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Research Article

Study of obesity and hypertension in adolescents and their relationship with anthropometric indices

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ABSTRACT

Background: Childhood obesity and hypertension are on the rise. Obesity leads to many complications like type 2 diabetes mellitus, polycystic ovaries, cancers, etc. Diagnosis of obesity is by various anthropometric indices, some not so accurate. Hence, this warrants intensive studies of these indices in relation with obesity and hypertension. This study was undertaken prevalence of obesity and hypertension in adolescents and its relationship with anthropometric indices and to study the waist-circumference-by-height ratio and its relationship with obesity.
Methods: This prospective, cross-sectional, observational study was conducted in Department of Pediatrics, Dr. Panjabrao Deshmukh Medical College and Hospital, Amravati, Maharashtra, India and data was collected from urban secondary schools of Amravati from 450 adolescents between ages 12-17years, selected randomly, with the help of preformed questionnaires. Anthropometric measurements were taken to calculate BMI, waist circumference and skin-fold thickness and blood pressure taken. Data was analyzed using WHO and teacher-made scales and statistically using contingency coefficient.
Results: Out of 450, prevalence of overweight was 19.1% (86) and obesity was 10.7% (48). Out of 48 obese, 32 were males. Prevalence of obesity was significantly higher among adolescents who had physical activity of ≤3hours/week and who watch TV and/or use computer for >2hours/day. Out of 194 adolescents who had normal BMI, 20 (26.3%) had central obesity. 29 (6.4%) had hypertension, 11 (37.9%) of them were obese.
Conclusions: The prevalence of primary hypertension among adolescents has increased, largely due to the childhood obesity epidemic and thus, steps should be taken to curb both these demons at the earliest. Waist-circumference-to-height ratio should be used more than other indices as it detects central obesity and related cardio-metabolic risk among normal-weighted children.

Keywords: Obesity, Hypertension, Adolescents, Anthropometry

INTRODUCTION

The prevalence of childhood overweight and obesity has increased worldwide in recent decades. Historically, a heavy child meant a healthy child, and the concept "bigger is better" was widely accepted. Today, this perception has drastically changed on the basis of evidence that obesity in childhood is associated with a wide range of serious health complications and an increased risk of premature illness and death later in life.[1] Rising prevalence of obesity in India may be attributed to various factors like sedentary life style, unhealthy food habits, cultural practices and increasing affluence of middle class population.[2]

Prenatal factors, including weight gain during pregnancy, high birth weight, and gestational diabetes, are associated with increased risk for later obesity. Paradoxically, intrauterine growth restriction with early infant catch-up growth is associated with the development of central adiposity and cardiovascular risk.[3]

Since the last few decades, levels of physical activity in children and adults have declined. Changes in the built environment have resulted in more reliance on cars, sedentary work and decreased walking. For children, budgetary constraints and pressure for academic performance have led to less time devoted to physical education in schools. The advent of television, computers, and video games has resulted in opportunities for sedentary activities that do not burn calories or exercise muscles. Changes in sleep patterns, another important health-related behaviour, might also contribute to obesity.[3]

Overweight and obesity are associated with increased risk for many types of cancers, including cancer of the breast, colon, endometrium, oesophagus, kidney, pancreas, gall bladder, thyroid, ovary, cervix, and prostate, as well as multiple myeloma and Hodgkin's lymphoma.[4] Obesity is associated with multiple co-morbidities such as type 2 diabetes mellitus, dyslipidemia, polycystic ovarian disease, hypertension and metabolic syndrome which are increasingly seen among children and urban adolescents.[5,6]

Studies suggest that a substantial percentage of overweight children and adolescents may be afflicted with metabolic syndrome because many have one or more of the following: an elevated triglyceride level, a low HDL cholesterol level, high blood pressure and elevated insulin levels, indicating an increase in insulin resistance.[7,8] Overweight in adolescence is associated with accelerated coronary atherosclerosis.[9]

Irrespective of ethnicity, insulin sensitivity is reduced, while fasting glucose levels are increased in both non-obese and obese children during Tanner stages II–IV of pubertal development.[10] The pancreatic cell may be unable to compensate adequately for the state of increased insulin resistance associated with puberty, and IGT or diabetes may ensue.[11]

Waist circumference (WC) is an easy-to-use, low cost and simple measure of adiposity in epidemiological studies and is an anthropometric indicator strongly associated with as diabetes and dyslipidemias.[12]

Skin fold thickness is a simple means of estimating body composition which is widely used in children but there is little information on its validity. The calliper method is based upon the assumption that the thickness of the subcutaneous fat reflects a constant proportion of the total body fat.

Skin fold thicknesses are more strongly associated with body fatness, as estimated by various reference methods, than is BMI.[13,14]

The waist-to-height ratio (WHtR) is an index developed relatively recently, calculated by dividing the WC by height, both measured in centimetres.[39] In male and female adults, a WHtR value of $\geq$0.5 classifies the individual to be at significantly greater risk of the metabolic syndrome and cardiovascular co-morbidities than a person with a WHtR<0.5.[16,17]

Hypertension is a major health problem in developed and developing countries. The incorporation of blood pressure (BP) measurement into routine pediatric examination has led to the discovery of significant number of children with asymptomatic hypertension.[18] Children with higher BP tend to maintain those levels of BP in adulthood.[19]

The on-going rise in the prevalence of hypertension becomes a common problem in children and adolescents, which is considered to be accompanied with the epidemic of childhood overweight and obesity.[20]

Aims and objectives

1. To study the prevalence of obesity and overweight in school going adolescent children.
2. To study the waist circumference by height ratio of school going adolescent children and its relationship to obesity and overweight.
3. To study the prevalence of hypertension in school going adolescent children and its relationship with anthropometric indices.

METHODS

The sampling was done by stratified random protocol. Keeping in mind the prevalence of obesity in adolescents of urban schools of India and taking 20% as allowable error, sample size of 450 was calculated.[21,22] The sampling population included urban public schools in Amravati. Boys and girls in the age group of 12 to 17 years were included in the study. After identifying the school, class/section was randomly selected, the students fulfilling the study criteria were included in the study. Necessary consent was obtained from the parents/guardians and a set of questions were asked to each student and the answers properly documented in a set proforma. Anthropometric measurements were taken to calculate BMI, waist circumference and skin fold thickness. General examination was conducted to exclude acute or long standing problem in the child. Children with kyphosis, scoliosis or any other physical abnormality were excluded from the study. The instruments required in the study were as follows:

An electronic weighing machine.

Stadiometer.

BP apparatus.

Measuring tape.

Herpenden calliper.

A. *Measurement of weight and height*

All anthropometric measurements were taken by trained investigators. Zero error was set after every 10 measurements. Height was measured in standing position on a stadiometer without any footwear. Weight was measured without any footwear with minimal clothing (school uniform) using a weighing machine (electronic) in standing position.

B. *Measurement of blood pressure*

Blood pressure was measured using a mercury sphygmomanometer. All the children who had BP more than 95th percentile were noted. For those children whose initial BP recording was found to be more than 95th percentile for their age and height, BP was measured again on two different occasions at 6 weeks interval.

C. *Measurement of skin fold thickness*

Triceps skin fold thickness was measured using Herpenden skin calliper.

Triceps skin fold thickness higher than the 95th percentile according to NHANES 1, provided evidence that the child has excess fat rather than increased lean body mass or large frame size.

D. *Measurement of waist circumference*

Waist circumference was measured to the nearest centimetre with a flexible steel tape measure while the subjects were in standing position at the end of gentle expiration. The following anatomical landmarks were used: anteriorly midway between the xiphoid process of the sternum and the umbilicus.

E. *Measurement of waist circumference and height ratio*

Waist to Height (WHtR) ratio was computed as the ratio of the waist circumference (cm) and the height (cm). The waist-height ratio, in principle, is a good measure to represent the waist circumference in relation to another easily measurable body proportion so that distortions based on the body frame size in different populations are removed.

BMI categories

Body mass index (BMI) is a simple index used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m^2).

The WHO definition used was:

BMI greater than or equal to 25 is overweight

BMI greater than or equal to 30 is obesity.

Children were categorized into five groups using WHO-BMI for age percentile charts 2007.

< 3 percentile - severe thinness

>3- ≤15 percentile - thinness

>15-<85 percentile - normal

≥85-<97 percentile - overweight

≥97 percentile - obese

Hypertension

Hypertension is defined as systolic or diastolic BP exceeding the 95th percentile for age, gender and height on at least three separate occasions.

The collected data was analysed and categorized according to aforementioned scales for some and teacher-made scales for the rest of the parameters.

RESULTS

In the present study, total 450 subjects were included, all in adolescents age group between 12 to 17 years and out of which 227 (50.4%) were boys and 223 (49.6%) were girls.

Table 1: Number of adolescents in various BMI categories.

		Gender		Total
		Male	Female	
BMI	≤3 (severe thinness)	30 (13.2%)	27 (12.1%)	57 (12.7%)
	>3-≤15 (thinness)	27 (11.9%)	38 (17.0%)	65 (14.4%)
	>15-<85 (normal)	82 (36.1%)	112 (50.2%)	194 (43.1%)
	≥85-<97 (overweight)	56 (24.7%)	30(13.5%)	86 (19.1%)
	≥97 (obesity)	32 (14.1%)	16 (7.2%)	48 (10.6%)
Total		227 (100%)	223 (100%)	450 (100%)
Contingency coefficient		0.205*		

*Significant at 0.01 level of probability

Table 1 shows number of adolescents in the various BMI categories. Out of 450 adolescents, 86 (19.1%) are overweight and 48 (10.6%) are obese. Among the overweight and obese categories, males represent the maximum population in the study. Data is statistically significant.

Table 2 classifies the adolescents into normal and the obese by using the triceps skin fold thickness assessing tool in the age groups between 12 to 17 years. The age groups 14-<15 years and 15-<16 years represent maximum obese group by using triceps skin fold thickness measurement. Data of all age groups except that of 16 -<17 years is statistically significant.

Table 3 shows the relationship of various categories of BMI percentile with waist circumference by height ratio. The total adolescents with central obesity were 76, out of which 20 (26.3%) were among the normal BMI category, 27 (35.5%) among the overweight group and 28 (38.2%) among the obese group. Data is statistically highly significant.

Table 2: Triceps skin fold thickness in the study population.

Age (years)	Triceps skin fold thickness		Gender		Total	Total
			Male	Female		
12 - <13	TSFT	Normal	23(100%)	9(90%)	32(97%)	0.259*
		Obese	0(0%)	1(10%)	1(3%)	
	Total		23(100%)	10(100%)	33(100%)	
13 - <14	TSFT	Normal	29(96.7%)	21(91.3%)	50(94.3%)	0.114**
		Obese	1(3.3%)	2(8.7%)	3(5.7%)	
	Total		30(100%)	23(100%)	53(100%)	
14 - <15	TSFT	Normal	65(97.0%)	87(91.6%)	152(93.8%)	0.111**
		Obese	2(3.0%)	8(8.4%)	10(6.2%)	
	Total		67 (100%)	95 (100%)	162(100%)	
15 - <16	TSFT	Normal	86(98.9%)	65(94.2%)	151(96.8%)	0.130*
		Obese	1(1.1%)	4(5.8%)	5(3.2%)	
	Total		87(100%)	69(100%)	156(100%)	
16 -<17	TSFT	Normal	18(90%)	24(92.3%)	42(91.3%)	0.041
		Obese	2(10%)	2(7.7%)	4(8.7%)	
	Total		20(100%)	26(100%)	46(100%)	

*Significant at 0.01 level of probability; **Significant at 0.05 level of probability

Table 3: Relationship between BMI categories and waist circumference to height ratio.

		Waist circumference/height ratio (WHtR)		Total
		<0.5 (Normal)	≥0.5 (central obese)	
BMI Percentile	≤3 (severe thinness)	57 (15.2%)	0(0%)	57(12.7%)
	>3≤15(thinness)	65 (17.4%)	0(0%)	65(14.4%)
	>15≤85(normal)	174 (46.5%)	20 (26.3%)	194(43.1%)
	≥85<97(overweight)	59 (15.8%)	27(35.5%)	86(19.1%)
	≥97(obese)	19(5.1%)	29(38.2%)	48(10.7%)
Total		374(100%)	76(100%)	450(100%)
Contingency coefficient		0.441*		

*Significant at 0.01 level of probability

Table 4: Relationship between BMI percentile categories and BP.

		BP		Total
		Normotensive	Hypertensive	
BMI Percentile	≤3 (severe thinness)	56(13.3%)	1(3.4%)	57(12.7%)
	>3≤15(thinness)	63(15.0%)	2(6.9%)	65(14.4%)
	>15≤85(normal)	186(44.2%)	8(27.6%)	194(43.1%)
	≥85<97(overweight)	79(18.8%)	7(24.1%)	86(19.1%)
	≥97(obese)	37(8.8%)	11(37.9%)	48(10.7%)
Total		374(100%)	421(100%)	29(100%)
Contingency coefficient		0.238*		

*Significant at 0.01 level of probability

Table 4 shows number of adolescents lying in normotension and hypertension group among the various BMI categories. Out of hypertension group, 2 (6.9%) lie in the thinness group, 8 (27.6%) among the normal group,

7 (24.1%) among the overweight category and 11 (37.9%) among the obese category. Data is statistically significant.

Table 5 shows age wise distribution of the normotensive and hypertensive group among the adolescents. Out of 29 hypertensives, 1 belongs to the age group 12-<13 years and 13-<14 years each, 6 belong to the age group 14-<15years, 18 belong to the age group 15-<16 years and 3 belong to the age group 16-<17 years. Data is statistically highly significant.

Table 5: Distribution of population according to the BP.

Age (years)			Gender		Total	Contingency Coefficient
			Male	Female		
12 - <13	BP	Normotensive	23(100)%	9(90.0%)	32(97.0%)	0.259*
		Hypertensive	0(0%)	1(10.0%)	1(3.0%)	
	Total		23(100%)	10(100%)	33(100%)	
13 - <14	BP	Normotensive	30(100%)	22(95.7%)	52(98.1%)	0.156*
		Hypertensive	0(0.0%)	1(4.3%)	1(1.9%)	
	Total		30(100%)	23(100%)	53(100%)	
14 - <15	BP	Normotensive	61(91.0%)	95(100%)	156(96.3%)	0.227*
		Hypertensive	6(9.0%)	0(0%)	6(3.7%)	
	Total		67(100%)	95(100%)	162(100%)	
15 - <16	BP	Normotensive	72(82.8%)	6(95.7%)	138(88.5%)	0.197*
		Hypertensive	15(17.2%)	3(4.3%)	18(11.5%)	
	Total		87(100%)	69(100%)	156(100%)	
16 -<17	BP	Normotensive	17(85.0%)	26(100%)	43(93.5%)	0.288*
		Hypertensive	3(15.0%)	0(0%)	3(6.5%)	
	Total		87(100%)	26(100%)	46(100%)	

*Significant at 0.01 level of probability

Table 6: The prevalence of the obesity and overweight among the adolescents in various studies.

	Kumar S et al[62]	Bharati DR et al[83]	Kotian MS et al[66]	Present study
Prevalence of overweight	-	3.1%	9.9%	19.1%
Prevalence of obesity	5.74%	1.2%	4.8%	10.7%

DISCUSSION

Prevalence of overweight and obesity

Prevalence rates were calculated using WHO-BMI for age percentile chart 2007. The prevalence of overweight in the study is 19.1% (86) and obesity is 10.7% (48). Out of 86 overweight adolescents, 56 (65.1%) were males and out of 48 obese children, 32 (66.7%) were males. Thus, in the present study, prevalence of overweight and obesity is higher in males. This could be due to the larger appetite of males and their improper dietary habits.

In a study done by Tharkar S et al, The overall prevalence of overweight was 12.1% among the children and 15.5% among the adolescents.[22] Both overweight (22%) and obesity (13.7%) were highest among girls from affluent families. The prevalence rates were similar but the sex distribution was different from our study.

In a study done by Kumar S et al, to know the prevalence of obesity in two affluent school children, prevalence was 5.74% which is lesser than that found in our study.[23] It was more in girls (8.82%) than boys (4.42%) which was different from our study.

In a study done by Laxmaiah A et al on adolescents the overall prevalence of overweight was 6.1% among boys and 8.2% among girls and 1.6% and 1.0% were obese, respectively, the sex distribution of obesity corresponding to ours.[24]

In a study done by Bharati DR, Deshmukh PR and Garg BS, the prevalence of overweight and obesity was found to be 3.1% and 1.2% respectively, which was much lesser compared to our study.[25]

In a study done by Kotian MS et al, the overall prevalence of overweight among adolescents was 9.9% and obesity was 4.8%.[26] The prevalence of overweight

was 9.3% among boys and 10.5% among girls; 5.2 and 4.3% were obese, respectively. However, the sex distribution in our study was different (Table 6).

Risk factors for overweight and obesity

In the present study, 86 adolescents were overweight and 48 adolescents were obese. The prevalence of obesity is significantly higher (45.8%) among adolescents who had physical activity of ≤3 hours in a week. Adolescents watching TV and/or using computer for >2 hours per day had significantly higher rate of obesity (75%). However, our study did not show a relationship between junk food and obesity.

In a study done by Tharkar S et al, about factors associated with overweight were upper socioeconomic status (P<0.0001) and greater than 2 hours television watching (P<0.0001). The findings are similar to our study.

Kumar S et al, who studied prevalence of obesity, found that increased snacking of high energy foods and lack of physical activity, were the important influencing factors of obesity. These findings of physical activity are similar to our study.

In a study done by Laxmaiah A et al, the prevalence of obesity was significantly higher ($p < 0.05$) among adolescents who watched television ≥3 hours/day (10.4%) whereas it was significantly lower among those participating regularly in outdoor games ≥6 hours/week (3.1%, $p < 0.004$) and household activities ≥3 hours/day (4.7%, $p < 0.001$).

A study done by Kotian MS et al, revealed that the risk of overweight was 21 times higher among those participating for <2 hours/week in any type of physical activity, 7.3 times higher among those who reported watching television and playing games on the computer for ≥4 hours/day, and 5.6 times higher among those who ate chocolates daily in addition to a normal diet, similar to our study.

Waist circumference by height ratio (WHtR) in assessing the status of central obesity

In the present study, the adolescents with WHtR ≥0.5 were classified as having central obesity and adolescents with WHtR<0.5 were considered as normal. Out of 194 adolescents who had normal BMI, 20 (10.31%) adolescents had central obesity.

In a study done by Mokha JS et al, children were classified as normal weight (5^{th} - 85^{th} percentiles) and overweight/obese (≥ 85^{th} percentile).9.2% of the children in the normal weight group was centrally obese (WHtR ≥0.5).

Prevalence of central obesity was almost similar (10.7% vs 9.2%) in our study amongst adolescents with normal BMI.

Results similar to our study were also shown in a study conducted by Panjikkaran ST.[27] They found that only 3.2% of the children were found to be obese using BMI percentiles based methodology whereas 8% of the children were found to be overweight..

Prevalence of hypertension among school going children

In the present study, 29(6.4%) subjects out of the total 450 were found to have hypertension.

Study done by Narayanappa D et al among apparently healthy school children showed an overall prevalence of prehypertension and hypertension was 2.8% and 2.4% respectively, which is much lower compared to our study, probably due to the differences in lifestyle and eating habits in the Southern states of India.[28]

Relationship between overweight and obesity with hypertension in children

In the present study, the relationship between the various BMI categories with hypertension was studied. Out of 29 hypertensives, 7 (24.1%) adolescents belonged to the overweight category and 11 (37.9%) belonged to the obese category. The relationship between the BMI categories and hypertension was statistically significant.

In a study done by Verma M et al, the prevalence of hypertension was 2.8% at the first screening but decreased to 1.3% and 1.1% by 6 and 9 months, respectively. The prevalence of hypertension was much higher in obese as compared to non-obese children (13.7% vs 0.4%). The correlation between obesity and hypertension was statistically significant ($p<0.01$) as found in our study. It is concluded that obesity in childhood has a significant association with hypertension.

A study was conducted by Buch N et al to find the prevalence of hypertension and its associations with various factors.[29] They found that total prevalence of hypertension was 6.48%. Hypertension in males was 6.74% and in females was 6.13%.Prevalence of obesity in hypertension was 8.7% against normotensive 1.1% ($p <0.05$), which was slightly lesser than that found in our study.

A study conducted by Mohan B et al to see the prevalence of sustained hypertension and obesity showed that prevalence of hypertension was about 7.0% and 2.6% amongst urban and rural children.[30] They also found that there was significant increase in prevalence of hypertension with an increased BMI.

CONCLUSION

In the present study, 450 adolescent children between the age group 12 to 17 years were included. Prevalence rates were calculated using WHO-BMI for age percentile chart 2007. The prevalence of overweight in the study was 19.1% (86) and obesity was 10.7% (48) and the prevalence of hypertension was 6.4% (29).

The present findings indicate that prevalence of childhood obesity in Amravati is slightly higher than the incidence reported by other studies. However, the frequency of overweight and obesity was observed to be much higher in boys when compared to girls. Hence, it is a serious problem, which requires immediate attention, creating awareness programs in the schools and parents encouraging their children to be involved in more physical exercises, sports and outdoor activities, thus avoiding the march towards obesity.

The present study tries to understand some of the environmental and personal factors influencing adolescents' health in terms of obesity like lack of physical activity, snacking with high energy foods (junk food) and spending the leisure hours in watching TV or playing computer/ video games, thus explaining the sedentary lifestyle of today's school children.

Although triceps skin fold thickness is a reliable method of measuring body fatness, waist circumference to height ratio should be used more as it not only detects central obesity and related adverse cardio-metabolic risk among normal weight children, but also identifies those without such conditions among the overweight/ obese children.

Central obesity is predominantly higher among girls of both urban and rural schools as compared to boys.

The prevalence of primary hypertension among adolescents has increased, largely due to the childhood obesity epidemic and thus, steps need to be taken to curb both these demons at the earliest.

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