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Original Article

Physiology Section

Effect of Isotonic Exercise on Cardiovascular Parameters in Medical Students with Different Body Mass Indices: A Cross-sectional Study

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ABSTRACT

Introduction: Obesity is a known risk factor for hypertension. Baseline Heart Rate (HR) and blood pressure are known to scale linearly with Body Mass Index (BMI) values. Recent studies have reported an exaggerated acute response of blood pressure and HR to exercise.

Aim: To assess the effect of isotonic exercise on cardiovascular parameters among individuals with different body mass indices in students at Osmania Medical College and look for any association between BMI and cardiovascular responses to isotonic exercise.

Materials and Methods: A cross-sectional study was conducted in the Department of Physiology at Osmania Medical College, Hyderabad, Telangana, India, from January 2022 to December 2023, involving 100 healthy individuals with different body mass indices in the age group of 17 years-30 years. The subjects were divided into four groups based on their BMI. Baseline HR, Systolic Blood Pressure (SBP), and Diastolic Blood Pressure (DBP) were measured for all participants. Subsequently, the participants performed isotonic exercise for three minutes. Post-exercise HR, SBP, and DBP were measured immediately. One-way ANOVA was used to determine the significance of HR, SBP, DBP, Mean Arterial Pressure (MAP), and Pulse Pressure (PP) among the different BMI groups. A p-value of <0.05 was considered statistically significant.

Results: A total of 100 subjects (28 males, 72 females) with a mean age of 18.64±0.92 years participated in the study. Significant differences were observed in pre-exercise HR (p=0.0002), SBP, DBP, and MAP (p<0.001), and post-exercise HR, SBP, DBP, and MAP (p<0.001) among the different BMI groups. Overweight and obese individuals showed an increased tendency for an exaggerated increase in HR. Changes in PP and MAP, affected by a combination of SBP and DBP, also showed statistical significance. Furthermore, there was an increased tendency for an exaggerated increase in blood pressure in the overweight and obese BMI groups.

Conclusion: Individuals with higher BMI exhibit exaggerated increases in SBP, Mean and PP, as well as HR. Additionally, obese individuals demonstrated a significant elevation in DBP. The response of blood pressure and HR after exercise in overweight/obese individuals suggests a higher risk of developing hypertension and other cardiovascular diseases.

Keywords: Body mass index, Diastolic, Hypertension, Obesity, Pressure, Systolic

INTRODUCTION

Obesity is considered an epidemic that has been increasing since the 1980s. The prevalence of obesity has doubled from 1980 to 2015 in 73 countries and has been increasing in most other countries [1]. According to the Global Burden of Disease (GBD) Obesity Collaborators, an estimated 603.7 million adults are obese [2]. A BMI over 25 is considered overweight, and over 30 is obese. Obesity and hypertension have a linear relationship with cardiovascular disease, and BMI is positively correlated with SBP and DBP [3,4]. The assessment of blood pressure response to exercise is considered an essential diagnostic tool for evaluating the cardiovascular system [5]. BP response to submaximal intensity exercise has both prognostic and clinical significance [5]. Baseline and post-exercise HR and blood pressure are known to scale linearly with BMI values. Trained individuals have been observed to exhibit significant suppression of short-term blood pressure variability after exercise compared to untrained individuals, as training affects BMI [6,7]. Several studies have shown increased resting blood pressure with increased BMI [8-11]. Few some have shown acute response of exercise on blood pressure with changing BMI [12-14]. Previous studies have either analysed response to exercise in large samples without examining changes across different BMI categories or have focused on effects across different BMI categories but in smaller samples [13,15,16]. The present study aimed to analyse the effect of exercise on cardiovascular parameters in individuals with different BMI and to look for an exaggerated cardiovascular response in obese individuals compared to other groups, with the goal of implementing early interventions. The aim was to assess the effect of isotonic exercise on cardiovascular parameters among individuals with different body mass indices in students at Osmania Medical College and investigate the association between BMI and cardiovascular responses to isotonic exercise.

MATERIALS AND METHODS

A cross-sectional study was conducted in the Department of Physiology at Osmania Medical College, Hyderabad, Telangana, India, over a one-year period from January 2022 to December 2022. The study included 100 healthy individuals with different Body Mass Indices (BMIs) in the age group of 17 years to 30 years. Ethical approval was obtained from the institutional ethics committee (vide ECR/300/Inst/AP/2013/RR-16 Regd No. 20116001005D in the year 2022).

Inclusion criteria: The study included all healthy individuals aged between 17 years to 30 years.

Exclusion criteria: Individuals with a known history of hypertension or those suffering from coronary artery disease, diabetes mellitus, hyperthyroidism, hypothyroidism, and pregnant females were excluded from the study.

Sample size calculation: Informed consent was obtained from the enrolled subjects. The sample size for the study population was calculated based on a 95% confidence level, an anticipated

proportion of obesity of 10%, and a margin of error of 6%, resulting in a calculated sample size of 100.

Study Procedure

The detailed procedure was explained to the subjects, and data was obtained after individual approval. Weight was measured using a digital weighing machine, and height was measured using a stadiometer. BMI was calculated for each subject. The subjects were divided into four groups based on BMI: underweight (BMI <18.5); normal (BMI 18.5-24.99); overweight (BMI 25-29.99); and obese (BMI ≥30) [17]. Baseline HR, SBP, Pulse Pressure (PP), Mean Arterial Pressure (MAP), and DBP were measured for all study subjects. The participants were then instructed to perform isotonic exercise. Post-exercise HR, SBP, DBP, PP, and MAP were measured immediately after the isotonic exercise. Based on the recorded blood pressure, the subjects were grouped into four categories: normal (SBP <120 mmHg and DBP <80 mmHg); elevated (SBP 120-129 mmHg and DBP <80 mmHg); Stage-1 (SBP 130-139 mmHg or DBP 80-89 mmHg); Stage-2 (SBP ≥140 mmHg or DBP ≥90 mmHg) [18].

STATISTICAL ANALYSIS

Data was collected using a prestructured proforma and tabulated in Microsoft Excel. Statistical analysis was done using SPSS statistical analysis software version 22.0. One-way ANOVA was used to find the significance of SBP, DBP, mean, PP, and HR among the different BMI groups. The change in the above parameters from baseline was calculated, and one-way ANOVA was used to determine if there was a significant difference in the degree of change from baseline in the above parameters among the different BMI groups. A p-value of <0.05 was considered statistically significant. Additionally, f-value and f critical value were presented to assess significance.

RESULTS

There were 28 males and 72 females [Table/Fig-1]. Among the 100 subjects who participated in the study, females outnumbered males, and their mean age was higher [Table/Fig-1]. No significant difference was observed among the different BMI groups for grades of hypertension [Table/Fig-2].

Gender	n	Age (mean±SD)
Male	28	18.6±40.92
Female	72	19±0.91

[Table/Fig-1]: Demographic data (N=100).

Classification	BMI <18.5	BMI 18.5-24.9	BMI 25-29.9	BMI >30	Total N=100
Normal	8	20	2	2	32
Elevated	4	15	7	3	29
Stage-1	2	5	7	9	23
Stage-2	0	0	12	4	16
			P	0.79	
			f-value	0.35	
			F Crit	3.49	

[Table/Fig-2]: Analyses of grades of hypertension among the different BMI groups.

There was a significant difference in pre-exercise HR, SBP, DBP, and MAP among the different BMI groups [Table/Fig-3]. The p-value was <0.05, indicating statistical significance. The f-value was above the F Critical Value of 2.7, further supporting statistical significance. There was no significant difference in pre-exercise PP among the different BMI groups. The p-value=0.41 as shown in [Table/Fig-3]. The f-value of 0.96 was much lesser than the F critical value of 2.7, suggesting no statistical significance. There was a significant difference in post-exercise SBP, DBP, PP, and MAP among the different BMI groups [Table/Fig-4]. The p-value was <0.05, indicating statistical significance. The f-value was above the F critical value of 2.67, supporting statistical significance.

Regarding the degree of change in SBP and HR among different BMI groups, there was no statistically significant difference (p-value=0.06) [Table/Fig-5]. The f-value was close to the F critical value of 2.7, suggesting a tendency toward statistical significance. However, there was a significant difference in the change in PP and MAP among the different BMI groups. The p-value was <0.05, and the f-value was higher than the F critical value of 2.7, also suggesting statistical significance.

DISCUSSION

[Table/Fig-6] showed comparison of the parameters before and after exercise in subjects without a parental history of hypertension, comparing the values obtained in this study with those conducted by Ammireddy S et al., Jyothy S et al., Srivastava S and Kaur S, and Prajapatti TT et al., [15,16,19,20]. The findings of the present study are in line with the studies conducted by Ammireddy S et al., Prajapati TT et al., and Kerhervé HA et al., which demonstrate an increased incidence of hypertension in the obese and overweight BMI groups [15,20,21]. Ammireddy S et al., studied 44 subjects aged between 17 to 19 years at SVS Medical College in 2016 and found significant differences in SBP, DBP, and mean arterial blood pressure before exercise (p=0.002, 0.008, and 0.003) and in SBP and PP after exercise (p=0.007 and 0.037) among underweight, normal weight, and overweight subjects [15]. Prajapati TT et al., studied 90 female subjects aged 17-22 years at Pramukhswami Medical College in 2020 and found a significant difference in the exercise response change of SBP among different BMI groups [20]. Kerhervé HA et al., studied 35 premenopausal women at the University of Queensland in 2020 and found significant differences among different groups for SBP, DBP, and MAP [21].

Pre-exercise HR in the present study was higher compared to the study by Ammireddy S et al., but similar to the study done by Prajapatti TT et al., [15,20]. The comparison of post-exercise HR elevation among different BMI groups was similar to the studies by Ammireddy S et al., and Prajapati TT et al., but not observed in the study done by Kerhervé HA et al., [20,21]. Post-exercise SBP rise with increasing BMI in this study was similar to the results in the study by Ammireddy S et al., and Kerhervé HA et al., but this change was less pronounced in the study done by Prajapati TT et al., [15,20,21]. Post-exercise DBP change with increasing BMI in the present study showed a rise, while a fall in DBP was observed in the study done by Ammireddy S et al., and minimal change was observed in the study done by Kerhervé HA et al., [15,21]. Measurements of PP were not done by Prajapati TT et al., and Kerhervé HA et al., The observed PP changes in our study were similar to those observed by Ammireddy S et al., [15,20,21]. Post-exercise MAP was lower in the

Variables	Groups	Number	Groupwise mean±SD	Overall mean±SD	p-value	F-value
Heart Rate (HR)	Underweight	14	87.08±4.95	86.9±7.11	0.0002	7
	Normal	40	83.2±8.55			
	Overweight	28	88.89±6.69			
	Obese	18	91.89±5.30			

SBP	Underweight	14	104.08±7.16	115.15±10.53	p<0.001	11.77
	Normal	40	111.52±11.29			
	Overweight	28	121.96±12.78			
	Obese	18	121.22±5.92			
DBP	Underweight	14	77.46±4.99	84.83±7.85	p<0.001	16.46
	Normal	40	80.43±8.32			
	Overweight	28	91.07±9.05			
	Obese	18	90.61±6.33			
Pulse Pressure (PP)	Underweight	14	26.62±5.99	30.33±8.55	0.41	0.96
	Normal	40	31.1±8.91			
	Overweight	28	30.9±10.03			
	Obese	18	30.61±6.6			
Mean Arterial Pressure (MAP)	Underweight	14	68.59±5.78	74.72±8.91	p<0.001	12.38
	Normal	40	70.06±9.29			
	Overweight	28	80.77±10.07			
	Obese	18	80.41±7.98			

[Table/Fig-3]: Comparison of pre-exercise Heart Rate (HR), SBP, DBP, PP, MABP IN all four groups.

Variables	Groups	Number	Group wise mean±SD	Overall mean±SD	p-value	f-value
Heart Rate (HR)	Underweight	14	116.08±16.68	119.37±13.71	p<0.001	8.34
	Normal	40	112.25±14.13			
	Overweight	28	123.21±10.61			
	Obese	18	131.78±14.55			
SBP	Underweight	14	120.38±3.89	115.87±35.19	p<0.001	6.36
	Normal	40	100.83±43.52			
	Overweight	28	117.07±37.67			
	Obese	18	143.89±19.61			
DBP	Underweight	14	83.31±3.64	89.18±8.73	p<0.001	9.89
	Normal	40	85.18±10.59			
	Overweight	28	94.25±8.32			
	Obese	18	94.72±7.29			
Pulse Pressure (PP)	Underweight	14	37.08±5.59	42.64±13.47	0.03	3.09
	Normal	40	39.78±11.21			
	Overweight	28	45.32±16.81			
	Obese	18	49.17±16.24			
Mean Arterial Blood Pressure (MABP)	Underweight	14	70.95±5.25	74.96±9.9	p<0.001	4.3
	Normal	40	71.92±12.88			
	Overweight	28	79.14±7.75			
	Obese	18	78.33±7.52			

[Table/Fig-4]: Comparison of Heart Rate (HR), SBP, DBP, PP, MABP in all four groups after exercise.

Variables	Groups	Number	Mean±SD	p-value	f-value
Heart rate (HR)	Underweight	14	29±15.14	0.06	2.49
	Normal	40	29.05±15.58		
	Overweight	28	34.32±15.61		
	Obese	18	39.89±13.18		
SBP	Underweight	14	16.31±8.43	0.06	2.53
	Normal	40	13.43±11.29		
	Overweight	28	17.60±21.6		
	Obese	18	22.67±19.61		
DBP	Underweight	14	8±5.85	0.63	0.56
	Normal	40	16±4.75		
	Overweight	28	15±3.18		
	Obese	18	25±4.11		
Pulse Pressure (PP)	Underweight	14	-10.46±7.43	0.01	3.87
	Normal	40	-8.68±7.58		
	Overweight	28	-14.43±11.87		
	Obese	18	-18.56±16.68		

Mean Arterial Blood Pressure (MABP)	Underweight	14	-8.26±11.9	p<0.001	12.38
	Normal	40	35.73±44.53		
	Overweight	28	46.2±38.74		
	Obese	18	8.98±12.97		

[Table/Fig-5]: Comparisons of changes in HR, SBP and DBP, PP and MABP in all the four groups.

	Parameters	Present study (Mean±SD)	Study by Ammireddy S et al., [15]	Study by Jyothy S et al., [16] (Mean±SD)	Study by Srivastava S et al., (Mean±SD) [19]	Study by Prajapatti TT et al., [20]
Details of study	Sample size	100	44	30	50	90
	Place of study	OMC, Hyderabad,Telangana	SVSMC, Mahabubnagar, Telangana	AIMS, B G Nagara, Karnataka	AIMSR, Bathinda, Punjab	Pramukhswami Medical College, Karamsad, Gujarat
	Year of study	2022	2016	2019	2022	2021
Before exercise	Heart rate	86.9±7.11	72.4±8.8	76.4±3.6	83.86±13.0	87.76±12.98
	SBP	115.15±10.53	109.0±9.4	118.6±7.2	123.31±12.8	101.5±8.02
	DBP	84.83±7.85	75.5±11.0	77.2±5.0	80.93±7.42	65.6±6.69
After exercise	Heart rate	119.37±13.71	102.0±20.1	84.7±8.2	145.41±17.11	130.73±16.72
	SBP	115.87±35.19	127.0±23.2	129.6±5.1	150.9±22.86	122.66±11.53
	DBP	89.18±8.73	62.6±8.6	82.8±5.3	87.41±8.93	64.86±6.88

[Table/Fig-6]: Comparison of Heart Rate (HR), SBP, DBP with studies done on subjects without parental history of hypertension.

study conducted by Ammireddy S et al., compared to pre-exercise values, as DBP showed a decrease [15]. However, in the present study, it was observed that MAP increased after exercise, which is similar to the results obtained by Kerhervé HA et al., Prajapati TT et al., did not record changes in MAP [20].

In the present study, a significant number of individuals in the normal BMI group (N=20) and underweight group (N=6) were categorised as having elevated or stage 1 blood pressure. This suggests that factors other than BMI contribute to increased blood pressure, such as stress, altered lifestyle, reduced sleep, etc., as found in study done by Sarnecki J et al., and Toriumi S et al., [22,23]. It is interesting to note that although the degree of change in systolic and diastolic blood pressure among the different BMI groups was not significant, changes in PP and MAP, which are influenced by a combination of SBP and DBP, showed statistical significance. These changes can be attributed to various mechanisms, including activation of the Sympathetic Nervous System (SNS), the Renin-Angiotensin-Aldosterone System (RAAS), leptin resistance, insulin resistance, and endothelial dysfunction. Obesity is characterised by overactivation of the SNS and hence has a critical role in the development of hypertension [24-27]. There is impairment in the baroreceptor reflex in obese individuals, which contributes to less bradycardia and less sympathetic inhibition by baroreceptor stimulation [28]. Therefore, in the present study, isotonic exercise was used as a tool to assess the cardiac functional status among different BMI groups. The exaggerated response in blood pressure and HR after exercise in overweight/obese individuals suggests that they are at a higher risk of developing hypertension and other cardiovascular diseases. Baroreceptor sensitivity measurements in response to physiological challenges, deep breathing, and isotonic exercise may be more sensitive investigations for detecting early attenuation of cardiac autonomic function. This would enable timely intervention, thereby delaying complications and improving the quality of life [29].

Limitation(s)

The study has several limitations, including a small sample size and the potential confounding factor of gender differences. To obtain more robust results, future studies should be conducted on a larger sample size, ensuring a more representative population.

Further research is needed to assess whether weight reduction in individuals with increased BMI leads to improvements in baseline and post-exercise blood pressures and HR. It is also important to investigate the impact of removing confounding factors on these outcomes.

CONCLUSION(S)

From the above, it can be concluded that increased BMI is a strong predictor of and is positively associated with hypertension. BMI also influences hemodynamic responses to exercise. Individuals with a high BMI exhibit exaggerated cardiovascular responses to exercise.

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