Correlation of Baseline and Isometric Exercise-induced Blood Pressure with Total Body Fat Percentage and Body Mass Index in Female Medical Students

Sri Nageswari Kalluri, E Syamala Bhupathi[1], Vidya Ganji[2]

Professor, Department of Physiology, Dr. VRK Womens Medical College, [1]Department of Physiology, Patnam Mahender Reddy Institute of Medical Sciences, [2]Department of Physiology, Kamineni Academy of Medical Sciences, Hyderabad, Telangana, India

Abstract

Background and Aim: Studies on obese and nonobese Indian girls from minority community, spending less time in outdoor activities due to conservative restrictions imposed on them, are scanty in literature. The aim of this study were as follows: (1) Recording Baseline systolic (SBP) and diastolic blood pressure (DBP) and pressor response to isometric exercise and (2) Measurement of total body fat% (TBF), visceral fat (VF), body age (BA) and correlations with each other and with body mass index (BMI). **Methods:** Ninety female medical students (aged 18-22 years) filled up a detailed questionnaire and were classified as obese (BMI ≥30), overweight (BMI≥25-30, clubbed with obese, *n*=24) and nonobese (BMI<25, *n*=66) groups. Baseline DBP and SBP and DBP and SBP at 1, 2 and 3 min of isometric exercise (hand grip dynamometer Test at 30% of T_{max} value) were recorded. The TBF%, VF and BA were obtained using HBF-362 Karada scan. Student's *t*-test, Independent and paired sample comparison, Pearson's correlation coefficient, and linear regression analysis were done. **Results:** High baseline DBP, SBP and SBP at 2 and 3 minutes of isometric exercise in the obese group ($P < 0.002$, 0.003, <0.04 and <0.007 respectively) correlated positively with BMI ($r = 0.4,0.4,0.35$ and 0.38 respectively; $P < 0.001$). Significant ($P < 0.001$) positive correlation among TBF%, VF, versus BA ($r = 0.9$ and 0.88, respectively) and TBF % versus VF ($r = 0.8$) and linear relationship with BMI ($P < 0.001$, $r = 0.95$, 0.89, and 0.95; BA, TBF, and VF, respectively) was observed in obese group. In 50% of non-obese students having TBF% >28%, the BA was significantly higher ($P < 0.03$) than rest of the controls. **Conclusion:** Obesity is associated with increase in baseline BP and higher pressor response to isometric exercise. Higher BA and total TBF% can lead to cardiovascular anomalies within normal BMI limits and hence should be considered while classifying obesity.

Keywords: Body mass index, body/biological age, chronological age, hand grip test, HBF-362 Karada scan, total body fat%, visceral fat

Received: 29th April, 2018; ***Revised:*** 27th May, 2018; ***Accepted:*** 01st June, 2018

Introduction

Studies on Indian urban children have reported high prevalence of obesity and overweight with higher incidence of hypertension than their normal counterparts.[1] It is documented that for any proposed value of body mass index (BMI), Indians have higher magnitude of adiposity, abdominal obesity, and a lower muscle mass as compared to White Caucasians.[2] Adolescent and young adult obesity is a public health concern as it has impact on physical and psychological health such as loss of confidence and self-esteem leading to isolation and depression.[3] Prevalence of obesity and occurrence of hypertension in obese young adults has been reported to be 15%[3,4] and 12%,[3,5] respectively. The widely used cutoff points in adults for overweight and obesity are BMI values of 25 and 30 kg/m^2, respectively.[6] Young adults of high socioeconomic status spend most of the time indoors with computers, surfing Internet, or watching television that reduce their daily physical activity outdoors. They consume fat- and carbohydrate-rich

Access this article online	
Quick Response Code:	**Website:** www.ijcep.org
	DOI: 10.4103/ijcep.ijcep_23_18

Address for correspondence: Prof. Sri Nageswari Kalluri, 203, B Block, Manjeera Heights Phase1, Chitra Layout, NTR Nagar, Hyderabad, Telangana - 500 074, India. E-mail: srina_kalluri@yahoo.com

How to cite this article: Kalluri SN, Bhupathi ES, Ganji V. Correlation of baseline and Isometric exercise-induced blood pressure with total body fat percentage and body mass index in female medical students. Int J Clin Exp Physiol 2018;5:81-6.

fast foods. As obesity is a disorder of energy balance, without much expenditure of energy, the balance tilts toward energy deposition.

Increase in BMI[1-3,5,7-12] and percentage body fat[2] was significantly and positively associated with hypertension in overweight and obese children/adolescents. Understanding the altered hemodynamic mechanisms that form the basis of exacerbated arterial pressure response to exercise in obese individuals will prevent the progression to hypertension. Studies in obese and nonobese girls belonging to minority community are scanty in literature. These girls spend less time in outdoor activities due to conservative restrictions imposed on them. They are in traditional outfit which does not expose them to much of sunlight.

Materials and Methods

The experimental protocol was (1) to record the baseline systolic blood pressure (SBP) and diastolic BP (DBP) and the pressor response to isometric exercise in obese and nonobese female medical students of the same age group, ethnicity, socioeconomic status, belonging to same minority community and (2) correlation of BMI, total body fat% (TBF%), visceral fat (VF), and body age (BA) in the above groups.

Ninety female medical students were identified (aged 18–22 years) after excluding students with past or present history of any major illness, hypertension, cardiovascular abnormalities, or family history of any of these ailments. Students unwilling to join the study were also excluded from the study.

The students were explained about the experimental procedures and informed consent was obtained as per Helsinki declaration. After getting signed informed consent from them, they were administered a detailed questionnaire (Personal Data Form) addressing various demographic and other parameters such as their socioeconomic status, literacy status, food habits, extent of physical activity, family history, and parental and subjective health-related parameters.

The anthropometric data such as height and weight of the subjects (three readings each) were measured and BMI was calculated using standard formula. The medical students were classified as nonobese (BMI <25), overweight (BMI ≥25–30), and obese (BMI ≥30) as per standard protocol.[6] In the present study, the overweight and obese students were clubbed together as obese group (n = 24). The nonobese group consisted of 66 medical students.

All the subjects were explained about the experimental protocol and were made to rest for 10 min. Their baseline DBP and SBP were recorded (three readings each) by manual and digital methods. An average baseline BP value was obtained for SBP and DBP for each subject.

Isometric exercise: Hand grip dynamometer test

Recording of pressor response to isometric exercise, performed with hand grip dynamometer (HGT), is a valuable tool to evaluate sympathetic cardiovascular functions. The subjects were asked to exert maximal force by gripping the hand grip dynamometer as hard as possible for few seconds and the maximum force exerted was noted down (T_{max}). After giving rest for few minutes, each subject was asked to perform isometric exercise at 30% of her T_{max} value, as long as possible. The SBP and DBP were recorded at 1, 2, and 3 min of isometric exercise. The maximum values/ceiling values achieved and the delta values (difference between ceiling value and baseline value) were noted down.

Total and visceral body fat distribution and body age

With the help of body fat analyzer (OMRON body fat analyzer, HBF-362 Karada scan that works on the principle of bioelectrical impedance analysis), TBF% and VF (number), were determined. The BA (computed value) was obtained from these data on fat distribution and was compared with the actual age.

Statistical analysis of data

The results were analyzed by Student's t-test at 95% confidence interval (paired and independent sample comparison, $P < 0.05$). Pearson's correlation coefficient analysis was done to find out the interrelationship of various parameters.

The following comparisons were done for various parameters:

Intragroup comparison

Paired sample comparison

The mean values of SBP and DBP at 1, 2, and 3 min of isometric exercise and maximum value were compared with baseline values within obese or nonobese groups [Figure 1]. Only significant parameters are shown in illustrations.

Intergroup comparison

a. Independent sample comparison: The baseline values for SBP and DBP (mean ± standard error [SE]) were compared in both the groups [Figures 1 and 2]. From

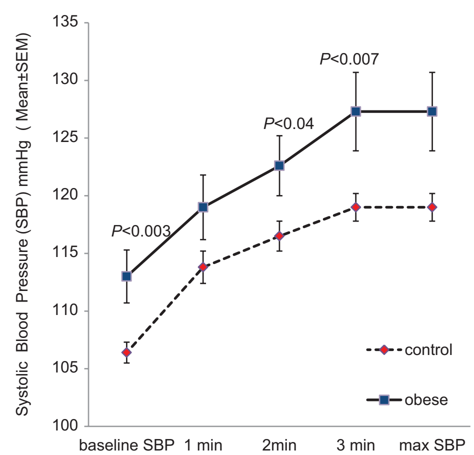

Figure 1: Systolic blood pressure values (mmHg, mean ± standard error) at baseline, at various time points and maximum values achieved during hand grip dynamometer test in control (n = 66) and obese (n = 24) groups

the data, Δ (response/range) was calculated for SBP and DBP for each subject by subtracting baseline value from the values obtained at each time point. Comparison of mean values of Δ SBP and Δ DBP between the obese and nonobese groups, at each time point, i.e., 1, 2, and 3 min of isometric exercise and maximum or ceiling value, was done [Figure 1].

b. Pearson correlation (*r*): (1) BMI and baseline DBP and SBP and SBP at 1, 2, and 3 min of exercise and maximum value were correlated with each other for any significant association
c. TBF%, VF, BA, and BMI were correlated with each other for any significant association
d. The curve fit/scatter plot to show inter-relationship between the variables was done [Figures 3-5]
e. Linear regression analysis of BMI versus TBF%, VF, and BA was done to establish the nature of relationship.

Results

The results of the present study indicated the prevalence of obesity in young females (aged 18–22 years) as 25%. The baseline DBP and SBP values were significantly higher in the obese group as compared to the control group [$P < 0.002$ and 0.003, respectively, Figures 1 and 2]. The SBP during isometric exercise increased significantly at 2 and 3 min of HGT [$P < 0.04$ and 0.007 respectively, Figure 1]. The maximum SBP and maximum DBP values (ceiling values) were attained at 3 min of HGT. The BMI correlated positively with baseline SBP and DBP and SBP at 1, 2, and 3 min of isometric exercise (Pearson's correlation, $r = 0.4$, 0.4, 0.32, 0.35, and 0.38, respectively; $P < 0.001$).

All the parameters correlated positively ($P < 0.001$) with each other (Pearson's correlation coefficient) showing linear relationship between TBF% and BA [$r = 0.9$, Figure 3], VF and BA [$r = 0.88$, Figure 4], and TBF% and VF [$r = 0.8$, Figure 5]. Linear regression analysis of BMI

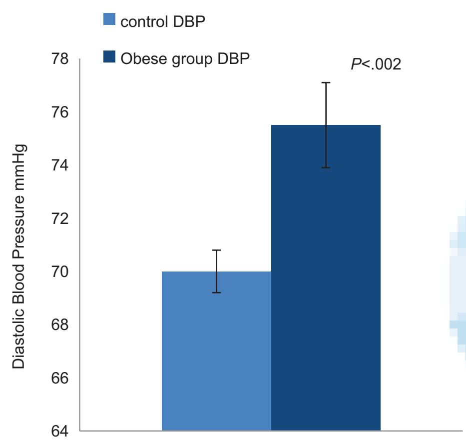

Figure 2: Baseline diastolic blood pressure values (mmHg, mean ± standard error) in control (body mass index <25, $n = 66$) and obese group students (body mass index ≥25, $n = 24$)

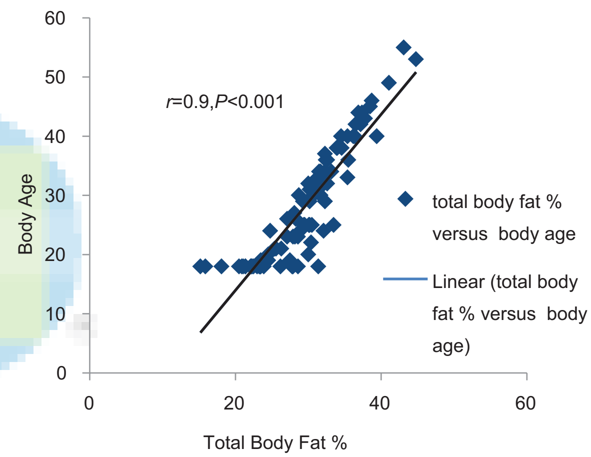

Figure 3: Scatter plot showing significant correlation ($r = 0.9$; $P < 0.001$) between total body fat% and body age in both control ($n = 66$) and obese ($n = 24$) groups

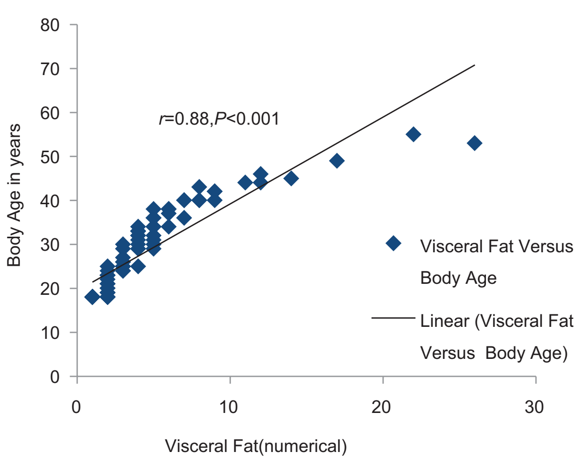

Figure 4: Scatter plot showing significant correlation ($r = 0.88$; $P < 0.001$) between visceral fat and body age in both control ($n = 66$) and obese ($n = 24$) groups

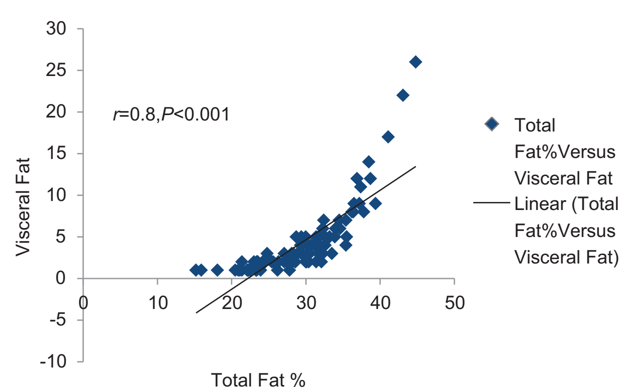

Figure 5: Scatter plot showing significant correlation ($r = 0.8$; $P < 0.001$) between total body fat% and visceral fat in both control ($n = 66$) and obese ($n = 24$) groups

versus BA, TBF%, and VF exhibited highly statistically significant ($P < 0.001$) linear relationship ($r = 0.95$, 0.89, and 0.95, respectively).

The students of obese group had TBF% more than 31% (range: 31.4%–44.8%; mean ± SE = 36.2 ± 0.7, normal values <28%[13]). Forty-one percent of the obese group had VF above the cutoff value of 9 (range 5–26, mean ± SE = 9.58 ± 1.1). The BA/biological age was much more in obese subjects (31–55 years, mean ± SE = 41 ± 1.1) as compared to their actual/chronological age (range: 18–19 years) as their TBF% and VF content were more. In 50% of nonobese students having TBF% >28% (BMI <25, $n = 33$), the BA was significantly higher ($P < 0.03$) than rest of the controls. Majority (88%) of obese students had no physical activity.

Discussion

Higher incidence of obesity at 25% in the current study as compared to 15% in adults and adolescents[3,4] and childhood obesity at 6.2% and 7.4% in two cities from India[1] can be attributed to clubbing together of data from overweight and obese students by us. In addition, the prevalence of obesity varies in children, adolescents, and adults.[6,7]

There are reports in literature indicating significant baseline hypertension in overweight/obese children/adolescents/young adults correlating positively with BMI.[2,3,5,7-12,14] Chhatwal *et al*.[11] observed the prevalence of hypertension as 15.33% and 43.1% in overweight and obese urban children, respectively. The present study reports the incidence of hypertension as 12.5% against reported 12%.[3,5]

BMI was consistently associated with SBP and DBP in all age- and gender-matched groups.[7] BMI and body fat were significantly and positively associated with risk of BP in boys and girls.[2] However, the same authors reported that in girls, weight only was significantly associated with SBP independent of age or percentage fat.[2] Overweight and obese children had significantly higher SBP and DBP values than controls.[9]

In the present study, both baseline SBP and DBP increased with the increasing BMI values in an older age group. Ibhazehiebo *et al*.[3] found both diastolic and systolic hypertension (12%) in medical students (BMI >30) that positively correlated with BMI. Their study group was similar to the age group of our subjects (18–22 years), but included male and female students.

There are also reports of isolated diastolic[14] or systolic hypertension[2] in obese children correlating positively with BMI. A number of proposed mechanisms link obesity with sympathetic nervous system (SNS) including baroreceptor dysfunction, hypothalamic–pituitary axis dysfunction, hyperinsulinemia/insulin resistance, hyperleptinemia, and elevated circulating angiotensin II concentrations.[1] However, Simran and Vidushi[15] have observed that there is impaired function of both sympathetic and parasympathetic divisions of autonomic nervous system in obese adults.

Regional blood flow alterations, diminished resting muscle blood flow, and altered hemodynamic response to exercise that demand blood flow alterations in obese children, adolescents, and adults have been reported.[16,17] Weight loss through diet and exercise training significantly reduced BP levels during HGT and increased muscle blood flow and conductance.[16,17] It was hypothesized that reduction in BP response to isometric exercise in obese could be due to neurovascular sympathetic attenuation and a decrease in muscle sympathetic and overall sympathetic activity.[18]

Significant progressive increases in SBP at 2 and 3 min of isometric exercise (HGT) in young obese girls was observed by us, supporting earlier reports of significant increase in SBP at all levels of exercise in obese group medical students of the same age group.[3] They also observed that increase in the intensity of exercise produced marked increases in SBP, DBP, and mean arterial pressure values.[3] The pressor response in our studies also correlated positively with BMI. Ribeiro *et al*.[12] used the same study design as ours (30% maximum voluntary contraction [MVC], 3 min) in obese children of 8–12 years age and observed high baseline mean B*P* values and progressive increase in mean BP during HGT exercise.

Some researchers have found BP parameters to rise to higher levels in obese adolescents and young adults under conditions of graded exercise compared with nonobese adolescents and young adults.[3,19-22] In the present experimental protocol, subjects did not perform graded exercise.

The DBP response to HGT was not significant as compared to controls in our study which supports the findings by others.[3,14] This could be explained as "SBP is more labile and changes more rapidly during exercise than DBP."[3] On the contrary, DBP response to isometric exercise is slow. Truncated response in DBP to HGT has been documented in young obese children,[14] indicating autonomic instability. The exercise tolerance levels of the obese young adults are reported to be considerably lower compared to controls, and exercise tolerance levels in young female subjects are further lower than their male counterparts.[3]

Regional forearm and systemic hemodynamic responses to exercise are abnormal in obesity and can be explained as the basis for hypertension. Supporting this hypothesis, isometric handgrip exercise at 25% MVC for 4 min produced significant increase in mean heart rate, SBP, DBP, and mean pressures without any change in stroke volume and systemic vascular resistance in normal adolescents.[23]

The cutoff points for BMI of 25 kg/m^2 for overweight and 30 kg/m^2 are widely used for adults. It is well known that BMI, TBF%, and VF are significantly associated with the risk of having high BP. Results of the present study indicate significant positive correlation between BMI, BA, VF, and TBF%. Further, highly significant linear relationship of BMI with the above parameters was established through linear regression analysis. Whereas low SNS activity is a causative factor for development of obesity, SNS activation is characteristic of metabolic and cardiovascular diseases that occur in obese individuals.[24] VF has been implicated as an important depot linking obesity with skeletal SNS activation.[24] Abdominal VF is an important adipose tissue depot linking obesity with sympathetic neural activation in humans and hence leading to cardiovascular diseases.[25,26] Metabolic syndrome, insulin resistance, release of inflammatory cytokines such as adipokines from VF cells, activation of renin–angiotensin–aldosterone system have all been implicated in the pathophysiology of obesity.[1,24-26]

Although VF has been linked to pathological activation of SNS, our results indicate TBF% to be a better predictor of BA than VF. The basis of this statement is twofold: first, the nonobese students (50%), having higher TBF% (>28%[13]) and normal VF within the cutoff value of 9 (as per the guideline values provided along with equipment), had higher BA than their actual chronological age. Biological age defines how time and lifestyle have affected organs and cells and includes changes in the physical structure of the body, performance of motor skills, and sensory awareness as compared to other people of similar chronological age.[27] This indicates the aging process occurring in individuals belonging to much lower chronological age that makes them more susceptible to age-related disorders.

Second, all the obese group students had TBF% as >31% and only 41% of the obese group had VF higher than cutoff value of 9 (range: 9–26). Thus, it can be hypothesized that higher TBF% and higher biological/BA can lead to cardiovascular ailments and morbidity even if the BMI is within normal limits. One must also consider the need for further reduction and revision of the cutoff value for VF, as central fat distribution is reported to be a better predictor for hypertension than overall fat mass. In a recent study by Kanai *et al*.,[28] change in mean BP after weight reduction was correlated with changes in VF and not with changes in BMI, suggesting that decrease in VF reduces BP in obese hypertensive subjects. This dilemma has to be sorted out and the exact role played by each of them or VF and TBF% taken together needs to be explored further.

Conclusion

Obesity is almost invariably associated with increase in baseline BP, SBP or DBP, or both. The pressor response to isometric exercise is variable (systolic or diastolic or both) and exaggerated in obese individuals. One of the causes for the growing prevalence of obesity and its associated diseases is a reduction in daily physical activity as obesity is the disorder of energy balance. In our study, we have observed that girls belonging to minority community spend most of the time indoors after college hours without much expenditure of energy. They are in traditional outfit during day time without exposure to sunlight. All the female medical students belonged to elite background and consumed fast foods. Prevention of weight gain through regular physical activity and reduced dietary fat intake should be the primary target for reducing the prevalence of obesity-induced hypertension. Reduction in TBF% and VF to reduce overall obesity and central obesity should be aimed at as these can predispose to cardiovascular disorders and morbidity within normal BMI limits. This can be achieved by small changes in lifestyle.

Acknowledgement

The authors are thankful to Prof. R. Pushpanjali and Dr. M. Kalpana for the necessary help rendered.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Nanaware LN, Gavkare AM, Surdi AD. Study of correlation of body mass index with blood pressure in school going children and adolescents. Int J Recent Trends Sci Technol 2011;1:20-6.
2. Al-Sendi AM, Shetty P, Musaiger AO, Myatt M. Relationship between body composition and blood pressure in Bahraini adolescents. Br J Nutr 2003;90:837-44.
3. Ibhazehiebo K, Dimkpa UI, Iyawe VI. Hypertension, and blood pressure response to graded exercise in young obese and non-athletic Nigerian university students. Niger J Physiol Sci 2007;22:37-42.
4. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. JAMA 2002;288:1728-32.
5. Bertsias G, Mammas I, Linardakis M, Kafatos A. Overweight and obesity in relation to cardiovascular disease risk factors among medical students in Crete, Greece. BMC Public Health 2003;3:3.
6. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. BMJ 2000;320:1240-3.
7. Paradis G, Lambert M, O'Loughlin J, Lavallée C, Aubin J, Delvin E, *et al.* Blood pressure and adiposity in children and adolescents. Circulation 2004;110:1832-8.
8. Berkey CS, Gardner J, Colditz GA. Blood pressure in adolescence and early adulthood related to obesity and birth size. Obes Res 1998;6:187-95.
9. Schiel R, Beltschikow W, Kramer G, Stein G. Overweight, obesity and elevated blood pressure in children and adolescents. Eur J Med Res 2006;11:97-101.
10. Raj M, Sundaram KR, Paul M, Deepa AS, Kumar RK. Obesity in Indian children: Time trends and relationship with hypertension. Natl Med J India 2007;20:288-93.
11. Chhatwal J, Verma M, Riar SK. Obesity among pre-adolescent and adolescents of a developing country (India). Asia Pac J Clin Nutr 2004;13:231-5.
12. Ribeiro MM, Silva AG, Santos NS, Guazzelle I, Matos LN, Trombetta IC, *et al.* Diet and exercise training restore blood pressure and vasodilatory responses during physiological maneuvers in obese children. Circulation 2005;111:1915-23.
13. Lohman TG, Jeukendrup A, Gleeson M. Normal Ranges of Body Weight and Body Fat this is an Excerpt from Sport Nutrition. 2nd ed.; 1993. Available from: http://www.humankinetics.com/excerpts/excerpts/normal-ranges-of-body-weight-and-body-fat. [Last accessed on 2018 May 27].
14. Nageswari KS, Sharma R, Kohli DR. Assessment of respiratory and sympathetic cardiovascular parameters in obese school children. Indian J Physiol Pharmacol 2007;51:235-43.
15. Simran G, Vidushi G. Effect of obesity on autonomic nervous system. Int J Bio Med Sci 2011;1:15-8.
16. Rocchini AP, Moorehead C, Katch V, Key J, Finta KM. Forearm resistance vessel abnormalities and insulin resistance in obese adolescents. Hypertension 1992;19:615-20.
17. Trombetta IC, Batalha LT, Rondon MU, Laterza MC, Kuniyoshi FH, Gowdak MM, *et al.* Weight loss improves neurovascular and muscle

metaboreflex control in obesity. Am J Physiol Heart Circ Physiol 2003;285:H974-82.
18. Mertens IL, Van Gaal LF. Overweight, obesity, and blood pressure: The effects of modest weight reduction. Obes Res 2000;8:270-8.
19. Dempsey JA, Reddan W, Balke B, Rankin J. Work capacity determinants and physiologic cost of weight-supported work in obesity. J Appl Physiol 1966;21:1815-20.
20. Lampman RM, Schteingart DE, Henry GC. Medical management of severe obesity: Graded exercise testing. J Cardiopulm Rehabil 1987;7:358-64.
21. Segal KR, Pi-Sunyer FX. Exercise and obesity. Med Clin North Am 1989;73:217-36.
22. Shephard RJ, Bouchard C. Principal components of fitness: Relationship to physical activity and lifestyle. Can J Appl Physiol 1994;19:200-14.
23. Laird WP, Fixler DE, Huffines FD. Cardiovascular response to isometric exercise in normal adolescents. Circulation 1979;59:651-4.
24. Davy KP, Orr JS. Sympathetic nervous system behavior in human obesity. Neurosci Biobehav Rev 2009;33:116-24.
25. Alvarez GE, Beske SD, Ballard TP, Davy KP. Sympathetic neural activation in visceral obesity. Circulation 2002;106:2533-6.
26. Canale MP, Manca di Villahermosa S, Martino G, Rovella V, Noce A, De Lorenzo A, *et al.* Obesity-related metabolic syndrome: Mechanisms of sympathetic overactivity. Int J Endocrinol 2013;2013:865965.
27. Swaroopa Rani NG. Body composition analysis of staff members of college using bioelectrical impedance analysis method. Int J Chem Eng Appl 2014;5:259-65.
28. Kanai H, Tokunaga K, Fujioka S, Yamashita S, Kameda-Takemura KK, Matsuzawa Y, *et al.* Decrease in intra-abdominal visceral fat may reduce blood pressure in obese hypertensive women. Hypertension 1996;27:125-9.