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RESEARCH ARTICLE

Effect of gender and body mass index on cardiorespiratory parameters after an acute bout of aerobic exercise: A physiology laboratory-based study

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ABSTRACT

Background: Exercise testing is a way to assess the cardiorespiratory fitness (CRF). Conventionally, it has been reported that CRF decreases with an increase in body mass index (BMI). Moreover, there are gender-associated differences in the CRF. However, in the under-equipped physiology laboratory, the results of exercise testing may not produce the ideal results, as it has been accepted traditionally. **Aims and Objectives:** The aim of the current study was to assess the effect of BMI and gender on the cardiorespiratory parameters after dynamic exercise. The primary objective of the study is to set an example for students to report authentic results rather than making falsified ideal results. **Materials and Methods:** Twenty-one females and 23 males were involved in the study that was further divided into three groups based on BMI – normal weight, underweight, and overweight. Participants performed a 3-min exercise bout on the cycle ergometer. Cardiorespiratory parameters of each participant were recorded in front of other participants just before and after the exercise by the locally available instruments available in the laboratory. Analysis of variance with *post hoc* Tukey was applied and $P \leq 0.05$ was considered as statistically significant. **Results:** Pre-exercise cardiorespiratory study parameters were unaffected by BMI, although males showed a higher resting blood pressure than the females. Post-exercise cardiorespiratory parameters remained unaffected by BMI, but females showed a significantly higher percentage change in post-exercise systolic blood pressure, pulse rate, rate pressure product, and respiratory rate than the males. **Conclusion:** The results of the present study are far from the traditionally accepted results; however, it has set an example for the budding doctors to report genuine results.

KEY WORDS: Body Mass Index; Cardiorespiratory; Exercise; Gender

INTRODUCTION

Conventionally, exercise testing has been used to assess and promote the health status of otherwise normal subjects. It has been made a part of the MBBS 1st year study as competency in the physiology curriculum by the Medical Council of India.[1]

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Evaluation of cardiorespiratory responses to exercise is being used as a diagnostic approach to the patients of various diseases, especially that of the cardiovascular system.[2]

Conventionally, it has been established that different grades of dynamic exercise in either gender of human subjects show a significant increase in blood pressure, pulse rate (PR), rate pressure product (RPP), and minute ventilation (MV) after exercise.[2-4] It has been shown that with an increasing body mass index (BMI), cardiorespiratory response to exercise increases significantly.[5,6] Females show a more heightened cardiorespiratory response to exercise than males of the same age and BMI.[7,8]

Many studies from India have used international classification of BMI by the World Health Organization, which does not apply to the Asian population.[6,9,10] Moreover, the cardiorespiratory responses to dynamic exercise may vary when exercise testing is done in the physiology laboratory with under-equipped facilities. The present study aims to know the effect of gender and BMI on cardiorespiratory parameters after an acute bout of aerobic exercise on cycle ergometer kept in a physiology laboratory.

MATERIALS AND METHODS

The present experimental cross-sectional study was carried out in the Physiology Laboratory of Shri Guru Ram Rai Institute of Medical and Health Sciences (SGRRIMHS), Dehradun, India, after approval from the Institutional Ethical Committee. Forty-four subjects (23 males and 21 females) aged 18–25 years from SGRRIMHS were involved in the study. Both male and female groups were further divided into three subgroups based on the Asian classification of BMI – underweight (BMI <18.5 kg/m^2), normal weight (BMI = 18.5–22.9 kg/m^2), and overweight (BMI = 23–24.9 kg/m^2).[10]

Informed written consent was taken from every subject and their fitness to perform exercise test was screened by "Get Active Questionnaire" from the Canadian Society for Exercise Physiology.[11] All the participants were moderately active as assessed by the "UK Health Department's General Practice Physical Activity Questionnaire."[12] Thorough history taking and general and systemic examination excluded the presence of any condition that could have prevented the safe performance of the exercise test.

All study parameters were recorded by the same investigator. An electronic "platform scale" weighing machine (ATKO, New Delhi, India) was used to measure the bodyweight of the participants to the nearest 0.1 kg. Locally, available rigid stadiometer (INCO, Ambala, India) was used to measure the height of participants to the nearest 0.1 cm. BMI was calculated as weight in kilograms divided by the square of height in meters.

A 3-min bout of exercise was performed by each participant on the cycle ergometer (INCO, Ambala, India) with the cadence of 60 rotation per minute and a weight of 5 kg. Exercise testing was done during the laboratory hours of 11 am–1 pm in front of other students (participants). Systolic blood pressure (SBP) and diastolic blood pressure (DBP) in mmHg were recorded immediately before and after the exercise while the subject remained seated on the cycle ergometer. Blood pressure measurement was done by locally available mercury sphygmomanometer (Diamond, Maharashtra, India) and stethoscope (Microtone, India) as per the recommendations of the American Heart Association.[13] Heart rate (HR) per minute was determined as the PR by palpating the radial artery for 1 min. RPP, a linear correlate of myocardial oxygen consumption, was calculated as the product of SBP and HR divided by 100 (RPP = SBP × HR ÷ 100) and reported in arbitrary units.[14] Respiratory rate (RR) per minute was counted manually by looking at the chest movement of the participants and tidal volume (TV) in liters was estimated by the student's spirometer (INCO, Ambala, India). MV in liters per minute was calculated as the product of TV and RR. Percentage change in the parameters was calculated as ([value after exercise – resting value] ÷ resting value) × 100. Care was taken to record post-exercise reading as quickly as possible.

Statistical Analysis

Microsoft Excel 2016 was used for initial data entry. Further, statistical analysis was carried out in IBM SPSS Statistics Software for Windows, version 25. Analysis of variance with the *post hoc* Tukey test was applied to know the statistical difference in the group data. Data are represented as mean ± standard deviation. All values are rounded to one decimal place. $P \leq 0.05$ was considered as statistically significant.

RESULTS

Table 1 shows the division of study subjects into six subgroups based on gender and BMI – namely, male underweight (MUW), male normal weight (MNW), male overweight (MOW), female underweight (FUW), female normal weight (FNW), and female overweight (FOW). Table 2 shows the baseline values of the study parameters for all the groups. Table 3 shows the percentage change in the study parameters after exercise in all the groups. Tables 2 and 3

Table 1: Division of groups based on BMI and gender

Group	Gender	Age	Height in cm	Weight in kg	BMI in kg/m^2	Number of subjects
MUW	Male	19.6±1.3	167.6±0.7	51.6±0.5	18.4±0.1	7
MNW	Male	19.6±1.4	157.5±0.5	53.8±0.3	21.7±0.2	8
MOW	Male	20.0±1.4	157.6±0.4	61.6±0.4	24.8±0.2	8
FUW	Female	18.9±0.9	157.6±0.4	45.8±0.3	18.4±0.1	7
FNW	Female	20.0±1.5	157.4±0.5	53.6±0.3	21.6±0.2	7
FOW	Female	19.7±1.3	147.4±0.5	53.5±0.3	24.6±0.2	7

MUW: Male underweight, MNW: Male normal weight, MOW: Male overweight, FUW: Female underweight, FNW: Female normal weight, FOW: Female overweight, BMI: Body mass index

Table 2: Comparison of baseline study parameters of different groups

Parameters	UW	NW	OW	*P*-value
PR per minute				
M	68.9±3.0	73.0±3.6	70.8±3.9	NS
F	72.3±2.1	71.1±2.8	73.4±2.2	NS
P-value	NS	NS	NS	
SBP in mmHg				
M	124.9±7.2	116.0±4.8	121.2±6.8	NS
F	96.9±4.9	100.9±5.5	94.3±5.4	NS
P-value	<0.001	<0.001	<0.001	
DBP in mmHg				
M	77.1±5.0	72.3±6.5	74.8±4.8	NS
F	57.7±3.9	58.3±5.1	56.0±3.5	NS
P-value	<0.001	<0.001	<0.001	
RRP in AU				
M	85.9±5.6	84.9±7.6	85.6±5.5	NS
F	70.1±4.2	71.3±4.9	69.3±4.9	NS
P-value	<0.001	<0.001	<0.001	
RR per minute				
M	12.1±0.7	13.1±1.1	13.0±1.1	NS
F	13.1±1.1	13.0±1.0	14.0±0.8	NS
P-value	NS	NS	NS	
TV in mL				
M	441.4±33.4	393.8±46.6	412.5±38.5	NS
F	360.0±24.5	377.1±38.2	342.9±29.3	NS
P-value	0.002	NS	0.008	
MV in L				
M	5.4±0.4	5.1±0.4	5.4±0.7	NS
F	4.7±0.6	4.9±0.5	4.8±0.6	NS
P-value	NS	NS	NS	

AU: Arbitrary unit, DBP: Diastolic blood pressure, F: Female, M: Male, MV: Minute ventilation, NS: Not significant, NW: Normal weight, OW: Overweight, PR: Pulse rate, RPP: Rate pressure product, RR: Respiratory rate, SBP: Systolic blood pressure, TV: Tidal volume, UW: Underweight. Analysis of variance was applied with *post hoc* Tukey, $P \leq 0.05$ was considered statistically significant

Table 3: Comparison of the percentage change in the parameters after exercise for different groups

Parameters	UW	NW	OW	*P*-value
% change in PR				
M	32.1±2.8	38.1±6.6	36.3±4.7	NS
F	61.1±8.2	55.6±7.6	64.0±7.2	NS
P-value	<0.001	0.013	<0.001	
% change in SBP				
M	20.1±4.5	17.4±2.3	18.1±3.5	NS
F	21.0±3.7	22.4±3.6	20.1±4.6	NS
P-value	<0.001	<0.001	<0.001	
% change in DBP				
M	0.9±2.9	−2.9±4.2	−1.3±3.4	NS
F	−4.0±4.5	0.7±5.5	−0.9±4.4	NS
P-value	NS	NS	NS	
% change in RRP				
M	59.1±5.1	62.0±7.9	61.5±5.3	NS
F	94.6±12.5	91.6±14.2	96.6±14.0	NS
P-value	<0.001	<0.001	<0.001	
% change in RR				
M	25.9±6.2	31.6±7.1	29.3±7.5	NS
F	42.7±9.5	46.3±7.3	45.1±5.2	NS
P-value	0.001	0.005	0.002	
% change in TV				
M	120.3±11.4	112.1±8.5	111.9±14.3	NS
F	107.3±11.6	107.6±10.9	109.4±12.2	NS
P-value	NS	NS	NS	
% change in MV				
M	177.3±15.5	179.3±18.3	174.3±24.8	NS
F	195.3±20.7	203.6±24.7	204.3±22.0	NS
P-value	NS	NS	NS	

AU: Arbitrary unit, DBP: Diastolic blood pressure, F: Female, M: Male, MV: Minute ventilation, NS: Not significant, NW: Normal weight, OW: Overweight, PR: Pulse rate, RPP: Rate pressure product, RR: Respiratory rate, SBP: Systolic blood pressure, TV: Tidal volume, UW: Underweight. Analysis of variance was applied with *post hoc* Tukey, $P \leq 0.05$ was considered statistically significant

compare—MUW, MNW, and MOW group; FUW, FNW, and FOW group; and MUW, MNW, and MOW with FUW, FNW, and FOW group, respectively.

DISCUSSION

The present study was carried out to know the effect of a 3-min exercise bout performed by males and females of three different BMI groups, namely – underweight, normal weight, and overweight, on cardiorespiratory parameters.

The previous studies have reported a positive correlation of BMI with PR, SBP, and DBP with higher values in males than females.[15-18] However, the present study results show that SBP, DBP, and PR are not affected by BMI in either of the genders. The use of relatively less precise and less accurate instruments such as locally available mercury sphygmomanometer and stethoscope and manual counting of PR could have resulted in unavoidable errors in the present study. These errors along with small sample size per subgroup and use of Asian classification of BMI within a narrow range could be the reasons that the results of the present study show no effect of BMI on SBP, DBP, PR, and RPP. The result of the present shows a significantly higher SBP, DBP, and RPP in all the male subgroups as compared to female subgroups. Possibly due to androgens, males have a higher resting blood pressure as compared to females.[19,20]

In the present study, there was no effect of BMI on RR, TV, and MV. The TV was significantly higher in the MUW and

MOW group as compared to the FUW and FOW group, respectively. Although TV was higher in the MNW group than the FNW group, the result was not significant statistically. The higher TV in males might be related to the larger size of males than females.[21] Based on the results of the previous studies, Littleton in a review stated that RR tends to increase while TV tends to decrease with an increase in BMI. Further, despite the decrease in TV, MV increases significantly in obese due to an increase in RR.[22] Our results contradict these findings which might be due to the usage of locally available student spirometer, manual counting of RR, recruitment of subject as per Asian classification of BMI, and small sample size per subgroup.

The cardiorespiratory parameters in all the subgroups of the male and female groups increased significantly after exercise (data not shown) except that of DBP. DBP was reduced in some of the subgroups that might be due to the decrease in total peripheral resistance of the vessels within the exercising muscles by the release of local vasodilators, a phenomenon called "sympatholysis."[23] The brain through the combined activity of central command, exercise pressor reflex, baroreceptor reflex, and chemoreceptor reflex regulates the increase in cardiorespiratory parameters during exercise. Furthermore, local mechanisms that include metabolic, endothelial, and myogenic components play an important role in cardiorespiratory homeostasis during exercise.[4,23,24]

The results of the present study show a non-significant effect of BMI on the percentage change in PR, SBP, DBP, RPP, TV, RR, and MV in either gender group. De Araujo *et al*. reported that cardiorespiratory fitness of school-going boys was higher than the girls, but there were no differences concerning BMI.[8] However, Bonney *et al*. indicated that increased BMI correlates with decreased cardiorespiratory and musculoskeletal fitness in South African adolescent girls.[5] Setty *et al*. reported that with an increase in BMI, there is a significant increase in HR and volume of oxygen inhaled.[6]

The percentage change in SBP, PR, RPP, and RR was significantly less while percentage change in TV was significantly more in male subgroups than the female subgroups. Kilbride *et al*. reported that the increases in post-exercise MV were achieved by a significantly greater TV in males, whereas females adopted a significantly greater RR.[25] Our study results are in contradiction with the results reported by Parkhad and Palve.[9] They reported that the post-exercise HR, SBP, DBP, and RPP were significantly greater in males than females that might be attributed to the greater exercise pressor response in males than the females. The measurement of the study parameters in the presence of other students (participants) along with non-calibrated instruments with questionable precision and accuracy, small sample size, unavoidable manual errors in the measurement, only a 3-min exercise bout, and difference in BMI classification could be the reasons for the contradictory results of the present study.

The main objective of the study is to teach the students to report the exact results that they get in the laboratory while experimenting. The results might not be ideal but so is the laboratory instruments and environment. The current study was not able to reproduce the ideal results of the effect on gender and BMI on cardiorespiratory parameters as mentioned in physiology textbooks and practical books. However, the study succeeded in installing a seed in young student's minds that they should report the authentic results rather than the ideal one. The difference in the ideal results and the observed results should be critically analyzed, and sources of error could be found rather than reporting false data.

CONCLUSION

The results of the present study show that the percentage increase of SBP, PR, RPP, and RR was significantly higher in females than males, while the percentage increase in TV was significantly higher in males than the females. BMI does not cause any effect on the post-exercise study parameters. The results of the present study are not ideal but must have sensitized the young minds present in the physiology laboratory of our institute to report the authentic results rather the made-up ideal results.

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