DOI: 10.21276/aimdr.2018.4.4.PH2

Original Article ISSN (O):2395-2822; ISSN (P):2395-2814

Cardiac Response to Exercise in Obese, Overweight and Normal Subjects – An Observational Study.

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Received: April 2018
Accepted: May 2018

ABSTRACT

Background: Obesity is characterized by an abnormally large adipose tissue mass which imposes additional stress to cardio-respiratory system during exercise. The purpose of this study is to evaluate the cardiac response to exercise in normal weight, overweight and obese young adults. **Methods:** The present work was conducted on total 210 young adults of MMU, Mullana, Ambala, (Haryana) of which 70 forming the normal weight group, 70 forming overweight group and 70 forming obese group in MMU, Mullana, Ambala (Haryana), for assessing the cardiac parameters in response to exercise. **Results:** The mean PR was increased with increasing BMI but it was not significant ($p>0.05$). In response to exercise PR was increased very highly significantly ($p<0.001$) in all the three groups. There was no significant ($p>0.05$) difference in mean PR found between boys and girls. The mean values of blood pressure i.e. SBP, DBP, MAP and PP were increased with increasing BMI but the increase was not significant ($p>0.05$) and in response to exercise blood pressure was very highly significantly ($p<0.001$) increased in all the groups. There was no significant ($p>0.05$) difference found in blood pressure between boys and girls in all the three groups. **Conclusion:** The HR and BP was more in overweight and obese subjects as compared to normal weight. In response to exercise, cardiac parameters were increased in all the three groups.

Keywords: Cardiac parameters, exercise, obesity.

INTRODUCTION

Obesity is characterized by an abnormally large adipose tissue mass which imposes additional stress to cardio-respiratory system during exercise. The price we are paying for an affluent and developed society is a sedentary life style and faulty dietary habits which result in an imbalance between energy intake and energy expenditure, which in turn leads to obesity. Overweight and obesity represent a rapidly growing threat to the healthy populations in an increasing number of countries. Obesity is becoming a global epidemic, 1 and in the past 10 years in Europe and the United States, dramatic increase in obesity has occurred in both children and adults. Thorough the use of Body mass index (BMI), the epidemic of study that began in the 1980s has been tracked through the end of the century. The original alarm was sounded in 1994 by the National Center for Health Statistics in USA when they reported data from the National Health and Nutrition Examination Survey (NHANES). The authors observed that over a span of 10 years from 1988 to 1999, the prevalence of overweight in adults increased from 55.95 to 64.5%. During the same period, the prevalence of obesity increased from 22.9% to 30.5%.[1,2]

Obesity is extensively associated with coronary heart disease whose manifestations appear quite later in life though risk related behaviour patterns are evident in childhood and adolescence. Obesity may lead to occurrence of heart diseases with poor cardio respiratory fitness. People are prone to develop cardiovascular diseases and other chronic diseases at young age of their life because of early life obesity. The influence of increased percentage of body fat and central obesity on blood pressure has also been well documented.[3]

In obese people there is an increase of cardiac work at rest, estimated at 40-190 percent relative to that of subjects of ideal body weight. It is well established that indexes of obesity such as Body mass index (BMI), correlate with left ventricular wall thickness and cavity dimension. Chronic obesity is associated with an increased left ventricular mass and with high cardiovascular morbidity and mortality.[4]

Sound health and physical fitness are positively associated with good mental health and well being. People who take regular physical exercise report less anxiety and depression and lower level of stress than do sedentary people. Physical fitness is a required

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element for all the activities in our society. Health related physical fitness of an individual is mainly dependent on lifestyle related factors such as daily physical activity. It was believed that the low physical fitness level of an individual is associated with higher mortality rate.[1,5]

Physical fitness is also considered as the degree of ability to execute a physical task under various ambient conditions. Physical fitness of an individual has three main aspects. These are static fitness (absence of disease), dynamic fitness (ability to perform strenuous work) and motor skills fitness, of these three the dynamic fitness is very important in athletes.[6,7]

The purpose of this study is to evaluate the cardiac response to exercise in normal weight, overweight and obese young adults of MMU, Mullana, Ambala (Haryana).

MATERIALS AND METHODS

The study was conducted in the Department of Physiology, Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana (Ambala). The students of Maharishi Markandeshwar University (MMU), Mullana, between the age groups of 18 to 30 years were included in the study population.

The selected subjects, which include male and female students of MMU, were divided into three groups according to body mass index (BMI) classification of WHO.

Group I- Seventy subjects with BMI 18.5-24.9 kg/m² - (Normal weight)

Group II- Seventy subjects with BMI 25.0-29.9kg/m²- (Overweight)

Group III- Seventy subjects with BMI ≥30kg/m²- (Obese)

Each group was comprised of equal number of male and female students. The 70 subjects in each group were chosen by Simple Random Sampling method. Thus total of 210 subjects were included in the study.

Inclusion criteria

1. Subjects between 18 to 30 years.
2. Healthy male and female subjects.
3. Untrained subjects.

Exclusion Criteria

1. Subjects below 18 years.
2. Subjects above 30 years.
3. Smokers.
4. Subjects with respiratory illness, any cardiovascular disease, musculoskeletal disease, or any chronic illness.
5. Subjects undergoing regular physical training.

The purpose of study was explained to subjects and informed consent was taken. The subjects were explained about the whole procedure in detail and a demonstration was given before readings. All the subjects were asked to refrain from eating for 2 hours prior to exercise. A brief history including smoking history and a clinical examination of cardiovascular system and respiratory system was done to exclude hidden medical problems that could have negative impact on cardio- respiratory responses to exercise testing.

To determine the BMI, height (in m), and weight (in kg) were measured with a standard weighing machine that included a height measuring stand. Body mass was measured to an accuracy of 0.5 kg and height to an accuracy of 0.1cm. The measurements were taken from the participant without shoes and light clothing with the shoulders in relaxed position and arms hanging freely. The BMI was calculated using formula (Quetelet's Index).

BMI (kg/m²) = weight (kilograms)/ height (m²)

To determine WHR, waist circumference was measured around the abdomen on the midpoint between the lower border of the rib cage and the iliac crest, while the participant was standing with the abdomen relaxed, both feet touching and arms hanging freely at the end of normal expiration. Where there was no waist line, the measurement was taken at the level of umbilicus. The hip circumference measured at the greatest gluteal protuberance while the subject stood with the feet together.

WHR = waist circumference (cm) / hip circumference (cm)

Blood pressure

Blood pressure was taken with the help of mercury sphygmomanometer in the sitting position using appropriate sized cuff. Inflate the cuff slowly until the pulsations disappear, note the reading with the help of stethoscope, and then raise the pressure another 30-40 mmHg. Then deflate the cuff slowly and note the reading when the sound just reappeared. The pressure at which the sound was first heard was the systolic pressure (SBP). Then deflate the cuff and heard the sounds (Korotkoff sounds) and at the point when the sound again disappeared recorded as diastolic pressure (DBP).155 Cardiac parameters like systolic blood pressure, diastolic blood pressure, mean arterial pressure and pulse pressure were assessed.

Pulse pressure was calculated as

PP = SBP-DBP

Mean arterial pressure was calculated as

MAP = DBP+1/3PP

The radial artery at the wrist was used to count the pulse rate. It was counted over one minute.

The step test was performed using a stool of 16.25 inches (or 41.30cm) height. Subject stepped up and down on a stool for three minutes at the rate of 24 steps per minute for males and 22 steps per minute

for females which was set by a metronome. After 3 minutes of exercise, recovery pulse rate was taken for 5 to 20 seconds, i.e. 15 seconds. This 15 second pulse rate was converted into beats per minute and the following equation was used for calculating the VO2max (ml/kg/min).

Statistical analysis

Data was then tabulated and statistically analysed. Data was reported as mean and their corresponding standard deviation (mean±SD). The values were compared within same group (pre exercise vs. post exercise) as well as amongst different groups using statistical tests (Student's `t'-test – paired and independent) & Analysis of Variance (ANOVA). A p value of <0.05 were considered as significant (S), p <0.01 highly significant (HS), p <0.001 very highly significant (VHS) and p >0.05 as not significant (NS).

RESULTS

The present study was conducted in the Department of Physiology, MMU Mullana, Distt. Ambala. The study population included students of MMU, Mullana between the age groups of 18 to 30 years.

The selected subjects included in the study were student of both sexes of MMU, Mullana were divided into three groups (70 each) according to their body mass index (BMI) classification of WHO.[1]

Group A (n=70) Normal weight group

Group B (n=70) Overweight group

Group C (n=70) Obese group

Each group comprised of equal number of male and female subjects. Thus total of 210 students were included in the study.

Table 1: Comparison of anthropometric & cardiac parameters in three different groups in boys.

Parameters	Group I Normal weight boys n=70 (mean±SD)	Group II Overweight boys n=70 (mean±SD)	Group III Obese boys n=70 (mean±SD)	Statistical significance		
				Group I vs. II p-value	Group II vs. III p-value	Group I vs. III p-value
Age (years)	20.45±3.10	19.91±1.80	19.37±1.30	>0.05 NS	>0.05 NS	>0.05 NS
Weight (kg)	61.14±7.46	78.74±9.12	87.31±13.38	<0.001 VHS	<0.01 S	<0.001 VHS
Height (m)	165.65±8.41	169.71±9.37	164.11±11.55	>0.05 NS	<0.05 S	>0.05 NS
BMI (kg/m²)	22.23±1.53	27.23±1.25	32.21±1.98	<0.001 VHS	<0.001 VHS	<0.001 VHS
HC (cm)	79.48±5.50	94.22±3.25	104.94±4.78	<0.001 VHS	<0.001 VHS	<0.001 VHS
WC (cm)	104.68±3.61	106.85±3.18	112.02±5.57	<0.01 S	<0.001 VHS	<0.001 VHS
WHR	0.756±0.05	0.88±0.030	0.93±0.02	<0.001 VHS	<0.001 VHS	<0.001 VHS
PR (beats/min)	79.31±8.32	79.17±8.15	78.91±7.02	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
SBP (mmHg)	113.6±9.54	114.68±9.68	115.02±13.21	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
DBP (mmHg)	71.22±5.21	71.22±4.31	72.2±5.39	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
MAP (mmHg)	85.34±5.93	85.71±5.39	86.49±7.18	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
PP (mmHg)	42.37±7.73	43.45±8.08	42.8±10.83	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.

Table 2: Comparison of anthropometric & cardiac parameters in three different groups in girls.

Parameters	Group I Normal weight girls n=70 (mean±SD)	Group II Overweight girls n=70 (mean±SD)	Group III Obese girls n=70 (mean±SD)	Statistical significance		
				Group I vs. II p-value	Group II vs. III p-value	Group I vs. III p-value
Age (years)	19.22±2.23	19.08±1.66	19.54±2.52	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
Weight (kg)	54.25±6.72	67.25±6.34	80±12.43	<0.001 VHS	<0.001 VHS	<0.001 VHS
Height (m)	158.51±5.65	157.88±5.80	154.97±6.95	>0.05 N.S.	>0.05 N.S.	<0.05 S
BMI (kg/m²)	21.60±1.82	26.89±1.42	33.16±3.86	<0.001 VHS	<0.001 VHS	<0.001 VHS
HC (cm)	64.31±6.24	82.25±4.87	95.8±3.00	<0.001 VHS	<0.001 VHS	<0.001 VHS
WC (cm)	93.77±3.76	102.08±3.36	111.77±4.35	<0.001 VHS	<0.001 VHS	<0.001 VHS
WHR	0.68±0.08	0.80±0.04	0.85±0.043	<0.001 VHS	<0.001 VHS	<0.001 VHS
RR (/min)	16.97±3.51	16.4±3.05	17±3.64	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
PR (beats/min)	76.8±6.63	78.91±8.60	81.23±7.72	>0.05 N.S.	>0.05 N.S.	<0.01 S
SBP (mmHg)	111.22±8.74	113.2±9.70	112.02±10.39	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
DBP (mmHg)	70.42±3.49	72.22±6.13	71.97±6.74	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
MAP (mmHg)	84.02±4.72	85.88±6.80	85.32±7.34	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
PP (mmHg)	40.8±7.16	40.97±6.81	40.05±7.50	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.

Table 3: Comparison of cardiac parameters in three different groups of total study subjects.

Parameters	Group I Normal weight groups n=70 (mean±SD)	Group II Overweight group n=70 (mean±SD)	Group III Obese group n=70 (mean±SD)	Statistical significance		
				Group I vs. II p-value	Group II vs. III p-value	Group I vs. III p-value
PR (/min)	78.06±7.57	79.04±8.32	80.07±7.42	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
SBP (mmHg)	112.41±9.16	113.94±9.65	113.53±11.90	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
DBP (mmHg)	70.82±4.42	71.72±5.28	72.1±6.06	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
MAP (mmHg)	84.68±5.36	85.80±6.09	85.91±7.23	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.
PP (mmHg)	41.58±7.44	42.21±7.53	41.42±9.35	>0.05 N.S.	>0.05 N.S.	>0.05 N.S.

From the above [Table 1], the mean age of normal weight, overweight and obese boys was 28.45±3.10 years, 19.91±1.80 years, and 19.37±1.30 years respectively and difference between these three groups was not significant (p>0.05). The mean BMI of these three groups was 22.23±1.53kg/m², 27.23±1.25kg/m², and 32.21±1.98kg/m² respectively. The BMI was highly significantly (p<0.001) increased from normal to overweight, and overweight to obese boys. The mean WHR of these three groups was 0.756±0.05, 0.88±0.030, and 0.93±0.02 respectively. The WHR was highly significantly (p<0.001) increased from group I to II and from II to III.

The mean cardiac parameters of normal weight group were PR 79.31±8.32/min, SBP 113.6±9.54mmHg, DBP 71.22±5.21mmHg, MAP 85.34±5.93mmHg, PP 42.37±7.73mmHg.

The mean cardiac parameters of overweight group were PR 79.17±8.15/min, SBP 114.68±9.68mmHg, DBP 71.22±4.31mmHg, MAP 85.71±5.39mmHg, PP 43.45±8.08mmHg.

The mean cardiac parameters of obese group were PR 78.91±7.02/min, SBP 115.02±13.21mmHg, DBP 72.2±5.39mmHg, MAP 86.49±7.18mmHg, PP 42.8±10.83mmHg. The cardiac parameters in the above table, were decreased but the reduction was not significant (p>0.05).

From the above table 2, the mean age of normal weight, overweight and obese girls was 19.22±2.23 years, 19.08±1.66 years, and 19.54±2.52years respectively and difference between these three groups was not significant (p>0.05). The mean BMI of these three groups was 21.60±1.82kg/m², 26.89±1.42kg/m², and 33.16±3.86kg/m² respectively. The BMI was highly significantly (p<0.001) increased from normal to overweight, and overweight to obese girls. The mean WHR of these three groups was 0.68±0.08, 0.80±0.04, and 0.85±0.043 respectively. The WHR was highly significantly (p<0.001) increased from group I to II and from II to III boys.

The mean cardiac parameters of normal weight group were PR 76.8±6.63/min, SBP 111.22±8.74mmHg, DBP 70.42±3.49mmHg, MAP 84.02±4.72mmHg, PP 40.8±6.81mmHg.

The mean cardiac parameters of overweight group were PR 78.19±8.60/min, SBP 113.2±9.70mmHg, DBP 72.22±6.13mmHg, MAP 85.88±6.80mmHg, PP 40.97±6.81mmHg.

The mean cardiac parameters of obese group were PR 81.23±7.72/min, SBP 112.02±10.39mmHg, DBP 71.97±6.74mmHg, MAP 85.32±7.34mmHg, PP 40.05±7.50mmHg.

The cardiac parameters in the above table, PR was significantly (p<0.05) decreased in group I & III but the reduction was not significant (p>0.05) in group I & II and group II & III.

The mean Pulse Rate of normal weight, overweight, and obese groups was 78.06±7.57 beats/min, 79.04±8.32 beats/min, and 80.07±7.42 beats/min respectively. PR was increased in overweight groups, and in obese groups. The comparison of PR in three different groups showed PR was not significantly increase in Group I vs. II (p>0.05), Group II vs. III (p>0.05), and also in Group I vs. III (p>0.05) [Table 3].

The mean SBP in normal weight, overweight, and obese groups was 112.41±9.16 mmHg, 113.94±9.65 mmHg, and 113.53±11.90 mmHg respectively. SBP was increased in overweight groups, and in obese groups. The comparison of SBP in three different groups showed SBP was not significantly increase in Group I vs. II (p>0.05), Group II vs. III (p>0.05), and also in Group I vs. III (p>0.05) [Table 3].

The mean DBP in normal weight, overweight, and obese groups was 70.82±4.42 mmHg, 71.72±5.28 mmHg, and 72.1±6.06 mmHg. DBP was increased in overweight groups, and in obese groups. The comparison of DBP in three different groups showed DBP was not significantly increase in Group I vs. II (p>0.05), Group II vs. III (p>0.05), and also in Group I vs. III (p>0.05) [Table 3].

The mean MAP in normal weight group was 84.68±5.36mmHg, in overweight group was 85.80±6.09mmHg, and in obese was 85.91±7.23mmHg. The comparison of MAP in three different groups showed MAP was not significantly increase in Group I vs. II (p>0.05), Group II vs. III (p>0.05), and also in Group I vs. III (p>0.05). The mean PP in normal weight, overweight, and obese groups was 41.58±7.44mmHg, 42.21±7.53mmHg, and 41.42±9.35mmHg respectively. The comparison of PP in three different groups showed PP was not significantly increase in Group I vs. II (p>0.05), Group II vs. III (p>0.05), and also in Group I vs. III (p>0.05) [Table 3].

Table 4: Analysis of Variance (ANOVA)

		Sum of Squares	Degree of freedom	Mean Square	F-value	Significance (p-value)
PR	Between Groups	142.029	2	71.014	1.172	0.312
	Within Groups	12545.286	207	60.605		
	Total	12687.314	209			
SBP	Between Groups	87.495	2	43.748	.412	0.663
	Within Groups	22000.200	207	106.281		
	Total	22087.695	209			
DBP	Between Groups	59.838	2	29.919	1.065	0.347
	Within Groups	5816.086	207	28.097		
	Total	5875.924	209			
MAP	Between Groups	64.785	2	32.393	0.821	0.441
	Within Groups	8163.928	207	39.439		
	Total	8228.713	209			
PP	Between Groups	24.200	2	12.100	0.182	0.834
	Within Groups	13777.914	207	66.560		
	Total	13802.114	209			

Table 5: Comparison of mean difference between pre vs. post exercise of cardiac parameters.

Parameters	Mean Difference in normal weight N=70 (mean±SD)	Mean Difference in overweight N=70 (mean±SD)	Mean Difference in obese N=70 (mean±SD)	Statistical significance normal versus overweight (p-value)	Statistical significance overweight versus obese (p-value)	Statistical significance normal versus obese (p-value)
PR (/min)	-57.6±18.69	-52.44±16.77	-54.61±20.39	>0.05 NS	>0.05 NS	>0.05 NS
SBP (mmHg)	-32.01±18.42	-31.71±18.84	-34.62±17.06	>0.05 NS	>0.05 NS	>0.05 NS
DBP (mmHg)	-12.6±8.67	-13.24±8.54	-14.7±10.15	>0.05 NS	>0.05 NS	>0.05 NS
MAP (mmHg)	-19.0±10.19	-19.40±9.39	-21.34±10.60	>0.05 NS	>0.05 NS	>0.05 NS
PP (mmHg)	-19.41±16.37	-18.47±18.84	-19.92±15.53	>0.05 NS	>0.05 NS	>0.05 NS

In the [Table 4], with the help of ANOVA test F-value of PR was calculated 1.172 (p<.312) which showed that variation between the groups and within the groups was not significant. F-value of SBP was calculated 0.412 (p<.663) which also showed that variation between the groups and within the groups was not significant.

With the help of ANOVA test F-value of DBP was calculated 1.065 (p<.347) which showed that variation between the groups and within the groups was not significant. F-value of MAP was calculated 0.821 (p<.441) which showed that variation between the groups and within the groups was not significant. With the help of ANOVA test F-value of PP was calculated 0.182 (p<.834) which showed that variation between the groups and within the groups was not significant.

The mean difference between pre exercise PR and post exercise PR in normal weight groups, pre and post exercise PR in overweight groups, and pre and post exercise PR in obese groups was -57.6±18.69 /min, -52.44±16.77 /min, and -54.61±20.39 /min respectively. And the difference between pre exercise and post exercise PR was not significant (p>0.05) in normal vs. overweight groups, not significant (p>0.05) in overweight vs. obese groups, and was not significant (p>0.05) in normal vs. obese groups. The mean difference between pre exercise SBP and post exercise SBP in normal weight groups, pre and post exercise SBP in overweight groups, and pre and post exercise SBP in obese groups was -32.01±18.42 mmHg, -31.71±18.84 mmHg, and -34.62±17.06 mmHg respectively. And the difference between pre exercise and post exercise SBP was not significant (p>0.05) in normal vs. overweight groups, not significant (p>0.05) in overweight vs. obese groups, and was not significant (p>0.05) in normal vs. obese groups [Table 5].

The mean difference between pre exercise DBP and post exercise DBP in normal weight groups, pre and post exercise DBP in overweight groups, and pre and post exercise DBP in obese groups was -12.6±8.67 mmHg, -3.24±8.54 mmHg, and -14.7±10.15 mmHg respectively. And the difference between pre exercise and post exercise DBP was not significant (p>0.05) in normal vs. overweight groups, not significant (p>0.05) in overweight vs. obese groups, and was not significant (p>0.05) in normal vs. obese groups. The mean difference between pre exercise MAP and post exercise MAP in normal weight groups, pre and post exercise MAP in overweight groups, and pre and post exercise MAP in obese groups was -19.0±10.19 mmHg, -19.40±9.39 mmHg, and -21.34±10.60 mmHg respectively. And

the difference between pre exercise and post exercise MAP was not significant (p>0.05) in normal vs. overweight groups, not significant (p>0.05) in overweight vs. obese groups, and was not significant (p>0.05) in normal vs. obese groups [Table 5].

The mean difference between pre exercise PP and post exercise PP in normal weight groups, pre and post exercise PP in overweight groups, and pre and post exercise PP in obese groups was -19.41±16.37 /min, -18.47±18.84 /min, and -19.92±15.53 /min respectively. And the difference between pre exercise and post exercise PP was not significant (p>0.05) in normal vs. overweight groups, not significant (p>0.05) in overweight vs. obese groups, and was not significant (p>0.05) in normal vs. obese groups [Table 5].

DISCUSSION

In our study, we found, that cardiac parameters like heart rate, systolic blood pressure, and diastolic blood pressure, mean arterial pressure, and pulse pressure were increased in obese as compared to normal weight subjects but were not significantly (p>0.05) increased. Obesity produces an increment in total blood volume and cardiac output that is caused in part by the increased metabolic demand induced by excess body weight. The increase in blood volume in turn increases venous return to the heart, increasing filling pressures in the ventricles and increasing wall tension. This leads to the left ventricular hypertrophy and this can decrease the diastolic compliance of the ventricle which can further progress to diastolic dysfunction and as well tension increases further, can lead to systolic dysfunction. Thus through different mechanisms like increased total blood volume, increased cardiac output, left ventricular hypertrophy and further diastolic dysfunction, obesity may predispose to heart failure.[8-10]

Our study agreed with Tang BR,[11] who found that there was statistically significant increase in heart rate, systolic blood pressure, diastolic blood pressure in obese subjects when compared to non obese subjects. There was a positive correlation between body mass index and heart rate, systolic blood pressure, diastolic blood pressure, mean blood pressure and pulse pressure.[12] Mokdad AH,[13] also suggested that hypertension in obesity results from a discrepancy between an increased cardiac output due to increased body mass and a relatively unchanged arterial capacity.

In our study, we found that PR, SBP, DBP, MAP and PP were very highly significant (p<0.001) increased in all groups after exercise, but the mean difference between 3 groups was not significant (p>0.05). HR increases in a linear manner as work rate or VO2 increase until peak exercise when its plateaus. In normal individuals, this plateau ordinarily is observed at the person's age predicted maximum heart rate (220- age). However it is important to remember that this equation represents an average response, and normal individuals may be above or below the age predicted number by as much as 20 or 30 beats per minute.

Our study agreed with Kuczmarski RJ,[14] who found that heart rate was significantly higher in obese than that of normal weight at rest and during exercise up to the anaerobic threshold. Systemic Blood Pressure increases progressively with exercise. It is not uncommon for normal individuals to have systolic blood pressure rise into the 200mmHg range at peak exercise. While vascular resistance in exercising muscle decreases dramatically, the perfusion pressure to brain and coronary circulation must be preserved. Hence the increase in blood pressure reflects both the increase in cardiac output and the increase in vascular resistance to renal, splanchnic and skin vascular beds.

Though our study is by no means exhaustive it does provides a glimpse into the variety of alterations in cardiac function that occur as excessive adipose tissue accumulates, even in the absence of overt disease. The individuals with obesity are more likely to find it physiologically difficult to participate in physical activities that require movement of their increased body mass. Further research is recommended to have a more complete understanding of this condition. Promoting physical activity is a priority in this context and attention should not just be focused on more participation in sports club but should also stimulate normal outdoor activities, such as a walking and cycling and discouragement of 'sedentary behavior'.[15,16]

CONCLUSION

- The mean PR was increased with increasing BMI but it was not significant (p>0.05). In response to exercise PR was increased very highly significantly (p<0.001) in all the three groups. There was no significant (p>0.05) difference in mean PR found between boys and girls.
- The mean values of blood pressure i.e. SBP, DBP, MAP and PP were increased with increasing BMI but the increase was not significant (p>0.05) and in response to exercise blood pressure was very highly significantly (p<0.001) increased in all the groups. There was no significant (p>0.05) difference found in blood pressure between boys and girls in all the three groups.
- The HR and BP was more in overweight and obese subjects as compared to normal weight. In response to exercise, cardiac parameters were increased in all the three groups.

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How to cite this article: Chouhan S, Chauhan L. Cardiac Response to Exercise in Obese, Overweight and Normal Subjects – An Observational Study. Ann. Int. Med. Den. Res. 2018; 4(4):PH04-PH10.

Source of Support: Nil, **Conflict of Interest:** None declared