

ASSESSMENT OF RESPIRATORY AND SYMPATHETIC CARDIOVASCULAR PARAMETERS IN OBESE SCHOOL CHILDREN

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(Received on January 22, 2007)

Abstract : The study was undertaken to assess the respiratory and sympathetic cardiovascular functions in obese and non obese school children of 12–16 years age group, randomly selected from two schools of Rajpura (Punjab), representing *mixed* socioeconomic group of Punjabi ethnicity and categorized as obese or controls as per standard criteria for Body Mass Index (BMI). Dynamic lung function tests and pressor response to cold (Cold pressor test) and isometric exercise (Handgrip dynamometer test) were carried out. Statistical analysis comprised students' t-test, at 95% confidence level and simple linear regression analysis. The results indicated significantly higher baseline diastolic blood pressure (DBP) ($P < 0.004$) in obese children correlating positively with BMI ($r = 0.57$). Significantly increased DBP response to applied cold stimulus (response/ range, $P < 0.02$ and maximal value, $P < 0.001$) and borderline response to isometric exercise ($P < 0.002$) in obese children indicated autonomic instability. The dynamic lung functions were significantly decreased ($P < 0.04$) in obese subjects and correlated negatively with BMI. Personal data forms of obese children revealed less physical activity and excessive intake of junk foods. Thus it is concluded that obese children have derangement of sympathetic cardiovascular functions and reduced pulmonary functions.

Key words : baseline diastolic blood pressure body mass index
cold pressor test handgrip dynamometer
obesity overweight pulmonary function test

INTRODUCTION

Obesity is a disorder of energy balance affecting wide range of people belonging to diverse ethnic groups, age and socioeconomic status (1). Prevalence of overweight and obesity is increasing in children and adolescents in India as reflected in various

studies conducted in states of Punjab (2, 3), Delhi (4) and in South India (5).

However no data are available on the respiratory and sympathetic cardiovascular functions in obese school children of Punjabi ethnicity. The present study was undertaken to investigate the sympathetic cardiovascular

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parameters and pulmonary functions in obese school going children in comparison with age, sex and ethnically matched control group.

The causes of childhood obesity are manifold that include lack of regular exercise, sedentary habits, over consumption of high calorie foods, and genetic, perinatal and early life factors (1). Childhood obesity has been found to have a positive correlation with endocrinal dysfunction, lipid profile, hypertension, insulin resistance and morbidity from coronary heart disease in adulthood (6). The American Heart Association has recently added obesity to its list of major risk factors for heart disease (7). The prevalence of hypertension has been reported to be higher in obese as compared to non obese children which increases significantly with body mass index (2). Respiratory functions like Expiratory reserve volume (ERV), ERV/Inspiratory capacity and DLco/VA have also been found to be affected with degree of obesity in adults (8). There is strong epidemiological evidence indicating reduced FEV₁ as a marker for cardiovascular mortality independent of age, gender and smoking history (9). Pulmonary complications like asthma (10) and sleep apnoea (11) have been associated with obesity in children. Hence respiratory and cardiovascular systems have been reported to be two major systems reflecting the adverse effects of obesity.

METHODS

Two schools of Rajpura were randomly selected to obtain mixed group of children belonging to varied socio economic status. Students in the age group of 12–16 years

were screened to identify the obese/overweight school children by recording their weight (in kilograms) and height (in meters). The protocol of the study was approved by the institutional Ethics Committee. Body mass index was calculated as per the formula :

$$\text{Body mass index} = \frac{\text{Weight (Kilograms)}}{\text{Height}^2 \text{ (Meter}^2\text{)}}$$

The benchmark for obesity was taken on the basis of Body mass index-for-age as per the standard protocol (12).

The children having BMI of more than the cut-off value for their respective age and sex were designated as the test/obese group (both overweight and obese children were clubbed together). A total of 20 obese/overweight school going children were identified as per the criteria mentioned above and an identical number of age and sex matched non-obese school children served as controls. A brief personal history was taken. The exclusion criteria comprised of children suffering from any medical ailments or anxious, apprehensive and uncooperative children.

All subjects were explained about the procedures to be undertaken and written informed consent was obtained as per Helsinki Declaration, modified according to the test protocol. Informed consent forms were also signed by parents/guardians as the children were minors. The students were given a questionnaire/personal data form, which they were required to fill up with certain details like their dietary habits, extent of physical activity, family history etc. (Table I).

TABLE I: Assessment of respiratory and sympathetic cardiovascular parameters in obese school children.

Personal Data Form	
Name : School : Gender (tick): <input type="checkbox"/> Male <input type="checkbox"/> Female Age : Occupation of Father : Occupation of Mother : Total number of family members : Number of earning family members : Food habits (tick relevant boxes): <input type="checkbox"/> Breakfast <input type="checkbox"/> Lunch <input type="checkbox"/> Dinner <input type="checkbox"/> Food in-between meals snacks Do you enjoy or prefer eating any other foodstuff (pizzas, soft drinks, chips): Yes/No If yes, then how often? _____ How much time do you spend daily, doing physical exercise or outdoor sports (excluding physical training in school): How much time do you spend everyday watching television or using computer: _____ hours Is/are your parent(s) obese or overweight? (Tick one) <input type="checkbox"/> One parent obese <input type="checkbox"/> Both parents obese <input type="checkbox"/> None is obese	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> Weight : Height : BMI : History of illness : Family History of illness : </div> <div style="border: 1px solid black; padding: 5px;"> Ethnicity : Socio-economic status : Per capita income : </div>
(Signature of subject)	

The following tests were carried out in the test and control groups for the assessment of respiratory and sympathetic cardiovascular parameters.

Sympathetic Cardiovascular Parameters

The subjects were made to rest for 10 minutes before recording their baseline systolic and diastolic blood pressure as per standard procedure. Appropriate cuff size was used to measure blood pressure. For each subject, two recordings of blood pressure were taken from which the average baseline blood pressure (systolic or diastolic) was obtained before each of the following tests.

Cold pressor test (CPT)

The right hand of the subject was immersed up to the wrist in cold water at a temperature of 4°C for 1 minute. Blood pressure was recorded at 30 seconds and 1 minute of submersion of the hand. After taking out the hand, blood pressure was recorded after every minute, till it returned to the baseline (13).

The increase in blood pressure from the baseline value (average of two values) to maximal value, known as the range or response (Δ), was obtained. The maximal systolic and diastolic values of blood pressure

achieved at any time during the test, designated as the ceiling values (13), were also noted.

The subjects were given rest for about thirty minutes before performing the next test.

Handgrip dynamometer test (HGT)

Evaluation of circulatory alterations during sustained isometric muscle contractions is a useful method to assess cardiac function (14). Hence, handgrip dynamometer test was performed to elicit the sympathetic cardiovascular functions during the isometric exercise. The subjects were explained through self-demonstration by the investigators.

The baseline systolic and diastolic blood pressure values were recorded. The subjects were asked to perform Maximal Voluntary Contraction (MVC) by gripping the handgrip dynamometer, as hard as possible for few seconds and the maximum force exerted was noted down. After giving rest for a few minutes, the subjects were made to perform isometric exercise at 30% of the maximal voluntary contraction to the point of fatigue (15). Systolic and diastolic blood pressure recordings were taken at intervals of each minute during the period of exercise. The mean systolic and diastolic blood pressure, the increase in systolic and diastolic blood pressure during the isometric exercise were calculated and the maximal values of systolic and diastolic BP achieved during exercise were noted down.

Respiratory parameters (lung function tests)

Lung Function tests were performed using Medspiror. This simple non-invasive test is used to measure various dynamic lung

functions, including the volume of air expelled from fully inflated lungs as a function of time and also for exploring the flow-volume relationship. The subject was asked to take a deep breath and then exhale forcefully for as long as possible, into the mouthpiece of medspiror.

The investigated lung parameters were : FVC : Forced vital capacity, FEV₁ : Forced expiratory volume in one second, FEV₃ : Forced expiratory volume in three seconds, PEFR: Peak expiratory flow rate and FEF_{25-75%} : Mean forced expiratory flow during the middle half of the FVC.

Statistical analysis

The data were compared using the student's t-test, at 95% confidence level. The following comparisons were done :

- Various pulmonary function tests in control and test groups by independent sample comparison method.
- Baseline systolic and diastolic blood pressure in control and test groups.
- Maximal response/ceiling value and the response/range (difference between baseline and maximal response, Δ) in both the groups for Cold pressor test and Handgrip dynamometer test.

Simple linear regression was carried out to explore the relationship between :

- Lung functions versus BMI.
- Baseline diastolic blood pressure versus BMI.

RESULTS

The mean Body Mass Index of the test group was 28.17 ± 1.82 kg/m² as compared to

18.47±0.5 kg/m² of the control group.

The baseline diastolic blood pressure in obese children prior to the Cold pressor test and Handgrip dynamometer test was significantly higher (P<0.001 and P<0.004 respectively) as compared to the control group (Table II). The baseline diastolic blood pressure values prior to Cold pressor test (CPT) and Handgrip dynamometer test (HGT) were pooled and averaged for each subject in both the groups. A simple linear regression analysis was performed using these average diastolic blood pressure values for each subject and the BMI. This test revealed a positive correlation of DBP with BMI (r = 0.57, P<0.001, Fig. 1).

During the Cold pressor test, the response/range (Δ) and the ceiling value/ maximal response attained for the diastolic blood pressure were significantly higher in test group as compared to control group (P<0.02 and P<0.001 respectively. Table II). The response to isometric exercise (Δ), taken as the difference between the maximum diastolic blood pressure and the mean of 2 baseline diastolic blood pressure readings,

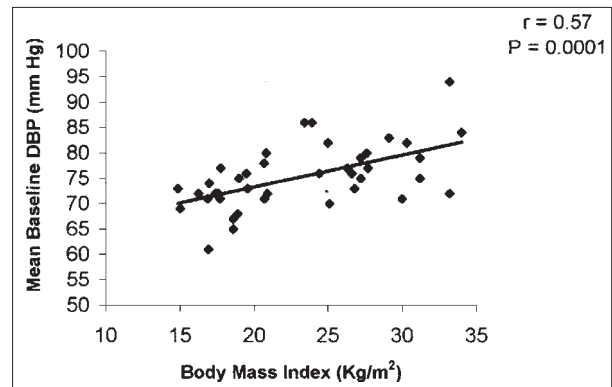


Fig. 1: Scatter Plot showing linear relationship and positive correlation of Mean Baseline Diastolic Blood Pressure (DBP) (mmHg) with Body Mass Index (BMI: kg/m²).

was significantly reduced in the obese group as compared to the control group (P<0.002, Table II). The other tested parameters i.e. mean baseline systolic blood pressure, mean systolic and diastolic blood pressure during exercise, maximum systolic blood pressure achieved during exercise and increase in the systolic blood pressure due to exercise (Δ) were not significant between the two groups.

The assessment of lung function tests revealed significant decrease for all pulmonary functions in test subjects as

TABLE II: Comparison of blood pressure response to hand grip dynamometer test and cold pressor test in control and obese groups (n=20 each).

Sympathetic cardiovascular parameters	Blood pressure (BP) (mmHg)	Control group	Test group	P-value*
Hand grip dynamometer test	Baseline diastolic BP (mean±SD)	74.5±5.69	81.1±7.5	<0.004
	Maximum diastolic BP (mean±SD)	90.4±5.75	92.5±6.42	NS
	Change in diastolic BP (Δ) (mean±SD)	15.9±4.61	11.4±4.02	<0.002
Cold pressor test	Baseline diastolic BP (mean±SD)	69.2±3.91	76.6±4.95	<0.001
	Maximum diastolic BP (mean±SD)	80.5±6.55	93.7±8.24	<0.001
	Change in diastolic BP (Δ) (mean±SD)	11.3±5.77	17.1±8.47	<0.02

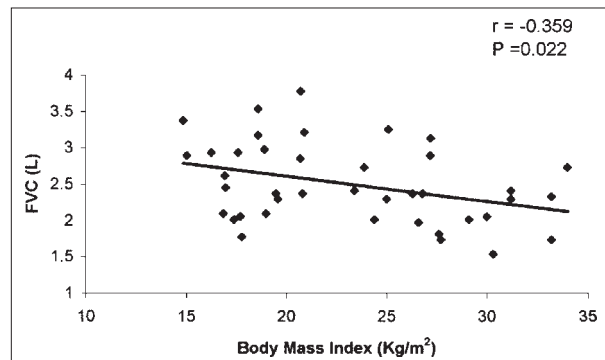
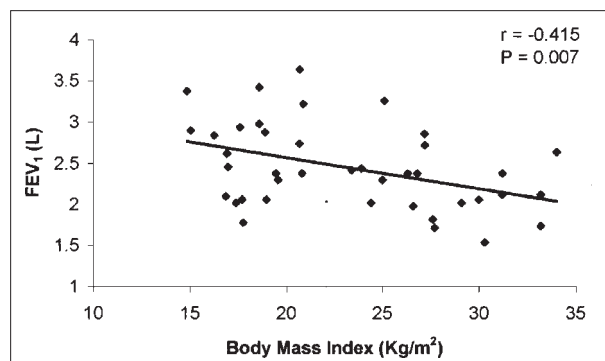
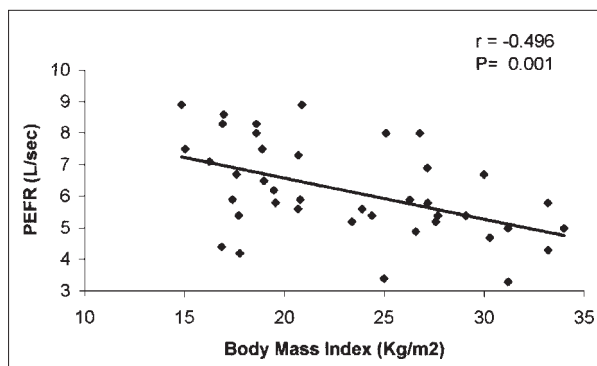
*P<0.05 - significant.

TABLE III: Comparison of parameters of respiratory functions in control and test groups (n=20 each).

Parameter	Control (C) group	Obese (T) group	P-value*
Forced vital capacity (L) (mean±SD)	2.7±0.56	2.31±0.47	<0.03
Forced expiratory volume (1st second (L) (mean±SD)	2.65±0.52	2.25±0.42	<0.002
Forced expiratory volume 3 seconds (L) (mean±SD)	2.7±0.56	2.31±0.47	<0.03
Peak expiratory flow rate (L/sec) (mean±SD)	6.85±1.42	5.5±1.23	<0.003
Forced expiratory flow _{25-75%} (L/sec) (mean±SD)	4.18±0.85	3.55±0.85	<0.04

*P<0.05 - significant.

compared to their control counterparts (Table III). The regression analysis revealed significant negative correlation between Body Mass Index and Forced Vital Capacity (Fig. 2), FEV₁ (Fig. 3) and Peak Expiratory Flow rate (Fig. 4).

Fig. 2: Scatter Plot showing linear relationship and negative correlation of Forced Vital Capacity (FVC) (L) with Body Mass Index (BMI, kg/m²).Fig. 3: Scatter Plot showing linear relationship and negative correlation of Forced Expiratory Volume (FEV₁) (L) with Body Mass Index (BMI, kg/m²).Fig. 4: Scatter Plot showing linear relationship and negative correlation of Peak Expiratory Flow rate (PEFR) (L/sec) with Body Mass Index (BMI, kg/m²).

DISCUSSION

Prevalence of sustained hypertension has been found to be 15.33% and 43.1% in overweight and obese urban children and 6.82% and 61.76% in the rural group children (3). Same authors have also observed sustained hypertension in normal group children (4.52%). These children could actually be overweight/ obese for their respective age (12) as the authors categorized the subjects based on the BMI values as per the criteria for adults (>25 kg/m² for overweight and >30 kg/m² for obese), though separate age-wise classification of overweight and obesity as per the BMI is available for the children in the age group of 12–16 years (12). Thus standard cut-off points of BMI,

for different age groups of children are actually much less than the values mentioned above. Hence, those children who are categorized as overweight could have been obese and those categorized as normal could have been overweight. This further supports the findings of our study as we have not observed hypertension in control group children, who are normal as per the age wise classification of BMI.

The results of the present study indicate high baseline diastolic blood pressure (DBP) values prior to cold pressor test and isometric exercise in the obese group children. The high values of baseline DBP had a significant positive correlation with BMI. These results of our study are in line with the results of Ribeiro et al (16) and Guizar et al (17) who have observed increased blood pressure levels in obese children and adolescents (respectively) as compared to their control counterparts.

It can be hypothesized that higher baseline diastolic blood pressure in obese/overweight children could be due to higher vasoconstrictor tone and/or increase in the cardiac output due to increased circulatory load on heart, as a consequence of increase in Body Mass Index.

The Cold pressor test (CPT) elicits the pressor response to a cold stimulus and is an indicator of vasoconstrictor tone. The response of blood pressure to Cold pressor test is characteristic for the individual. In the present study, the maximal/ceiling value as well as range/response (Δ) of diastolic blood pressure during cold pressor test was found to be higher in test group subjects as compared to control group. Hines and co-workers (13, 18) indicated that the

vasopressor response to locally applied cold was due to an increase in the total peripheral resistance as a result of vasoconstriction and that the cardiac output did not change. On the contrary, Hejl (19) has mentioned that the pressor response in most normotensive subjects was due to a rise in cardiac output and the pressor response in hypertensive subjects was due to an increase in peripheral resistance.

A rise of 20/20 mmHg or more during the Cold Pressor Test has been documented to be an abnormal response (20). In our study, though the increase in diastolic blood pressure (Δ DBP) was significant in test/obese group children, pointing to heightened sympathetic responses, the values were within the normal range.

For the Isometric exercise, the test group revealed truncated response as compared to the control group. Ewing et al (15) have defined a rise of diastolic blood pressure of 15 mmHg or more as normal, 11–15 mmHg as borderline and 10 mmHg or less as abnormal, response to Handgrip dynamometer test. The obese children in the present study showed borderline response while the control group children exhibited normal response. During Handgrip dynamometer test, the literature mentions heart rate dependent increase in cardiac output and blood pressure with little change in total peripheral resistance (14). Thus the responses observed during the Cold pressor test and Handgrip dynamometer test have been explained on varied Physiological principles.

Hence, derangements in the sympathetic cardiovascular function in the form of elevated baseline diastolic blood pressure,

enhanced response to Cold pressor test and borderline response to Handgrip dynamometer test in the obese children points towards autonomic instability. In the literature, both increased sympathetic activity in response to exercise (16, 17) and hypofunction of the sympathetic system in obese children (21) have been reported. The following hypothesis can be put forward to explain the dichotomy in our findings.

It is well established that stimulation of sympathetic system results in increase in arterial pressure either due to (i) increase in heart rate and force of contraction, leading to increase in cardiac output and blood pressure or alternately (ii) vasoconstriction and resultant increase in total peripheral resistance and blood pressure, or both. The first effect is due to increased activity in cardiac sympathetic fibers and second due to increased activity in peripheral vasoconstrictor fibers. Such preferential activation of peripheral vasoconstrictor fibers has been attributed to cause cold induced vasoconstrictor response in normotensive population (13, 16) and in hypertensives (18). The isometric exercise induced increase in heart rate, cardiac output and blood pressure, reported in the literature (14) can be explained on the basis of activity in the cardiac sympathetic fibers. The obese children showed truncated response in cardiac sympathetic activity resulting in borderline response to isometric exercise. However they exhibited enhanced peripheral sympathetic activity in the form of cold induced vasoconstriction leading to increase in total peripheral resistance and diastolic blood pressure. They also had increased vasoconstrictor tone at rest resulting in increased baseline diastolic blood pressure

prior to the application of any type of stimulus (cold or exercise). This hypothesis can be substantiated by conducting tests to evaluate (i) parasympathetic system and (ii) cardiac output measurement in obese children.

The lung function tests revealed significant decrease in pulmonary functions in obese subjects as compared to their control counterparts. The regression analysis revealed a significant negative correlation between Body Mass Index and Forced Vital Capacity, FEV₁, FEV₃, PEF_R and FEF_{25-75%}. Literature indicates decrease in chest wall compliance in obesity due to increased amount of adipose tissue around chest and abdomen (22). This might have been the reason for decrease in dynamic lung functions in the test group children.

Autonomic instability, enhanced basal vasoconstrictor tone and pressor response to applied cold stimulus could make these obese children prone to hypertension and other cardiovascular disorders later in life. The negative correlation of the respiratory parameters with BMI and decreased pulmonary functions could further predispose them to associated respiratory and cardiovascular risks.

Follow up advice

The assessment of the lifestyle of the subjects pointed towards a relative lack of physical exercise and greater frequency of consumption of junk food among the obese children. Such habits contribute towards obesity. The obese children were advised about corrective measures in the form of regular exercise, eating a well balanced diet rich in fiber and low in fat, and avoiding junk foods to counter ill effects of obesity.

ACKNOWLEDGEMENTS

This study was undertaken for the Short-term Studentship programme (STS fellowship 2005) of the Indian Council of Medical Research for undergraduate medical students.. The studentship was availed by Divyanshoo Rai Kohli, MBBS III, GMC,

Chandigarh under the guidance of Dr. K. Sri Nageswari, Professor & Head, Department of Physiology, GMC Chandigarh. The authors are thankful to ICMR for the sanction of the project. The authors acknowledge the secretarial assistance rendered by Ms. Parminder Kaur, Jr. Stenographer, Department of Physiology.

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