Correlation between body mass index and blood pressure in urban school-going children of age 6–14 years

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ABSTRACT

Background: Obesity and hypertension (HT) have been on a rise in children. Both are associated with the increased cardiovascular disease risk and related morbidity and mortality in adulthood. **Objectives:** The objectives of the study were to determine the body mass index (BMI) and blood pressure (BP) of school-going urban children and to find out the correlation between BMI and BP. **Materials and Methods:** This study was performed on 1000 healthy school-going children (492 males and 508 females). BMI and BP were determined and recorded. Relevant statistical analysis was performed to divulge the relationship. **Results:** A significant ($p<0.001$) and positive correlation was observed between BMI and BP irrespective of gender. HT and prehypertension were observed in a higher proportion of obese and overweight study subjects. **Conclusion:** Control of obesity is one of the most important preventive aspects of HT in children.

Key words: *Children, Correlation, Hypertension, Obesity*

Childhood obesity is emerging as global health problems which was earlier considered as a problem of developed countries but has started appearing gradually even in developing countries. Among the Indian children, the magnitude of overweight ranges from 3.0 to 25.8% and obesity ranges from 1.2 to 14.6%, respectively [1-4]. The complications related to childhood obesity include hypertension (HT), type 2 diabetes mellitus, dyslipidemia, non-alcoholic steatohepatitis, obstructive sleep apnea, and psychosocial problems [5]. The method used most widely for measuring obesity is the body mass index (BMI) [6].

HT is a major risk factor for cardiovascular disease and is the leading cause of morbidity worldwide [7]. The estimated prevalence of HT among Indian children and adolescents is reported to range from 1.0 to 12.3% [8]. Studies have consistently reported that elevated blood pressure (BP), both systolic BP (SBP) and diastolic BP (DBP) components are significantly correlated with BMI [9]. Keeping in retrospect these facts, this study was undertaken to determine the BMI and BP of school-going urban children and to further define the correlation between obesity and HT.

MATERIALS AND METHODS

This cross-sectional observational study was conducted among 1000 school-going urban children aged between 6 and 14 years from January 2018 to June 2019. A total of five different private schools of urban area of Jaipur city were considered for study and 200 healthy students from each school were included by random sampling method after obtaining consent from school authorities and their parents. Those having present or past history suggestive of cardiovascular, respiratory or any other systemic illness, family history of HT, asthma, diabetes, or having any physical disability were excluded from the study.

For measuring the height, all study subjects were asked to remove their shoes, bulky clothing, and hair ornaments and were asked to stand with head, shoulders, buttocks, and heels straight and feet flat together and against the wall with the head in the Frankfort horizontal plane and the line of sight being parallel to the floor. A metallic non-stretchable tape measure fixed to a plane surface wall and a set square was used as a pointer for corresponding reading. Height was recorded to the nearest decimal fraction of 0.01 m. For recording the weight, all study subjects were asked to remove shoes and heavy clothing and were asked to stand with both feet in the center of the scale to avoid the error. Weight was recorded in kilograms using standard electronic weighing scale to the nearest decimal fraction of 0.1 kg.

All measurements were done at the same time of the day and with the same instrument every time to avoid the error by the usage of a different set. BMI was calculated using the formula: BMI = Mass (kg)/Height (m^2). The children were classified into BMI categories as per the revised WHO-IAP 2015 growth charts [10] as follows: Below 23rd adult equivalent (AE) – No risk of overweight, below 27th AE – No risk of obesity, above 23rd AE: Risk of overweight, and above 27th AE – risk of obesity.

According to "the fourth report on the diagnosis, evaluation, and treatment of high BP in children and adolescents," HT in children is defined as average SBP and/or DBP that is greater than or equal to the 95th percentile for sex, age, and height on three or more occasions. Prehypertension (PHT) in children is defined as average SBP or DBP levels that are greater than or equal to the 90th percentile, but less than the 95th percentile [11].

Standard methodology was employed to measure BP. Before recording, all study subjects were taken to a separate room away from noise to avoid disturbance in recording and also its effect on their autonomic system. The whole procedure of recording was explained and they were reassured that the procedure is neither painful nor harmful and efforts were made to eliminate the factors which might affect the BP such as anxiety, fear, crying, laughing, and recent activities to facilitate the recording under simulated "basal" or "near basal" conditions. When the child had become comfortable, BP was recorded in sitting position with his/her back supported, uncrossed feet on the floor, and right arm supported with cubital fossa at heart level to avoid parallax error. The right arm was used for consistency and comparison with standard tables.

Standard clinical sphygmomanometer and stethoscope were used to record BP by auscultatory method. Appropriate size cuff bearing a width approximately 40%, and length of at least 80% of arm circumference was used. A chestpiece of stethoscope was placed over the brachial artery, proximal and medial to the cubital fossa, and below the bottom edge of the cuff. BP recordings were expressed to the nearest 2 mmHg of standard clinical sphygmomanometer. Appearance of Korotkoff sounds, K1 was noted as SBP reading and disappearance of sounds K5 was noted as DBP reading. All the recordings were taken on the same time of the day and recorded by the same person with the same instrument to avoid bias.

Systemic examination was also done to exclude cardiovascular, renal, and other diseases which could affect BP. Height centiles were noted for each child from revised IAP 2015 growth charts for height, weight, and BMI for 5–18-year-old boys and girls, which were then utilized to grade the BP using the standard tables as mentioned in the fourth report on the diagnosis, evaluation, and treatment of high BP in children and adolescents.

Appropriate statistical analysis using the SPSS version 20.0 was carried out. The relationship between BMI and BP was determined by Pearson's correlation coefficient and $p<0.001$ was considered as statistically significant. The permission to perform this study was granted by the Institutional Ethics Committee.

RESULTS

The study was conducted in total 1000 school-going urban children of age 6–14 years, in which 492 were boys and 508 were girls with a M: F ratio being 0.9:1. The study subjects were divided into two groups, according to age. There were 566 study subjects in Group I (6–10 years of age) and 434 study subjects in Group II (11–14 years of age).

Table 1 shows the distribution of subjects according to the different BMI grades. The prevalence of obese children was 5.2% and overweight was 11.2% in all study subjects. The distribution of the study subjects according to BMI grade with SBP and DBP stage in two different age groups was considered, as shown in Table 2.

A significantly positive correlation ($p<0.001$) of BMI with SBP and DBP is seen, as shown in Table 3.

DISCUSSION

HT is the most common and most potent universal contributor to cardiovascular mortality. Elevated BP, labile or fixed, systolic or diastolic, at any age, in either sex is a contributor to all forms of cardiovascular diseases. Several national health surveys in Asia showed significant differences in the prevalence of overweight and obesity among different countries. Obesity has increased markedly with this nutritional evolution in most Asian countries. A similar nutritional transition is under way in India as well. In addition to the nutritional and socioeconomic transitions, the behavioral transition of children is also possibly contributing significantly to the rapidly rising prevalence of obesity. Unhealthy eating habits and physical inactivity are the major culprits. The sedentary lifestyle of children and adolescents has been attributed mainly to television viewing, computer games, internet, and overemphasis on academic excellence, unscientific urban planning, and ever-increasing automated transport [12].

In the present study, the prevalence of obesity was 5.2%, overweight was 11.2%, and total obesity and overweight was 16.4%. This was similar to a study done by Jain *et al*. in 2016 in Rajasthan who reported a prevalence of 12.5% overweight and 5.6% obese children in the age group of 5–18 years [13]. Other studies done by Aggarwal *et al*. and Khadilkar *et al*. reported a prevalence of 3.4% and 5.7%, respectively [14,15]. The differences in reported prevalence of obesity among different studies could be due to regional differences, different age range of children studied, and non-uniformity in the criteria to define socioeconomic status.

The prevalence of HT in the present study was found to be more significant in overweight and obese children as compared to normal weight children. In the present study, the prevalence of PHT and HT in obese and overweight children was 6.4% in Group I subjects and 8.5% in Group II subjects. Similar results were also seen in a study done in Surat by Buch *et al*., in which the prevalence of HT in obese children was 8.7% [16]. This association was also demonstrated in other studies [17-19]. Kaur

Table 1: Distribution of all study subjects according to body mass index grade

Classification of obesity	Number of subjects, n (%)		
	Group I	Group II	Total
Obese	27 (4.7)	25 (5.7)	52 (5.2)
Overweight	52 (9.1)	60 (13.8)	112 (11.2)
Normal	487 (86.0)	349 (80.4)	836 (83.6)
Total	566 (100)	434 (100)	1000 (100)

Table 2: Distribution of Group I and II subjects according to BMI grade and BP stage

BMI grade	SBP, n (%)				DBP, n (%)			
	Normal	PHT	HT	Total	Normal	PHT	HT	Total
Group I subjects								
Obese	28 (93.3)	1 (3.3)	1 (3.3)	30	28 (93.3)	1 (3.3)	1 (3.3)	30
Overweight	45 (93.7)	2 (4.2)	1 (2.1)	48	45 (93.7)	2 (4.2)	1 (2.1)	48
Normal	482 (98.7)	4 (0.8)	2 (0.4)	488	483 (98.9)	3 (0.6)	2 (0.4)	488
Total	556 (98.2)	7 (1.2)	4 (0.7)	566	556 (98.2)	6 (1.1)	4 (0.7)	566
Group II subjects								
Obese	20 (90.9)	1 (4.5)	1 (4.5)	22	20 (90.9)	1 (4.5)	1 (4.5)	22
Overweight	34 (91.8)	1 (2.7)	2 (5.4)	37	34 (91.8)	1 (2.7)	2 (5.4)	37
Normal	371 (98.9)	2 (0.5)	3 (0.8)	375	371 (98.9)	2 (0.5)	3 (0.8)	375
Total	425 (97.9)	4 (0.9)	6 (1.3)	434	425 (97.9)	4 (0.9)	6 (1.3)	434

n: Normal blood pressure, PHT: Prehypertension, HT: Hypertension, BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, BP: Blood pressure

Table 3: Correlation of BMI with SBP and DBP in different age groups

Age group (years)	Correlation coefficient (r)		p value
	SBP	DBP	
6–10	0.319	0.308	<0.001
11–14	0.373	0.348	<0.001

BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

et al. observed the prevalence of high SBP in 3.8% of lower income group school population and 4.4% of middle-income group school population having high waist circumference and BMI [20].

The present study confirms a significant positive correlation (p<0.001) of BMI with SBP and DBP. A study done by Jena and Pattnaik also reported a significant positive correlation between BMI and BP (SBP and DBP) in 6–12-year-old school-going children [21]. Similar significant positive correlation has also been suggested by other studies [22,23]. Rosaneli *et al*. found that SBP and DBP were correlated well with BMI, waist circumference, and hip circumference [24]. Sukhonthachit *et al*. also reported that children with HT had higher weight, height, waist circumference, and BMI [25]. Various studies suggested that the key predictors of high BP among children are BMI followed by increasing age, parental history, and sedentary lifestyle [26,27]. There has been evidence that genetic factors account significantly for the correlation observed between BMI and BP [28].

One of the causes of HT is abnormal sodium and fluid balance. In obesity, abnormal kidney function initially is due to increased tubular sodium reabsorption, which causes sodium retention and expansion of extracellular and blood volumes. There are several potential mechanisms that could mediate the sodium retention and HT associated with obesity, including sympathetic nervous system activation, and renin–angiotensin–aldosterone system activation. Thus, the prevention of obesity should be a primary target for reducing the problem of HT [29].

The study had a few limitations. It was inadequately powered due to minimal sample size. A convenient sample size of only 1000 children was considered due to financial and logistic constraints. Other limitations were that the authors measured BMI for obesity and did not consider measurements such as waist–hip ratio and skinfold thickness which measure fat mass.

CONCLUSION

It is recommended that the school health services should include a component of screening of children for the presence of overweight, obesity, and HT. It is important to implement nutritional counseling and similar effective obesity control programs to control obesity which will subsequently prevent HT and related cardiovascular complications in children and eventually in adult population.

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