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Correlation between Post Exercise Heart Rate Recovery and Body Composition in Healthy Female Adults

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ABSTRACT

Introduction: Post-exercise heart rate recovery (HRR) is an indicator of parasympathetic stimulation and impaired HRR is an independent predictor of cardiometabolic risk factors.

Aims & Objectives: This study aims at documenting the correlation between different body composition variables and post-exercise HRR in the apparently healthy female population of Pakistan.

Place and duration of study: The study was conducted at Shifa College of Medicine from April 10, 2019 to July 20, 2020.

Material & Methods: Ninety healthy females aged 18 to 50 years participated in this cross-sectional study. Body composition variables including waist circumference (WC), body fat ratio (BFR), body mass index (BMI), and physical activity were measured. Resting heart rate and the systolic and diastolic blood pressure prior to the exercise were measured. Peak heart rate (HR) was recorded immediately after exercise. After two minutes of rest, the drop in HR was measured and HRR was calculated.

Results: Mean age and BMI of the participants were 30.63±9.18 years and 24.56±4.24, respectively. Impaired HRR after two minutes of exercise (HRR2) was found in 63.3% of participants. A significant negative correlation was found between the BMI, BFR and WC with heart rate recovery (r=-0.64, r=-0.67 and -0.66 respectively; $p<0.001$*). Participants with BMI less than 23 reported higher HRR compared to the subjects with BMI ≥ 23 ($p<0.001$*). Study subjects with a BFR of less than 30 reported significantly higher HRR compared to the participants with a body fat ratio≥30 ($p<0.001$*).

Conclusion: A significant correlation was found between HRR2 and body composition variables in healthy female adults.

Keywords: body fat; body mass index; heart rate; physical activity; waist circumference

INTRODUCTION

Heart rate recovery (HRR), the decrease in heart rate after the termination of exercise, has gained importance as anestablished indicator of the status of autonomic nervous system function.[1] HRR reflects the cardiac status of an individual andis attributable to a coordinated interaction between excitatory sympathetic signals and inhibitory parasympathetic control.[2] During exercise, the stimulation of the sympathetic autonomic nervous system results in increased heart rate due to the release of catecholamines. Cessation of the physical activity results in a reduction of the activity of the sympathetic nervous system and stimulation of the parasympathetic system causing the increased heart rate to returnto its normal value. There has been a disagreement on an appropriate time to measure HRR, but a drop of more than 22 beats per minute (bpm) after two minutes is widely acknowledged as an indicator of a normal and healthy cardiovascular system.[3,4] Therefore, a decrease of less than 22 bpm in HRR after two minutes of rest indicatesan abnormal vagal reactivation and points towards an increased risk of cardiovascular events.[3,5]

The risk of developing non-communicable diseases such as cardiovascular diseases, hypertension, atherosclerosis and diabetes mellitus as a consequence of obesity is fast becoming pandemic.[6] Pakistan shares this burden of obesity with nearly 28% male and 38% female obese population; and the risk becomes even higher in urban areas necessitating the use of non-invasive, easy and feasible measures such as HRR to predict cardiometabolic risk factors.[7]

Body mass index (BMI) is one of the common tools being used to screen for obesity and generally, a BMI of 20-24.9kg/m^2 is considered normal worldwide but the literature suggests using lower cut-off limits of 22.9 kg/m^2 for BMI inthe Asian population.[8] One major limitation of using BMI to screen for the obese population is that it is an over-simplistic tool and therefore the use of computing body fat ratio as a tool for screening for obesity has become popular owing to its better prognostic and predictive value.[9,10]

Difference of opinion exists over suitable reference values for normal BFR for females of various ages, however, BFR> 35 percent of body weight is generally considered obese in females.[11]

With this background, we aimed to measure post-exercise HRR in an apparently healthy female population and its correlation with various body composition parameters (BMI, BFR, and WC), sleep and physical activity.

MATERIAL AND METHODS

This was a cross-sectional study conducted at Shifa College of Medicine from April 10, 2019, to July 20, 2020, after obtaining ethical approval from the Institutional Review Board & Ethics Committee of Shifa Tameer-e-Millat University (IRB#903-178-2017) and comply with the ethical standards laid down by the Helsinki declaration of 1964 and its later amendments. Participationwas voluntary and each participant was asked to provide written informed consent before data was collected.

A total of ninety apparently healthy adult females aged between 18 to 50 yearsfrom the faculty and staff of Shifa College of Medicine participated in the study. Females who were pregnant or had any serious heart or lung diseases were excluded from the study. All volunteers participated in a structured interview regarding their daily physical activity, sleep pattern, smoking and menstrual history. Physical activity was categorized into three classes based on self-reported physical activity; I: with minimal participation in games or exercise, II: regular daily exercise at home and III: strenuous exercise at home or gym. A calibrated vertical stadiometer was used to measure the height of study participants in cm. Body composition indicators likebody fat, lean muscle mass and weight of all participants were recorded using a device to measure leg-to-leg bio-electrical impedance. The body composition scale (living diagnostic analyzer; BG-42 Beurer) uses preprogrammed algorithms automatically applied by an analyzer.

BMI was computed by using the formulaweight (kg) / height (m^2). Using the WHO recommended BMI cut-offpoints for Asians, the participants were categorized into three categories of normal weight (18.5–22.9 kg/m^2), overweight (23–27.5kg/m^2)and obese (>27.5 kg/m^2).[8,12] Central adiposity measure that is waist circumference was measured by using a tape measure.

The participants' resting heart rate and blood pressure were measured prior to the exercise. They were asked to wear a Fitbit Charge 3 device for continuous monitoring of heart rate. Six-minute walk test (6MWTs) protocol[13]was used for exercise and all participants were informed about the details of the exercise. They were asked to walk as fast as possible on a 100 feet flat, smooth corridor according to their exercise tolerance for 6 minutes. The ends of the corridor were highlighted with coloured tapes as an indicator of finishing and starting points. The participants were asked to stop walking and take rest in case they experienced breathlessness, palpitations, leg cramps and dizziness.The peak heart rate of participants was recorded immediately after exercise and after two minutes. Blood pressure was also recorded after cessation of exercise.

The heart rate of participants was noted immediately and after two minutes of cessation of exercise. Blood pressure immediately after the exercise was also recorded.HRR was calculated by computing the difference in the post-exercise heart rate immediately and after a rest of two minutes. Impaired HRR was documented when the difference was less than 22 beats per minute after two minutes.

MS Excel software was used to enter and store the data. The data was computed by IBM's statistical package for the social sciences (SPSS) version 23 (IBM, Armonk, NY). The normality of data was analyzed by the Shapiro-Wilk test and Wilcoxon signed-rank test was used for the analysis of non-normally distributed data. The Pearson correlation statistical test was applied to analyze the correlation between body composition measurements and HRR.

Multiple regression analysis was applied to compute the standardized coefficients after controlling for variables such as heart rate, blood pressure and age. A P-value less than 0.05 was considered significant.

RESULTS

Ninety healthy females participated in the study. The mean age of the participants was 30.6 ± 9.1 years. Out of ninety participants, thirty-six (40%) were overweight and twenty-one (23%) were obese. The baseline variables, body composition measurements and pre-and post-exercise variability in heart rate and blood pressure are shown in Table-1.

Characteristics	**Mean ± SD**	**Range (Min to Max)**
Age (years)	30.63± 9.18	17-50
BMI (kg/m2)	24.56±4.24	15.20-33.38
BFR (%)	30.51±5.58	18-39.60
WC (cm)	32.37±3.58	22.5-38.16
Resting HR (bpm)	79.47±9.03	64-98
SBP before exercise (mmHg)	111.60±12.71	85-157
DBP before exercise (mmHg)	82.63±8.90	66-101
Maximum HR after exercise (bpm)	125.87±13.22	99-154
SBP after exercise	128.86±17.35	100-162
DBP after exercise	86.86±9.76	71-117
HR after 2 minutes rest (bpm)	106.60±13.38	76-130
HRR2 (bpm)	19.27±10.34	2-41
Average sleep duration (hours)	6.88±0.93	5-9

Table-1: Characteristics of the study participants at baseline and changes in blood pressure, heart rate after exercise and heart rate recovery (n=90)

BMI = Body mass index; BFR = Body fat ratio; WC = Waist circumference; HR = Heart rate; SBP= Systolic blood pressure; DBP = Diastolic blood pressure;
HRR2 = Heart rate recovery after 2 minutes

Correlation analysis showed BMI, BFR and WC having a significant inverse correlation with HRR (*p*-value <0.001) after controlling for age, resting heart rate and blood pressure as shown in Table-2.

Fifty-seven females (63.33%) showed impaired HRR2 of less than 22 bpm after a rest of two minutes. A statistically significant difference was observed in HRR2 between BMI < 25 and ≥ 25 individuals. Similarly, the difference in HRR2 in individuals with BMI < 23 and ≥ 23, BFR< 30 and ≥ 30 and various levels of physical activity was statistically significant. (Table-3).

Variables	**Pearson's correlation**		**Linear regression analysis**	
	r	*p*-value	β	*p*-value
Age	-0.23	0.016*	-0.09	0.434
BMI	-0.64	< 0.001*	-0.13	0.723
Body fat ratio(%)	-0.67	< 0.001*	-0.30	0.316
Waist circumference (cm)	- 0.66	< 0.001*	-0.19	0.358
Sleep duration	0.21	0.185	0.01	0.917

Table-2: Correlation coefficient (r) between age, body composition parameters, sleep and HRR, (Pearson correlation analysis) and standardized coefficient (β) between body composition measures, sleep duration and HRR subsequently controlling for blood pressure, resting heart rate and age (Linear regression analysis

BMI = Body mass index

Variables	**No. of participants (%)**	**Post-2-minutes exercise HRR (Mean ± SD)**	**p-value**
BMI < 25 (Range = 15.20-24.9)	54 (60)	24.27±8.29	< 0.001*
BMI ≥ 25 (Range = 25 – 33.38)	36 (40)	11.75±8.43	
BMI < 23 (Range = 15.20– 22.9)	33 (36.66)	25.36±7.85	< 0.001*
BMI ≥ 23 (Range = 23– 33.38)	57 (63.33)	15.73±10.00	
Body fat ratio < 30 (Range = 18– 29.9)	42 (46.66)	25.71±8.84	< 0.001*
Body fat ratio ≥ 30 (Range = 30– 39.6)	48 (53.33)	13.63±8.04	
Sleep ≥ 8 hours	24 (26.66)	18.62±13.81	0.304
Sleep < 8 hours	66 (73.33)	19.50±8.86	
Sleep ≥ 6 hours	84 (93.33)	19.96±10.34	0.006*
Sleep < 6 hours	6 (6.67)	9.50±1.64	
Non-smokers	90	-	-
Smokers	0		
Regular physical activity	9 (10)	*24.67±15.50	0.037 *
Occasional physical activity	45 (50)	20.67±10.86	
Sedentary lifestyle	36 (40)	*16.17± 6.97	

Table-3: Mean heart rate recovery of study subjects with various categories of BFR, BMI, sleep, smoking and Physical activity (n=90)

BMI = Body mass index

DISCUSSION

The high prevalence of cardiovascular diseases has become a huge burden on the health care system worldwidenecessitating early identification of individuals with risk factors to minimize the associated morbidity and mortality.[14] Given that obesity is an important contributor to cardiovascular diseases there is a need to develop non invasive and simple techniques that could predict the overall status of the cardiovascular system.[15]

The holistic assessment of the cardiovascular system with noninvasive and cost-effective tools, health care systems ofboth developed and developing countries could be benefited. HRR has the potential to be one such tool that could be useful to screen impaired cardiovascular functioning.[16-18]

We measured body composition parameters and HRR at 2 minutes (HRR2) of healthy females to find out any possible correlation. We found a significant negative correlation between age, BMI, body fat ratio and waistcircumference with HRR. Females with less BMI and body fat ratio had significantly higher mean HRR in comparison to healthy females with higher BMI and body fat ratio. To our knowledge the association of body fatratio with HRR2 in apparently healthy adult females has not been explored; however, our findings are in agreementwith two previous studies which have shown an inverse association of HRR at 1 minute with BMI in both genders in Brazilian adults [19] and with waist, BMI and body fat ratio in healthy adult Nigerian males and females.[20]Our findings are also in accordance with a study that reported a negative correlation of HRR2 with waist, BMI and body fat ratio in Malaysian children.[21]Similarly, another study has reported a strong negative correlation of HRR2 withage, BMI, fat ratio, waist circumference and sleep duration in Pakistani adult males.[22] A previous study conducted by Jezdimirovic and others could not establish the direct association of body fat and HRR in apparently healthy adults which could be due to the limited sample of females (38) versus 165 males and the majority of participants had a too low amount of body fat to disrupt autonomic function considerably.[23]

The mean body fat ratio of our participants corresponds to the BMI correlation model proposed for females by Branco and colleagues.[11] The mean BMI of our participants was 24.56 ± 4.2 which was slightly higher than the healthy population reference ranges recommended for the Asian population.[23]

Out of ninety participants, 40% had BMI ≥ 25 and showed significantly slow HRR after the exercise test in comparisonto 60% of participants with BMI < 25. Similarly, 57% of participants with BMI ≥23 had significantly slower HRRin comparison to participants with BMI < 23. BMI cut-off value of 23 was used for comparison taking into account the revised WHO guidelines for the Asian population owing to different genetic makeup and prevalence of risk factors associated with obesity.[12]

The mean peak heart rate after physical activity increased by approximately 1.5 times which is slightly lower than other similar studies in which the peak rate was approximately twice that of the resting heart rate but this difference could be due to the fact that subjects in other studies continued the exercise till they achieved a targeted and predicted maximum heart rate.[20]

We did not find a significant correlation between the number of hours of sleep with HRR2; furthermore, participants with more than eight hours of sleep did not have a significantly higher HRR2 in comparison to females with lower than eight hours of sleep. However, there was a significant difference in mean HRR2 in females with sleep less than six hours in comparison to females with more than six hours of sleep. These results are in agreement with previously conducted studies that have shown a significant association between impaired HRR with sleep deprivation.[24, 25]

Overall, our results suggest that an average sleep duration of six to eight hours does not greatly affect HRR2 but a duration of sleep less than six hours does contribute to a significant impairment of the HRR. There is a need to further explore the association of sleep quality i.e. onset, latency, duration, chronic sleep deficiency with body composition variables and HRR.We wanted to explore the effect of smoking on HRR but fortunately, none of our study participants reported smoking so we could not observe the effect of this variable. Lastly, we observed that participants who reported regular physical activity had significantly higher HRR2 in comparison to participants with a sedentary lifestyle. Our findings are substantiated by previous studies that have seen the effect of exercise and cardiac rehabilitation in cardiac patients but the effect of exercise on HRR in healthy individuals needs to be further studied.[26, 27]

CONCLUSION

In conclusion, the present study demonstrates a negative correlation of heart rate recovery with variables of body composition (BMI, waist circumference and body fat ratio) and physical activity in apparently healthy females. Future studies are required to evaluate the role of HRR as an independent and noninvasive prognostic marker for screening the individuals at risk of developing cardio-metabolic-disorders.

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