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Obesity: Effect on sympathetic nervous system

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Abstract
Obesity is recognized as a major, worldwide, health problem. Excess weight greatly increases the risk for cardiovascular diseases, diabetes and renal diseases. The present study was conducted in the Department of Physiology, Index Medical College, and Indore. 50 obese (25 male and 25 female) and 50 non-obese (25 male and 25 female) were included. Sympathetic tests were performed on both the groups. All data are expressed as mean± standard deviation. Comparison between groups (obese male, non-obese male, obese female and non-obese female) was performed using the student's t-test (t-test for two independent samples / Two-tailed test). Differences was considered significance at $p< 0.05$. It was observed that young obese adults had reduced sympathetic activity. This altered balance of the autonomic nervous system increases the risk of cardiovascular disorders.

Keywords: Cardiovascular diseases and obesity, obesity, sympathetic system and obesity

Introduction
Obesity is a nutritional health problem which is gradually increasing and affecting all population in children, adolescents and adults. It is a vexing problem in the developed economies [1]. According to WHO (World Health Organization [2] 1.9 billion people are overweight and 650 million are obese worldwide. Obesity can be seen as a first wave of a defined cluster of non-communicable diseases called "New World Syndrome" [3] that creates an enormous socioeconomic and public health burden in poor & developing countries also.
Nutritional population in India is gradually shifting from undernourishment to obesity [4]. Obesity is a condition, which has evolved with the advent of civilization, sedentary life style and high calorie diet [5]. Obesity is also on the rise in our society due to socioeconomic developments leading to change in lifestyle particularly dietary patterns [6].
The obesity can be measured by Body Mass Index (BMI), a person's weight (in kilogram) divided by the square of his or her height (in meters) (QUETELET'S INDEX) [7]. A person with a BMI of more than 25 Kg/m^2 is considered obese. Other approaches to quantify obesity include [8]: Anthropometry (Skin fold thickness), Densitometry (Underwater weighing), CT OR MRI, and Electrical impedance.
Many disorders occur in obese people with greater frequency. The most important and common of these disorders are hypertension, type 2 diabetes mellitus, dyslipidemia, coronary artery disease, degenerative joint disease and psychosocial disability [9].
Approximately 60% of individuals with obesity are suffering from the metabolic syndrome (including elevated abdominal circumference, high blood pressure, increased blood triglycerides, raised fasting blood sugar and increase in low density lipo-protein). Obese patients also have a greater risk of pulmonary functional impairment including obstructive sleep apnea, endocrine abnormalities and proteinuria [10].
Obesity increases cardiovascular morbidity and mortality risk through various mechanisms [11]. Various studies have shown that salt intake, blood volume and cardiac output are higher in obese persons than normal subjects [12].
The present study is an attempt to determine sympathetic autonomic functions in young obese. Early establishment of this correlation will help in preventing future cardiac autonomic disturbances like congestive heart failure, coronary artery disease, hypertension etc.

Material and Methodology

The present study was conducted among the students of Index Medical College, Indore. It is a comparative type of study that effect of obesity on 100 young obese and non-obese adults between age group 18-26 years divided into 4 groups on the basis of obesity and gender.

1. Group 'A' - 25 obese boys [OB+ boys]
2. Group 'B' - 25 obese girls [OB+ girls]
3. Group 'C' - 25 non-obese boys [OB- boys]
4. Group 'D' - 25 non-obese girls [OB- girls]

Inclusion criteria

Consent participants; Students within the age group of 18-26 years; both gender were included.

Exclusion criteria

Subjects who were not interested; cases of diabetes mellitus, hypertension, cardiovascular or Endocrine disorders**;** on any drug that may alter autonomic function of their body; chronic smokers and chronic alcoholics.

Tests of sympathetic function

1. Orthostatic test

Blood pressure response was measured from supine to standing posture. A blood pressure recording of the subject was first taken in supine position. Then immediately the subject was asked to stand for at least 3 minutes thereafter two recordings of blood pressure were taken 1st immediately after standing and 2nd at about 2 to 3 mins. The difference in systolic and diastolic pressure at 1st min and 3rd min of standing from that of lying (baseline) pressure was calculated. A decrease in systolic blood pressure by at least 20 mmHg or in diastolic blood pressure by at least 10 mmHg within 3 mins of active standing was considered abnormal as defined by consensus of the American Society and the American Academy of Neurology.

2. Cold Pressor test

The Cold Pressor Test (C.P.T) consists of placing the hand into ice water which is a painful stimulus. It has been used to study the autonomic response of many individuals [13]. The afferent fibers (which are stimulated by placing the hand in cold water) and the efferent fibers are sympathetic fibers of the autonomic nervous system.

The subject was asked to immerse his/her hands in a container of ice water for one minute with temperature maintained at 1-4 ^{0}C, throughout the test. Blood pressure was recorded before CPT, after 1 min of CPT and at 3 minutes after CPT. Difference the blood pressure at three different stages of cold Pressor test was recorded and observed [14].

Statistical analysis

Mean differences were tested for significance by Students unpaired't' test. The statistical significance was assigned at $p< 0.05$

Tests for sympathetic functions

Orthostatic tolerance test

Table 1 (a): Comparison of blood pressure (SBP, DBP & MBP) by Student ' t' test at 2 different phases of orthostatic test in Group A (obese boys) and B (non-obese boys).

	Group 'A'(Obese Boys)	Group 'B' (Non-obese Boys	P value
Resting BP(mmHg)	**Mean ± SD**	**Mean ± SD**	
SBP	128.07 ± 3.72	118.9 ± 4.50	<0.001
DBP	84.16 ± 3.65	80.16 ± 4.21	<0.05
MBP	98.42 ± 3.15	93.06 ± 3.56	<0.001
BP after Standing			
SBP	121.28 ± 3.55	109.21 ± 4.39	<0.001
SBP	84.31 ± 3.55	82.72 ± 3.95	0.138
MBP	96.92 ± 2.83	91.54 ± 3.26	<0.001

Table 1 (b): Comparison of mean values of blood pressure (SBP, DBP & MBP) by Student 't' test at 2 different phases of orthostatic test in Group C (obese girls) & D (non-obese girls).

	Group 'C'(Obese Girls)	Group 'D' (Non-obese Girls)	p value
Resting BP(mmHg)	**Mean ± SD**	**Mean ± SD**	
SBP	130.07 ± 3.52	125.5 ± 4.42	<0.001
DBP	83.36 ± 2.75	79.26 ± 3.21	<0.05
MBP	98.93 ± 2.57	93.06 ± 3.47	<0.001
BP after Standing			
SBP	123.04 ± 3.42	111.31 ± 4.78	<0.001
SBP	84.56 ± 2.55	81.62 ± 3.33	<0.001
MBP	97.17 ± 2.58	91.46 ± 3.49	<0.001

Table 1 (c): Comparison of mean values of BP by Student 't' test at 2 different phases of orthostatic test in Group A (obese boys) & C (obese girls)

	Group 'A'(Obese Boys)	Group 'C' (Obese Girls)	P value
Resting BP(mmHg)	**Mean ± SD**	**Mean ± SD**	
SBP	128.07 ± 3.72	125.5 ± 4.42	<0.001
DBP	84.16 ± 3.65	83.36 ± 2.75	0.933
MBP	98.42 ± 3.15	98.93 ± 2.57	0.409
BP after Standing			
SBP	121.28 ± 3.55	123.04 ± 3.42	0.081
SBP	84.31 ± 3.55	84.56 ± 2.55	0.783
MBP	96.92 ± 2.83	97.17 ± 2.58	0.755

Table 1 (d): Comparison of mean values of BP by Student t test at 2 different phases of orthostatic test in Group B (non-obese boys) & D (non-obese girls)

	Group 'B'(Non-obese Boys)	Group 'D' (Non-obese Girls)	P value
Resting BP(mmHg)	**Mean ± SD**	**Mean ± SD**	
SBP	118.9 ± 4.50	120.5 ± 4.42	0.174
DBP	80.16 ± 4.21	79.26 ± 3.21	0.247
MBP	93.06 ± 3.56	93.06 ± 3.47	0.791
BP after Standing			
SBP	109.21 ± 4.39	111.31 ± 4.78	0.103
SBP	82.72 ± 3.95	81.62 ± 3.33	0.251
MBP	91.54 ± 3.26	91.46 ± 3.49	0.931

Cold Pressor test

Table 2 (a): Comparison of mean values of blood pressure (SBP, DBP and MBP) by Student 't' test at 3 different phases of Cold presser test (CPT) in groups A (obese boys) and B (non-obese boys).

	Group 'A'(Obese Boys)	Group 'B' (Non-obese Boys	P value
Resting BP(mmHg)	**Mean ± SD**	**Mean ± SD**	
SBP	128.08 ± 3.71	118.9 ± 4.51	< 0.001
DBP	84.16 ± 3.64	80.16 ± 4.2	<0.05
MBP	98.42 ± 3.14	93.06 ± 3.56	< 0.001
BP after 1 min of CPT			
SBP	133.52 ± 3.33	126.8 ± 4.72	< 0.001
DBP	86.88 ± 3.46	86.08 ± 4.45	0.482
MBP	101.32 ± 3.35	99.65 ± 3.69	< 0.001
BP after 3 mins of CPT			
SBP	128.76 ± 3.33	120.88 ± 3.78	< 0.001
DBP	83 ± 3.43	81.36 ± 4.30	0.144
MBP	98.24 ± 3.03	94.53 ± 3.40	< 0.001

Table No. 2 (b): Comparison of mean values of blood pressure (SBP, DBP & MBP) by Student t test at 3 different phases of cold pressor test (CPT) in Group C (obese girls) & D (non-obese girls).

	Group C (obese girls)	Group D (non-obese girls)	P value
Resting BP (mmHg)	**Mean (±)SD**	**Mean (±)SD**	
SBP	130.08± 3.53	120.64 ± 4.49	< 0.001
DBP	83.36 ± 2.75	79.28 ± 3.20	< 0.05
MBP	98.93 ± 2.58	93.06 ± 3.47	< 0.001
BP after 1 min of CPT			
SBP	135.84 ± 3.50	128.72 ± 4.31	< 0.001
DBP	88.08 ±2.19	85.12 ± 3.41	< 0.001
MBP	103.83 ± 2.25	99.51 ± 3.80	< 0.001
BP after 3 mins of CPT			
SBP	131.04 ± 2.56	122.3 ± 4.15	< 0.001
DBP	84.16 ± 2.93	80.64 ± 2.75	< 0.001
MBP	99.78 ± 2.40	94.29 ± 2.72	< 0.001

Table 2 (c): Comparison of BP at 3 different phases of CPT by Student t test in groups A (obese boys) & C (obese girls)

	Group A (Obese Boys)	Group C (Obese Girls)	p-value
Resting BP (mmHg)	**Mean (±)SD**	**Mean (±)SD**	
SBP	128.08 ± 3.71	130.08± 3.53	0.057
DBP	84.16 ± 3.64	83.36 ± 2.75	0.933
MBP	98.42 ± 3.14	98.93 ± 2.58	0.247
After 1 min of CPT			
SBP	133.52 ± 3.33	135.84 ± 3.50	0.020
DBP	86.88 ± 3.46	88.08 ±2.19	0.150
MBP	101.32 ± 3.35	103.83 ± 2.25	0.003
After 3 mins of CPT			
SBP	128.76 ± 3.33	131.04 ± 2.56	0.024
DBP	83 ± 3.43	84.16 ± 2.93	0.206
MBP	98.24 ± 3.03	99.78 ± 2.40	0.785

Table 2 (d): Comparison of BP at 3 different phases of CPT by Student t test in groups B (non-obese boys) & D (non-obese girls

	Group B (Non-Obese Boys)	Group D (Non-Obese Girls)	P value
Resting BP	**Mean (±)SD**	**Mean (±)SD**	
SBP	118.9 ± 4.51	120.64 ± 4.49	0.174
DBP	80.16 ± 4.2	79.28 ± 3.20	0.247
MBP	93.06 ± 3.56	93.06 ± 3.47	0.791
After 1 min of CPT			
SBP	126.8 ± 4.72	128.72 ± 4.31	0.140
DBP	86.08 ± 4.45	85.12 ± 3.41	0.397
MBP	99.65 ± 3.69	99.51 ± 3.80	0.900
After 3 mins of CPT			
SBP	120.88 ± 3.78	122.3 ± 4.15	0.206
DBP	81.36 ± 4.30	80.64 ± 2.75	0.485
MBP	94.53 ± 3.40	94.29 ± 2.72	0.785

Discussion

The mean values of blood pressure response to standing from supine posture (Orthostatic Test) were found to be reduced in obese subjects as compared to the control subjects in present study. The mean values of blood pressure response to cold pressor test (CPT) were decreased in obese subjects as compared to control subjects.

The cardiovascular responses were measured as changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), mean blood pressure (MBP) before, during and after the application of orthostatic tolerance test and cold pressor test in all the four groups (a, b, c & d).

a) Orthostatic tolerance test

When comparison was done between mean value of SBP, DBP & MBP in Group A (Obese Boys) & Group B (non-obese boys), a highly significant difference was observed ($p<0.001$) in SBP and MBP at 2 different phases of Orthostatic test but non-significant difference ($p>0.05$) in DBP in standing position was observed between Group A (Obese boys) & B (non-obese boys) (Table No. 1(a).

When comparison was done between mean values of SBP, DBP & MBP in Group C (Obese girls) & Group D (non-obese girls), a highly significant difference was observed($p<0.001$) in SBP, DBP & MBP at2 different phases of orthostatic test between Group C(obese girls) & Group D (non-obese girls) (Table No. 1(b).

In the present study it was observed that the blood pressure response to standing from supine posture was significantly lower in obese subjects as compared to non-obese subjects. It indicates the decrease activity of the sympathetic nervous system.

Obese subjects was less responsive to blood pressure changes to standing posture, similar result were shown by [15, 16].

The result of the study was contradictory to a study where they observed orthostatic tolerance values were significantly increased in obese subjects [17].

b) Cold Pressor test

When comparison was done between mean values of SBP, DBP and MBP at resting, at 1 min of CPT & at 3 mins of CPT in Group A (obese boys) and B (non-obese boys), a significant difference ($p< 0.05$) was observed between SBP, DBP & MBP before CPT; between SBP after 1 minute of CPT and 3 minutes after CPT but a non-significant difference ($p> 0.05$) was observed between DBP and MBP at 1 minute of CPT and at 3 minutes of CPT in Group A (obese boys) & B (non- obese boys). (Table No 2 (a)

When comparison was done between mean values of SBP, DBP and MBP at resting, at 1 min of CPT & at 3 mins of CPT in Group C (obese girls) & D (non-obese girls), the mean values of SBP, DBP & MBP showed a highly significant difference ($p < 0.001$) in Group C (obese girls) & D (non-obese girls). (Table No. 2 (b)

The result of the present study showed the less increase of blood pressure response to cold presser test in obese subjects as compared to the control subjects. A lesser increase in the blood pressure after the cold water immersion points towards sympathetic insufficiency in obese subjects [13].

The difference in mean systolic blood pressure recorded before and after cold pressor test was low in the study Group a (obese boys) compared to the control group. Obese subjects exhibit lower sympathetic response on exposure to cold. Our study results were in accordance with reported study of Monterio *et al*. 2012 [18].

Increased sympathetic activity induced by cold water stress causes release of nor-epinephrine and increase in blood pressure more in obese subject as compare to control, which is contradictory to our studies [19, 20].

Obesity is associated with both sympathetic and parasympathetic nervous system dysfunction [20]. Decrease in the sympathetic activity may result in a disordered homeostatic mechanism thus promoting excessive storage of energy [21].

Conclusion

Present study conclude that with irrespective of gender, reduced sympathetic activity predict increased risk for subsequent cardiac events in obese individuals. Furthermore studies are still needed in future to explore and clinically help in reduce the risks of various diseases due to obesity.

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