Original Article

Are the current Indian growth charts really representative? Analysis of anthropometric assessment of school children in a South Indian district

V. Kumaravel, Vanishree Shriraam[1], M. Anitharani[1], S. Mahadevan[2], A. N. Balamurugan[3], B. W. C. Sathiyasekaran[1]

Institute of Diabetes and Endocrinology, Alpha Hospital and Research Center, Madurai, Departments of [1]Community Medicine, and [2]Endocrinology and Diabetes, Sri Ramachandra Medical College and Research Institute, Porur, Chennai, Tamil Nadu, India, [3]Clinical Islet Transplant Program, Schulze Diabetes Institute, University of Minnesota, Minneapolis, MN 55455, USA

ABSTRACT

Background: India currently is posed by the double threat of thinness and overweight/obesity among children. Different growth charts have taken different population and give different cut-off points to assess these conditions. **Objective:** The objective of this study is to assess the anthropometry of school children, 5-18 years of age and thereby estimate the prevalence of childhood thinness, overweight and obesity. To analyze how the study population compares with that of Agarwal's growth chart. **Materials and Methods:** The anthropometric measurements of all the students who were studying from 1st to 12th standards were taken from 27 randomly selected Government and private schools. Prevalence of thinness, overweight and obesity were assessed using two standards – Indian standard given by Agarwal and International Standards given by International Obesity Task Force (IOTF). **Results:** The prevalence of thinness, overweight and obesity among 18,001 students enrolled as per Indian standard were 12.2%, 9.5% and 3% and as per International standard were 15.3%, 8.1% and 2.6% respectively. The mean and the 95th percentile values of body mass index for both boys and girls at all ages in this study are falling short of Agarwal's and IOTF values. Using international cut-offs as well as Indian cut-offs given by Agarwal, underestimate the prevalence of obesity among boys and girls of all age groups. **Conclusion:** This study shows that under and over-nutrition among school children is in almost equal proportions. There is an underestimation of obesity among children whenever an Indian or an International growth chart is used. Thus, this study brings out the need for a really representative growth chart.

Key words: Growth chart, obesity, prevalence, school children, thinness

Introduction

"For the first time in human history, the number of overweight people rivals the number of underweight people...." as quoted by the World Watch Institute in 2004.[1] Both problems have serious consequences when started in childhood as there is a long period of exposure before they reach adulthood.

Childhood obesity is strongly associated with cardiovascular diseases, diabetes, orthopedic problems, mental disorders, non-alcoholic fatty liver disease and sleep-associated breathing disorders as they age.[2,3] Obese children often suffer from stigmatization[2] and it is found that 50-80% of them will continue as obese adults.[4] Under-nutrition manifesting as stunting was found to increase the risk of morbidity, impair cognitive development and reduce work productivity in later life.[5] The consequences of under nutrition are extended not only in later life, but also into

Access this article online	
Quick Response Code:	Website: www.ijem.in
	DOI: 10.4103/2230-8210.126541

Corresponding Author: Dr. Vanishree Shriraam, Department of Community Medicine, Sri Ramachandra Medical College and Research Institute, Porur, Chennai - 600 116, Tamil Nadu, India. E-mail: docvanishri@yahoo.com

future generations.[6] Thinness results in poor pregnancy outcomes, in particular low birth weight.[7] Both childhood obesity and thinness are linked to underachievement in school and lower self-esteem.[8,9]

India being a developing country, undergoing a rapid epidemiological and nutritional transition along with demographic transition, is posed by the double threat of under and over nutrition.[10] Cross-sectional studies performed in various parts of India among school children report the prevalence of overweight to range between 2.3% and 25.1% and that of obesity to range from 0.3% to 11.3%.[11-26] The prevalence of under-nutrition among school children vary from 17% to 65%.[6,13-16,27,28] Most studies performed among school children in India assess the prevalence of overweight/obesity in isolation.[13,18-26] Many studies restrict themselves to either one sex or a narrow age range.[12-14,16,18-26] Furthermore, these studies use different cut-off points to assess the same. These cut-off points are derived from studies done at different places, time points and including different study population.

Therefore, this study was undertaken to assess the anthropometry of school children, both boys and girls from 1st to 12th standards in the district of Madurai in the state of Tamil Nadu in order to get an overall picture of their nutritional status. The prevalence of childhood thinness, overweight and obesity were determined based on the growth chart compiled by Agarwal *et al*.[29,30] as recommended by the Indian Association of Pediatrics (IAP)[31] as well as the international standard as proposed by the International Obesity Task Force (IOTF).[32,33] Since the growth chart proposed by Agarwal *et al*. is more than two decades old now, this study assesses how the current population compares with that of Agarwal.

Materials and Mathods

Madurai is one of the 32 districts and the second largest municipal corporation in Tamil Nadu, that is located in southern part of India with a population of 3,041,038 (2011 census). About 60% of the district is urbanized and the literacy rate is about 81.7%. There are totally 369 primary, secondary and higher secondary schools in Madurai city.[34] Out of them, 50 schools, 25 government and 25 private were randomly selected, which included primary, middle, high schools and higher secondary schools. A request letter seeking permission for anthropometric assessment was sent to the school authorities. Out of them, 10 government and 17 private schools agreed to participate. An appointment was fixed with the school authorities. The anthropometric measurements of all the students who were studying from 1st to 12th standards present on that day were taken. Children with disabilities or history of chronic illness were excluded from analysis.

Anthropometric measurements were taken by four study team members who were trained adequately. The students removed their shoes and any heavy items before measurement. Height and weight were measured using standardized stadiometer and weighing scale to the nearest 0.5 cm and 0.1 kg respectively.

The calculation of thinness, overweight and obesity were based on two standards. Indian standards used in this study was that given by Agarwal *et al*. which represents the measurements of affluent school children from 23 public schools of different cities in India.[30,15] The International Standard was that of the IOTF as described by Cole *et al*. which is based on pooled international data for body mass index (BMI) where the adult cut-off points of BMI was linked to BMI centiles for children and have provided age and sex specific cut-off points for children aged 2-18 years.[32,33]

Data entry and analysis of the variables was performed using the Statistical Package for Social Sciences version 15 software. Descriptive statistics of mean, standard deviation and centiles were calculated for height, weight and BMI of students of all ages and both sexes. Analysis for testing the difference between the boys and girls for the continuous variables (height, weight and BMI) was performed by independent sample *t*-test and for testing difference in proportion of thinness, overweight and obesity by Chi-square test.

Results

There were 19668 students aged 5-18 years in the 27 schools. Of them, 1667 students (8.5%) were absent on the day of measurement. A total of 18,001 students aged 5-18 years were enrolled. Boys constituted 55.1% of them. Of them, 9918 students (55.1%) were from government schools and the remaining 8083 (44.9%) were from private schools.

Table 1 shows the mean and standard deviation of height, weight and BMI of boys and girls in the current study. The height, weight and BMI followed a normal distribution in all the age groups except at 18 years where the sample size was very small ($n = 87$).

Boys become taller than girls from 14 years and girls become heavier than boys from 10 years; however, there is a crossing over (no difference) in weight at 15 years and from 16 years of age, the boys become heavier. There is no difference in mean BMI between boys and girls until 9 years of age and from 10 years onward, the mean BMI of girls at each age is higher compared with that of boys ($P < 0.01$).

The prevalence of thinness (12% vs. 12.4%), overweight (9.7% vs. 9.3%) and obesity (3.1% vs. 3%) among government and private school students were almost similar ($P = 0.675$).

The children were grouped into 4 age groups as 5-9, 10-12 (early adolescence), 13-15 (mid adolescence) and 16-18 (late adolescence) for calculating the prevalence.[35]

Thinness is more prevalent among boys compared with girls in all the age groups. The International standard overestimates the prevalence of thinness when compared to Indian standard among all ages and both sexes except among mid adolescent girls. As compared with boys, the proportion of overweight and obesity among girls is lower in the younger age groups and higher in the older age groups. As per the international standard, the prevalence of obesity and overweight are higher among girls compared to boys in all the age groups. Furthermore seen from the table is that the international standard underestimates the prevalence of obesity among boys and girls of all age groups as compared with Indian standard [Table 2].

When compared with that given by Agarwal *et al*., in this study, the mean height of boys is lower from 15 years and that of girls from 12 years of age. In the study by Agarwal, there is difference in height between boys and girls until 13 years of age, which is not seen in this study. Even though, the trend in mean weight among boys and girls in the current study is exactly similar to that in Agarwal's study, the mean weight of boys and girls in this study are lower compared to Agarwal's from 13 years of age [Figure 1].

In this study, the BMI curve of girls rises more steadily as compared with that of boys. The mean BMI values of boys and girls at all ages in this study is lesser than that given by Agarwal *et al*. though the difference is very minimal up to 12 years for boys and up to 9 years for girls. In spite of this difference, the trend was similar in both the studies [Figure 1].

The 95th percentile values of BMI in the present study were lower than that of Agarwal's and international cut-off at all ages and both sexes except at 5 years for boys and at 17 years for both sexes. The values are comparable with

Table 1: Mean (SD) values of height, weight, and BMI of study population (*n*=18,001)

Age (years)	*n*		Height (cm) mean (SD)		Weight (kg) mean (SD)		BMI (kg/m^2) mean (SD)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
5	453	372	105.8 (6.1)	105.2 (6.1)	16.3 (3.9)	15.9 (2.8)	14.4 (1.7)	14.3 (1.7)
6	610	478	111.7 (6.5)	111.1 (6.9)	17.9 (3.5)	17.7 (3.8)	14.3 (1.7)	14.2 (2.1)
7	622	515	117.4 (6.1)	117.0 (6.2)	20.4 (4.2)	20.2 (4.0)	14.7 (2.1)	14.7 (2.1)
8	531	413	123.2 (6.5)	122.4 (6.7)	23.0 (5.0)	22.9 (5.1)	15.1 (2.3)	15.2 (2.4)
9	523	428	129.2 (6.9)	128.6 (7.1)	25.8 (5.7)	26.2 (6.0)	15.4 (2.4)	15.7 (2.5)
10	656	575	132.9 (6.8)	132.6 (7.5)	27.5 (5.8)	28.4 (6.7)*	15.5 (2.4)	16.1 (2.8)*
11	836	680	137.5 (7.7)	137.8 (8.3)	31.4 (7.9)	32.3 (8.1)§	16.4 (3.1)	16.9 (3.2)*
12	885	693	142.9 (8.2)	143.1 (8.3)	34.6 (8.9)	36.2 (8.7)*	16.8 (3.1)	17.5 (3.3)*
13	1195	1123	148.7 (9.0)	148.2 (7.6)	37.2 (9.0)	39.8 (8.8)*	16.7 (2.9)	18.1 (3.4)*
14	1371	963	154.5 (9.6)	152.2 (7.0)*	41.(9.8)	42.9 (8.9)*	17.1 (3.0)	18.5 (3.5)*
15	1016	947	159.5 (9.0)	153.5 (6.3)*	45.7 (10.7)	45.3 (9.3)	17.8 (3.2)	19.2 (3.6)*
16	774	708	164.9 (8.3)	154.2 (6.5)*	50.9 (10.8)	47.2 (9.5)*	18.7 (3.4)	19.8 (3.7)*
17	380	167	166.6 (7.7)	153.8 (6.3)*	54.0 (12.7)	47.9 (9.3)*	19.4 (4.0)	20.2 (3.5)§
18	59	28	165.3 (7.1)	152.4 (5.9)*	54.3 (9.6)	49.8 (10.2)§	19.8 (3.3)	21.4 (4.5)

Independent sample *t* test was applied to test difference in means between boys and girls, (*P<0.01, §P<0.05). SD: Standard deviation, BMI: Body mass index

Table 2: Prevalence of thinness, overweight and obesity as per Indian and international standards

Age group	Sex	*N*	Prevalence of thinness (%)		Prevalence of overweight (%)		Prevalence of obesity (%)	
			Indian standard#	IOTF standard¥	Indian standard#	IOTF standard¥	Indian standard#	IOTF standard¥
5-9	M	2739	12.1	17.3	10.9	4.5	4.6	2.3
	F	2206	9.2*	17.4	12.6	7.2*	2.7*	2.4
10-12	M	2377	9.4	13.3	10.9	8.4	3.7	1.9
	F	1948	8	10.0*	8.1*	10.6*	2.5*	2.1
13-15	M	3582	15.9*	18.8	8.5	6.0	1.7	0.9
	F	3033	13.3	12.3*	7.7	8.9*	2.3	1.7*
16-18	M	1213	16.3	17.7	7.5	8.1	4	2.0
	F	903	11.6*	14.6	9.9	9.6	5	2.7
Total	M	9911	13.4	17.0	9.6	7.3	3.2	1.7
Total	F	8090	10.7*	13.4*	9.4	9.0*	2.7	2.1*
Total		18,001	12.2	15.3	9.5	8.1	3	2.6

Chi-square test to test the difference in proportion between boys and girls;*P<0.01. Thinness: #<5th percentile value, ¥BMI analogue for age and sex<BMI value of 17 in adults. Overweight: #≥85th percentile but<95th percentile value, ¥BMI analogue for age and sex≥BMI value of 25 kg/m^2 but<30 kg/m^2 in adults. Obesity: #≥95th percentile value, ¥BMI analogue for age and sex≥BMI value 30 kg/m^2 in adults. IOTF: International obesity task force, BMI: Body mass index

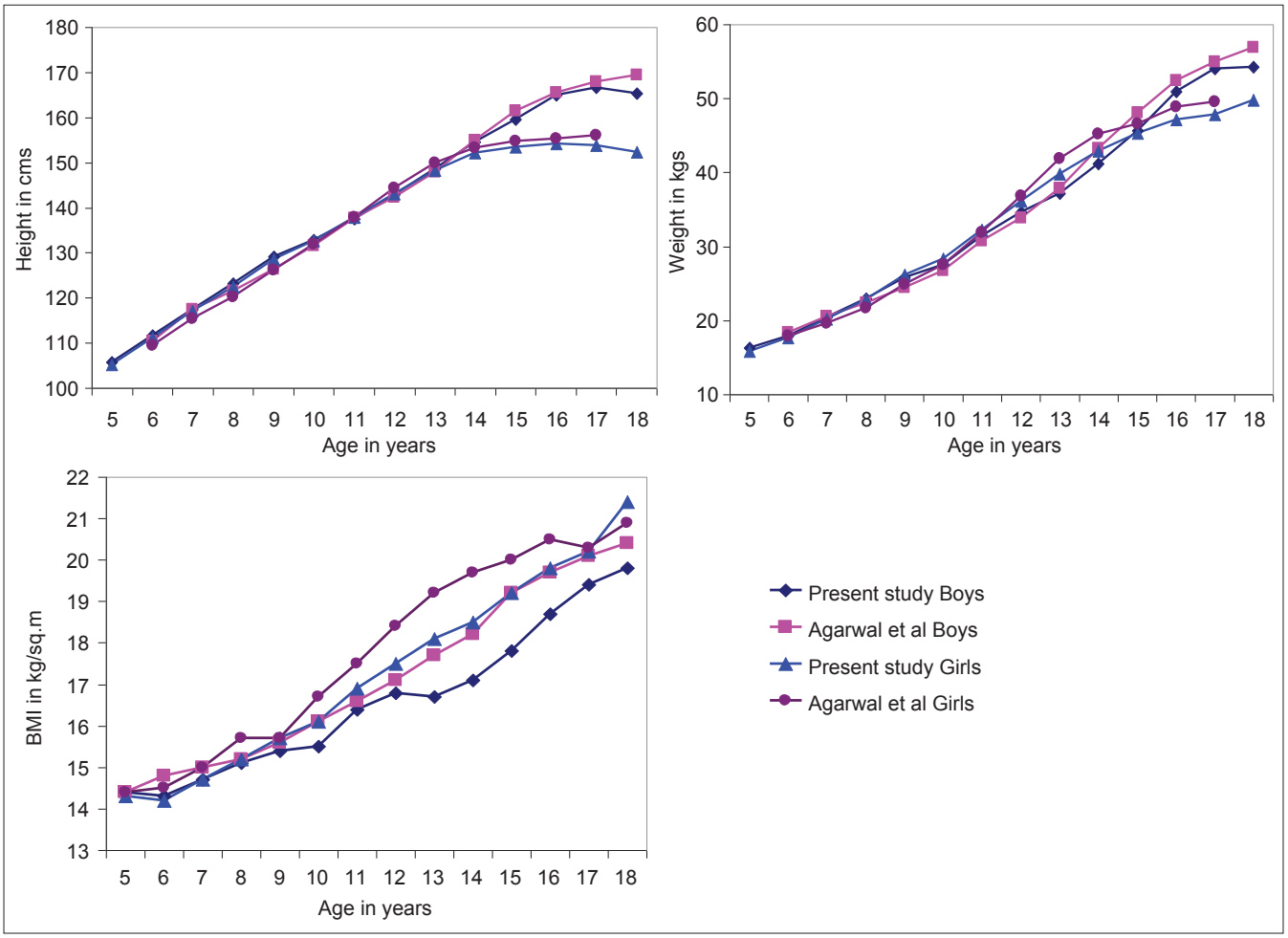

Figure 1: Comparison of mean height, weight, and body mass index of boys and girls at different ages between present study and Agarwal's study. (For this comparison the cut-offs at mid-year values from the tables were used)

Agarwal's cut-off until 11 years for boys and 9 years for girls after which the difference increases [Table 3].

Discussion

This study gives the height, weight and BMI values of 18,001 children (both boys and girls) of age 5-18 years in the South Indian city of Madurai. The prevalence of underweight (12.2%) was nearly equal to the prevalence of overweight and obesity (12.5%) in the study population.

The prevalence of thinness found in this study is much lower than that found by the National Nutritional Monitoring Bureau (NNMB) survey performed in 2004-06 in rural areas across nine states (57% in 10-13 years and 30% in 14-17 years).[28] Furthermore, it is lower than that found by studies in various parts of India such as Mysore, Vadodara, Coimbatore, Jaipur and Wardha.[6,11,13-16] This might be because of the inclusion of children from both rural and urban areas studying in government and private schools in contrast to other studies where they have included only rural areas or government schools. However, the prevalence of underweight being much higher in boys compared to girls at all age groups is just similar to that found by NNMB survey.[28]

The prevalence of overweight/obesity in the current study is lesser than that found by studies done in New Delhi, Ahmedabad, matriculation and corporation schools in Coimbatore and Pune and comparable to that found in Mangalore, Mysore, Panchayat schools in Coimbatore.[12,14-16,20,22,26] The prevalence of overweight/obesity found in this study is higher than that found in Hyderabad, Wardha and Jaipur.[13,18,25] Thus, the district of Madurai stands in between the metropolitan cities and other towns/cities in India in terms of BMI.

In both developed and developing countries, there are proportionately more obese girls than boys.[36] This study follows the same pattern as per IOTF standard. Furthermore, the mean BMI of girls were significantly higher than that of boys since 10 years of age. This finding is opposed to that found in New Delhi or Ahmedabad.[12,26]

Table 3: Comparison of 95th percentile of BMI among boys and girls in the present study with those of Indian standard given by Agarwal *et al.* and the IOTF standard

Age	Present study		Indian Standard		IOTF standard	
	Boys	Girls	Boys	Girls	Boys	Girls
5	17.30	17.44	17.0	18.3	19.30	19.17
6	17.35	17.71	17.8	18.8	19.78	19.65
7	18.60	18.60	18.8	19.7	20.63	20.51
8	19.50	19.60	19.7	21.4	21.6	21.57
9	20.36	20.26	21.0	21.7	22.77	22.81
10	20.32	21.84	22.1	23.2	24	24.11
11	22.70	22.60	23.4	24.5	25.1	25.42
12	23.11	24.00	23.8	25.7	26.02	26.67
13	22.62	24.18	25.3	27.1	26.84	27.76
14	22.64	25.20	25.3	27.4	27.63	28.57
15	23.52	26.20	27.3	27.7	28.3	29.11
16	25.65	27.21	27.6	27.4	28.88	29.43
17	27.69	26.82	26.8	25.9	29.41	29.69
18			28.0	-	30	30

BMI: Body mass index, IOTF: International obesity task force

In contrast to the findings from the studies performed in Delhi, Coimbatore or Udupi district of Karnataka, wherein there was a significant difference in the prevalence of thinness, overweight, and obesity among government and private school children, there is no such difference in this study.[14,24,26] In Madurai, the private schools do not equate to the affluent urban public schools included in the other studies. They cater to similar population as that of the Government schools.

When the trend in 95th percentile of BMI is compared between the three studies, [Table 3] girls have a higher cut-off compared to boys from 5-14 years of age in the study by Agarwal *et al.* where as in the other 2 studies, the centiles of boys and girls are comparable until 12 years of age after which girls overtake boys. This will have an impact in the assessment of prevalence of obesity, such that in the younger age groups, there will be an underestimation of obesity among girls compared to boys when assessed by Indian Standard as depicted in Table 2.

Although, there are more recently published growth charts in India by Khadilkar *et al.* and Marwaha *et al*., the height, weight and BMI cut-offs are much higher for both boys and girls at all age groups compared to that given by Agarwal.[29,37,38] The authors have themselves suggested changing the definition of overweight to the 75th centile from the traditionally used 85th centile while using their cut-offs. This might lead to confusion in definitions.[39] Therefore in this study we took the Indian standard as Agarwal's as recommended by IAP.[31] But to our surprise found that even after 2 decades have elapsed, the mean and the 95th percentile values of BMI for both boys and girls at all ages in this study are falling short of Agarwal's. The reasons might be the inclusion of school children irrespective of whether they are from urban or rural background or their economic status. Furthermore the age at sexual maturity might have been later than that of Agarwal's owing to the above reasons, which will reflect on the anthropometric parameters.

From Table 3, we can infer that, there might be an underestimation of obesity when we use Agarwal's or IOTF standards for the current population. The Indian Council of Medical Research (ICMR) growth chart devised in 1956-65 was based largely on children from lower socio-economic status and so its use was dismissed as it was thought to underestimate the prevalence of underweight.[40] The growth charts devised by Agarwal, Kadilkar or Marwaha are based on the height and weight parameters from school children who are from urban and affluent background. The rational for such a selection was that in a developing country such as India, children belonging to affluent families in urban areas have fewer constraints on growth than other children. Another rationale was that affluent children of our country approach the western children in growth.[29,36,37] This rationale has been proven right when in the studies by Kadilkar or Marwaha, the 85th and 95th centiles of BMI of Indian urban affluent children were found to be comparable or higher than the IOTF cut- offs at corresponding ages.

Any prescription of standard should be correlated with future health outcomes. Usage of growth charts based only on urban affluent school children may underestimate the prevalence of overweight and obesity, labeling such children as having "normal BMI." In this scenario, when the prevalence of non-communicable diseases is rising, India becoming the diabetic capital of the world, childhood obesity is increasing; doubt arises on the appropriateness of usage of parameters based only on urban and affluent school children for prescribing growth standards. The time tested practice of taking +2 standard deviation from the mean taken from a representative sample would itself tell about the status of overweight/obesity in the population. Given these, it is suggested that Indian growth chart must be devised from a representative sample of all currently healthy children, both urban and rural and also across all socio-economic groups. For estimating the prevalence of short stature/thinness, we may continue to utilize the chart given by Agarwal *et al.* as it is proven not to overestimate them.[40] Utilizing IOTF chart tends to overestimate thinness and underestimate obesity for most ages in both sexes.

The major strength of this study is the huge sample size covering a wide range of age group of 5-18 years among

both sexes, such that the height, weight and BMI followed a normal distribution curve at all ages except at 18 years where the sample size was small. The limitation of this study is that it does not take into account the sexual maturity among adolescents.

Conclusion

From this large study on anthropometry of school going children from the south Indian city of Madurai, we conclude that we are facing a twin problem of both under (12.2%) and overnutrition (12.5%), in almost equal proportions in the current economic scenario. There is an underestimation of obesity among children whenever an Indian or an International growth chart is used. Thus, this study brings out the need for a really representative growth chart.

Acknowledgment

We thank Ms. Syed Ali Fathima for helping us in coordinating with the schools and data collection.

References

1. Gardner G, Halweil B. Chronic hunger and obesity epidemic eroding global progress. Available from: http://www.web.archive.org/web/20030316051456/http://www.worldwatch.org/press/news/2000/03/04/. [Accessed on 2012 Sep 5].
2. Dietz WH. Health consequences of obesity in youth: Childhood predictors of adult disease. Pediatrics 1998;101:518-25.
3. Lobstein T, Baur L, Uauy R, IASO International Obesity Task Force. Obesity in children and young people: A crisis in public health. Obes Rev 2004;5 Suppl 1:4-104.
4. Styne DM. Childhood and adolescent obesity. Prevalence and significance. Pediatr Clin North Am 2001;48:823-54, vii.
5. World Health Organization. Fact sheet EURO/06/05: The health of children and adolescents in Europe. Copenhagen, Bucharest: World Health Organization; 2005.
6. Bhoite R, Iyer U. Magnitude of malnutrition and iron deficiency anemia among rural school children: An appraisal. Asian J Exp Biol Sci 2011;2:354-61.
7. Kramer MS. Determinants of low birth weight: Methodological assessment and meta-analysis. Bull World Health Organ 1987;65:663-737.
8. Adolescents' nutrient and dietary intake: The gap adolescent nutrition: A review of the situation in selected South-East Asian countries. Available from: http://www.searo.who.int/LinkFiles/Nutrition_for_Health_and_Development_Adolescent_Nutrition_%28Nut-163%29.pdf. [Accessed on 2012 Jul 18].
9. Peeters A, Barendregt JJ, Willekens F, Mackenbach JP, Al Mamun A, Bonneux L, *et al*. Obesity in adulthood and its consequences for life expectancy: A life-table analysis. Ann Intern Med 2003;138:24-32.
10. Misra A, Khurana L. Obesity and the metabolic syndrome in developing countries. J Clin Endocrinol Metab 2008;93:S9-30.
11. Deshmukh PR, Gupta SS, Bharambe MS, Dongre AR, Maliye C, Kaur S, *et al*. Nutritional status of adolescents in rural Wardha. Indian J Pediatr 2006;73:139-41.
12. Goyal RK, Shah VN, Saboo BD, Phatak SR, Shah NN, Gohel MC, *et al*. Prevalence of overweight and obesity in Indian adolescent school going children: Its relationship with socioeconomic status and associated lifestyle factors. J Assoc Physicians India 2010;58:151-8.
13. Gupta R, Rastogi P, Arora S. Low obesity and high under nutrition prevalence in lower socioeconomic status school girls: A double jeopardy. Hum Ecol 2006;14:120-32.
14. Rema N, Vasanthamani G. Prevalence of nutritional and lifestyle disorders among school going children in urban and rural areas of Coimbatore in Tamil Nadu, India. Indian J Sci Technol 2011;4:131-40.
15. Premanath M, Basavanagowdappa H, Shekar MA, Vikram SB, Narayanappa D. Mysore childhood obesity study. Indian Pediatr 2010;47:171-3.
16. Saraswathi YS, Najafi M, Gangadhar MR, Malini SS. Prevalence of childhood obesity in school children from rural and urban areas in Mysore, Karnataka, India. J Life Sci 2011;3:51-5.
17. Kaur S, Sachdev HP, Dwivedi SN, Lakshmy R, Kapil U. Prevalence of overweight and obesity amongst school children in Delhi, India. Asia Pac J Clin Nutr 2008;17:592-6.
18. Laxmaiah A, Nagalla B, Vijayaraghavan K, Nair M. Factors affecting prevalence of overweight among 12- to 17-year-old urban adolescents in Hyderabad, India. Obesity (Silver Spring) 2007;15:1384-90.
19. 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;57:185-90.
20. Khadilkar VV, Khadilkar AV. Prevalence of obesity in affluent school boys in Pune. Indian Pediatr 2004;41:857-8.
21. Kapil U, Singh P, Pathak P, Dwivedi SN, Bhasin S. Prevalence of obesity amongst affluent adolescent school children in Delhi. Indian Pediatr 2002;39:449-52.
22. Kotian MS, S GK, Kotian SS. Prevalence and determinants of overweight and obesity among adolescent school children of South Karnataka, India. Indian J Community Med 2010;35:176-8.
23. Kumar S, Mahabalaraju DK, Anuroopa MS. The prevalence of obesity and its influencing factor among affluent school children of Davangere city. Indian J Community Med 2007;32:15-7.
24. Kumar MK, Prashanth K, Baby KE, Rao KR, Kumarkrishna B, Hegde K, *et al*. Prevalence of obesity among high school children in Dakshina Kannada and Udupi districts. Nitte Univ J Health Sci 2011;1:16-20.
25. Bharati DR, Deshmukh PR, Garg BS. Correlates of overweight and obesity among school going children of Wardha city, Central India. Indian J Med Res 2008;127:539-43.
26. Gupta DK, Shah P, Misra A, Bharadwaj S, Gulati S, Gupta N, *et al*. Secular trends in prevalence of overweight and obesity from 2006-2009 in urban Asian Indian adolescents aged 14-17 years. PLoS One 2011;6:e17221.
27. National Nutrition Monitoring Bureau (NNMB), Diet and nutritional status of rural population, Report No. 21, National Institute of Nutrition, Indian Council of Medical Research Hyderabad, India:; 2002.
28. National Nutrition Monitoring Bureau (NNMB), Diet and nutritional status of population and prevalence of hypertension among adults in rural areas.-Report No. 24, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad, India:; 2006.
29. Agarwal DK, Agarwal KN, Upadhyay SK, Mittal R, Prakash R, Rai S. Physical and sexual growth pattern of affluent Indian children from 5-18 years of age. Indian Pediatr 1992;29:1203-82.
30. Agarwal KN, Saxena A, Bansal AK, Agarwal DK. Physical growth assessment in adolescence. Indian Pediatr 2001;38:1217-35.
31. Khadilkar VV, Khadilkar AV, Choudhury P, Agarwal KN, Ugra D, Shah NK. IAP growth monitoring guidelines for children from birth to 18 years. Indian Pediatr 2007;44:187-97.
32. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard

definition for child overweight and obesity worldwide: International survey. BMJ 2000;320:1240-3.
33. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: International survey. BMJ 2007;335:194.
34. Available from: http://www.en.wikipedia.org/wiki/Madurai. [Accessed on 2012 Aug 20].
35. Funke OM. Prevalence of underweight: A matter of concern among adolescents in Osun State, Nigeria. Pak J Nutr 2008;7:503-8.
36. Elamin A. Obesity: Epidemiologic and aetio-pathological aspects. Khartoum Med J 2010;3:457-65.
37. Khadilkar VV, Khadilkar AV, Cole TJ, Sayyad MG. Crosssectional growth curves for height, weight and body mass index for affluent Indian children, 2007. Indian Pediatr 2009;46:477-89.
38. Marwaha RK, Tandon N, Ganie MA, Kanwar R, Shivaprasad C, Sabharwal A, *et al*. Nationwide reference data for height, weight and body mass index of Indian schoolchildren. Natl Med J India 2011;24:269-77.
39. Bhatia V. Growth charts, the secular trend and the growing concern of childhood obesity. Natl Med J India 2011;24:260-2.
40. Khadgawat R, Dabadghao P, Mehrotra RN, Bhatia V. Growth charts suitable for evaluation of Indian children. Indian Pediatr 1998;35:859-65.

Cite this article as: Kumaravel V, Shriraam V, Anitharani M, Mahadevan S, Balamurugan AN, Sathiyasekaran B. Are the current Indian growth charts really representative? Analysis of anthropometric assessment of school children in a South Indian district. Indian J Endocr Metab 2014;18:56-62.

Source of Support: Nil, **Conflict of Interest:** No.