewis, B. A., Albrecht, A. E., & Marcus, B. H. (2008). Acute affective response to a moderate-intensity exercise stimulus predicts physical activity participation 6 and 12 months later. *Psychology of Sport and Exercise*, *9*(3), 231–245. https://doi.org/10.1016/j.psychsport.2007.04.002

Yu, H., Sun, C., Sun, B., Chen, X., & Tan, Z. (2021). Systematic Review and Meta-Analysis of the Relationship between Actual Exercise Intensity and Rating of Perceived Exertion in the Overweight and Obese Population. *International Journal of Environmental Research and Public Health*, *18*(24), 12912. https://doi.org/10.3390/ijerph182412912