Double burden of malnutrition among urban Bengalee adolescent boys in Midnapore, West Bengal, India

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Abstract

Malnutrition is an important public health problem worldwide. Therefore a study was undertaken to assess the prevalence of adolescent thinness, overweight and obesity in Midnapore town, West Bengal, India. A total of 974 adolescent boys aged 10-18 years were selected following multistage cluster sampling method from three higher secondary schools. Data was collected using pretested questionnaire following standard technique. Presence of thinness was evaluated using the cut-off values of international survey as suggested by Cole et al (2007). While overweight and obesity was determine by using international cut-off values develop by Cole et al (2000) based on international surveys as recommended by IOTF. Overall the prevalence of thinness, overweight and obesity were 20.8%, 14.9% and 3.8%, respectively. This study developed age specific smooth BMI percentile values using LMS method. Moreover, the study also developed BMI cut-off values to define thinness, overweight and obesity. In conclusion, the present analyses indicated that the prevalence of adolescent undernutrition is still a major problem. In addition, there was also an emerging trend for overweight/obesity, thereby indicating a double burden of malnutrition as observed in other developing countries.

Key Words: Adolescent, Thinness, Overweight, Obesity, Nutrition, BMI.

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Introduction:

The prevalence of overweight has rapidly increased over the last two decades in both developed and developing countries (Doll et al 2002). Obesity in childhood is associated with an increased incidence of hypertension, diabetes, coronary heart disease, osteoarthritis. The most significant long-term consequences of obesity are the tracking of obesity from childhood to adulthood and its contribution to adult obesity-related morbidity and mortality (Kotani et al 1997). Although under-nutrition remains a major health problem in many developing countries, over-nutrition is also emerging with the improvement in socio-economic condition and increasing urbanization. Consequently, the double burden of under- and over-nutrition exerts considerable impact on the economy and health system in many developing countries (Popkin 2002).

It is well known fact that nutritional status is a major determinant of the health and well-being among children and there is no debate on the importance of the study of child nutritional status according to spatial and temporal dimension (NFHS-1998-1999). Undernutrition continues to be a primary cause of ill-health and premature mortality among children and adolescent in developing countries (Nandy et al. 2005, Bose and Bisai 2008). As in other developing nations, malnourishment is a burden on considerable percentage of population, the most vulnerable being the youngest of this country (Chatterjee and Saha 2008).

Moreover, the problems appear to be increasing rapidly among children and adults and the health consequences may become more serious in the next decade or so. Representative data on the prevalence of obesity and associated diseases have been collected in most of the developed and many developing countries. However, there is limited data from the Indian subcontinent about the prevalence of obesity (Bhave et al 2004, Bose et al 2007, Chhatwal 2004, Kapil et al 2002, Sidhu et al. 2006, Yadav 2001, Sood 2007) and thinness (Bisai et al 2009, Bose and Bisai 2008, Das and Bisai 2009, Kurz 1996, Prashant and Shaw, 2009) among children and adolescent. Several school-based data demonstrated that obesity range of 5.6% to 24% for the children and adolescents in India (Bhave et al 2004, Chhatwal 2004, Kapil et al 2002, Yadav 2001). However, an earlier study (Subramanyam et al 2003) reported that there is no statistical significant change in the prevalence of obesity in a 17-year time span among Chennai girls of India. Little is known about these aspects among adolescents of West Bengal.

Generally, childhood undernutrition is assessed by stunting (low height for age), underweight (low weight for age) or wasting (low weight for height) following different

internationally and regionally recommended standards (WHO 1995). The body mass index (BMI) provides a simple measure of a person's "fatness" or "thinness", allowing health professionals to discuss over and underweight problems more objectively with their patients. Therefore it has been widely used for assessing nutritional status of adults (WHO 1995, WHO 2000) and more recently in children (WHO Multicentre Growth Reference Study Group, 2006). Very recently, international cut offs of child overweight and obesity for the aged between 2-18 years (Cole et al. 2000) and for underweight or thinness (Cole et al. 2007) have been developed. In the latter study, undernutrition has been termed as thinness (as in adults) defined as low BMI for age and it has been graded as III, II, I (severe, moderate and mild, respectively) similar to adult chronic energy deficiency (CED) grades of CED III, II and II. Among other anthropometric measures body mass index (BMI) is not only the single most appropriate, cost effective and non-invasive tool for the assessment of the nutritional status of adolescents and adults (WHO 1995) but it is also the best indicator of thinness during adolescence (de Onis et al 2001). Numerous surveys conducted in rural and urban areas in the South-East Asia Region show high prevalence of thinness among adolescents (WHO 2005). Earlier studies have investigated nutritional status using BMI among adolescents from rural (Bose et al 2008, Bose and Bisai 2008a, b, Chakraborty and Bose 2009, Das and Biswas 2005, Das et al 2007) and urban (Bose and Mukhopadhyay 2004, Das and Bisai 2009, de Onis et al 2001, Ghosh and Bhandhopadyay 2009) areas in West Bengal, as well as different parts of India (Anand et al 1999, Deshmukh et al 2006, Haboubi and Saikh 2009, Kurz 1996, Malhotra and Passi 2007, Medhi et al 2007, Rao et al 2006, Venkaiah et al 2002). However, there is a paucity of data on the prevalence of thinness among urban adolescents in the West Bengal state of India (Das and Bisai 2009, de Onis et al 2001, Ghosh and Bhandhopadyay 2009). In view of this, the present study is proposed to carry out the prevalence of obesity (Cole et al 2000) and thinness (Cole et al 2007) among adolescents aged 10-18 years in Mindapore town of West Bengal.

Objectives:

1) To evaluate the prevalence of overweight, obesity and thinness among the study subjects.
2) To compare growth pattern of body mass index with International reference population.

Methods:

This cross-sectional study was undertaken during April – December, 2011 in Midnapore town of West Bengal, India. The city lies just north of the Kasai River, near about

130 km way from Kolkata, the provincial capital of West Bengal. Midnapore is located at 22.25^0N, 87.65^0E and is 23 metres above sea-level. Total area of the town is 18.36 sq. km. According to latest census, the city had a population of 153,349. Medinipur has an average literacy rate of 75%, higher than the national average of 59.5%. The male and female literacy rate is 80%, and 71%, respectively.

Subjects were selected from three schools from Midnapore town. School were selected by lottery method. This study also included healthy children following screening using multistage cluster sampling method. Students were informed about the objectives of the study and their consent was obtained. The study protocol was approved by the ethics committee of Vidyasagr university and schools authority before study. All information was recorded with the help of pre-tested questionnaire.

The estimated sample size was calculated based on standard formula ($n=4pq/d^2$), a single population prevalence rate of 6.5 % overweight and obesity of our preliminary observation in urban areas, a confidence interval of 95%, relative precession of 2%., a minimum of 678 individuals is required to answer the research questions. Therefore, a total of 974 adolescents boys aged 10-18 were included in the present analyses.

Anthropometric measurements such as weight and height were made and recorded following the standard techniques as described by Lohman et al. (1988). Height and weight was measured using anthropometer rod and weighing scale to the precession of 0.1cm and 0.5kg, respectively. The weighing scales were calibrated daily against standard weight. Technical errors of measurements (TEM) were computed and they were found to be within acceptable limits (Ulijaszek and Kerr 1999). BMI was computed using the following standard equation: BMI = Weight in kg) / height in meter square.

Presence of thinness was evaluated using the cut-off values of international survey as suggested by Cole et al (2007). While overweight and obesity was determine by using international cut-off values develop by Cole et al 2000 based on international surveys as recommended by IOTF.

The BMI smooth percentile values were developed using the LMS method as described Cole and Green (1992). Firstly, summarizes the distribution of BMI by age in terms of three curves as skewness (L curve), the median (M curve) and coefficient of variation (S curve). The M curve is median BMI by age, the S curve is the coefficient of variation of BMI, while the L curve represent the skewness of the BMI distribution in terms of the Box-Cox power transform for normality of the data. This method uses a penalized maximum likelihood to fit cubic smoothing splines to the L, M and S values. Generally, a BMI

centile chart is prepared based on a user define set of centiles (for example, 5th, 10th, 25th, 50th, 75th, 90th, 95th).

The principle used to obtain cut off points for over-weight and obesity in children could also provide a cut off point for underweight in children, based on the World Health Organisation's cut off point of a body mass index of 18.5 kg/m^2 for adult underweight. Although substantial data link cut off points of 25 and 30 kg/m^2 to morbidity in adults and the corresponding centile cut off points are associated with morbidity in children (Cole at al 2000). In the present study the cut-off point for thinness, overweight and obesity was set as BMI of 18.5 , 25 and 30 kg/m^2 , respectively. Smoothed age specific percentile curves and cutoff values to define thinness, and overweight and obesity were constructed using the LMS Chart Maker pro, version 2.3, software package.

The distributions of the height, weight and BMI were not significantly skewed. Student's t-tests and one-way analysis of ANOVA were performed to test for differences in mean anthropometric characteristics by age of children. Chi-square test was employed to compare the prevalence of thinness, overweight and obesity. All statistical analyses were undertaken using the SPSS Statistical Package. Statistical significance was considered as $p < 0.05$.

Results:

Mean ±SE of height, weight and BMI by age of the studied subjects are presented in figure 1-3. Results reveal that there was a significant increasing trend in height, weight and BMI with age.

The nutritional status of studied subjects is presented in Table 1. Overall the prevalence of thinness, overweight and obesity were 20.8%, 14.9% and 3.8%, respectively. The overall prevalence of thinness was 37.55% using the cut-off suggested by Cole et al (2007). The prevalence of thinness was higher in late adolescent (15-18years) than early adolescent (10-14years). However, the prevalence of overweight and obesity was higher in early adolescent than late adolescent. Smooth BMI percentile distribution of adolescent school boys is shown in table 2 and figure 4. Cut-off values of BMI to define thinness, overweight and obesity are given in table 3 and graphically presented in figure 5. A cut-off value of BMI at age 18 is fixed as 18.5, 25 and 30 kg/m^2 to define thinness, overweight and obesity. The cut-off values are gradually decreased with decreasing age. At the age of 10, the corresponding cut-off values of BMI were 15.73, 21.70 and 24.92 kg/m^2 is obtained by LMS method. Comparison of BMI 5th, 85th, and 95th percentile value of present study with CDC 2000 and British 1990 growth study (figure 6-8). At all age group, the 5th percentile value of

BMI in present study children is lower than American (CDC 2000) and British (1990) children. More importantly 85th and 95th percentile values of BMI in present study children is higher than British (1990) children at all age group and early adolescent period than American (CDC 2000) children. Comparison of cut-off values of thinness, overweight and obesity with different studies are shown in figure 9-11.

Figure 1. Mean weight by age of adolescent school boys in Midnapore town

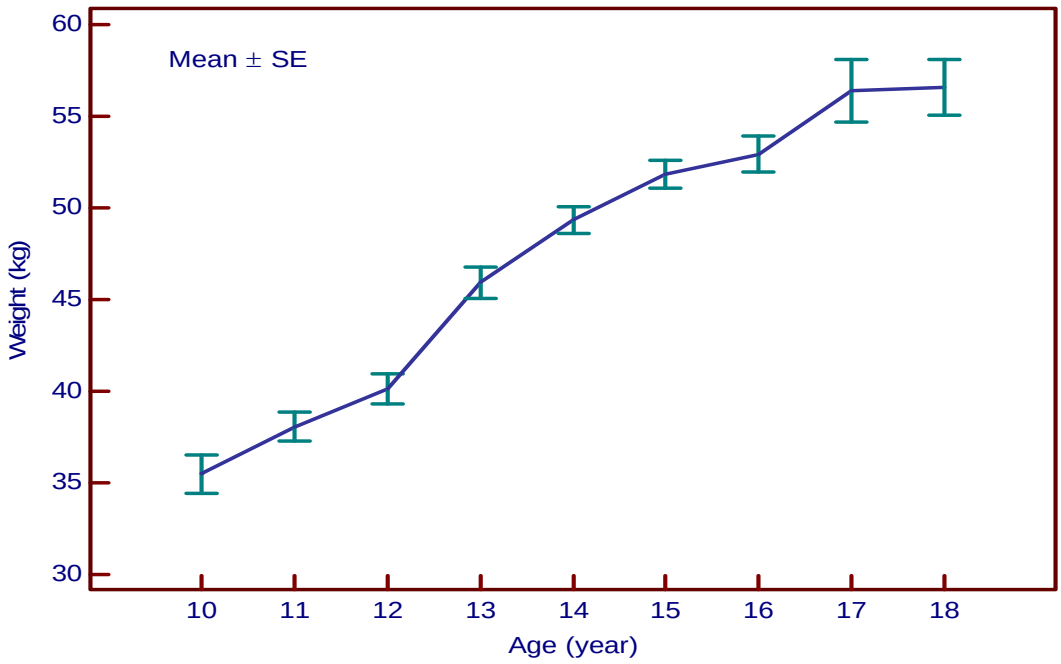


Figure 2. Mean height by age of adolescent school boys in Midnapore town

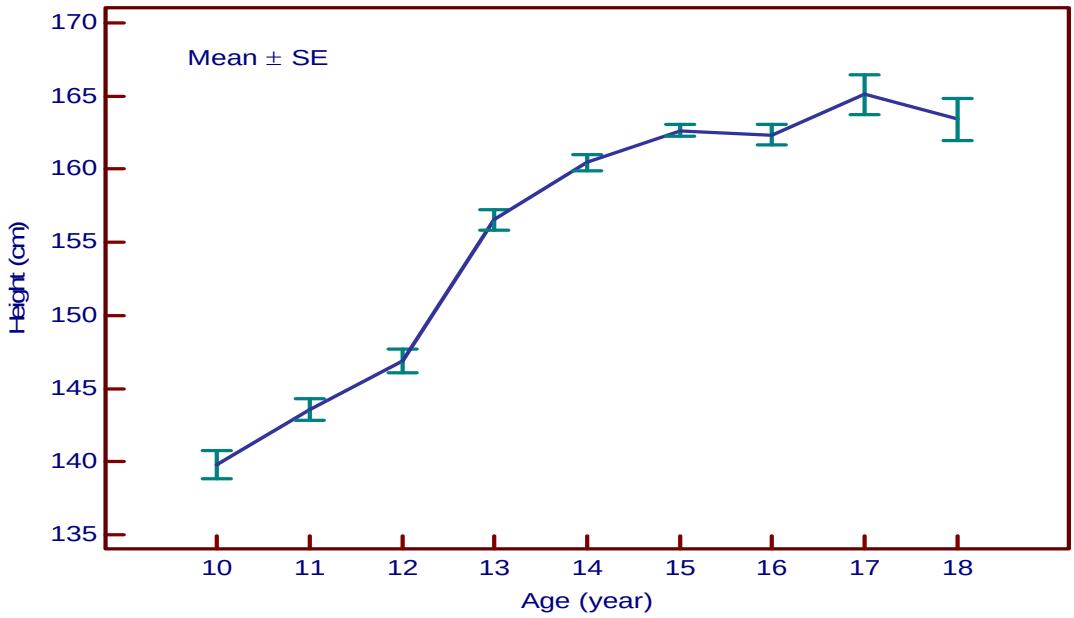


Figure 3. Mean BMI by age of adolescent school boys in Midnapore town

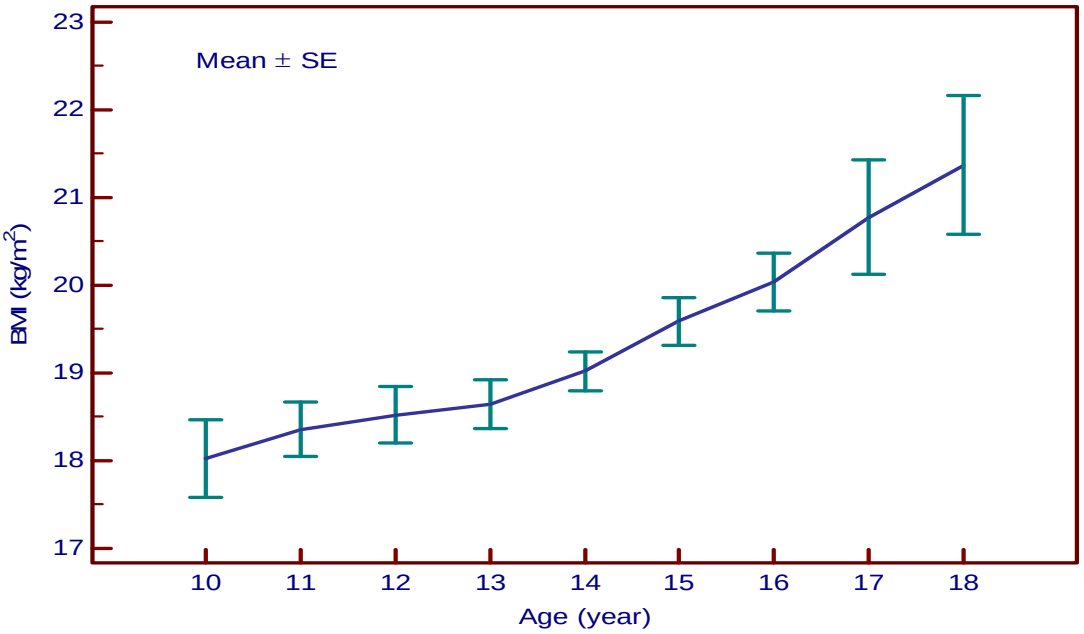


Table 1. Nutritional status of studied children

Age (Year)	Nutritional status				Total
	Thinness	Normal	Overweight	Obesity	
10	15 (22.4)	29 (43.3)	20 (29.9)	3 (4.5)	67 (6.9)
11	16 (15.7)	62 (60.8)	20 (29.9)	4 (5.9)	102 (10.5)
12	13 (12.3)	71 (67.0)	16 (15.1)	6 (5.7)	106 (10.9)
13	18 (14.3)	89 (70.6)	15 (11.9)	4 (3.2)	126 (12.9)
14	46 (21.8)	135 (64.0)	24 (11.4)	6 (2.8)	211 (21.7)
15	52 (27.9)	103 (55.4)	25 (13.4)	6 (3.2)	186 (19.1)
16	29 (26.1)	62 (55.9)	17 (15.3)	3 (2.7)	111 (11.4)
17	8 (21.6)	21 (56.8)	5 (13.5)	3 (8.1)	37 (3.8)
18	6 (21.4)	17 (60.7)	3 (10.7)	2 (7.1)	28 (2.9)
Total	203 (20.8)	589 (60.5)	145 (14.9)	37 (3.8)	974 (100)

Values are frequency and percentage (%), Chi-square = 41.297, DF = 24, p=0.0154.

Table 2. Smooth BMI percentile distribution of adolescent school boys in Midnapore town

Age (year)	5P	10P	25P	50P	75P	85P	90P	95P
10	13.35	14.15	15.63	17.55	19.82	21.21	22.24	23.89
11	13.68	14.45	15.89	17.79	20.07	21.50	22.56	24.29
12	14.00	14.74	16.15	18.03	20.32	21.78	22.88	24.69
13	14.32	15.04	16.42	18.28	20.58	22.07	23.21	25.11
14	14.67	15.38	16.73	18.57	20.89	22.41	23.58	25.58
15	15.08	15.76	17.10	18.92	21.26	22.82	24.04	26.14
16	15.53	16.20	17.52	19.34	21.70	23.31	24.57	26.80
17	16.00	16.67	17.97	19.79	22.18	23.83	25.14	27.50
18	16.49	17.15	18.44	20.25	22.67	24.36	25.72	28.21

Figure 4. Smooth percentile curve of BMI

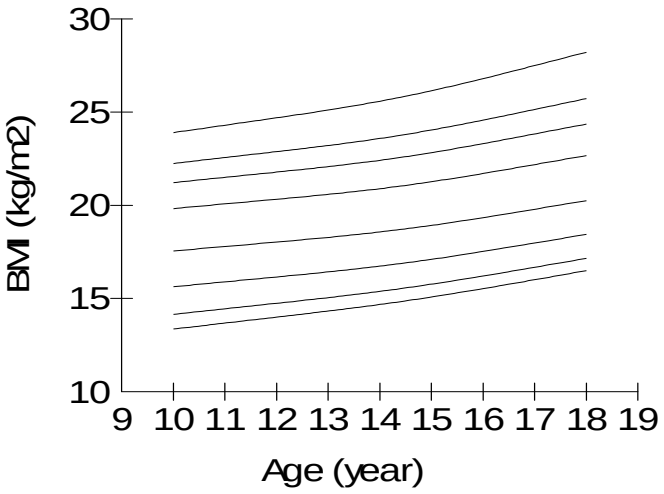
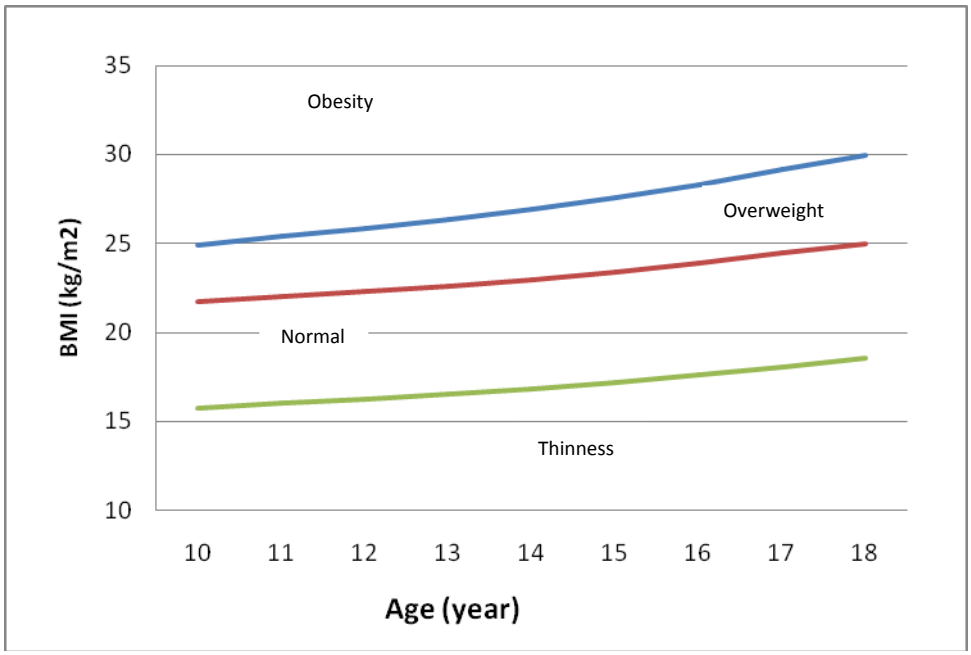
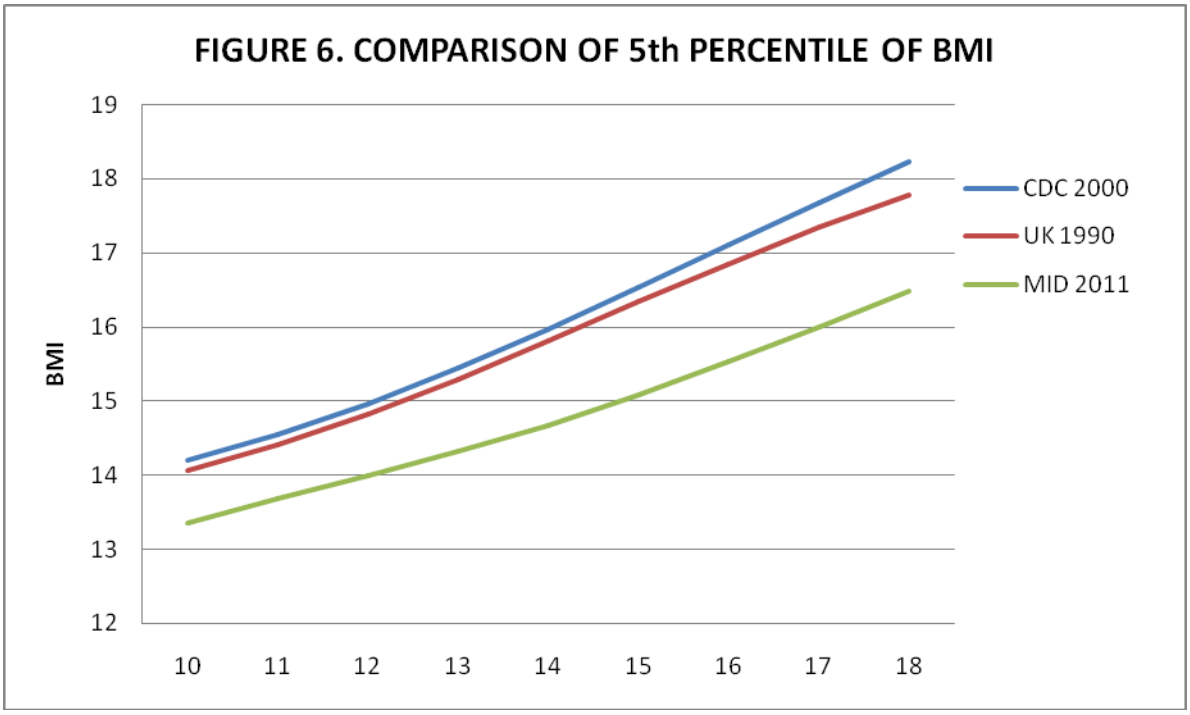


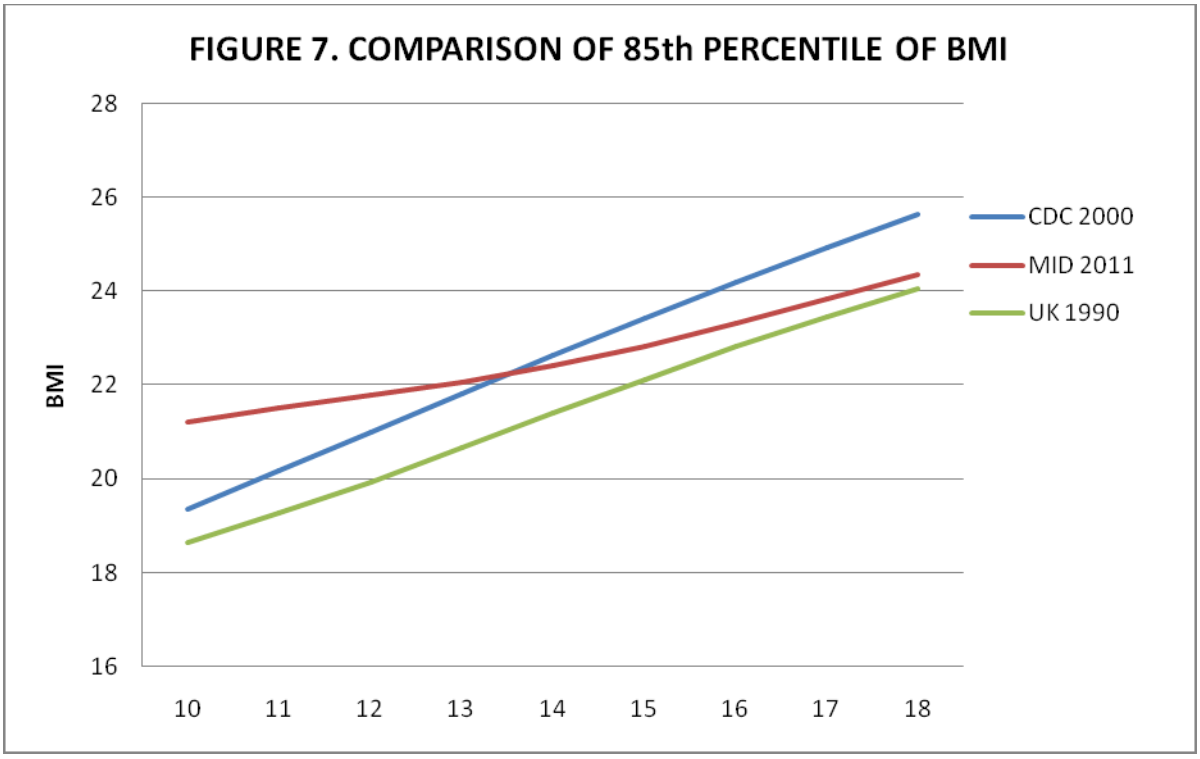
Table 3. Cut-off values of BMI to define thinness, overweight and obesity.

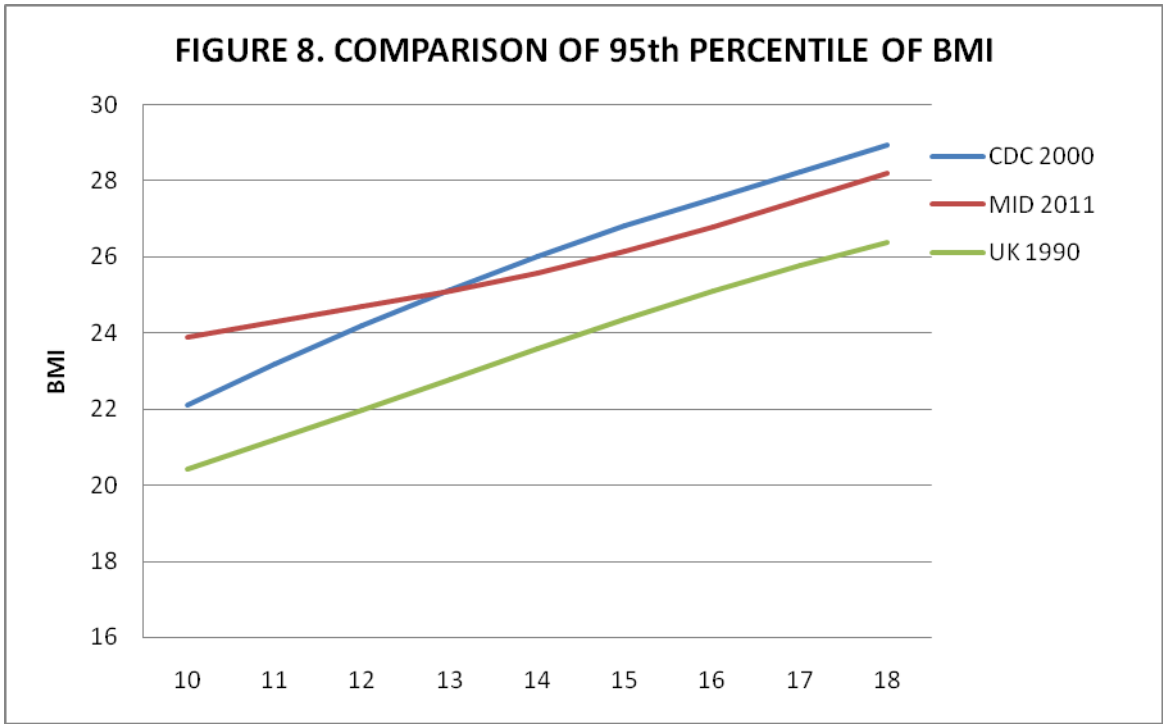
Age (year)	Thinness	Overweight	Obesity
10	15.73	21.70	24.92
11	16.00	22.00	25.38
12	16.25	22.30	25.85
13	16.52	22.61	26.34
14	16.83	22.96	26.89
15	17.19	23.39	27.55
16	17.62	23.90	28.31
17	18.07	24.44	29.13
18	**18.5**	**25.0**	**30.0**

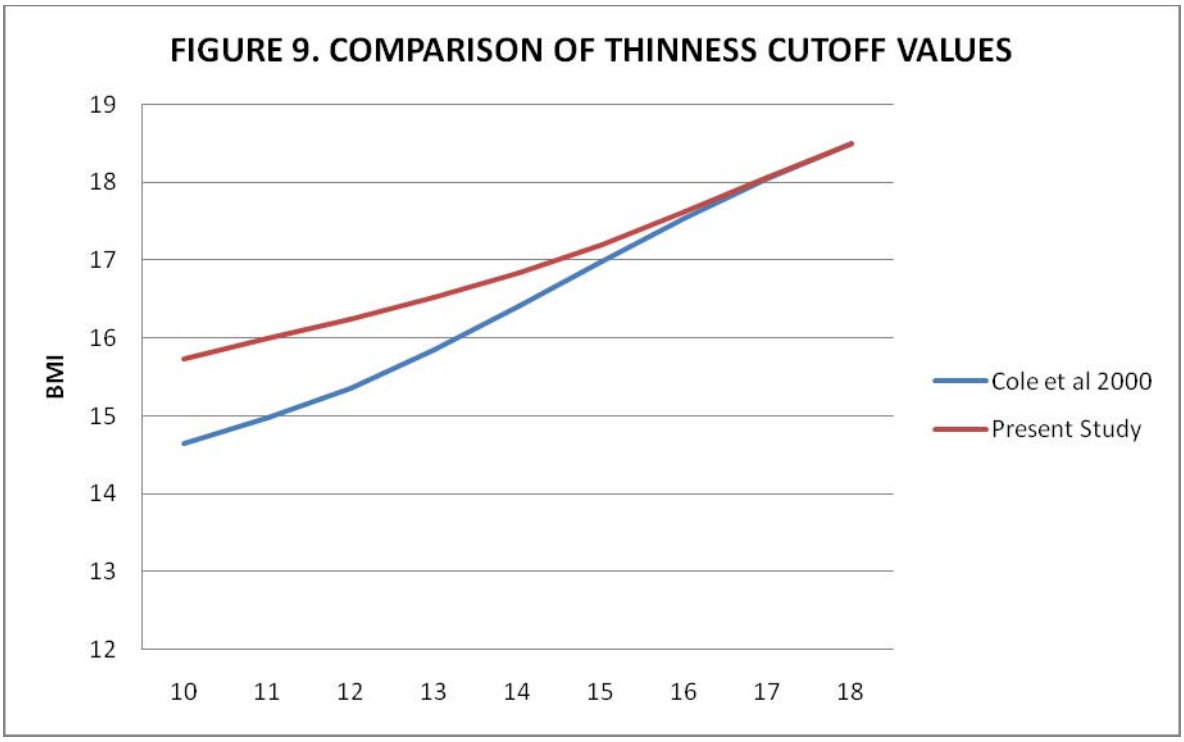
Figure 5 shows cut-off values of BMI to define thinness, normal, overweight and obesity.

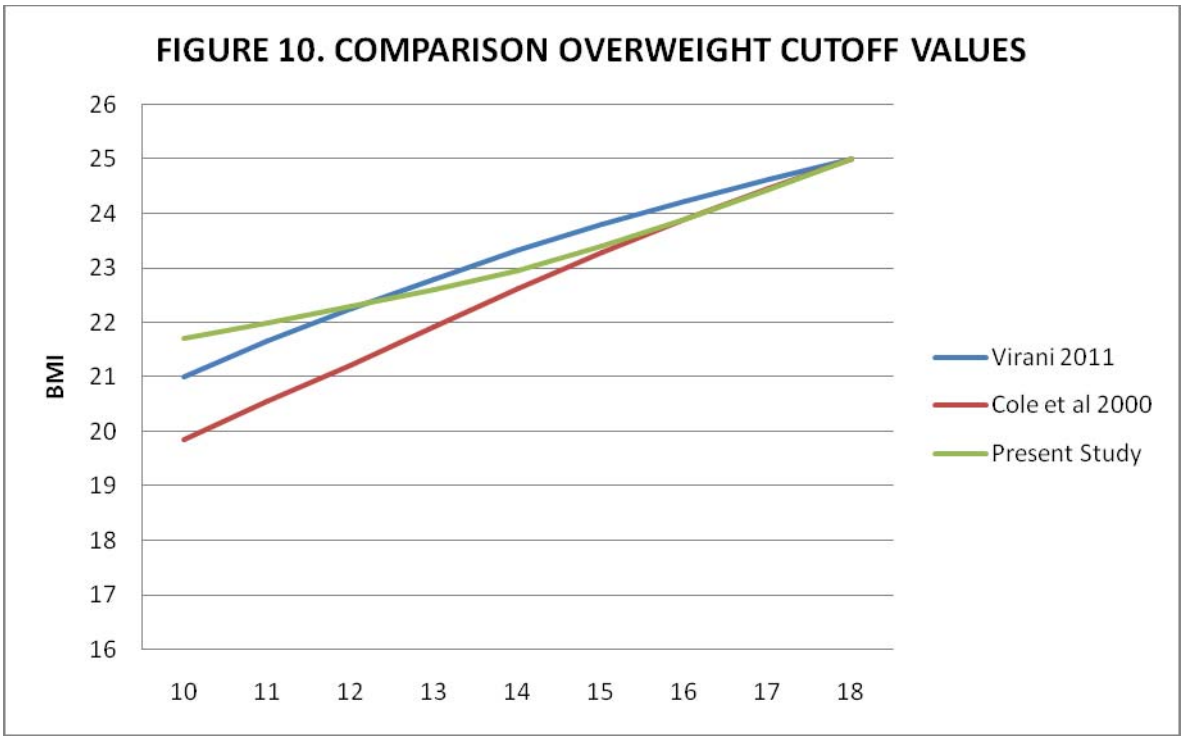


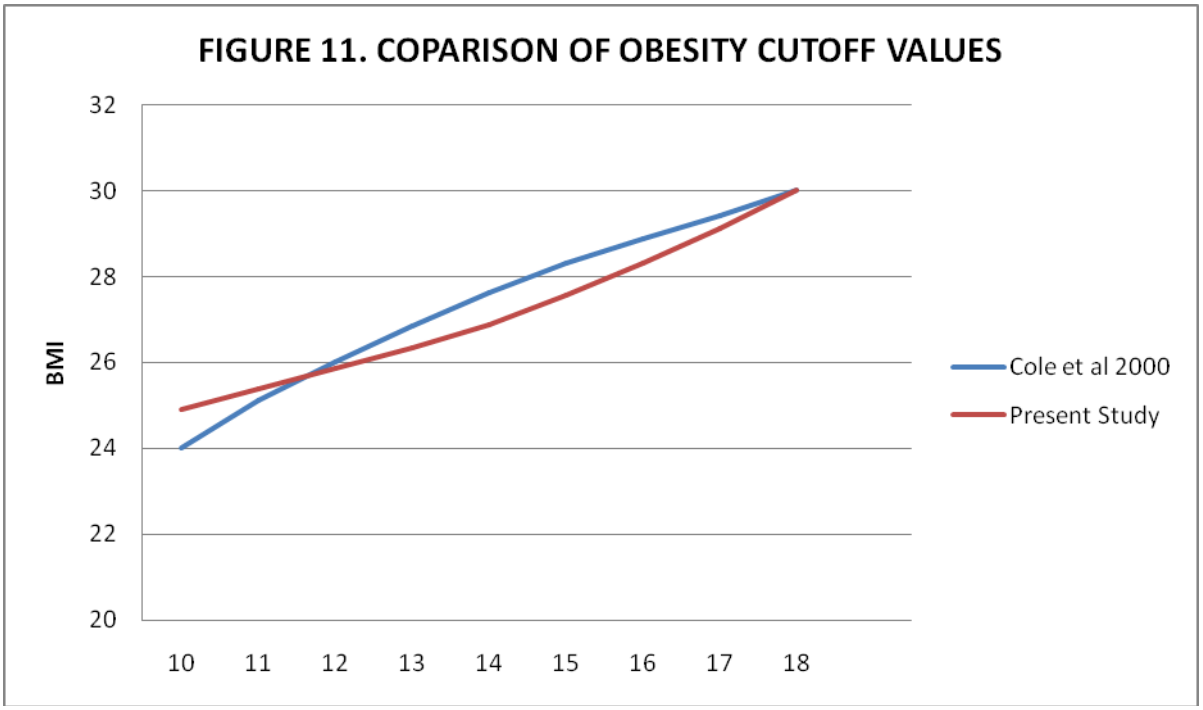












Discussion:

In a recent period anthropometric measurements have become a popular measure for the assessment of nutritional status among children and adolescents. It is well established that among other anthropometric measures body mass index (BMI) is not only the single most appropriate, cost effective and non-invasive tool for the assessment of the nutritional status of adolescents and adults (WHO 1995) but it is also the best indicator of thinness during adolescence (de Onis et al 2001).

In the present study the prevalence of total thinness was 20.8%. The prevalence of thinness in the present study was lower than those reported from other parts of India (Medhi et al 2007, Kurz 1996, Rao et al 2006, Venkaiah et al 2002, Mandot et al 2009, Deshmukh et al 2006) and neighboring countries (Sahabuddin et al 2000).

The study thinness is of particular interest because it is associated with poor school achievement and work productivity. Thinness is defined as Body Mass Index (BMI) less than 5th percentile of the NCHS (Must et al., 1991) and World Health Organization (1995) reference data. BMI (weight/height^2) for age was recommended as the best indicator for use in adolescence. It has been validated as an indicator of total body fat at the upper percentiles. However, BMI has not been fully validated as an indicator of thinness or undernutrition in adolescents. Nonetheless, it provides a single index of body mass, applicable at both extremes (Himes and Bouchard, 1989). The relationship between BMI and body fatness is dependent on maturation state, race and gender in children and adolescents (Daniels et al., 1997). However, there is question that NCHS BMI reference data (from adolescents in USA) be used internationally. In this context, WHO (1995) recommends that in the absence of other data specifying optimum cut off values of BMI in adolescence, BMI-for-age data for US children may be used until country-specific reference data are available.

Overall the prevalence of overweight and obesity were 14.9% and 3.8%, respectively. The prevalence of overweight and obesity is higher the earlier study conducted in Midnapore town among lower middle socio-economic group of people (Bisai et al 2010). Developed and developing countries are facing rapid increases in overweight and obesity among children and adolescents. Overweight and obesity has become a global health problem so much so that a new word *"globesity"* has been coined which refers to the universal health burden of obesity (Mukhopadhyay et al., 2005). The patterns of overweight/obesity differ by age, sex, rural or urban residence and socioeconomic position (SEP) and vary between and within countries (Matijasevich et al., 2009). Overweight and obesity is influenced by several factors among which socio-economic status is an important one (Sobal and Stunkard, 1989; Bose et al., 2007a). It has been shown that the social

patterning of overweight varies between and within populations over time (Matijasevich et al., 2009). It has also been suggested that specific approaches should be developed within populations in order to contain the obesity epidemic and reduce disparities (Matijasevich et al., 2009). However, although this health burden has been well documented in most developed and some developing countries, there is paucity of data from Indian, particularly among the Bengalee ethnic population of West Bengal (Sadhukhan et al., 2007). Moreover, to the best of our knowledge, there is no data available on the prevalence of overweight and obesity among adolescents of Midnapore town of West Bengal, India.

Among the many possible causes of higher prevalence of overweight and obesity among higher socioeconomic groups could be the role of change in the dietary pattern and physical activities with increase in income levels. However, one of the major limitations of most of these studies, including ours, is that they did not study in details the dietary intake and physical activity levels of the subjects.

In conclusion, the present analyses indicated that the prevalence of adolescent undernutrition is still a major problem. In addition, there was also an emerging trend for overweight/obesity, thereby indicating a double burden of malnutrition as observed in other developing countries. Future investigations in India should utilize these new cut-off values to evaluate the thinness, overweight and obesity during childhood. There is need for BMI standards for diagnostic purposes of thinness and obesity for Indian children. Ethnic group specific standards are more appropriate for comparing health-compromised children, especially in our country where the problem is more pronounced for underweight than overweight (Agarwal 2001). Such studies will provide valuable data on prevalence of thinness, overweight and obesity which can be used for the formulation of effective nutritional intervention and public health policies. Moreover, they would also provide useful datasets for national and international comparisons.

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References:

1. Ahmed F, Zareen M, Khan MR, Banu CP, Haq MN, Jackson AA. Dietary pattern, nutrient intake and growth of adolescent school girls in urban Bangladesh. Public Health Nutr 1998; 1(2):83-92.
2. Anand K, Kant S, Kapoor SK. Nutritional status of adolescent school children in rural north India. Indian Pediatr 1999; 36: 810-815.
3. Bisai S. Nutritional status and growth pattern of urban infants in relation to birth weight. Curr Sci 2008; 95 (2): 175.
4. Biswas S, Bose K, Bisai S and Chakraborty R. Prevalence of undernutrition using new international cutoff body mass index values among Bengalee preschool children in Chapra Block, Nadia District, West Bengal, India. Malay J Nutr 2009 (inpress).
5. Bose K and Mukhopadhyay A. Nutritional status of adolescent Bengalee boys. Indian Pediatr 2004; 41: 633.
6. Bose K, Bisai S, Mukherjee S. Anthropometric characteristics and nutritional status of rural school children. The Internet J Biological Anthropology. 2008. Volume 2 Number 1.
7. Bose K and Bisai S. Nutritional status of rural adolescent school children in Paschim Medinipur, West Bengal. Indian Pediatr 2008a 6: 515 – 516.
8. Bose K and Bisai S. Prevalence of undernutrition among rural adolescents of West Bengal, India. J Trop Pediatr 2008b 54 (6): 422-423.
9. Chakraborty R, Bose K. Very high prevalence of thinness using new international body mass index cut off points among 5-10 year old school children of nandigram, west Bengal, India. J Res Med Sc. 2009; 14 (2): 129-133.
10. Chatterjee S and Saha S. A study on knowledge and practice of mothers regarding infant feeding and nutritional status of under-five children attending immunization clinic of a medical college. Internet J Nutr Wellness 2008; vol 5, no. 1.
11. Cole TJ, Bellizzi MC, Flegal KM & Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. British Med J 2000; 320: 1240–1243.
12. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: international survey. British Med J 2007; 335: 194.
13. Daniels SR, Khoury PR, Morrison JA. The utility of body mass index as a measure of body fatness in children and adolescents: differences by race and gender. Pediatrics. 1997 Jun; 99 (6):804-807.

14. Das BK & Bisai S. Prevalence of undernutrition among Telaga adolescents: An endogamous population of India. Internet J Biol Anthropol 2009 Vol 2 No 2.
15. Das DK, Biswas R. Nutritional status of adolescent girls in a rural area of North 24 Paraganas district, West Brngal. Ind J Pub Health 2005; 49 (1): 18-21.
16. Das P, Ray SK, Joardar GK, Dasgupta S. Nutritional profiles of adolescents in rural community of Hooghly district in West Bengal. Ind J Pub Health 2007; 51(2): 20-21.
17. de Onis M, Dasgupta P, Saha S, Sengupta D, Blossner M. The National Center for Health Statistics reference and the growth of Indian adolescent boys. Am J Clin Nutr. 2001 Aug; 74(2): 248-53.
18. Deshmukh PR, Gupta SS, Bharambe MS, Dongre AR, Maliye C, Kaur S, Garg BS. Nutritional status of adolescents in rural Wardha. Indian J Pediatr. 2006; 73(2):139-41.
19. Ghosh JR and Bandyopadhyay AR. Prevalence of Thinness and Overweight Among Urban Adolescents of West Bengal, India. J Trop Pediatr 2009, doi:10.1093/tropej/fmp002.
20. Haboubi GJ and Saikh RB. A comparison of nutritional status of adolescents from selected schools of South India and UAE: A cross-sectional Study. Indian J Comm Med, 2009; 34(2): 108-111.
21. Himes JH, Bouchard C. Validity of anthropometry in classifying youths as obese. Int J Obes. 1989; 13(2):183-193.
22. Kramer MS. Determination of low birth weight: methodology assessment & meta-analysis. Bulletin of the World Health Organization, 1987; 65(5): 663- 737.
23. Kurz KM. Adolescent nutritional status in developing countries. Proc Nutr Soc. 1996 Mar; 55(1B): 321-31.
24. Lohman TG, Roche AF, Martorell R. Anthropometric Standardization Reference Manual. Chicago: Human Kinetics Books; 1988.
25. Malhotra A, Passi SJ. Diet quality and nutritional status of rural adolescent girl beneficiaries of ICDS in north India. Asia Pac J Clin Nutr 2007;16 (Suppl 1):8-16 8.
26. Medhi GK, Hazarika NC, Mahanta J. Nutritional status of adolescents among tea garden workers. Indian J Pediatr. 2007; 74(4): 343-347.
27. Must A, Dallal GE, Dietz WH. Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht^2) and triceps skinfold thickness. Am J Clin Nutr. 1991 Apr; 53(4): 839-846. Erratum in: Am J Clin Nutr 1991 Nov; 54(5): 773.
28. Nandy S, Irving M, Gordon D, Subramanian SV, & Davey Smith G. Poverty, child undernutrition and morbidity: new evidence from India. Bull World Health Organ 2005; 83 (3): 210-216.
29. National Family Health Survey (NFHS 2). Chhattisgarh (1998-1999). Mumbai;

International Institute of Population Sciences 2002.

30. National Nutrition Centre, Myanmar (NNCM). National hemoglobin and nutritional status survey among adolescents. Yangon, 2002.
31. Rao KM, Laxmaiah A, Venkaiah K, Brahmam GN. Diet and nutritional status of adolescent tribal population in nine states of India. Asia Pac J Clin Nutr 2006; 15 (1): 64-71.
32. Rao S. Nutritional status of Indian population. J Bisoc Sc 2001; 26: 481-489
33. Shahabuddin AK, Talukder K, Talukder MK, Hassan M, Seal A, Rahman Q, Mannan A, Tomkins A, Costello A. Adolescent nutrition in a rural community in Bangladesh. Indian J Pediatr. 2000; 67(2): 93-8.
34. Ulijaszek SJ, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. Br J Nutr 1999; 82:165 -177.
35. Venkaiah K, Damayanti K, Nayak, MU, Vijayaraghavan K. Diet and nutritional status of rural adolescents in India. Eur J Clin Nutr 2002; 56: 1119-1125.
36. World Health Organization. Measuring change in nutritional status. Geneva: World Health Organization, 1983.
37. World Health Organization. Physical Status: The Use and Interpretation of Anthropometry. Technical Report Series No. 854. Geneva: World Health Organization; 1995.
38. World Health Organization. The Asia Pacific Perspective: Redefining obesity and its treatment. World Health Organization, Geneva, Switzerland: 2000.
39. World Health Organization. Adolescent Nutrition: A review of the situation in selected South-East Asian countries. Executive Summary. World Health Organization Regional Office for South-East Asia, New Delhi, 29 Dec 2005.
40. WHO Multi-centre Growth Reference Study Group (2006) WHO child growth standards based on length/height, weight and age. *Acta Ped* 450: 76S-85S.