Research Article

Hemodynamic parameters and sympathetic autonomic function tests in obesity

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Abstract

Background: Obesity is a medical condition in which excess body fat accumulates to an extent that it poses a negative effect on health, leading to decrease in life expectancy and increased health problems. Childhood obesity is an emerging global public health challenge such that obesity has now become the most important nutritional disease of the children and adolescents. The effect of adiposity and body mass index (BMI) on cardiovascular reactivity to stress invariably warrants documentation. **Aims and Objective:** To assess the hemodynamic parameters and sympathetic autonomic function tests in obese children. **Materials and Methods:** The study was conducted on 100 obese school-going children (BMI of more than cutoff value for their respective age and sex) aged between 10 and 16 years belonging to varied socioeconomic status. An identical number of age/sex-matched nonobese/normal weight school-going children served as controls. The subjects were interviewed for age, personal/dietary habits, relevant recent or history, etc. The children presenting any medical ailment such as diabetes, asthma, heart disease, anxiety, apprehension, or with noncooperative attitude were excluded. General physical and relevant cardiovascular system examinations were done. Blood pressure, cold pressor test (CPT), and hand grip dynamometer test were done. Statistical analysis was done by using unpaired Student's *t*-test. **Result:** The study demonstrates a significant increase in body mass index, heart rate, and blood pressure in obese children, while insignificant change in the respiratory rate. The study demonstrates significant increase in maximum blood pressure response to CPT in obese male and female children, a significant increase in maximum systolic blood pressure response to hand grip dynamometer test, while insignificant decrease in maximum diastolic blood pressure response to hand grip dynamometer test in obese male and female children. **Conclusion:** The study demonstrates the increased propensity of obese individuals to develop hypertension in basal conditions and in response to stress as revealed by CPT and decreased peripheral vascular response owing to decreased sympathetic activation during isometric exercise indicating a weak cardiorespiratory response to exercise.

KEY WORDS: Obesity; Children; Hemodynamic Parameters; Sympathetic Autonomic Function Tests

Introduction

Obesity is a nutritional disorder of energy balance characterized by an excess accumulation of body fat. Obesity is designated as a global epidemic,[1] and this epidemic has reached the young population.[2] The prevalence of childhood obesity is increasing greatly in all parts of the world.[3] Pediatric obesity represents one of the most pressing nutritional problems in children in the United States.[4] Tremblay and Willms[5] stated that cause for the growing prevalence of obesity and the associated diseases is a reduction in daily physical activity by children.

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Obesity is a major feature in several rare genetic syndromes, such as Prader–Willi syndrome, Bardet–Biedel syndrome, Cohen syndrome, and MOMO syndrome. The term nonsyndromic obesity is used to exclude this condition. Besides syndromic obesity, the medical conditions that increase the risk of obesity are congenital or acquired conditions such as hypothyroidism,

Cushing syndrome, growth hormone deficiency, and eating disorders such as binge eating and night eating syndrome.

Certain medications may cause weight gain such as insulin, sulphonylureas, thiazolidinediones, atypical antipsychotics, steroids, anticonvulsants (phenytoin valproate), pizotifen, and hormonal contraceptives.

Obesity results from chronic imbalance between energy intake and energy expenditure, high energy and fat diet in young children, sedentary activities such as prolonged television watching, and genetic causes. The health consequences of obesity fall in two broad categories—increase in fat mass, as in obstructive sleep apnea, osteoarthritis, and increase in fat cells as in diabetes mellitus, cancer, cardiovascular complications such as ischemic heart disease, myocardial infarction, congestive heart failure, hypertension, and nonalcoholic fatty liver.

The excess fat decreases the body's response to insulin and leads to proinflammatory and prothrombotic states. Leptin is the marker of obesity and signals the fat stores of body. Obesity is a serious health problem that warrants documentation on basal hemodynamic parameters and reactivity of sympathetic nervous system to stress and exercise.

Chhatwal et al.,[6] in their study, determined the prevalence of obesity by using the WHO guidelines for defining overweight and obesity in preadolescent and adolescent children (aged 9–15 years) in a developing country such as India.

The appearance of obesity-related high blood pressure in children forecasts a major health-care burden and a need for early intervention strategies.[7]

This study was conducted to document the effect of obesity on basal hemodynamic parameters and sympathetic autonomic function tests.

Materials and Methods

This study was conducted on 100 obese (50 male and 50 female) and equal number of nonobese children in the age group of 10–16 years. The children were selected randomly among families, neighborhood, sports club, health clinics, and schools.

The body mass index (BMI) (kg/m^2) was calculated by dividing weight (in kilogram, measured by platform beam balance) with height (in square meter, measured by measuring scale fixed to the wall). The subjects were classified as overweight and obese by the WHO classification:[1]

- BMI <18.5 kg/m^2—underweight
- BMI 18.5–24.9 kg/m^2—normal
- BMI 25–29.9 kg/m^2—overweight
- BMI $\geqslant 30$ kg/m^2—obese

The hemodynamic parameters recorded were basal heart rate (HR), respiratory rate (RR), while basal blood pressure was recorded prior to sympathetic autonomic function test viz., cold pressor test (CPT) and hand grip dynamometer test.

The blood pressure was also recorded 1.5 s after immersion of hand in cold water and every 1 min till it reached basal level such that the maximum increase in blood pressure was the measure of cold pressor response. The blood pressure was also recorded during isometric exercises at 30% of maximum contraction by hand grip dynamometer.

Statistical analysis was done using unpaired Student's *t*-test. A *p*-value of <0.05 was considered statistically significant.

Table 1: Mean values of hemodynamic parameters of obese and nonobese male children

Parameters	Obese (mean ± SD)	Nonobese (mean ± SD)	*p*
BMI	32.82 ± 0.92	22.50 ± 1.40	0.00*
RR	14.46 ± 3.53	15.67 ± 2.14	0.08
HR	88.40 ± 4.46	79.26 ± 4.26	0.01*

BMI, body mass index; RR, respiratory rate; HR, heart rate.
*Significant.

Result

The mean age of obese versus nonobese children was 14.03 versus 14.00 years.

Table 1 shows that while mean values of BMI and HR were significantly more in obese male children when compared with nonobese male children, the mean values of RR in obese and nonobese male children were comparable.

Similarly, as in Table 1, Table 2 also shows that the mean values of BMI and HR were significantly more in obese female children when compared with nonobese female children, while the mean values of RR in obese and nonobese female children were comparable.

Table 3 shows the mean values of basal and maximum systolic blood pressure (SBP) during hand grip and CPTs significantly more in obese male children when compared with nonobese male children.

Whereas the mean values of basal diastolic blood pressure (DBP) during hand grip and CPTs were significantly more in obese male children, the maximum DBP during hand grip was insignificantly less in obese male children, while the maximum DBP during CPT was significantly more in obese male children when compared with nonobese male children.

Table 2: Mean values of hemodynamic parameters of obese and nonobese female children

Parameters	Obese (mean ± SD)	Nonobese (mean ± SD)	*p*
BMI	31.84 ± 0.80	20.41 ± 0.28	0.00*
RR	14.27 ± 2.14	14.54 ± 2.90	0.81
HR	89.80 ± 4.16	78.62 ± 4.73	0.01*

BMI, body mass index; RR, respiratory rate; HR, heart rate.
*Significant.

Table 3: Mean values of basal and maximum blood pressures in obese and nonobese male children during sympathetic autonomic function tests

Parameters	Obese (mean ± SD)	Nonobese (mean ± SD)	*p*
SBP in hand grip dynamometer test			
Basal	120.4 ± 5.20	113.4 ± 5.14	0.01*
Maximum	138.46 ± 4.5	134.76 ± 3.71	0.00*
DBP in hand grip dynamometer test			
Basal	82.46 ± 4.04	76.40 ± 4.70	0.01*
Maximum	90.70 ± 4.07	93.40 ± 3.26	0.80
SBP in CPT			
Basal	120.96 ± 6.02	114.9 ± 4.41	0.01*
Maximum	140.97 ± 4.70	134.70 ± 5.26	0.02*
DBP in CPT			
Basal	82.17 ± 4.21	76.22 ± 4.70	0.01*
Maximum	96.80 ± 5.41	84.66 ± 4.76	0.00*

DBP, diastolic blood pressure; SBP, systolic blood pressure; CPT, cold pressor test.
*Significant.

Table 4 shows the mean values of basal and maximum SBP during hand grip and CPTs, which were significantly more in obese female children when compared with nonobese female children.

Whereas the mean values of basal DBP during hand grip and CPTs were significantly more in obese female children, the maximum DBP during hand grip was insignificantly less in obese female children, while the maximum DBP during CPT was significantly more in obese female children when compared with nonobese female children.

Table 4: Mean values of basal and maximum blood pressure in obese and nonobese female children during sympathetic autonomic function tests

Parameters	Obese (mean ± SD)	Nonobese (mean ± SD)	*p*
SBP in hand grip dynamometer test			
Basal	118.24 ± 6.94	112.26 ± 6.04	0.01*
Maximum	137.18 ± 9.04	133.76 ± 4.53	0.00*
DBP in hand grip dynamometer test			
Basal	82.56 ± 4.07	77.02 ± 4.27	0.00*
Maximum	90.07 ± 4.14	92.86 ± 4.07	0.24
SBP in CPT			
Basal	120.76 ± 5.32	110.26 ± 6.98	0.01*
Maximum	140.26 ± 4.26	133.03 ± 4.00	0.00*
DBP in CPT			
Basal	80.28 ± 4.36	74.42 ± 2.34	0.01*
Maximum	98.02 ± 3.87	87.24 ± 4.26	0.00*

DBP, diastolic blood pressure; SBP, systolic blood pressure; CPT, cold pressor test.
*Significant.

Discussion

Obesity is an emerging serious health problem that is the harbinger of future health problems such as hypertension, type-2 diabetes mellitus, osteoarthritis, and renal disease.[8] Obese persons experience an increased mortality risk owing to cardiovascular disorder related to continuously lowered parasympathetic or altered sympathetic activation.[9] Obesity being the precursor of various health problems needs to be evaluated. This study was conducted on 100 obese children and same number of healthy controls between the age group of 10 and 16 years. The difference in the mean values of BMI, basal HR, and blood pressure between obese and nonobese children was statistically significant. The maximum mean blood pressure response to CPT was also statistically significant, while the maximum mean SBP during isometric exercise was statistically higher in obese children, but the mean DBP in obese was insignificantly lower than nonobese children.

Our study is analogous to the study conducted by Akhter et al.,[10] who reported significantly higher resting blood pressure and significantly lower blood pressure in response to hand grip exercise.

Dipla et al.[11] stated that blood pressure response to exercise is exacerbated in obese when compared with the lean individuals. The DBP rise of 15 mmHg or more is considered normal, 11–15 mmHg as borderline, and 10 mmHg or less as abnormal response to hand grip dynamometer test. The SBP rise in hand grip dynamometer test is owing to an increase in cardiac output to pump extra amount of blood to the fat cell. The higher supply of blood pressure is owing to an increase in cardiac output to pump greater amount of blood to fat cells causing greater circulatory load on heart. The low DBP response to isometric exercise in obese individuals is owing to a decrease in peripheral vascular resistance because of a lower sympathetic stimulation.

This study demonstrates a significant increase in the maximum blood pressure response to CPT. The study is analogous to the studies conducted by Dipla et al.,[11] Nageswari et al.,[12] and Kuniyoshi et al.[13] It was reported that forearm vascular resistance is significantly higher in obese individuals when compared with the lean individuals during sympathoexcitation induced by CPT.[13]

Our observations were similar as reported by Guizar et al.,[14] who stated that an overweight male adolescent of developing nature shows an imbalanced sympathetic heart activity and higher blood pressure levels than an appropriate weight adolescent. Ribeiro et al.[15] observed an increased resting blood pressure, reduced anoreceptor sensitivity, and decreased resting forearm blood flow among obese children, while high blood pressure response was observed in obese children during sympathetic stimulation induced by isometric handgrip exercise when compared with the lean age-matched children.

Cold-induced vasoconstriction leads to an increase in peripheral resistance pointing to heightened sympathetic response indicating autonomic instability and dysfunction.

Obesity is a worldwide problem related to excess food intake that is a precursor of future health diseases such as osteoarthritis, insulin resistance, type-2 diabetes mellitus, myocardial infarction, hypertension, and deep vein thrombosis. Obesity predisposes the risk to health problems in the form of increased sympathetic activity in the resting conditions leading to hypertension, reduced sympathetic response after isometric hand grip exercise predisposing to impaired cardiovascular response to exercise, and increased blood pressure response to cold stimuli, predisposing to rise in blood pressure during condition of stress.

Prevention of obesity is a public health priority with concern on childhood and adolescence, because children and adolescent adiposity are precursors to long-term development of adult diseases.

Obesity predisposes the individual to a variety of future health problems and needs adequate treatment in the form of decreased food intake, exercise, decrease in sedentary activities, medication such as orlistat, lorcaserin, phentermine, and topiramate, and surgical treatment in the form of ballooning and decreasing the stomach volume by gastric banding and decreasing gastric bowel length.

Conclusion

There is an increased sympathetic response in resting condition but decreased sympathetic response after isometric hand grip exercise, whereas blood pressure response to CPT is increased, but values are within normal limits. Obesity is a critical condition associated with the increase in cardiac output, resting blood pressure, and autonomic instability, and, so, it should not be ignored.

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