Original Article

A Study of Growth Parameters and Prevalence of Overweight and Obesity in School Children from Delhi

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Objectives: *(1) To assess the height, weight and body mass index (BMI) of school children from Delhi and generate percentile charts as appropriate for age, gender and socio-economic status. (2) To determine the prevalence of overweight and obesity in school children from low and upper socioeconomic status (LSES and USES respectively).* ***Design:*** *Cross sectional evaluation of anthropometric parameters in Delhi school children (5-18 years) from different geographical zones.* ***Setting:*** *Government schools (non-fee paying) and Private Schools (fee paying) in Delhi.* ***Subjects:*** *21485 children, 8840 (3566 boys, 5274 girls) from government schools and 12645 (6197 boys, 6448 girls) from private schools. Methods: Subjects underwent assessment of height and weight and calculation of BMI. Children were classified as normal, overweight and obese as per IOTF guidelines. Height, weight and BMI percentile charts specific for the socioeconomic status were generated using the LMS method. Prevalence of overweight and obesity was assessed and compared between the two socio-economic groups.* ***Results:*** *A significant difference was noted in height, weight and BMI between LSES and USES. The prevalence of overweight and obesity in USES children was 16.75% and 5.59% in boys and 19.01% and 5.03% in girls respectively.* ***Conclusions:*** *There is a significant disparity in anthropometric parameters between children from USES and LSES, with a high prevalence of overweight and obesity in USES children.*

Key words: *BMI, Obesity, Overweight, School children, Socioeconomic groups.*

OVER the last few decades, children worldwide have become taller, and in some countries also significantly heavier(1). There has been an increase in the percentage of overweight and obese children in affluent urban families of India in the past decade(2). Evaluation of obesity in children is important as it provides an opportunity to identify the problem and prevent disease progression into adulthood. In developed societies, several studies have shown increasing number of over weight children. Approximately 14-15% of all 15 year olds in USA can be classified obese(3).

Childhood obesity is associated with several risk factors for later heart disease and other chronic diseases including dyslipidemia, hyperinsulinemia, and hypertension. The ideal definition based on percentage body fat is impracticable for epidemiological use. BMI is widely used in adult population to define obesity and a cut off point of 30 kg/m^2 is

recognized internationally as a definition of adult obesity and 25 kg/m^2 as a cut off for overweight. BMI in childhood changes substantially with age. Hence, cutoff points related to age would better define child obesity. To have an absolute and internationally relevant definition of child over weight and obesity, Cole, *et al.* developed age and sex specific cutoff lines from data derived from six countries (India not included) across several continents using BMI. These charts extrapolate risks from adult experience to children. These cut off points are recommended for use in international comparisons of prevalence of over weight and obesity(4).

There has been a trend towards increasing prevalence of overweight and obesity among developing countries. The data on prevalence of childhood obesity from India, which is also undergoing an epidemiological transition, is scant. In view of this, the study was planned to assess the growth parameters and prevalence of overweight and obesity in Delhi school children.

Subjects and Methods

School children from both sexes in the age group of 5-18 years, belonging to Government and Private Schools, located in four different geographical zones in Delhi were studied. At least one government and one private school were studied from each zone. The children attending Government schools were considered to represent the LSES, while those attending Private schools were considered representative of the USES. Of the above 21485 subjects, 8840 (3566 boys, 5274 girls) belonged to LSES group, and 12645 (6197 boys, 6448 girls) made up the USES group. The subjects were further grouped into one-yearly age groups. Since the number of USES students in the age group of 18 years was small, all the comparative analysis between the two socio-economic groups has been restricted to the age group 5-17 years.

The study protocol was approved by the institutional ethics committee of Institute of Nuclear Medicine and Allied Sciences (INMAS). A prior consent for the study was taken from the school administration and from the parents. At the time of initiating the study the parents of each participant were informed about the study protocol and gave written consent to their children's participation.

This entire cohort of 21485 children and adolescents underwent assessment of height and weight and calculation of BMI. Height was measured to the nearest 0.1 cm using a stadiometer with the subject standing straight with head held in Frankfurt horizontal plane. Subject's weight, without shoes and with light clothes on was measured to the nearest 0.1 kg, using an electronic scale. Height and weight measurements were taken twice and the mean of two measurements was used to calculate BMI, which was defined as the ratio of body weight to body height squared, expressed in kg/m^2. Every morning, the scale and stadiometer were calibrated with standard weight and height respectively.

The cut off values of BMI, at each age and for each gender obtained by Cole, *et al.*(4) were used to classify children as Normal, Overweight and Obese. Prevalence of overweight and obesity was assessed for LSES and USES at each age group and for both sexes. Finally, a comparison of the prevalence of overweight and obesity in LSES and USES was done for each age group for both sexes.

Data was recorded on a pre-designed proforma. Height, weight and BMI percentile charts specific for the socioeconomic status were generated using the LMS method(5). The LMS method is used to obtain standardized and smoothed centile curves. The need for which

arises when the measurement is strongly dependent on some covariate, for instance age, so that the reference range changes with the covariate. This method summarizes the data in terms of three smooth age specific curves, called L, M and S. The M and S curves correspond to the median and coefficient of variation for the variable at age, whereas L curve allows for substantial age dependent skewness of the variable. Currently, this is the recommended method for establishing percentiles. Descriptive statistics for anthropometric variables were computed by mean and standard deviation. To see the significant difference between two groups of continuous variables student *t*-test (unpaired) was applied. Analysis was performed using intercooled STATA 8.0 (College station, TX 77845, USA) statistical software. P value <0.05 was considered statistically significant.

Results

A total of 21485 children in the age group 5 to 18 years were evaluated for height, weight and BMI. These included 12645 (6197 boys, 6448 girls) from the USES and 8840 (3566 boys, 5274 girls) from the LSES.

Percentile charts for height, weight and BMI were constructed separately for USES and LSES children. These charts depicted the 3rd, 25th, 50th, 75th, and 97th percentile for height and weight. *Tables I & II* depict the percentiles for height for boys and girls for both socioeconomic groups. Children from LSES were significantly shorter compared to those belonging to USES. This difference is seen for each age category, across all the percentile values and for both the sexes.

Tables III & IV depict the percentiles for weight for boys and girls for both socioeconomic groups. Children from LSES weighed significantly less compared to those from USES. Once again, this difference was seen in both sexes, in all age groups and across all percentile values.

TABLE I–*Percentile of Height Distribution of Boys (5-17 yr)*

	3		25		50		75		97	
Age	LSES	USES	LSES	USES	LSES	USES	LSES	USES	LSES	USES
5	98.7	104.0	105.0	110.3	109.1	113.9	112.8	116.8	124.3	124.6
6	102.6	108.1	109.3	114.7	113.6	118.5	117.4	121.5	129.1	129.8
7	106.5	112.3	113.5	119.2	118.1	123.3	122.0	126.5	134.0	135.2
8	110.5	116.8	118.0	124.0	122.7	128.3	126.8	131.7	139.0	141.0
9	114.7	121.3	122.6	129.0	127.6	133.4	131.7	137.1	144.2	146.9
10	119.2	126.0	127.5	134.1	132.6	138.8	137.0	142.6	149.6	152.9
11	124.0	130.9	132.8	139.5	138.2	144.5	142.6	148.4	155.3	159.1
12	129.3	136.1	138.5	145.3	144.1	150.5	148.6	154.6	161.1	165.4
13	134.7	141.4	144.4	151.2	150.1	156.5	154.6	160.7	166.6	171.4
14	140.1	146.5	150.1	156.6	155.7	162.0	160.1	166.2	171.4	176.5
15	145.0	151.0	155.0	161.2	160.4	166.6	164.6	170.6	174.9	180.3
16	149.2	154.9	158.9	164.9	164.0	170.1	167.8	173.9	177.1	83.0
17	152.8	158.4	161.9	168.1	166.6	173.0	170.0	176.5	178.3	185.1

TABLE II–*Percentile of Height Distribution of Girls (5-17 yr)*

	3		25		50		75		97	
Age	LSES	USES	LSES	USES	LSES	USES	LSES	USES	LSES	USES
5	95.7	102.6	102.4	107.6	106.8	111.3	110.6	114.4	122.7	123.2
6	100.0	107.3	107.2	112.6	111.8	116.5	115.7	119.7	127.2	128.7
7	104.4	112.1	112.1	117.8	116.8	121.9	120.7	125.2	131.8	134.3
8	109.0	117.2	117.2	123.2	122.1	127.5	126.0	130.9	136.7	140.2
9	113.8	122.5	122.5	128.9	127.4	133.4	131.3	136.9	141.6	146.2
10	118.8	128.1	127.8	134.8	132.8	139.4	136.7	143.0	146.6	152.3
11	124.0	133.6	133.1	140.5	138.1	145.2	141.9	148.8	151.5	157.9
12	129.0	138.5	138.1	145.5	143.0	150.1	146.7	153.7	155.9	162.5
13	133.4	142.4	142.3	149.2	146.9	153.7	150.5	157.1	159.3	165.7
14	136.9	145.2	145.2	151.7	149.6	156.0	153.0	159.3	161.3	167.4
15	139.4	147.0	147.1	153.2	151.3	157.3	154.4	160.4	162.3	168.2
16	141.1	148.2	148.3	154.1	152.2	158.0	155.2	160.9	162.6	168.3
17	142.3	149.2	149.0	154.7	152.6	158.4	155.4	161.2	162.3	168.1

Tables V & VI depict the percentiles for BMI for boys and girls from both socioeconomic strata. The BMI percentiles for children from LSES, were significantly lower than those from USES across all age groups and for both sexes.

Children from both socioeconomic groups were categorized on the basis of BMI into normal, overweight and obese, as per the cut-offs provided by Cole, *et al.*(4). The age wise prevalence of normal, overweight and obese boys and girls from LSES and USES is shown in *Tables VII* and *VIII* respectively.

The overall prevalence of overweight and obesity among the LSES school boys was 2.66% and 0.42% respectively, while that among boys from USES was significantly higher at 16.75% and 5.59 % respectively ($P < 0.05$). Similarly, the prevalence of overweight and obesity among the LSES school girls was 2.14% and 0.28% as compared to 19.01% and 5.73% respectively among girls from USES ($P < 0.05$). Children as young as 5 years of age started showing an increase in BMI, with 9% being overweight and 8% obese in this age group. Among the different age groups, 11-13 years old USES boys (19.5% overweight) and 9-11 year old USES girls (20-23%) showed higher prevalence of overweight compared to other age groups.

To summarize, children from USES were significantly taller and heavier and consequently had a significantly higher BMI compared with their age matched counterparts from LSES. A higher prevalence of overweight and obesity were seen in USES, starting as early as 5 years of age.

Discussion

There has been a trend toward increasing prevalence of obesity as well as its metabolic complications in developing countries. India is in the midst of an escalating 'epidemic' of Type 2 Diabetes and Coronary Heart Disease

TABLE III–*Percentile of Weight Distribution of Boys (5-17 yr)*

	3		25		50		75		97	
Age	LSES	USES	LSES	USES	LSES	USES	LSES	USES	LSES	USES
5	12.1	14.4	15.0	17.2	16.9	19.4	18.5	21.5	23.3	30.5
6	13.1	15.7	16.2	19.0	18.3	21.4	20.1	23.9	25.7	34.2
7	14.2	17.2	17.6	20.9	19.9	23.8	21.9	26.6	28.4	38.4
8	15.4	18.9	19.1	23.2	21.7	26.6	24.0	29.9	31.6	43.2
9	16.9	20.8	20.9	25.8	23.8	29.7	26.4	33.5	35.2	48.5
10	18.5	22.8	23.0	28.7	26.1	33.1	29.1	37.4	39.2	54.2
11	20.4	25.1	25.4	31.9	28.9	37.0	32.2	41.8	43.4	60.2
12	22.7	27.8	28.3	35.5	32.2	41.2	35.8	46.7	48.1	66.7
13	25.4	30.8	31.7	39.5	36.1	45.9	40.0	51.9	53.2	73.5
14	28.6	34.0	35.6	43.6	40.3	50.6	44.6	57.1	58.5	80.2
15	32.1	37.4	39.5	47.7	44.6	55.1	49.0	62.1	63.5	86.3
16	35.4	40.6	43.2	51.5	48.4	59.3	53.1	66.6	67.7	91.8
17	38.6	43.8	46.6	55.2	51.9	63.3	56.6	70.8	71.2	96.7

TABLE IV–*Percentile of Weight Distribution of Girls (5-17 yr)*

	3		25		50		75		97	
Age	LSES	USES	LSES	USES	LSES	USES	LSES	USES	LSES	USES
5	10.6	13.7	13.7	16.5	15.7	18.7	17.3	20.8	22.2	29.2
6	11.7	15.1	15.1	18.4	17.2	21.0	19.1	23.4	24.6	33.1
7	12.9	16.6	16.6	20.5	19.0	23.5	21.0	26.3	27.2	37.3
8	14.4	18.4	18.3	23.0	21.0	26.5	23.3	29.8	30.4	42.1
9	16.1	20.5	20.4	25.9	23.3	29.9	25.9	33.7	34.0	47.4
10	18.1	23.0	22.8	29.3	26.0	33.9	28.9	38.2	37.9	53.5
11	20.4	25.8	25.6	33.0	29.2	38.2	32.3	43.1	42.2	60.0
12	23.0	28.9	28.8	36.8	32.7	42.5	36.1	47.8	46.7	66.2
13	25.5	31.8	31.9	40.2	36.1	46.3	39.7	51.9	50.8	71.6
14	27.6	34.5	34.5	43.1	38.9	49.4	42.7	55.2	54.0	75.6
15	29.2	36.7	36.4	45.5	40.9	51.8	44.8	57.6	56.1	78.4
16	30.4	38.7	37.7	47.4	42.4	53.6	46.2	59.4	57.4	80.2
17	31.4	40.6	38.9	49.0	43.5	55.2	47.4	60.9	58.4	81.4

TABLE V–*Percentile of BMI Distribution of Boys (5-17 yr)*

	3		25		50		75		97	
Age	LSES	USES	LSES	USES	LSES	USES	LSES	USES	LSES	USES
5	10.5	12.2	12.4	13.8	13.4	14.9	14.4	16.4	16.2	20.6
6	10.8	12.4	12.7	14.1	13.8	15.3	14.9	17.0	16.8	21.6
7	11.1	12.5	13.1	14.3	14.2	15.7	15.3	17.5	17.5	22.6
8	11.4	12.8	13.4	14.7	14.6	16.1	15.8	18.0	18.2	23.6
9	11.7	13.0	13.7	15.0	14.9	16.6	16.3	18.7	19.0	24.7
10	12.0	13.2	14.0	15.4	15.3	17.1	16.7	19.3	19.7	25.7
11	12.3	13.5	14.3	15.8	15.7	17.6	17.2	19.9	20.3	26.6
12	12.6	13.7	14.7	16.2	16.1	18.1	17.6	20.6	20.9	27.4
13	12.9	14.0	15.0	16.7	16.4	18.7	18.0	21.2	21.5	28.2
14	13.4	14.4	15.4	17.2	16.8	19.3	18.4	21.9	22.1	29.1
15	14.0	14.8	15.9	17.7	17.2	19.9	18.8	22.6	22.7	30.0
16	14.5	15.1	16.3	18.2	17.6	20.4	19.2	23.3	23.5	30.8
17	15.0	15.5	16.7	18.6	18.0	21.0	19.6	23.9	24.3	31.6

TABLE VI–*Percentile of BMI Distribution of Girls (5-17 yr)*

	3		25		50		75		97	
Age	LSES	USES	LSES	USES	LSES	USES	LSES	USES	LSES	USES
5	9.4	11.8	11.6	13.6	12.8	14.9	14.0	16.5	16.1	21.0
6	9.9	12.1	12.1	14.0	13.3	15.4	14.6	17.1	16.8	21.7
7	10.4	12.4	12.5	14.4	13.8	15.9	15.1	17.7	17.6	22.5
8	10.9	12.7	13.0	14.8	14.3	16.4	15.6	18.3	18.3	23.3
9	11.4	13.0	13.4	15.3	14.7	16.9	16.2	19.0	19.1	24.2
10	11.8	13.3	13.9	15.8	15.2	17.5	16.8	19.7	20.0	25.1
11	12.2	13.7	14.3	16.3	15.7	18.2	17.3	20.5	20.7	26.1
12	12.5	14.1	14.7	16.8	16.2	18.8	17.9	21.3	21.5	27.3
13	12.8	14.5	15.1	17.4	16.7	19.5	18.4	22.1	22.1	28.5
14	13.0	14.9	15.5	18.0	17.2	20.2	19.0	22.9	22.8	29.8
15	13.2	15.4	15.9	18.6	17.7	20.9	19.6	23.8	23.5	31.2
16	13.4	15.8	16.3	19.1	18.2	21.6	20.2	24.6	24.1	32.7
17	13.6	16.2	16.7	19.7	18.6	22.2	20.7	25.5	24.8	34.1

TABLE VII–*Prevalence of Normal, Overweight and Obese Boys from LSES and USES for Ages 5-18 years*

Age (yrs)	LSES boys (n =3566)				USES boys (n = 6197)				P value
	N	Normal N(%)	Over wt N(%)	Obese N(%)	N	Normal N(%)	Over wt N(%)	Obese N(%)	
5	118	115 (97.5)	3 (2.5)	–	70	60 (85.7)	6 (8.6)	4 (5.7)	0.003
6	155	155 (100)	–	–	423	353 (83.4)	41 (9.7)	29 (6.8)	<0.0001
7	185	181 (97.8)	3 (1.7)	1 (0.5)	594	481 (81)	75 (12.6)	38 (6.4)	<0.0001
8	266	260 (97.7)	6 (2.3)	–	699	536 (76.7)	102 (14.6)	61 (8.7)	<0.0001
9	181	173 (95.6)	6 (3.3)	2 (1.1)	597	450 (75.4)	106 (17.7)	41 (6.9)	<0.0001
10	255	240 (94.1)	10 (3.9)	5 (1.9)	604	456 (75.5)	113 (18.7)	35 (5.8)	<0.0001
11	208	202 (97.1)	6 (2.9)	–	573	438 (76.4)	112 (19.5)	23 (4.0)	<0.0001
12	303	292 (96.4)	11 (3.6)	–	609	464 (76.2)	118 (19.4)	27 (4.4)	<0.0001
13	371	363 (97.8)	8 (2.2)	–	579	445 (76.9)	113 (19.5)	21 (3.6)	<0.0001
14	386	378 (97.9)	10 (2.6)	–	547	424 (77.5)	102 (18.6)	21 (3.8)	<0.0001
15	394	388 (98.4)	3 (0.8)	3 (0.8)	379	296 (74.5)	62 (16.3)	21 (5.5)	<0.0001
16	370	354 (95.7)	14 (3.8)	2 (0.5)	279	212 (76)	51 (18.3)	16 (5.7)	<0.0001
17	251	236 (94.0)	13 (5.2)	2 (0.8)	213	173 (81.2)	32 (15.0)	8 (3.7)	<0.0001
18	123	121 (98.4)	2 (1.6)	–	31	25 (80.6)	3 (9.7)	3 (9.7)	0.001

TABLE VIII–*Prevalence of Normal, Overweight and Obese Girls from LSES and USES for Ages 5-18 years*

Age (yrs)	LSES boys (n =3566)				USES boys (n = 6197)				P value
	N	Normal N(%)	Over wt N(%)	Obese N(%)	N	Normal N(%)	Over wt N(%)	Obese N(%)	
5	69	67 (97.1)	2 (2.9)	–	84	72 (85.7)	8 (9.5)	4 (4.8)	0.034
6	151	148 (98.0)	1 (0.7)	2 (1.3)	453	355 (78.4)	62 (13.7)	36 (7.9)	<0.0001
7	156	156 (100)	–	–	578	440 (76.1)	100 (17.3)	38 (6.6)	<0.0001
8	229	225 (98.2)	4 (1.8)	–	683	494 (72.3)	128 (18.7)	61 (8.9)	<0.0001
9	200	192 (96.0)	8 (4.0)	–	593	441 (74.4)	121 (20.4)	31 (5.2)	<0.0001
10	341	333 (97.6)	6 (1.8)	2 (0.6)	616	462 (75.0)	128 (20.8)	26 (4.2)	<0.0001
11	417	411 (98.6)	3 (0.7)	3 (0.7)	560	409 (73.0)	129 (23.0)	22 (3.9)	<0.0001
12	705	680 (96.6)	23 (3.3)	2 (0.3)	596	446 (74.8)	113 (18.9)	37 (6.2)	<0.0001
13	755	740 (98.0)	14 (1.8)	1 (0.1)	594	449 (75.6)	118 (19.9)	27 (4.5)	<0.0001
14	761	740 (97.2)	20 (2.6)	1 (0.1)	521	396 (76.0)	99 (19.0)	26 (5.0)	<0.0001
15	558	540 (96.8)	16 (2.9)	2 (0.3)	472	356 (75.4)	94 (19.9)	22 (4.7)	<0.0001
16	493	477 (96.7)	15 (3.0)	1 (0.2)	478	360 (75.3)	89 (18.6)	29 (6.1)	<0.0001
17	332	322 (97.0)	9 (2.7)	1 (0.3)	208	163 (78.4)	35 (16.8)	10 (4.8)	<0.0001
18	107	101 (94.4)	6 (5.6)	–	12	11 (91.7)	1 (8.3)	–	0.535

(CHD). It is now emerging convincingly that the genesis of these disorders begins in childhood, with childhood obesity serving as an important factor. In recent years, Type 2 diabetes is beginning to emerge even in children(6,7).

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 in detail, the complete spectrum of childhood obesity and compare the prevalence in two different socio-economic strata.

Two earlier large nation wide surveys have been conducted in India to assess growth parameters: ICMR survey from 1956-1965(8); and Agarwal, *et al.* 1992(9). While the ICMR study largely recruited from LSES, the Agarwal charts represented children from USES.

Our study is the first one, which aims to give updated and separate percentile charts of height and weight for LSES and USES children. These charts clearly show a secular trend when compared to ICMR charts and Agarwal charts at each age group and for various percentiles. On comparing the ICMR charts (all India data) to our LSES group, we find that children today are taller and heavier compared to their counterparts 50 years ago. Similarly, on comparing our data with the height and weight percentiles of Delhi children reported in the Agarwal study, we found that USES children today are already taller and heavier than their counterparts were 15 years ago. It is important to mention here, that the statistical method used by Agarwal, *et al.* for smoothening their percentile curves (cubic spline method) was different from that adopted by us (LMS method). In contrast, a recent study of middle-income school children from North Kolkata, showed a declining trend for BMI compared with age matched affluent Indian school children, who were evaluated a decade earlier(10).

This study also brings out clearly the significant difference in percentiles of height, weight and BMI in children from different socioeconomic strata at all ages and in both genders. This significant disparity in anthropometric parameters between the two socio-economic strata highlights the difficulty in creating one set of national norms.

The other main aim of this study was to highlight the growing problem of childhood and adolescent obesity. Literature is replete with information on the increasing prevalence of obesity in the developed world. The National Health and Nutrition Examination Survey (NHANES) data in United States clearly shows the epidemic proportion of this problem(3). As per 1999-2000 NHANES data, 30.3% of children (ages 6 to 11) exceeded 85th percentile of weight for age charts (comparable to the overweight category in the current study). This included 15.3 % children who were more than the 95th percentile of these charts (comparable to the obese group in the current study). For adolescents (ages 12 to 19), 30.4% were overweight, of which 15.5 % were obese. The prevalence of obesity quadrupled over 25 years in children aged 6-11 years, while it doubled over the same period among adolescents.

The data from India on this important issue are meager. Our study found that the prevalence of over weight and obese among children from USES was significantly higher than those from the LSES. In a study from Chennai(2), Ramachandran, *et al.* reported that 17.8% boys and 15.8% girls were overweight, while obesity was reported in 3.6% boys and 2.7% girls. Prevalence of overweight in low, middle and high socioeconomic group was 4.2%, 13.9% and 23.5% respectively for boys

and 5.0%, 17.6% and 21.5% respectively for girls. In children from the same age category (13-18years) in our study, the prevalence of overweight in LSES and USES is 2.7% and 17.9% for boys and is 2.7% and 19.1% for girls respectively, which is similar to data reported by Ramachandran *et al.*

The study by Subramanyam, *et al.*(11) evaluating the prevalence of overweight and obesity in affluent girls aged 10- 15 years in Chennai revealed a prevalence of 9.6% and 6.2% respectively in 1998 using 85th and 95th percentiles of BMI as cut off. In the present study, in a comparable age group, the prevalence of overweight and obesity in USES is 20.27 and 4.76% respectively. However, the use of different criteria to establish the diagnosis of overweight and obesity makes it difficult to compare these two studies.

Two other studies from India have evaluated prevalence of obesity among affluent school children using cut-offs proposed by Cole, *et al.* In a study from a single school from Delhi(12), the prevalence of obesity was 8% for boys and 6% for girls, compared to 4.6% and 4.9% for boys and girls from the same age group in the present study. The difference observed could be because Kapil, *et al*.(12) have evaluated a smaller sample size and that too from a single school. In the second study from Pune(13), the overweight and obesity prevalence in boys aged 10-15 years was 19.9% and 5.75% respectively which is comparable to our data. The above studies suggest that there is a significant problem of childhood overweight and obesity in urban India.

Another feature this study highlights is higher prevalence of overweight in girls compared to boys. Prevalence of overweight among USES schoolgirls was significantly higher at 19.01% compared to 16.75% for USES schoolboys. A higher prevalence of overweight among girls has also been reported by earlier studies from Chennai and Delhi (2, 12).

Another significant point brought out by our study is the fact that overweight and obesity start manifesting as early as 5 years of age. At the time of entry to school at 5 years about 9% of boys and girls were overweight and about 5% were obese. These data suggest that any intervention planned to combat the menace of obesity in childhood should begin very early in life.

Assessment of changing prevalence of overweight and obesity in India is difficult in view of lack of comparable data and cutoff guidelines to describe overweight and obesity. However, if we compare with NHANES data, India today stands comparable to United States NHANES II, 1976-1980) when the prevalence of obese in USA was 6.5% for children aged 5-11 years and 5% for children aged 12-19 years.

In conclusion, there is a significant disparity in anthropometric parameters of children belonging to the upper and lower socio-economic strata, with USES children being significantly taller and heavier. This precludes any attempt to create one set of national norms. There is a high prevalence of overweight and obesity in children from the upper socio-economic strata, starting from as early as 5 years of age. These data indicate the urgent need to tackle the burgeoning prevalence of childhood obesity with a concerted national effort.

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REFERENCES

1. Lobstein T, Baur L, Uauy R for the IASO International Obesity Task Force. Obesity in children and young people: a crisis in public health. Obes Rev 2004; 5 (Suppl 1): 4-85.
2. Ramachandran A, Snehalatha C, Vinitha R, Thayyil M, Kumar CK, Sheeba L, *et al*. Prevalence of overweight in urban Indian adolescent school children. Diabetes Res Clin Pract 2002; 57: 185-190.
3. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. JAMA 2002; 288: 1728-1732.
4. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. BMJ 2000; 320:1240-1243.
5. Cole TJ. The LMS method for constructing normalized growth standards. Eur J Clin Nutr 1990; 44: 45-60.
6. Sinha R, Fisch G, Teague B, Tamborlane WV, Banyas B, Allen K, *et al*. Prevalence of impaired glucose tolerance among children and adolescents with marked obesity. N Eng J Med 2002; 346: 802-810.
7. Vikram NK, Tandon N, Misra A, Srivastava MC, Pande RM, Mithal A, *et al*. Correlates of type 2 diabetes mellitus in children, adolescents, and young adults in north India: A multisite collaborative case-control study. Diabet Med. 2006; 23: 293-298.
8. Growth and physical development of Indian infants and children. Technical Report Series No. 18, New Delhi. ICMR; 1989.
9. Agarwal DK, Agarwal KN, Upadhyay SK, Mittal R, Prakash R, Rai S. Physical and sexual growth pattern of affluent Indian children from 5 to 18 years of age. Indian Pediatr 1992; 29:1203-1282.
10. Banerjee I, Ghia N, Bandopadhyay S, Sayed HN, Mukherjee D. Body mass index in Bengali adolescents. Indian Pediatr 2005; 42: 262-267.
11. Subramanyam V, Jayshree R, Rafi M. Prevalence of overweight and obesity in affluent adolescent girls in Chennai in 1981 and 1998.Indian Pediatr 2003; 40: 332-336.
12. Kapil U, Singh P, Pathak P, Dwivedi SN, Bhasin S. Prevalence of obesity amongst affluent adolescent school children in Delhi. Indian Pediat. 2002; 39: 449-452.
13. Khadilkar VV, Khadilkar AV. Prevalence of obesity in affluent school boys in Pune. Indian Pediatr 2004; 41:857-858.