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THE USE OF BODY MASS INDEX AND WAIST-HIP RATIO FOR PREDICTION FOR AUTONOMIC RECOVERY FROM EXERCISE

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ABSTRACT

Anthropometric variables have been associated with autonomic nervous system function. However, it's unclear whether the measures of body mass index (BMI) or waist-hip ratio (WHR) can provide insight into its recovery. A total of 52 men (22.38 + 2.75 years) had resting heart rate variability (HRV) measured followed by a 30-minute treadmill submaximal exercise test (60% V_{max}), and 60-minute of HRV recovery recording. Participant data was divided into the following groups for analysis: G1: mass between 54 kg-74.6 kg; G2: mass between 75 -100.4 kg; G3: BMI between 18.6-24.9 kg/m^2; G4: BMI between 25-29.9 kg/m^2; G5: WHR between 0.73-0.829; G6: WHR between 0.83-0.93. When evaluating trial x time interactions, no significant interactions in the Mass groups (G1, G2) for lnrMSSD and lnHF as well as in the WHR groups (G3, G4) for lnrMSSD and lnHF were observed. The BMI groups (G5, G6) showed significant differences for lnrMSSD and lnHF. G5 recovered significantly faster at the 35-40 minute (p=0.044, 0.042), 45-50 minute (p=0.052, 0.025), and 55-60 minute (p=0.018, 0.041) time points. In conclusion, BMI was the strongest predictor for autonomic recovery following exercise. Overweight healthy physically active men presented delayed return to baseline levels.

Keywords: Anthropometry; Autonomic nervous system; Body composition; Cardiovascular system; Exercise.

INTRODUCTION

Body composition is a commonly assessed metric of health used in applied and clinical settings. Criterion methods such as hydrostatic weighing and dual x-ray absorptiometry are preferable in research medical fields (1), but may not be practical or even available in local health facilities, clinics, or areas of underserved populations. With this in mind, several techniques have been developed to quantify body composition to improved ease of use, portability and cost. Perhaps the most commonly used of these methods would be body mass index (BMI) and waist-to-hip ratio (WHR). These methods are used as surrogate indicators of obesity and as risk factors for cardiovascular mortality (2). Song et. al, (2) demonstrated that WHR was a more reliable measure for cardiovascular disease (CVD) risk and mortality. This was believed to be due to the waist circumference and hip circumference measurements, which are directly associated with increased subcutaneous fat, dyslipidemia, diabetes, hypertension and death (3). Whereas BMI simply considers the mass (kg) over the height squared (m^2) without information on distribution of mass (4).

It is widely established that excessive adiposity is associated with increased risk of CVD and morbidity (5). The risk of negative alterations in cardiovascular function related to adiposity can range from hormonal imbalance to changes in the vasculature (5-10). These physiological deviations have been associated with negative adjustments in the balance of the autonomic nervous system (ANS) (6, 7, 11). In this sense, cardiovascular autonomic regulation can be analyzed through heart rate variability (HRV), which is a non-invasive method that evaluates the oscillations in the periods between consecutive heart beats (RR intervals) (12). The evaluation of HRV at rest and its recovery following an exercise bout provides valuable information regarding the ability of the ANS to deal with physiological stress and return the system back to homeostasis. The early phase of HRV recovery from exercise can be attributed to rapid parasympathetic rebound (e.g., 10s – 3 min), while recovery beyond the first few minutes is believed to be a mix of rebounding parasympathetic activity, withdrawal of sympathetic activity may last up to 48 hours depending on the intensity and duration of the exercise bout; however, a significant amount of recovery occurs withing 10-60 minutes (13). Importantly, delays in HRV recovery following exercise can be indicative of certain diseases and is considered a strong predictor of mortality and cardiovascular events in the general population (14). Importantly, the vast majority of data evaluating adiposity and cardiovascular autonomic regulation focuses on highly obese participants or those at risk for CVD (15, 16).

Currently, little information regarding the relationship on changes in cardiac autonomic rebound in healthy normal and overweight individuals using cost-effective measures of body composition (i.e., BMI and WHR) exists. The manner of which physical features such as adipose tissue, height, and weight are distributed influences the functionality of the cardiovascular system (17) and therefore the regulatory response of the ANS. BMI takes into account length of the vasculature via height whereas WHR can identify centralized distribution of mass, which has been linked to various cardiovascular conditions (18). Better understanding of this relationship may further help to plan preventive strategies and reduce the need for the use of expensive equipment. Moreover, it is not totally clear whether there is a difference between BMI and WHR regarding their potential in predicting autonomic recovery after exercise, though we hypothesize that WHR will be the stronger marker as it accounts for some distribution of mass. Therefore, the purpose of this study was to evaluate HRV recovery following a submaximal exercise test in healthy physically activate men based on their mass, BMI, and WHR.

METHOD

This study conforms to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines. Our investigation contains details of the study design, setting, participants, variables, data sources, measurement, description of potential sources of bias, quantitative variables description, and statistical methods. All experimental protocols were approved by the Research Ethics Committee in Research and were undertaken in accordance with the 466/2012 resolution of the National Health Council of December 12nd 2012. Informed consent was attained from all participants prior to participation.

Study Overview

Data collection occurred on two separate occasions between 5:00 p.m. and 10:00 p.m. in a soundless room with controlled temperature between 21° C and 25° C and humidity between 40% and 60%. The volunteers were instructed not to drink alcohol or perform exercise 24 hours prior to the evaluation and to abstain from food or caffeine drinks eight hours prior. Additionally, participants were advised to eat only a light meal 2-hours before the procedures and to wear appropriate and comfortable clothing to allow for physical exertion. The descriptive profile of the subjects was defined to characterize the sample, reduce the unpredictability of the variables, improving reproducibility and physiological interpretation.

The first visit consisted of the following: obtaining informed consent, preliminary evaluation and screening, and recording participant characteristics (e.g., age, height, weight). Following participant characteristics, a maximal graded exercise test was performed in order to determine the maximum velocity (V_{max}), which was used to determine the work performed on visit two. A minimum of 48-hours was required between visits one and visit two in order for adequate recovery to occur (Gomes et al, 2018). Visit two consisted of a 15-minute resting period to record resting cardiac autonomic function, a 30-minute sub max (60% V_{max}) exercise protocol performed on a treadmill, 5-minute active cool down, and a 60-minute recovery period where cardiac autonomic activity was evaluated. Before the start of the experimental procedures, subjects were documented according to age, mass (kg), height (m), systolic (mmHg) and diastolic arterial pressure (mmHg), waist (cm), abdominal (cm) and hip (cm) circumferences, waist-to-hip ratio and body mass index (BMI).

Participants

Fifty-two healthy, physically active college aged males were recruited for participation in this study. Volunteers were not included under the following conditions: cardiorespiratory, neurological, musculoskeletal, renal, metabolic, endocrine and other known or reported deficiencies that avoided the performance of the protocols. Participants with resting systolic blood pressure higher than 130 mmHg and resting diastolic higher than 90 mmHg, smokers, subjects under pharmacological treatment, sedentary and insufficiently active individuals according to International Physical Activity Questionnaire (IPAQ) (19). Demographic information is provided in Table 1.

Anthropometric Measures

The follow participant characteristics were obtained during visit one: age, mass, height, heart rate (HR), respiratory rate (F), systolic (SBP) and diastolic blood pressure (DBP), BMI and WHR. The anthropometric variables were collected following the recommendations described by Lohman et al (Lohman et al, 1988). Mass was assessed through a digital scale (W200 / 5, Welmy, Brazil) with a precision of 0.1 kg. The height was measured with a stadiometer (ES2020, Sanny, Brazil) with an accuracy of 0.1 cm. The BMI was calculated via the following formula: mass (kg)/height (m)^2. Measurements of waist and hip circumferences were performed in orthostatism, with the abdomen relaxed, arms extended along the body, feet together and weight equally distributed on both legs. Waist circumference was measured with the tape measure positioned in the zone of minimal curvature located between the last rib and the iliac crest. The hip circumference was taken with the tape measure positioned in the greater trochanter region, in the area of greater protuberance. The WHR was calculated via the following formula: waist circumference (m) /hip circumference (m).

Anthropometric Classification

In order to determine the influence of common assessments in body composition on cardiac autonomic rebound, participants performed the submaximal test, and their data were compared and contrasted based on three different variables (Mass, WHR, and BMI). All participant data were stratified by Mass and placed into either Low Mass (G1) or High Mass (G2) groups and analyzed. Participant data were then stratified by WHR and placed into either Low WHR (G3), High WHR (G4) groups and analyzed. Lastly, participant data was stratified by BMI and placed into either Low BMI (G5), and High BMI (G6) groups and analyzed. G1 and G2 were stratified based on the mean, those who's mass fell below the mean were considered Low (G1: between 54 kg and 74.6 kg, n=26) and those above the mean were considered High (G2: between 75 kg and 100.4 kg, n=26). G3-G4 were Stratified by the American College of Sports Medicines (ACSM) guidelines for BMI health risk; Normal Weight: 18.6-24.9 (G3, n=26) and Overweight: 25-29.9 (G4, n=26). Because participants in this study were healthy active males, the WHR were all under risk stratification of 0.95. Therefore, stratification was based on the mean, those who's mass fell below the mean were considered Low (G5: between 0.73 and 0.829, n=26) and those above the mean were considered High (G6: between 0.83 and 0.93, n=26) (Table 1).

Procedures

Maximal Effort Test

Following the initial assessment, participants were fitted with the HR Polar RS800cx monitor (Polar Electro, Finland) strap, which was positioned at the distal third of the sternum in the thorax zone. The participants then began the test with an initial velocity of 8km/hour on a motorized treadmill (Evolution Fitness, EVO 4000). Load increments of 1km/hour were applied every 2-minutes until exhaustion. In order to be considered as maximal effort, volunteers should reach 90% of the maximal HR (HR_{max}) calculated by the 220 - age formula (20).

Table 1.

Variables	**Mass**		**WHR**		**BMI**	
	G1	**G2**	**G3**	**G4**	**G5**	**G6**
n	27	24	30	21	33	18
Age (Yrs)	21 ± 2.65	23± 2.61	22.5 ± 2.9	22.2 ± 2.5	22 ± 2.6	23 ± 2.7
Mass (Kg)	67.07 ± 5.9	82.67 ± 6.5*	74.9 ± 10.2	74.05 ± 9.6	69.2 ± 7.2	83.7 ± 7.1*
Height (m)	1.73 ± 0.05	1.77 ± 0.006	1.77 ± 0.06	1.74 ± 0.06	1.75 ± 0.05	1.76 ± 0.06
BMI (Kg/m^2)	22.2 ± 2.0	26.2 ± 2.1*	23.9 ± 2.6	24.5 ± 3.1	22.5 ± 1.9	26.9 ± 1.8*
WHR	0.82 ± 0.03	0.83 ± 0.04	0.8 ± 0.02	0.85 ± 0.02*	0.82 ± 0.03	0.84 ± 0.04

Note: BMI: body mass index; WC: waist circumference; HC: hip circumference; kg: kilogram; m: meters; G1: mass between 54 kg and 74.6 kg; G2: mass between 75 kg and 100.4 kg; G3: BMI between 18.6 and 24.9 kg/m^2; G4: BMI between 25 and 29.9 kg/m^2; G5: WHR between 0.73 and 0.829; G6: WHR between 0.83 and 0.93. * = significantly different between corresponding group.

Sub-maximal protocol

In order to determine the work rate for the sub-maximal protocol, a calculation of V_{max} through the Conconi threshold was administered to the maximal effort test. This determines the indirect anaerobic threshold by the identification of the HR deflection point (HRDP) using a progressive test using the D_{max} method (21). For the identification of the HRDP, the HR points and corresponding velocities were plotted; then, the values were adjusted by means of a first-degree linear equation and a third-degree polynomial function derived from the data of each individual. Next, the difference of the HR values obtained by the respective equations was calculated and when manipulating a curve with these values, the highest value was designated HRDP before a change in the direction in the curve occurred (21). The value of HRDP corresponds to the speed at which the volunteer reached his anaerobic threshold. This value was related to 60% of the V_{max} reached in the exercise test and for use of the intensity in the subsequent stage this should be lower than that found in the anaerobic threshold.

Upon arrival to the lab, participants were fitted with a heart rate monitor and asked to sit quietly for 15-minutes to obtain resting measures. Following resting measures, participants began the 30-minutes sub-maximal treadmill protocol. The initial warm up stage of the protocol was five-minutes at a velocity of 6.0 km / hour at a 1% incline, followed by 25-minutes with the intensity equivalent to 60% of the participants V_{max} at a 1% incline. Following the completion of the protocol participants were asked to recover in a seated position for 60-minutes in order to determine cardiac autonomic rebound.

Cardiorespiratory variables

Blood pressure was measured indirectly by auscultation using a calibrated aneroid sphygmomanometer (Premium, Barueri, SP, Brazil) and stethoscope (Premium, Barueri, SP, Brazil) on the left arm with the subject in the seated position. HR was quantified with the Polar RS800cx Heart Rate monitor (Polar Electro, Finland). To avoid distortions in the measurements, the same researcher measured the same variables.

HRV analysis

Heart rate variability recordings were obtained through the use of a commercially available HR monitor (Polar RS800cx, Finland). Recordings of beat-to-beat intervals were transferred to the Polar Pro Trainer program (3.0 v., Polar Electro, Finland) where they could be visually inspected for ectopic beats or irregularities. For each recording, a moderate digital filtering mode was applied to remove artifacts, while visual ectopic beats were manually removed. In order to avoid over filtering, only recordings with 256 stable RR intervals and only series with more than 95% of sinus beats were included in the study (22). During the trial visit (visit two), two HRV recordings were collected; a 15-minute recording prior to and a 60-minute recording following the bout. The recordings were divided into Seven, five-minute recordings: Rest (10^{th}-15^{th} minute) and during recovery (Rec): R1 (5^{th}-10^{th} minute), R2 (15^{th}-20^{th} minute), R3 (25^{th}-30^{th} minute), R4 (35^{th}-40^{th} minute), R5 (45^{th}-50^{th} minute) and R6 (55^{th}-60^{th} minute) (23).

The chosen markers for HRV were the time domain analysis index of the root mean square of successive differences (rMSSD) and the frequency domain index of the high frequency spectral component (HF) of the power spectral density (0.15 to 0.4 Hz) (22). Acquired R-R interval recordings were transformed into time and frequency domain components using specialized online HRV software (Kubios, Version 1.1 for windows). In order to assess rMSSD, R-R intervals were converted into a tachogram, which plots the successive R-R intervals (y-axis) against the number of beats within the total number of beats in the recording (x-axis). Five-minute recordings were sampled from the tachogram in order to analyze rMSSD. HF was analyzed through power spectral analysis through the application of a fast Fourier transformation of the R-R intervals.

Study Size

The sample size was calculated based on a pilot test, in which the online software in the website www.lee.dante.br was used. We considered the rMSSD index for sample size calculation, the assumed degree of significant difference was 14.11 ms, with a standard deviation of 12.8 ms, and with alpha risk of 5% and beta of 80%. The sample size calculation recommended minimum of 13 volunteers per group.

Statistical Analysis

Data for HRV was entered into the SPSS 19.0 statistical software (Chicago, Illinois, USA) for analysis. In order to determine if the data was normally distributed, a Shapiro Wilk test was performed. Due to a violation of normality, data underwent a natural log transformation (ln) prior to further analysis (lnrMSSD and lnHF). Three Group (two) x time (seven) repeated measures analysis of variance (ANOVA) were performed in order to determine differences in recovery between the body composition variables (Mass, BMI, WHR) and HRV variables (lnrMSSD and lnHF) following the bout of exercise. A Bonferroni adjustment was run for all RM ANOVAs. The data of the repeated measurements were checked for sphericity violation using the Mauchly test and the Greenhouse-Geisser correction was required when the sphericity was violated. A Paired samples t-test was run in order to further assess differences between same trial points. Statistical significance for all tests were set to an alpha of <0.05 (or $<5\%$). The determination of effect sizes came from the guidelines of Quintana (24) for HRV analysis; thresholds were categorized as small effect (<0.25), moderate effect (0.50), and large effect (0.90).

In order to verify the association between anthropometric variables and HRV, we applied Pearson correlation test for parametric distributions and Spearman correlation test for non-parametric distributions. We considered strong correlation for correlation coefficient > 0.75 and moderate correlation between 0.75-0.5.

RESULTS

A total of 52 apparently healthy males (22.38 + 2.75 years old) completed this study. All participants were considered to be physically active according to the (IPAQ). Anthropometric classification group characteristics can be seen in Table 1. Each group was analyzed for changes in cardiac autonomic activity through lnrMSSD and lnHF. The RMANOVA revealed significant time-based differences in the Mass groups (G1, G2) for lnrMSSD ($p < 0.001$), and lnHF ($p < 0.001$), respectively; the WHR groups (G3, G4) for lnrMSSD ($p < 0.001$), and lnHF ($p < 0.001$), respectively; and the BMI groups (G5, G6) for lnrMSSD (p = < 0.001), and lnHF (p = < 0.001), respectively (Figures 1-3).

When evaluating trial x time interactions, The RMANOVA revealed no significant interactions in the Mass groups (G1, G2) for lnrMSSD ($p = 0.204$), and lnHF ($p = 0.385$); the WHR groups (G3, G4) for lnrMSSD ($p = 0.652$), and lnHF ($p =0.783$); However, the BMI groups (G5, G6) showed significant differences for lnrMSSD ($p = 0.018$), and lnHF ($p = 0.006$) with G5 recovering significantly faster. A paired samples t-test post hoc analysis was performed and demonstrated that BMI lnHF were significantly different at R4 (p = 0.042), R5 (p = 0.025), and R6 (p = 0.041), while BMI lnrMSSD R4 (p = 0.044), R5 (p = 0.052), and R6 (p = 0.018) (Figure 3).

Correlation analysis showed no significant association between anthropometric measurements and HRV indices at rest and during recovery from exercise (Table 2).

Figure 1: Mean values and respective standard deviations of lnrMSSD and lnHF obtained at rest and during recovery from the maximal test effort based on Mass. G1: mass between 54 kg and 74.6 kg; G2: mass between 75 kg and 100.4 kg. * significantly different from group (p<0.05), # significantly different from Rest (p<0.05).

Figure 1.

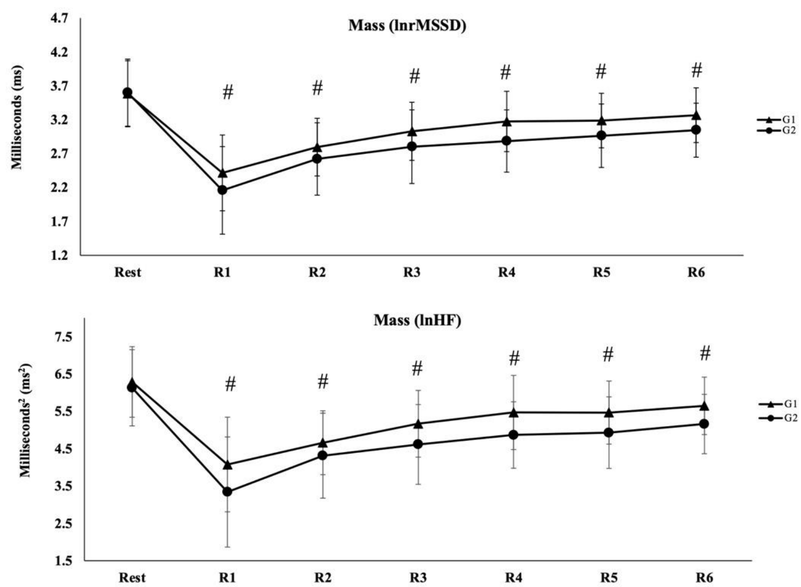

Figure 2: Mean values and respective standard deviations of lnrMSSD and lnHF obtained at rest and during recovery from the maximal test effort based on WHR. G3: WHR between 0.73 and 0.829; G4: WHR between 0.83 and 0.93. * significantly different from group (p<0.05), # significantly different from Rest (p<0.05).

Figure 2.

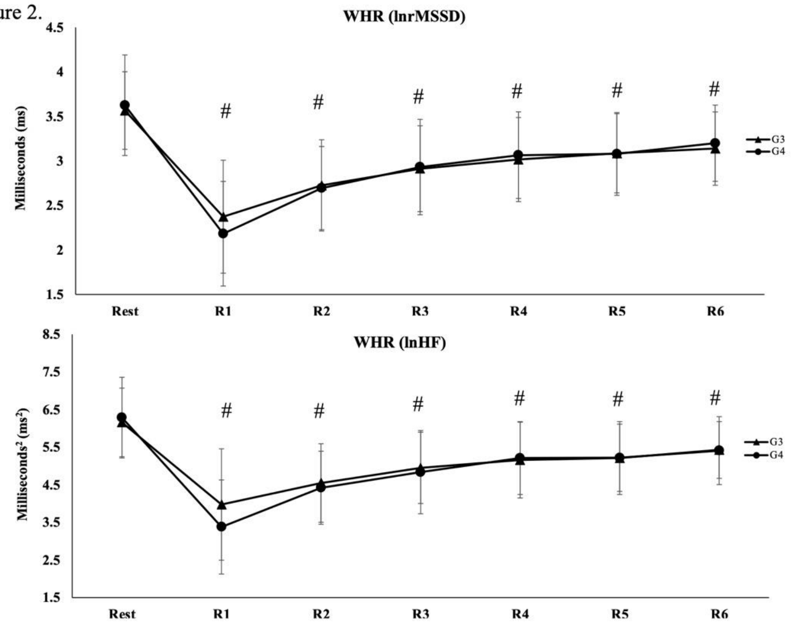

Figure 3: Mean values and respective standard deviations of lnrMSSD and lnHF obtained at rest and during recovery from the maximal test effort based on BMI. G5: between 18.6 and 24.9 kg/m^2; G6: BMI between 25 and 29.9 kg/m^2. * significantly different from group ($p<0.05$), # significantly different from Rest ($p<0.05$).

Figure 3.

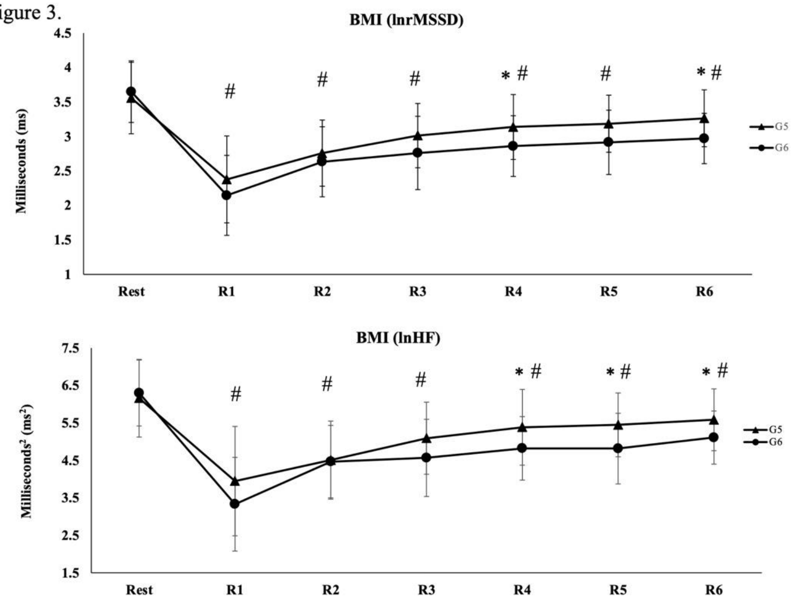

Table 2.

	Rest		Rec1		Rec2		Rec3		Rec4		Rec5		Rec6	
MASS	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
rMSSD	0.15	0.27	0.01	0.9	0.11	0.42	0.01	0.9	-0.05	0.68	-0.4	0.75	-0.1	0.4
HF	0.08	0.57	-0.01	0.9	0.18	0.19	0.04	0.72	-0.06	0.63	-0.05	0.7	-0.11	0.4
BMI	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
rMSSD	0.005	0.96	-0.02	0.8	-0.04	0.7	-0.12	0.36	-0.19	0.17	-0.12	0.36	-0.13	0.3
HF	-0.09	0.52	-0.02	0.8	-0.06	0.66	-0.19	0.16	-0.24	0.07	-0.2	0.13	-0.07	0.6
WHR	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
rMSSD	-0.006	0.96	-0.06	0.6	0.11	0.41	0.09	0.5	0.06	0.67	0.05	0.72	0.04	0.7
HF	-0.02	0.84	-0.14	0.3	0.11	0.4	-0.007	0.99	0.06	0.63	0.006	0.96	0.06	0.6

Note: Correlation between anthropometric variables and HRV. BMI: body mass index; WSR: waist-stature ratio; rMSSD: square root of the square mean of the differences between adjacent normal RR intervals; HF: high frequency.

DISCUSSION

Autonomic recovery following exercise is an important method in detecting cardiovascular disease. Several studies have demonstrated that slower autonomic recovery following exercise to be associated with increased cardiovascular risk (15, 16, 25, 26). Finding pragmatic methods of identifying risk for altered ANS rebound prior to the development signs and symptoms is of great interest. Therefore, the purpose of this study was to evaluate HRV recovery following a submaximal exercise test in healthy physically active males and comparing them based on their Mass, BMI, and WHR category. The primary findings of this study were that normal BMI participants demonstrated a greater vagal rebound when compared to the overweight BMI participants. Conversely, we found no significant relationship between anthropometric measures of BMI and WHR with resting and recovering HRV.

Body composition and its influence on the cardiovascular system has been well reported within the literature (5-7, 20, 27). Most of the current research examining this relationship use advanced techniques that provide insight into lean mass, fat mass, intra and extra-cellular water, and mineral content. These devices (e.g. dual-energy x-ray absorptiometry, bioelectrical impedance analysis, and air displacement plethysmography) are considered the gold standards in the medical field (1). Unfortunately, these devices can be limited on portability or may be impractical in underserved and underfunded institutions/communities. The WHR has advantages over other parameters because it is a simple and widely used measure and indicates the risk of developing cardiovascular diseases (2, 27). Moreover, when compared to other anthropometric factors, it has a stronger association with autonomic indexes and is more likely to predict an autonomic imbalance (28), revealing the importance for clinical practice. With this in mind, we expected faster HRV recovery after exercise in the group with lower WHR values. However, we observed no significant differences between groups. The group with moderate cardiovascular risk presented similar recovery to baseline levels compared to men with low cardiovascular risk. Yi et al. (28) analyzed the relationship between body fat and HRV measurements in healthy adults, the authors observed inverse correlations between WHR and HRV indices (rMSSD, LF [ms^2] and pNN50). Additionally, it was found to be more prominent that BMI or percentage of body fat are more likely to predict autonomic dysfunction. Yet, the abovementioned study analyzed resting HRV only and did not account for physical activity status, while we assessed only healthy and physically active men during recovery from exercise.

When evaluating healthy populations, it has been shown that increasing BMI results in a decreased resting parasympathetic activity and increase sympathetic drive. For instance, Molifino et al.(10), found that participants with a BMI higher than 20 had significantly lower HF values than those with a BMI less than 20. This observation is in contrast to the findings in the current study, which found no differences in resting lnrMSSD and lnHF values for any of the groupings (G1 vs G2, G3 vs G4, or G5 vs G6) at Rest. These findings better reflect those of Koenig et al.(9), who observed no differences in resting lnrMSSD, lnHFn.u., or lnLFn.u. between groups based on BMI (<20, 20-25, >25). An important distinction to be made between these studies is the age of the participants. In the current study and that of Koenig et al.(9), participants were in their mid-twenties, while those in Molifino et al.(10), ranged from early-twenties to early-sixties. This may suggest that resting HRV status is less sensitive to BMI status in earlier years, and that age in combination of BMI may be more reflective of ANS status.

The recovery of HRV following a submaximal exercise bout was a novel aspect of this study. The parasympathetic rebound for G3 and G4 (WHR) were nearly identical, while G1 and G2 (Mass) where slightly but not significantly different. Only BMI demonstrated a difference in rate of recovery between G5 and G6 for both lnrMSSD and lnHF. This response supports the notion that higher BMI impacts parasympathetic activity during physiological stress. Though it was outside the scope of this study to determine a mechanism behind the observed differences, a few postulations will be offered. BMI is likely more indicative of ANS rebound due to less inherent error with measures of WHR (i.e., site location for measurement). Additionally, WHR only provides information about local distribution of adipose tissue, while little is known about the rest of the composition. Whereas BMI takes into account both mass and height. When evaluating mass (G1 & G2) there was a visual difference in the rate of recovery seen in figure 1., but this difference was not significant, unlike WHR which showed no difference at all in the rate of recovery. When accounting for both and mass and height, as BMI does, a significant difference in recovery is observed. Height and mass are two important variables to consider; where height may indicate length of the vasculature, and mass provide insight into systemic volume (8). Vascular length and systemic volume account for major variables related to peripheral resistance, which is a major driving force behind cardiovascular function. Therefore, a lower BMI may indicate a lower peripheral resistance, resulting in a more efficient rate of recovery.

Though this study was a novel undertaking in evaluating autonomic recovery, it is not without its limitations. Only healthy men were evaluated in this study thus, our data should not be extrapolated to different populations, i.e. women and subjects with cardiovascular or metabolic disorders. Our study presented a standardization for the population composed of physically active and healthy young males. Future work should include various populations to better understand the differences amongst groups.

CONCLUSIONS

BMI was the best predictor for autonomic recovery following exercise in healthy men compared to mass and WHR, indicating that higher BMI is related to slower autonomic return to baseline. Our data reinforces the importance of overweight healthy physically active subjects to be careful with their health. This is an inexpensive and practical method to evaluate the patients in clinical routine.

Conflicts of interest. The authors certify that there are no conflicts of interest to report.

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