LINEAR GROWTH AND DEVELOPMENT OF SCHOOL STUDENTS AGED 8-16 YEARS FROM RURAL WEST BENGAL, INDIA: USING HEIGHT, WEIGHT AND BMI AS ANTHROPOMETRIC INDICES

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Abstract: Linear growth and development of individual can be measured by their nutritional status. Inspite of socioeconomic improvement, malnourishment was very common in rural West Bengal (WB), India. Anthropometric measurements like height and weight are simple and non-invasive ways to measure one's nutritional status. This study aims to determine the nutritional status and growth in the students of age group of 8-16 years using simple indicators like height, weight and body mass index (BMI). Survey was done on the students of four primary and secondary schools of southern West Bengal of Eastern India for the cross sectional investigation on subject's linear growth and weight. 551 students (283 boys and 268 girls) from lower to middle socio-economic class were selected by random sampling. Height (cm) and weight (kg.) of the students were measured and Body Mass Index [wt (kg.)/ht(sq m.)] was derived. One way ANOVA was done to find out significant gender-wise differences of growth in each age group. Statistical analysis was done using SPSS v.16.Values compared to Height for age (HAZ), BMI for age (BMIZ); for 8-16 years and Weight for age (WAZ; for 8, 9 and 10 years) maintaining international standard cut-offs (WHO, 2007). Significant differences in linear growth and development between boys and girls at the age of 9, 11 (late-childhood and early adolescence) and 14 onwards (late teenage) were found. 22.1% of students were found stunted, 15.4% were underweight and 11.7% were suffering from thinness. Tendency to be obese seemed less (7.3%). Students exhibited a lesser rate of malnutrition which is hopefully lower than other developing countries and less than earlier Indian studies. Age specific nutritional trends are found rather becoming region specific.

Keywords: Height; Weight; BMI; Growth; Rural Students; WB; India

Introduction

Nutritional status is found to be adequate in developed countries but not always adequate for healthy living in developing countries like India and Africa (Figueroa & Rodriguez, 2002). Inadequacy of the major nutrients; commonly referred as malnutrition; is most vulnerable for the adolescents and older of a population (WHO, 2007). Malnutrition is considered as a broad term encompassing both undernutrition and overnutrition and a health burden worldwide (Muller & Krawinkel, 2005). Undernutrition includes being remarkably short for one's age (stunting), being underweight for age and being thin (thinness) for age (UNICEF, 2003). Children with severe malnutrition possess a risk for death whereas they are large in numbers especially in the developing countries like India (Black *et al.*, 2008). Overnutriton is a cumulative effect of diet and less physical activity as reported in UNICEF 2003. On the other hand, overnutrition, being a common problem for affluent; is four times prevalent in urban than rural (Black, 2008).

Although India is growing fast in terms of socioeconomic perspectives; however, insufficient availability of potable water, lack of proper sanitation and cleanliness have been reported to impact normal growth in subjects in addition to malnutrition (Singh *et al.*, 2015) and correlated to poor height increase among the subjects (Hausmann *et al.*, 2009). Undernourishment has been quite common in rural West Bengal (WB) where subjects do not get enough nutrients required for normal growth and development (Kekan *et al.*, 2012). Prevalence of undernutrition is double in rural areas than urban in 1999 (Black, 2008) and higher in girls than boys which reduces the national progress from socioeconomic perspective (Venamann, 2008). Above all, nutrition is largely determined by the environment, not the genetic factors in one's growth and development (WHO, 2008).

Anthropometric measurements are well known for simplicity and non-invasive ways to measure nutritional status. Anthropometric indicators are typically based on age, height, weight and BMI (derived from height and weight). The standard indicators used here are "height-for-age", "weight-for-age" (5-10 years of age only) and "BMI-for-age" (8-16 years), (WHO, 2007). Low height-for-age is generally referred to as "stunting", and low weight-for-age as "underweight". Height; being independent of circumstances does not change much over short period. "Weight for-age" can be seen as a more comprehensive indicator. However, being short or lean is not a serious impairment in all cases. On the contrary, BMI is the best measure of overall obesity of children and young (Cole *et al.*, 2005). BMI-for-age best defines the extent of thinness and overweight including obesity of the children and adolescents from 5-19 years (de Onis *et al.*, 2004).

The distribution of height weight and BMI in the reference population is used to construct cut-offs values. A standard cut-off for those are "Median-2SD", based on the reference population (WHO, 2007); act as the best indicator to categorize the subject's stunting (when the indicator is height), underweight (here indicator is weight) and thinness (considering BMI as the indicator). "Median+2SD" cut-off values are considered for assessing overweight which also includes obesity according to the same gender and age. Besides, there is a paucity of data on the prevalence of thinness, underweight and stunting in the rural areas of WB of eastern India (de Onis *et al*., 2001).

The present study aims to determine the nutritional status in late-childhood and young adolescent students (in the age group of 8-16 years) using simple indicators like height, weight and BMI. The survey was done for cross sectional investigation on subject's linear growth and weight which reflect the overall development status.

Materials and Methods

Secondary school going boys and girls from low to middle socio-economic class (Dudala, *et al*., 2013) between the age range of 8-16 years in four schools in the district north 24 Parganas of rural southern WB were included for the cross-sectional study [D.B.F.P. School and D.B. High School (H.S) (Madhyamgram), S. S. B. Vidyatan (Sodepur), B. T. High School (Belgharia), R. R. High School, (Sealdah)]. The anthropometrical analyses included in the study are Height for age, Weight for age and BMI for age were the principles for consideration (Hu, 2002). Ages were verified from respective school records. Age group was taken from eight (8) as studies showed that due to precocious puberty in developed as well as developing countries adolescent is preceding now-a-days (Heger *et al*., 2008). Parental consent was to taken from the all participating subjects and all necessary ethical protocols were followed accordingly. Anthropometric measurements of 551 rural school-going subjects (283 boy and 268 girl subjects) were selected through simple random sampling. The values of anthropometric measurements such as height and weight were recorded for every subject twice and averages done for the study and compared with the World Health Organization (WHO) standard (WHO Growth reference Data for 5-19 years, 2007). One way ANOVA was done to derive the significant differences of growth among boys and girls of each age group. Statistical analysis was done with SPSS v.16.

Anthropometric measurements

Anthropometric measurements were conducted on the same day for each student in same session to avoid technical errors with criterion accredited by the International Society for the Advancement of Kinanthropometry (ISAK, 2011). Method described in the manual of International Society for the Advancement of Kinathropometry was followed for taking all the measurements (Brozek *et al.*, 1963).

- Height: Height was measured with an Anthropometric Rod (GPS) up to 1 mm. (Esrey, 1996).
- Weight: Body mass was calculated in minimal clothing. The subject stood on the centre position of the scales without support with the weight distributed evenly on both feet. Weighing was taken with a digital scale (calibrated beforehand, capacity 150 kg) having a precision of 0.5 kg. Time of taking weight was also noted (Waterlow, 1972).
- BMI: Derived by dividing weight (kg) by height (m) squared. BMI categories were based on age specific cut-offs in adolescent. WHO based classification for global database on Body Mass Index (BMI) was used as a cut points for BMI (Gallagher *et al*., 1996).

Technical Error Measurement (TEM)

TEM were computed and found to be within limits. Therefore TEM were not incorporated in statistical analysis. TEM was calculated as= sq root of {(sum of D^2)/2N}; where D=difference between two measurements, N=number of subjects measured (Ulijaszek & Karr, 1999)

Results and Discussion

Linear growth and physical maturation are dynamic processes which encompass changes at molecular, cellular and somatic levels of a body (Rogol, 2002). Traditionally, height has been primarily used for growth assessment, but changes in body proportion and composition are also essential elements of growth, especially of physical maturation (Nguyen *et al.,* 2001). Assessment of skeletal maturation is perhaps the best indicator of biological age or maturity status, because its development spans the entire period of growth (Grave *et al.,* 1976).

Table 1 reveals that there was no significant relationship between boys' and girls' height at the age group of 8. Mean height of the girls' was slightly higher than boys' up to age 13. Rise in boys mean height started from age 14 and last till 16. However, in the age group of 9 the difference was significant at0.05 level of significance. Precedence of puberty and menstrual age in girls, development of body stature and composition with adolescence growth spurt in accordance to that (Heger *et al.,* 2008) might be the causal factors for this remarkable difference. At the ages 11 and 14 there were significant differences found (at 0.01 level of significance) between boys' and girls' height and continued up to 16.

In the present study the average girl grows about 9 inches (22.8 cm) in height between the ages of 8 and 12 years while the average boy grows 8 inches (20.3 cm) only. It is due to the beginning of secretion of large amounts of various hormones earlier in girls by the pituitary gland which impact their physical and mental maturation. (Insel *et al*., 2013) The adolescents looks clumsy at the first phase of their development as growth pattern is uneven including the lengthening of the calves and forearm followed by the hips , chest and shoulder (Whiting *et al*., 2004). Proper nourishment is a determinant factor in entering sexual maturation and menarche (onset of menstrual cycle) in girls (Rogol *et al*., 2000). Now a days as menarche is preceded in girls about 8-9 years (Kipke, 1999), boys attain height surge after 13 as compared to girls. A typical girl attains 95% of her adult height at about 1 year before menarche and the rest after attaining adolescence. After the main growth spurt starts, it continues for 2-4 years at a much slower rate in boys whereas girls' growth outperforms (WHO, 2007). The beginning of the increase in growth velocity is about age 11 in boys and 9 in girls; but varies widely from individual to individual (WHO, 2007). The peak height velocity in this study occurs in about 14 and 16 years which is similar to US students (Neinstein & Kaufman, 2002). Long bones epiphysial closure is a remarkable end point of adolescent growth. If the epiphysial closure is earlier as a consequence of malnutrition, full potential height fails to attend (Ronnenberg *et al*., 2004). On average, children of smaller parents will eventually attain lesser height than children of taller parents; bone age approximates chronologic age, these children usually grow at an appropriate rate during childhood and attain sexual maturation and pubertal growth spurt at the usual ages (Rogol *et al*., 2000).

Table 1: Cross-tabulation between age groups in relation to Gender and height (cm)

Age group (years)	Sex	Mean	SD	Max	Min	SE	Sig. value
8	Boy n_1= 28	123.6174	4.76690	132.00	117.90	0.99397	.700
	Girl n_1= 28	124.5059	9.51206	140.90	114.70	2.30701	
9	Boy n_2=28	131.7071	5.04887	142.00	125.50	0.95415	.046*
	Girl n_2=27	128.4033	7.02063	137.10	118.80	1.28179	
10	Boy n_3= 29	131.1750	6.21501	144.00	123.00	1.17453	.435
	Girl n_3= 25	132.1281	2.73451	137.50	127.00	0.48340	
11	Boy n_4=30	137.6000	5.58331	154.00	132.80	1.05515	.002**
	Girl n_4=30	133.1871	4.91581	144.50	116.50	0.88291	
12	Boy n_5=34	142.0400	8.02954	154.50	125.80	1.13555	.066
	Girl n_5=30	145.8773	8.04250	154.00	128.00	1.71467	
13	Boy n_6= 36	146.5700	5.36529	165.00	133.50	0.97956	.626
	Girl n_6=31	147.1567	3.77913	153.50	133.10	0.68997	
14	Boy n_7=34	153.6250	6.24539	173.00	144.00	1.18027	.000**
	Girl n_7=34	142.1923	4.83003	152.50	134.00	0.77342	
15	Boy n_8=36	154.9821	3.98730	160.00	145.90	0.75353	.000**
	Girl n_8=36	147.3794	3.27227	156.00	144.00	0.56119	
16	Boy n_9= 28	165.5125	5.58598	175.00	153.00	0.88322	.000**
	Girl n_9= 27	151.6364	4.39117	163.00	142.50	0.76440	

(N =551; *implies .05 level of significance & **implies .01 level of significance)

Table 2: Cross-tabulation between age groups in relation to gender and weight (kg)

Age group (years)	Sex	Mean	SD	Max	Min	SE	Sig. value
8	Boy n_1= 28	22.0652	7.29150	40.50	14.50	1.52038	.708
	Girl n_1= 28	23.0294	8.88726	40.50	15.50	2.15548	
9	Boy n_2=28	20.4286	3.03289	28.00	18.00	.57316	.074
	Girl n_2=27	22.7000	5.91550	36.00	16.00	1.08002	
10	Boy n_3= 29	27.6607	5.85164	37.00	20.50	1.10586	.155
	Girl n_3= 25	29.7688	5.48355	37.00	20.00	.96936	
11	Boy n_4=30	31.3357	5.78985	45.00	24.50	1.09418	.045*
	Girl n_4=30	28.3548	5.07969	39.50	21.50	.91234	
12	Boy n_5=34	34.7700	10.58166	70.50	22.50	1.49647	.146
	Girl n_5=30	38.3227	6.04711	50.50	25.00	1.28925	
13	Boy n_6=36	37.2067	7.99560	54.00	25.00	1.45979	.226
	Girl n_6=31	40.0100	9.66930	64.50	24.50	1.76537	
14	Boy n_7=34	46.9857	8.09480	62.00	32.00	1.52977	.000**
	Girl n_7=34	35.2154	4.70372	45.50	25.50	.75320	
15	Boy n_8=36	41.8857	5.19185	49.70	29.00	.98117	.000**
	Girl n_8=36	35.6882	6.05499	51.50	28.50	1.03842	
16	Boy n_9= 28	53.6875	8.81701s	73.50	35.50	1.39409	.043*
	Girl n_9= 27	49.2242	9.67119	64.50	29.50	1.68354	

N =551; *implies significant at .05 level of significance & ** implies significant at .01 level of significance

Table 2 demonstrates that there was no significant relationship between boys' and girls' weight in the age group of 8, 9 & 10 years. Mean weight of the girl subjects was relatively higher up to 13 years; afterwards the boys outperformed. Significant differences in mean weight were found at the ages of 11 and 16 (0.05 level of significance), 14 and 15 (at 0.01 level of significance). Weight velocity increases and peaks during the adolescent growth spurt in both genders; pubertal weight gain accounts for about 50% of an individual's ideal adult body weight (Malina, 1994). The onset of accelerated weight gain and the peak weight velocity (PWV) attained are highly variable (Neinstein, 2002). External factors such as diet and physical exercise affect weight gain more than linear growth. Although it is expected that weight gain will start after height increase, eventually these two phase overlap. Again, in girls, peak weight gain occurs after attainment of menarche.

Body mass index (BMI) is considered to be more nutritionally than genetically related (Khongsdear, 2001) among all other anthropometric indices. Thus, in a country with diverse ethnic groups like India, it is more appropriate to use BMI as an indicator of the nutritional status of the population (Khongsdear, 2001). In the table 3, no significant relationship was found between boy and girl subjects' BMI at the age group of 8 years. At 9 and 14 years, the difference was significant at 0.01 level of significance. Girls were heavier than boys up to 13 years. They exhibited a better BMI than boys' up to age 13 years; rise in boys' BMI occurred afterwards. Boys' BMI differed significantly (at 0.05 level of significance) with girl subjects' at the age of 16. It is reported that most of the girls start their sexual development between the ages of 8 and 13 years as a result of precocious puberty (Heger *et al.*, 2008); and have a growth spurt between the ages of 10 and 14 years .Most boys start developing sexually between the ages of 10 and 13 years, and continue to grow until they are around 16 years (Dahl, 2004).

Adolescent boys increase to develop lean body mass and muscle differentiation, whereas girls face increase of body fat at about 21% (Berkey *et al.*, 2000) There is a weak positive correlation between subject's birth weight and BMI; a higher birth weight leads to a tendency of being overweight in adulthood (Ranke & Mullis, 2011). Chowdhury *et al.* (2000) determines the effect of weight on maturation of girls. Height weight and BMI have an accumulated effect on sexual maturation. According to Bosch (2005), taller and heavier girls show a better nutritional status and mature earlier than shorter and lighter girls. Classification of BMI is complex as subjects are in growing phase, the rate of body physique and composition changes frequently in them (Wells, 2007).

Table 3: Cross-tabulation between different age group with Gender and Body Mass Index (kg/sq m)

Age group (years)	Sex	Mean	SD	Max	Min	SE	Sig. Value
8	Boy n_1= 28	14.1957	3.53752	23.30	10.30	.73762	
	Girl n_1= 28	14.3412	3.11790	20.70	11.70	.75620	.893
9	Boy n_2=28	11.7321	.96917	13.90	10.90	.18316	.002**
	Girl n_2=27	13.6833	.55665	9.90	21.00	.55665	
10	Boy n_3= 29	16.1357	3.64013	22.90	11.10	.68792	.287
	Girl n_3= 25	17.0844	3.19305	21.10	11.50	.56446	
11	Boy n_4=30	16.5786	3.13267	25.50	12.80	.59202	.422
	Girl n_4=30	15.9710	2.63403	22.10	12.20	.47309	
12	Boy n_5=34	17.1740	4.83317	36.00	11.60	.68351	.422
	Girl n_5=30	18.0864	3.22598	28.50	14.00	.68778	
13	Boy n_6=36	17.2367	3.16048	24.70	12.00	.57702	.214
	Girl n_6=31	18.4867	4.44489	28.50	11.50	.81152	
14	Boy n_7=34	19.8964	3.03663	25.60	14.30	.57387	.000**
	Girl n_7=34	17.4385	2.29870	23.40	12.80	.36809	
15	Boy n_8=36	17.4036	1.77941	20.50	13.20	.33628	.120
	Girl n_8=36	16.4412	2.79492	21.80	12.70	.47933	
16	Boy n_9= 28	19.5500	2.80192	27.30	14.60	.44302	.024*
	Girl n_9= 27	21.3697	3.90708	27.60	13.50	.68014	

N =551; *implies significant at .05 level of significance & ** implies significant at .01 level of significance

Table 4: Comparison of age and gender-specific mean height (cm), weight (kg) and BMI (kg/ sq. m) of the subjects (gender-independent)

Age (years)	Height (cm) Boy	Girl	P value	Weight (Kg.) Boy	Girl	P value	BMI (kg/m^2) Boy	Girl	P value
8	123.61 (4.76)	124.50 (9.51)	.700	22.06 (7.29)	23.02 (8.88)	.708	14.19 (3.53)	14.34 (3.11)	.893
9	131.70 (5.04)	128.40 (7.02)	.046*	20.42 (3.03)	22.70 (5.91)	.074	11.73 (.96)	13.68 (3.04)	.002**
10	131.17 (6.21)	132.12 (2.73)	.435	27.66 (5.85)	29.76 (5.48)	.155	16.13 (3.64)	17.08 (3.19)	.287
11	137.60 (5.58)	133.18 (4.91)	.002**	31.33 (5.78)	28.35 (5.07)	.045*	16.57 (3.13)	15.97 (2.63)	.422
12	142.04 (8.02)	145.87 (8.04)	.626	34.77 (10.58)	38.32 (6.04)	.146	17.17 (4.83)	18.08 (3.22)	.422
13	146.57 (5.36)	147.15 (3.77)	.626	37.20 (7.99)	40.01 (9.66)	.226	17.23 (3.16)	18.48 (4.44)	.214
14	153.62 (6.24)	142.19 (4.83)	.000**	46.98 (8.09)	35.21 (4.70)	.000**	19.89 (3.03)	17.43 (2.29)	.000**
15	154.98 (3.98)	147.37 (3.27)	.000**	41.88 (5.19)	35.68 (6.05)	.000**	17.40 (1.77)	16.44 (2.79)	.120
16	165.51 (5.58)	151.63 (4.39)	.000**	53.68 (8.81)	49.22 (9.67)	.043*	19.55 (2.80)	21.36 (3.90)	.024*

Standard Deviations are given in parenthesis *p value<0.05; **p value<0.01

Table 4 exhibits gender specific comparative mean height weight and BMI .There were significant differences between weight of boys' and girls' at the ages of 11 and 16 years (0.05 level of significance) 14 and 15 years (at 0.01 level of significance); height at the age of 9 (0.05 level of significance), 11 and 14 years onwards (at 0.01 level of significance). BMI exhibited significant difference between boys and girls at the age of 9 and 14 years (at 0.05 and 0.01 level of significance respectively). Mean BMI was recorded to increase with age in both sexes in an earlier study held at Midnapore (West) district of WB (Chakraborty & Bose, 2009). Freedman (2006) revealed that there is a positive linear increasing trend in mean height and weight for boys between 11 and 15 years of age; in girls the trend shows an exception at 13 years (for height) and at 12 years (for weight).

The BMI gradually increases through adolescence and adulthood (Freedman, 2006). Children with an earlier increase in BMI are more likely to have increased BMIs in adulthood (Cole *et al*., 2005). Mean BMI for girls had been found to be slightly higher than boys. The mean height, weight and BMI of boys and girls in this study were higher than Rao *et al*. (2006) from India. However, the mean height of the boys of the present study was found to be lower; but the BMI was higher than urban boys of Kolkata previously reported by de Onis *et al*. (2001). WB rural adolescent boys are significantly taller and heavier than girls from 14 years of age and the overall rates of underweight and stunting were reported as 28.3% and 27.8%, respectively (Bisai *et al*., 2011). Furthermore the prevalence of overweight in affluent people was higher in India than other south Asian countries and a steady increase of overweight was seen from 6- 9 years and in the year six (6)-seven (7), there was a trend of maximum gain of all linear measurements along with BMI (Mandel *et al.*, 2004).

Table 5 and Fig. 1 represent stunting, underweight and thinness of the subjects by age groups. The overall age wise prevalence of stunting underweight and thinness were 22.1%, 15.4% and 11.7%, respectively. According to WHO (2007) public health problem of under nutrition among children, these rates were Medium (20-29%) for stunting and Low for underweight (<10-19%) and thinness (<15%), respectively.

Stunting and underweight were recorded to be as high as 23% and 27.9% respectively (Bose *et al.*, 2007) in studies performed at Bankura, Purulia and Midnapur districts of West Bengal. Considering the range of cut-offs (WHO, 2007) this table also reveals that 95.9% of the students are within normal range of height), only 4.1% are taller. It is found that about 98% of the subjects belong to normal weight (for 8, 9 and10 years of age only); only 2.4% of students are overweight. Due to lack of knowledge and maybe over concern for protein rich food has led to overweight and obesity among the children in the study area (Leidy *et al.*, 2010). The z score for BMI (BMIZ) reports that 92.7% students (gender-independent) belong to a normal range of BMI; whereas 7.3% are overweight including obese (WHO, 2007). This obesity might be a result of negligence of their wards among the well-off families in the study area. The sensitivity and specificity of a fixed cut-off for underweight and overweight are likely to differ by age, gender and geographic location in population (Launer & Harris, 1996).

Table 5: Prevalence of stunting, underweight and thinness from Height-for-age, Weight-for-age and BMI-for-Age (gender-combined)

Category	Height-for-age (HAZ) (Counts) (%)	Weight-for-age (WAZ) (8,9,10 years) (Counts) (%)	BMI-for-age (BMIZ) (Counts) (%)
>SD-2	122 (22.1)	26 (15.4)	65 (11.7)
SD-2=>Median	278 (50.5)	77 (46.5)	254 (46.2)
Median=>SD+2	128 (23.3)	58 (35.3)	192 (34.8)
>SD +2	23 (4.1)	4 (1.8)	40 (7.3)
Total	**551 (100)**	**165 (100)**	**551(100)**

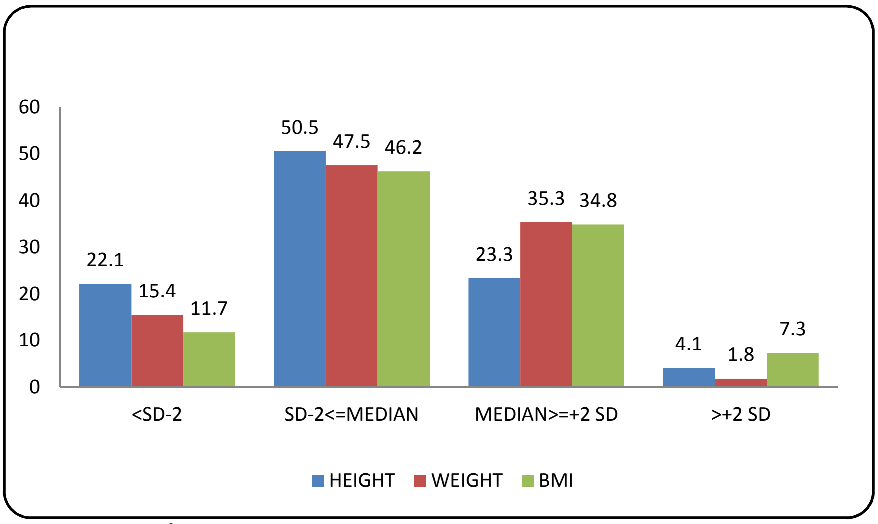

Fig. 1: Rate (%) of stunting, underweight and thinness in students (gender-combined)

Internationally, undernutrition among children and adolescents is a serious public health problem, especially in developing countries (Launer *et al.*, 1996; Rogol *et al.*, 2000). The study of Cole *et al.* (2005) stated that undernutrition is better assessed as thinness (low BMI-for-age) than other indicators. In a study among Bengali adolescents exhibited moderate rate of undernutrition regardless of sex (36.49%) which was lower than those reported in other developing countries including India and irrespective of sex, the rate of undernutrition increased with the advancement of age (Bose *et al.*, 2007). Stunting in young children affects their cognitive development, academic performance and economic productivity in adulthood (Kar *et al.*, 2008). 43.5% of young Indian children are undernourished with PCM (NNMB, 2006). Again, 56.6% of them from the lowest socioeconomic class are undernourished in comparison to 19.7% in the wealthiest class (NFHS-2, 2007).

Furthermore, undernutrition in children begins with mother (Jehn & Brewis, 2009). Mothers' own birth weight and diet from childhood to adulthood throughout the pregnancy affect ward's birth weight. Global reports estimates there are more than 195 million stunted and about 129 million underweight people are underweight, especially in Asia and Africa (UNICEF, 2009). Stunting is a chronic nutritional deprivation where as underweight reflects acute nutritional deficiency. The stunted children in weight earlier life didn't seem to gain optimum height in later life, whereas underweight, on the contrary, could be overcome with appropriate health development programmes (Black *et al.,* 2008).

The present rate of undernutrition (49.6%; a combination of stunting, underweight and thinness; sex-combined) is slightly higher than those among Nepali refugees reported by Woodruff *et al.* 1999 (34%); and much higher than rural African adolescents (23%) respectively as reported by Phinney *et al*. (1996). In the present study, under nutrition has been found to be lower (53%) than that reported by Mukhopadhyay *et al*. (2005); and two Kenyan reports- 61% Phinney *et al.* (1996); and 57% (Woodruff *et al.*, 2006). Another study also provides the same picture of undernutrition (67% on average) among rural boys across 9 states of India (Rao *et al*., 2006) and Kenyan refugees (75%) as reported by an International Rescue committee 1997 (Mukhopadhyay *et al*., 2005).

Table 6 indicates that weight followed by height and age justify the subjects' collected BMI at the time of the study. It demonstrates the normalized importance analyzed through classification based on regression tree of experimental variables on BMI. The BMI of the subjects are found to be highly associated with and weight (100%), height (34.8%) and age (30.4%); appropriately represents the fluctuations of BMI between and inter groups of the students of different schools belonging to different areas. In a regression analysis of risk factors regarding undernourishment in children and young in developing countries like India mothers' low BMI is suggested to be the topmost factor liable to underweight of their wards which is a vicious cycle which affects the nutritional status and economic development of future generation (Vir, 2001).

Table 6: Independent variable importance on BMI

Independent Variable	Importance	Normalized Importance
Weight in Kg	12.384	100.0%
Height in cm	4.304	34.8%
Chronological age of the Subjects	3.763	30.4%

Growing Method: CART; Dependent Variable: Body Mass Index (kg/m^2)

The majority of deaths (89%) associated with malnutrition occur who are generally malnourished up to a moderate extent (Bose & Chakraborty, 2009). Anthropometric indices serve as proxies for long food deprivation and diseases or illness (Sterling *et al.,* 2012). Undernutrition causes premature mortality and ill health. Stunting is a result of chronic food deprivation and poverty (Bisai *et al*., 2011). Stunting rate seems to decline with women's education (de Onis, 2003). Women empowerment ensures more investment in food, nutrition and health along with education of their offspring (NFHS, 2007), which reduces the risk of underweight of their wards and in turn, also associated to less domestic violence experienced by them (Vir, 2011).

From the present study we can conclude that school wise and gender wise differences were not statistically significant while monitoring nutritional status; however, age wise difference played a key role in shaping nutritional status in the study area.

Conclusion

Findings revealed from this study are that nutrition pattern in the areas in the selected schools had a specific nature. Students exhibited a medium extent of being stunted and less extent of underweight and thin, respectively. Significant differences in linear growth and overall development between boys and girls were found at the age of 9, 11 (late-childhood and early adolescence) and 14 onwards (late teenage). Students are found to be dependent on their family regarding availability of proper food and nutrition. Interestingly parents care less for the subjects after they attain late childhood. Undernutrition is a complex scenario caused from inadequate access to food and less concern for health in children and young. It is also aggravated by factors like household food insecurity, inadequate care for women and children, unhealthy environment and lack of proper drinking water and environmental sanitation. Those factors might be linked to poverty and also influenced by political, social and economic conditions. Higher education may act as proxy indicator of decision making power of women which in turn associated with a reduction of low BMI and underweight in children and young.

Improved national health is undoubtedly considered as a universal humanitarian goal. Parents believe that their elder children get sufficient nutrition from schools' mid day meal provision; and as a result they do not cater for their nutritional needs at home. But they usually don't have the knowledge about the foods actually taken by their wards. School mid day meal data also showed their options towards egg and soybeans, not towards Bengali staple foods (like rice or wheat etc). The present study also suggests that school wise and gender wise differences were not statistically significant in case of malnutrition; rather age played a key role in shaping malnutrition status in the study area.

Hence awareness programs are absolutely necessary to change the parents' attitudes to care for nutritional needs of their wards evenly. For proper selection of appropriate nutritious food items for their children; guidance and training are required for the parents. This can serve the purposes of curbing malnutrition levels among growing subjects as well as encourage the subjects to take nutritious meal at home. Parents also need to be educated about the effects of nutritious food on the body growth and non-communicable diseases that occur as a result of malnutrition. Education, training and information on the use of nutritious food and their inclusion in the subjects' everyday meal need to be incorporated in health intervention programme of the local government. Further investigations are needed to evaluate potential effects of malnutrition among growing subjects to develop their physical and mental health. The frequency of immunity related diseases become higher day by day. This is an indication that students of growing age suffer due to lack of provision of nutritious food. Anthropometric indices serve as proxies for long food deprivation and diseases or illness. Poor child care had harmful effects on the subjects' physiological growth as well as on their psychological development. Although it is very difficult to mitigate the problems of poverty and ignorance; the rates of undernutrition in this study is hopefully lower than other developing countries and less than earlier Indian studies.

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Conflict of Interest Statement

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