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Obesity in children and adolescents and its relationship with hypertension

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Aim: It is difficult to project the prevalence of obesity and overweight among children in India since there is no nationally representative data from India. We determined the time trends in childhood obesity in a representative sample of schoolchildren from Raichur District, Karnataka and investigated the relationship of obesity with blood pressure.

Materials and methods: We used a stratified random cluster sampling method to select the children. Anthropometric data were collected from 23,842 students, 5-16 years of age, during 2005-06. Blood pressure and anthropometric data were collected from 19,263 students during 2007-08. Overweight and obesity were defined by body mass index for gender and age. Gender, age, and height were considered for determining hypertension.

Results: The rate of overweight children increased from 4.94% of the total students in 2005 to 6.57% in 2007 (OR: 1.36; 95% CI: 1.25-1.47; P < 0.0001). The increase was significant in both boys and girls. The rate of overweight children was significantly higher in urban regions and in private schools, and the rising trend was limited to private schools. Systolic or diastolic incident hypertension was found in 17.34% of overweight children versus 10.1% of the remaining students (OR: 1.87; 95% CI: 1.60-2.17; P < 0.0001).

Conclusion: The present study shows that, childhood obesity showed a rising trend in a period of 2 years. The results put forward the need for greater public awareness and prevention programmes on childhood obesity and hypertension. Hypertension was common in overweight children. Overweight is a rising health problem in children and adolescents in Raichur city.

Key words: Child, adolescents, hypertension, obesity

Introduction

Adolescent obesity is on the rise and is associated in the literature with adverse health effects and with demographic factors that could help focus preventive efforts in the community. Excessive body weight (EBW), including overweight (OW) and obesity (OB), together with hypertension (HA), represents major civilisation threats of the 21st century.

Childhood overweight and obesity are global problems that are on the rise (1). Obesity in children appears to increase the risk of subsequent morbidity, whether or not obesity persists into adulthood (2). Outcomes related to childhood obesity include hypertension, type 2 diabetes mellitus, dyslipidemia, left ventricular hypertrophy, non-alcoholic steatohepatitis, obstructive sleep apnoea, and orthopaedic and psychosocial problems (1-3).

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According to WHO, 22 million children (under 5 years of age) are overweight (4). Obesity is evolving as a major nutritional problem in developing countries, affecting a substantial number of adults and resulting in an increased burden of chronic disease (1). In national surveys conducted in the USA from the 1960s to the 1990s, the prevalence of overweight in children increased from 5% to 11% (5).

Studies on urban Indian schoolchildren from selected regions report a high prevalence of obese and overweight children (6-10). In addition, studies on Indian schoolchildren have also demonstrated that the prevalence of hypertension in overweight children is significantly higher than that among normal children (11-14).

Obesity in childhood is associated with an increased incidence of hypertension, diabetes, coronary artery disease, osteoarthritis, and overall increase in morbidity and mortality during adult life. There is increasing evidence that children and adolescents are overweight; possibly because of decreased physical activities, sedentary lifestyles, altered eating patterns, and increased fat content of the diet (15).

Globally, the prevalence of childhood obesity varies from over 30% in USA to less than 2% in sub-Saharan Africa. The prevalence of obesity in school children is 20% in the UK and Australia, 15.8% in Saudi Arabia, 15.6% in Thailand, 10% in Japan, and 7.8% in Iran (16,17). While trends of increasing obesity in children have clearly shown in the developed world, studies from India are emerging. The present study was planned to evaluate obesity in children in detail.

We aimed to investigate the time trends of childhood obesity and overweight in a large population of schoolchildren from Raichur, Karnataka, over a period of 2 years. The relationship of obesity with childhood hypertension was also explored.

Materials and methods

A contiguous area with a population of approximately 1.67 million was selected from Raichur district, in North Karnataka. In the list of schools obtained from the District Education Office, Raichur, there were 524 schools in the area with a total of 291,203 students. Sampling was carried out by the stratified random cluster sampling method. The primary component of the study necessitated a sample size of 23,000. Schools were stratified into 5 groups according to the number of children and a representative sample of 45 schools with a cumulative population of 25,228 children was randomly chosen. Consent to conduct the school survey and blood pressure measurements of the students were obtained from parents through school authorities who arranged parent meetings in the respective schools. Verbal assent was obtained from the children after demonstrating and explaining the procedure.

Anthropometric data (height and weight) were collected from 23,842 students, 5-16 years of age, during 2005-06. Blood pressure and anthropometric data were collected from 19,263 students, 5-16 years of age, during 2007-08. Children with a body mass index (BMI) >85th percentile of reference data were considered overweight and those with a BMI >95th percentile were considered obese (1). The reference data used to identify the cut-off points were taken from the CDC 2000 dataset for BMI (18). Blood pressure (BP) was measured using the standard methodology as recommended by The Fourth Report on the Diagnosis, Evaluation and Treatment of High Blood Pressure in Children and Adolescents (19). Average systolic or diastolic BP >95th percentile for gender, age, and height was considered as hypertension. Pre-hypertension was defined as average systolic BP or diastolic BP that was >90th percentile but <95th percentile. Children with BP levels >120 mmHg systolic and/or 80 mmHg diastolic were also considered pre-hypertensive (19).

Children from the representative sample were called for screening and were given rest for 5 min. The procedures were explained briefly and demonstrated to them. Those children who were cooperative and relaxed underwent BP measurement. Others were given adequate time to come to terms with the procedures. The BP was measured using a standardized mercury sphygmomanometer and recorded by trained paramedical personnel. BP was measured in a sitting posture with the hands resting on the examining table with the cubital fossa

supported at the level of the heart. Chairs with an appropriate height were used for various groups. The stethoscope was placed over the brachial artery pulse, proximal and medial to the cubital fossa and below the bottom edge of the cuff (i.e. about 2 cm above the cubital fossa). Cuffs having a bladder width approximately 40% of the arm circumference midway between the olecranon and the acromion were used. The BP measurement was performed on the right arm for consistency and comparison with standard tables. Three readings of the BP of each child were taken, maintaining an interval of 2 min between readings. The mean of 3 readings was reported. The weight and height of each child were recorded. Height was measured by a WHO-approved wall-mounted height measuring scale. A calibrated and standardized mechanical weighing scale was used to measure weight.

Results

In 2005, a total of 23,842 children (10,827 boys and 13,015 girls) and in 2007, 19,263 children (9254 boys and 10,009 girls) were examined. The descriptive data of both 2005 and 2007 school surveys are shown in Tables 1 and 2. Overweight (including obesity) was found in 4.54% of the total students in 2005 and 6.17% in 2007. This increase is statistically significant (OR: 1.31; 95% CI: 1.25-1.47; P < 0.0001) and was seen in both sexes (Table 3). A comparison of mean BMI between 2005 and 2007 showed an increase across all age groups. This increasing trend was seen in both boys and girls. The prevalence of overweight was more in the age group of 5-11 years when compared with those in the age group of 12-16 years in 2005 and 2007.

A significantly higher proportion of children from urban schools were obese compared with rural schools both in 2005 and 2007. Both urban and rural schools showed an increasing trend between 2005 and 2007 (Table 4).

The prevalence of incident hypertension in normal weight, overweight, and obese groups was 10.10%, 17.04%, and 18.2%, respectively. In the total sample, children in the age group of 12-

16 years had a higher prevalence of incident hypertension when compared with those in the age group of 5-11 years (13.18% vs. 8.35%). The prevalence of systolic hypertension (first instance) in normal weight, overweight, and obese groups was 5.18%, 12.11%, and 14.06%, respectively. The prevalence of diastolic hypertension (first instance) in normal weight, overweight, and obese groups was

Table 1. Descriptive data of school survey, 2005.

Age (years)	Boys				Girls			
	N	Height (cm)	Weight (kg)	BMI	N	Height (cm)	Weight (kg)	BMI
5	398	109.6 (6.23)	16.8 (2.86)	13.9 (1.38)	324	108.4 (5.33)	16.2 (2.29)	13.7 (1.50)
6	788	115.2 (5.59)	18.8 (3.27)	14.1 (1.68)	697	114.5 (6.04)	18.7 (3.53)	14.2 (1.79)
7	824	120.8 (6.17)	21.1 (4.11)	14.4 (1.88)	639	119.8 (6.08)	20.7 (3.91)	14.3 (1.81)
8	889	125.8 (6.19)	23.2 (4.38)	14.6 (1.84)	648	125.0 (6.42)	23.1 (4.98)	14.7 (2.12)
9	939	131.2 (6.55)	25.9 (5.70)	14.9 (2.20)	1023	130.9 (6.55)	26.0 (5.59)	15.1 (2.31)
10	1185	135.5 (6.75)	28.3 (6.92)	15.3 (2.68	1374	136.3 (7.09)	28.7 (6.33)	15.3 (2.45)
11	1237	140.4 (7.52)	31.0 (7.37)	15.6 (2.67	1530	142.0 (7.47)	32.5 (7.36)	16.0 (2.72)
12	1317	145.7 (7.86)	34.4 (8.13)	16.1 (2.74)	1832	147.8 (7.14)	36.9 (7.95)	16.8 (2.80)
13	1203	152.8 (8.74)	39.7 (9.50)	16.8 (2.93)	1987	151.0 (6.57)	40.0 (7.59)	17.5 (2.73)
14	1172	158.6 (8.58)	44.0 (9.82)	17.3 (2.88)	1781	153.4 (6.05)	42.8 (7.79)	18.2 (2.83)
15	643	162.7 (8.04)	47.7 (9.71)	17.9 (2.80)	873	153.8 (5.80)	43.9 (7.55)	18.5 (2.88)
16	232	164.8 (7.43)	49.0 (9.12)	18.0 (2.56)	307	153.6 (6.17)	44.2 (7.75)	18.7 (2.93)

All values are mean (SD); BMI: body mass index

Table 2. Descriptive data of school survey, 2007.

Age (years)	Boys						Girls					
	N	Height (cm)	Weight (kg)	BMI	SBP	DBP	N	Height (cm)	Weight (kg)	BMI	SBP	DBP
5	166	111.6 (5.63)	17.8 (3.19)	14.2 (1.53)	95.2 (8.15)	61.0 (8.41)	215	110.0 (5.52)	17.2 (2.89)	14.2 (1.57)	94.1 (9.25)	5.92 (9.20)
6	627	116.1 (5.61)	19.5 (3.77)	14.4 (1.85)	96.5 (8.68)	60.9 (8.93)	512	114.8 (5.55)	18.9 (3.36)	14.2 (1.66)	95.9 (8.44)	61.7 (7.97)
7	704	122.0 (5.61)	21.9 (4.71)	14.6 (2.20)	97.7 (8.22)	62.9 (8.75)	559	121.6 (5.73)	21.8 (4.61)	14.6 (2.20)	97.9 (8.35)	63.3 (8.32)
8	746	127.4 (6.26)	24.5 (5.32)	15.0 (2.26)	99.5 (9.09)	64.3 (8.68)	624	126.2 (6.33)	23.8 (4.99)	14.8 (2.16)	98.8 (9.36)	63.7 (8.51)
9	923	132.1 (6.32)	26.8 (5.76)	15.2 (2.32)	100.5 (8.56)	66.0 (8.31)	823	132.3 (6.58)	26.7 (5.69)	15.1 (2.32)	101.5 (9.36)	66.5 (8.38)
10	1002	137.1 (6.48)	29.3 (6.50)	15.4 (2.48)	102.1 (8.67)	67.3 (8.08)	1116	137.6 (7.08)	29.9 (7.10)	15.7 (2.62)	104.4 (9.87)	68.5 (8.17)
11	1108	141.9 (7.24)	32.6 (7.94)	16.1 (2.83)	103.5 (9.60)	68.3 (8.24)	1251	142.8 (7.33)	33.7 (8.01)	16.3 (2.77)	107.3 (10.01)	70.0 (7.85)
12	1021	146.7 (7.87)	35.9 (9.13)	16.5 (2.96)	105.3 (10.00)	68.6 (8.08)	1207	148.6 (6.68)	38.2 (8.07)	17.2 (2.83)	109.8 (10.35)	71.7 (7.62)
13	998	153.7 (8.83)	40.9 (9.71)	17.2 (2.99)	108.0 (11.20)	69.1 (8.67)	1338	152.1 (6.24)	41.5 (7.82)	17.9 (2.84)	112.3 (10.57)	72.6 (7.80)
14	1018	159.8 (8.36)	45.1 (9.60)	17.5 (2.79)	111.0 (11.29)	71.2 (8.25)	1410	154.2 (5.99)	44.0 (8.53)	18.5 (3.08)	113.2 (10.42)	73.3 (7.85)
15	678	164.2 (7.71)	49.3 (10.51)	18.2 (3.05)	113.8 (10.92)	72.8 (8.46)	780	155.3 (6.28)	45.8 (8.39)	19.0 (2.88)	114.4 (10.47)	74.2 (7.94)
16	263	165.9 (7.50)	52.4 (11.42)	18.9 (3.28)	115.1 (11.44)	73.2 (8.20)	174	155.2 (6.58)	46.6 (8.92)	19.3 (3.28)	114.7 (10.87)	74.5 (7.10)

Table 3. Percentages of overweight and obese children in 2005 and 2007.

Dataset	Overweight			Obese		
	Overall	Boys	Girls	Overall	Boys	Girls
2007 (n = 19,263)	6.17	7.03	5.07	1.89	2.47	1.34
2005 (n = 23,842)	4.54	5.18	4.27	1.26	1.65	0.93
Odds ratio	1.31*	1.30	1.28	1.51*	1.51	1.45
95% confidence interval	1.25-1.47	1.24-1.56	1.16-1.46	1.29-1.76	1.24-1.84	1.13-1.85
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.002

Table 4. Percentages and trends of overweight children in urban and rural schools.

Dataset	Urban	Rural	Odds ratio, 95% CI, P value
2007	8.66	3.75	2.43 2.13-2.77, P < 0.0001
2005	6.43	2.91	2.29 2.00-2.62, P < 0.0001
Odds ratio	1.38*	1.30*	
95% CI	1.26-1.52	1.11-1.53	
P value	P < 0.0001	P < 0.005	

* Odds ratio adjusted for gender and age CI confidence interval

6.15%, 8.75%, and 8.2%, respectively. The sex-wise differences in various blood pressures among the 3 weight groups are given in Table 5.

Discussion

During a short span of 2 years, the proportion of overweight children increased significantly in all age groups and in both sexes. This was accompanied by an increasing trend in mean BMI values across all age groups. Even though urban schools had a higher proportion of overweight children, both urban and rural schools showed an increasing trend in the 2-year period. This speedy increase in a short span of 2 years indicates a substantial epidemiological importance.

Even if the prevalence values of childhood obesity in this study are lower than those of other studies from similar settings (6-10), the increasing trend of overweight and obesity in our study was significant. A high BMI correlates strongly with markers of secondary complications of obesity including current blood pressures (20-22) and blood lipid and lipoprotein levels (20,23-25). Hypertension in obese children is highly prevalent and is associated with a hyperkinetic hemodynamic state, as evidenced by increased resting HR and increased ambulatory BP variability (26).

Results of several national health surveys in Asia point to significant differences in prevalence of overweight and obesity among countries (27-31). Asian countries, such as Taiwan and China, have experienced rapid increases in prevalence of childhood obesity (32,33). Rapid economic growth has improved the nutritional, socioeconomic, and health status of many countries (31). In addition to the nutritional and socioeconomic transitions, the behavioural transition of children is also possibly contributing significantly to the rapidly rising prevalence of obesity, and unhealthy eating habits and physical inactivity are the major culprits (34). The sedentary lifestyle of children and adolescents have been attributed mainly to television watching, computer games, internet, over-emphasis on academic excellence, unscientific urban planning and ever-increasing automated transport; the difference in prevalence and trends of overweight between rural and urban schools are based on these factors. However, it is interesting that there was an upward trend noticeable in rural schools as well.

The prevalence of overweight and obesity among pre-school children in semi-urban South India is 4.5% and 1.4%, respectively (35). The prevalence of hypertension in normal weight children in our study was 10.1%. This phenomenon of low prevalence of hypertension on subsequent readings has been demonstrated previously. Sorof et al. (36) documented first instance hypertension as 19%, second instance as 9.5%, and third instance (persistent) as 4.5%.

Hypertension was seen in significantly higher percentages among overweight children compared with normal children (17.34% vs. 10.1%). This relationship has been reported by other studies as well (11,37-42). Irrespective of race, gender, or age, the risk of elevated BP was significantly higher for children in the upper compared with the lower decile of BMI, with an odds ratio of systolic hypertension ranging from 2.5 to 3.7. Freedman et al. (40) reported that overweight children in the Bogalusa heart study were 4.5 and 2.4 times as likely to have elevated

Table 5. Percentages of different forms of hypertension in children with regards to gender and weight group.

	Normal			Overweight			Obese		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
Hypertension	6.76	13.15	10.10	12.31	23.18	17.04	14.94	24.11	18.2
Systolic hypertension	2.82	7.72	5.18	7.97	17.34	12.11	10.79	21.28	14.06
Systolic pre-hypertension	8.76	11.62	10.25	16.50	16.21	16.37	18.67	23.40	20.42
Diastolic hypertension	4.74	8.02	6.15	6.85	11.18	8.75	7.88	10.64	8.2
Diastolic pre-hypertension	12.16	16.46	14.40	17.20	22.37	19.59	17.84	26.24	20.94

systolic BP and diastolic BP, respectively. Similar trends have also been reported in different studies from India (11-14). Data suggest that higher BMI is associated with higher values of SBP and DBP. Children and adolescents in the upper quartile of BMI are 1.5 times as likely to have at least 1 risk factor (43).

The obesity is directly related to the incidence of hypertension, type 2 diabetes, and hypercholesterolemia, as mentioned in prospective studies in Asia (28). According to WHO, chronic diseases are the major causes of death in almost all countries including those in Asia (4). It is estimated that 70% of these deaths will occur in developing Asian nations, such as China, India, Pakistan, Cambodia, and Vietnam. Cardiovascular diseases are responsible for the major share of these deaths due to chronic diseases (4). South Asians emerge to have worse cardiovascular disease risk profiles compared with Caucasian populations with similar BMI levels (28). Small increases in BMI may translate into a substantial increase in the burden of cardiovascular diseases. Therefore, the trends reported here are alarming even though the overall proportion of obesity and overweight children is far lower than that reported in other studies (44). Overweight is an emerging health problem in adolescent girls belonging to affluent families in Bangalore city and the prevalence of overweight and obesity in affluent adolescent school girls was seen in 13.1% and 4.3%, respectively.

While about 50% of the adults are overweight and obese in many countries, it is difficult to reduce excessive weight once it becomes established. Children should therefore be considered as the priority population for intervention strategies. Prevention may be achieved through a variety of interventions targeting built environment, physical activity, and diet. Some of these potential strategies for intervention in children can be implemented by targeting preschool institutions, schools or after-school care services as these are natural settings for influencing diet and physical activity. All in all, there is an urgent need to initiate prevention and treatment of obesity in children (45).

Even though the findings reported here is alarming, it provides an excellent opportunity for prevention of cardiovascular diseases by means of lifestyle interventions targeted at childhood and adolescent populations, thereby attempting to reduce morbidity and mortality arising from these diseases in the future.

Limitations of the study

Application of international reference standards of BMI and hypertension in an Indian setting may have limitations. We measured incident hypertension; hypertension can only be confirmed after a minimum of 3 separate BP measurements demonstrating high BP. As BP was measured in the field, an element of anxiety and apprehension might have affected a subset of children in our study.

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