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Nutritional status, nutrients diet and body mass index of rural adolescents in eight state of India

Mridula Gautam
Department of Home Science, Govt. Model Degree College, Kursanda Sadabad, Hathras, Uttar Pradesh, India

Abstract
Anthropometric and socio-economic information on 12 124 adolescent boys and girls and dietary information on 2579 individuals in 2019-2020 was available for the analysis. The major occupation of the heads of the households surveyed was agriculture. More than a third (37.3%) of the families with adolescents did not possess any land. The per capita income per month was about Rs 250/- at 2019-2020 prices. About 23% of the adolescent girls were married before the age of 18 year. About a quarter of the married adolescent girls had short stature and 18.6% were underweight. About 39% of the adolescents were stunted (< Median 7 2 s.d. of NCHS height for age) irrespective of sex. The prevalence of under nutrition (< median 7 2 s.d. of NCHS weight for age) is higher (53.1%) in boys than in girls (39.5%). The extent of stunting was higher (42.7%) among adolescents belonging to the Scheduled Caste community. In the case of girls, the extent of underweight was considerably less in each age group than their male counterparts. About 70% of adolescents consumed more than 70% of RDA for energy. The intakes of micronutrients such as vitamin A and riboflavin were woefully inadequate. The extent of under nutrition was high among adolescents and was higher among boys than girls. Adolescent girls in the rural areas could be at greater risk of nutritional stress because of early marriage and early conception before completion of their physical growth in eight states (provinces) of Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Uttar Pradesh and Tamil Nadu of India.

Keywords: Adolescence, body mass index, diet nutrients and nutritional status in India

Introduction

Adolescence is a period of rapid growth and maturation in human development. The nutritional status of adolescent girls, the future mothers, contributes significantly to the nutritional status of the community. It is only recently that efforts, although small, have been made to include adolescent girls as beneficiaries in some of the health and nutrition intervention programmes. Currently, it is estimated that there are about 69.7 million adolescent girls constituting about 7.0% of the total population.

Physical growth at adolescence occurs earlier and is more rapid than during pre-adolescence. In India, the proportion of adolescents getting married before completion of their growth is very high (23.0%)[1]. If these young girls become mothers, their growth ceases, exposing them to the consequences of cephalo-pelvic disproportions. There is very little information about diet and nutritional status of adolescents, particularly from rural areas of eight States (provinces) of Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Uttar Pradesh and Tamil Nadu in India. Therefore, there is a need to develop a database on the diet and nutritional status of the adolescents from different parts of the country to enable the governments and other non- governmental agencies to formulate policies and initiate strategies for the well-being of adolescent children. In this communication, an attempt has been made to assess the current nutritional status of the adolescent children using the available large data collected in nine States of the country by the National Nutrition Monitoring Bureau (NNMB) during 2019-2020 (National Nutrition Monitoring Bureau, 1999) [2]. The psychological and social problems in school adolescents in urban area of Aligarh [3], nutritional minerals supplements multivitamins and energy drinks consumed by senior adolescents at students and their effect on body mass index [4], investigation of nutritional status of adolescent girl in rural area [5] and study on creativity and intelligence of the adolescent students [6].

Materials and methods

The NNMB, funded by the Indian Council of Medical Research (ICMR), has been carrying out annual diet and nutrition 2019-2020. For the purpose of this inves- tigation, the most recent data collected during 1996 – 1997 by the NNMB on diet and nutritional status and Body Mass Index in the rural areas of the States (provinces) of Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Uttar Pradesh and Tamil Nadu of India was utilized. Trained Medical Officers, Nutritionists and Social Workers, conversant with local language and culture, collected the data using standard and uniform procedures[7]. In each State, 120 villages were selected from eight districts representing different geo- graphic locations of the State. From each of the selected villages, 20 households (HHs) were selected by adopting 'cluster sampling method'. From five clusters, of which one cluster represented socially backward Scheduled Caste (SC) and Scheduled Tribe (ST) community. From each of the selected clusters, four consecutive households were surveyed by selecting the first household randomly. If the number of households in a given cluster was too large, the cluster was further divided into sub-clusters and one of them was selected randomly to cover four households. Thus in each state, a total of 2400 households were targeted for survey.

The information on socio-demographic profile was collected in all 20 HHs, while data on body weight, standing height and clinical signs of nutritional deficiency was col- lected on all the available adolescents in these HHs. In every

fourth sampled household (five HHs per village), dietary information on all the members of the HHs was collected using 24 h dietary recall. The type of house was determined considering the type of its walls and roof as follows: kutcha — mud walls with thatched roof; semi-pucca—brick walls with thatched roof; and pucca— brick walls with RCC or tiled roof.

Statistical analysis

The statistical analysis was carried out using windows version of SPSS 7.5. Mean, median and s.d. of the anthropo-metric data, obtained on 10 – 17-y-old children, were calculated for each age group. The mean values of food and nutrient intakes of adolescents were calculated sepa- rately for each of the three age groups (10 – 12, 13 – 15 and 16 – 17 y).

Nutritive value tables for Indian foods [8] were used for calculating nutrient intakes. The food intakes were compared with the balanced diets recom- mended for Indians[9]. The intakes of nutrients were compared with the recommended dietary allowances (RDA) for Indians.[10] The groups were compared using non-parametric procedure wherever the assumptions were violated.[11]

For the purpose of comparison, NCHS reference values for height and weight[12] were used to assess undernutrition and the extent of stunting. The median body mass index (BMI) was calculated and prevalence of chronic energy deficiency (CED; BMI values less than 5th percentile of NHANES; WHO, 1995[13] was assessed. Association between underweight, stunting, CED and socio-economic parameters was tested using the chi-square test and Height and weights of well-nourished Indian scheme children [14].

Results and discussion

Anthropometric information on 12 124 adolescent boys and girls and dietary information on 2579 individuals in 2019-2020 was available for the analysis. The details of socio-economic status of the sample are presented in Table-1. More than 90% of the adolescents belonged to Hindu religion. About 39% belonged to socio-economically vulnerable sections of Scheduled caste (27%), and Scheduled Tribes (12%). In general, 77% of the families were large (5 – 10 members) and about 42% of the heads of the households were illiterate. Almost all the adolescents (97.9%) were residing in their own house, of which 61% were kutcha and 8.1% pucca houses. More than a third (37.3%) of the families with adolescents did not possess any land. The major occupation of the head of the household was agriculture, most being either labourers (27%) or tenant owner cultivators (45.5%). The mean per capita income (PCI) per month was about Rs 250/- at 2019-2020 prices. It was interesting to note that, while the PCI in the lowest quartile was Rs 77/-, in the highest quartile group it was Rs 626/-, indicating wide variation in the socio-economic status of the rural households.

Early marriage

About 23% of adolescent girls were married before the age of 18 y. It is well known that in growing children conception leads to cessation of growth. About 24% of the married adolescent girls had short stature (< 145 cm) and 18.6% were underweight (< 38 kg)[15] who could be considered as 'at risk'. However there were no significant differences between the married and unmarried adolescent girls in anthropometry within age groups (Table 2).

Dietary consumption

Foods

The mean consumption of all the foods except cereals and millets, and roots and tubers was below the recommended dietary intakes for Indian adolescents (Table 3). Since there was a large variation in the intakes of foods among the adolescents, a non-parametric Mann – Whitney test was used to study the differences between boys and girls. The intakes of cereals, pulses, condiments and spices, and fats were significantly higher in boys than in girls within an age group. A one-way ANOVA Kruskal – Wallis test was applied to test between ages and sexes. The median intakes of cereals, other vegetables, roots and tubers, fish, fat and other flesh foods were significantly different between age groups among boys. Among the girls, the median intakes of cereals, leafy vegetables, roots and tubers, condiments and spices and fats were significantly different between age groups.

Nutrients

The mean and median intakes of nutrients for three age groups for both the sexes are presented. As the coefficient variation of nutrient intakes was generally high, ranging from 40 to > 100%, the median nutrient intakes were compared with RDA values. The intakes of all the nutrients were below the RDA in all age groups of adoles- cents, irrespective of sex. The intake of all the nutrients was higher in the boys than in the girls (Mann – Whitney). All the nutrients are signifi- cantly different between age groups (Kruskal – Wallis) in boys and girls. As age increased, the intake of nutrients increased significantly in boys as well as girls.

Distribution of nutrient intakes by percentage of RDA

The distribution of nutrient intakes, as a percentage of RDA, revealed that about 70% of adolescents consumed more than 70% of RDA for energy. The proportion, however, was slightly higher among the girls (75%) than in boys (66%). The proportion of adolescents consuming less than 50% of RDA of energy was higher in males (9.3%) than in girls (5.3%). The intakes of micronutrients such as vitamin A and riboflavin were woefully inadequate. In the case of vitamin A, about 75% of males and 79% of females had intakes less than 50% of RDA. In the case of riboflavin, about 40% consumed < 50% of RDA (Table 4).

Anthropometry

The mean, median and standard devia- tions (s.d.) of anthropometric measurements according to age and sex are given in Table 5. The antropometric variable weight was analysed to see the skewness in different age groups for boys and girls separately. It is found that the skewness is present in younger ages but not at later age in both the sexes. At the age of 17 y, the girls were shorter than boys by about 10 cm and weighed 3 kg less. At all ages, the adolescents were shorter and lighter than their American

counterparts (NCHS). The prevalence and confidence intervals of stunting and under nutrition is presented in Table 6. About 39% of ado- lescents in both the sexes were stunted (< median 7 2 s.d. of NCHS height for age). The percentage of stunting increased with increasing age in boys from 34.7 at 10 y to 59.7 at 17 y. In the case of girls, the percentage of stunting increased with increasing age (32.5–46.7) up to 13 y, after which it decreased to 37.2% at the age of 17 y. The prevalence of under nutrition (< median 7 2 s.d. of NCHS weight for age) is higher (53.1%) in boys than in girls (39.5%). The extent of under nutrition increased from 41.6 to 68.6% in boys with increasing age. Body mass index, which is considered as an index of chronic energy deficiency, is not constant in growing indi- viduals. Therefore, median 7BMI values were compared with those of NHANES survey conducted in the USA (Table 7). The proportion of Indian adolescent males that were below the 5th percentile values of NHANES ranged from 77.6% at 11 y to 44% at 17 y, while in the case of girls, the extent of CED was considerably less in each age group than their male counterparts. The prevalence of stunting, under nutrition and CED are on an increasing trend, as age increases from 10 to 17 y (Table 8).Multiple logistic regression was carried out to determine the relationship between socio-economic variables and the nutritional status (BMI less than 5th percentile). Among the various socio-economic factors, type of house and family size are found to be significantly contributing factors in explaining nutritional status. The risk of undernutrition (< 5th percentile of NHANES standards) is greater in adolescents who reside in kuitcha houses (odds ratio 1.12) as compared to pucca houses. In adolescents who belong to family size > 4, the risk of under nutrition is slightly higher (OR 1.1).

Socio-economic factors and nutritional status of adolescents

Association between socio-economic factors and nutritional status of adolescents. All the demographic and socio-economic factors, except family size and possession of own house, were significantly ($P < 0.05$) associated with the stunting of adolescents. The extent of stunting was higher (42.7%) among adolescents belonging to the scheduled caste community. The adolescents belonging to extended families had a lower prevalence of stunting (34.6%) as compared to those belonging to joint families (42.0%).

The percentage of stunting among adolescents was higher in those living in kutcha houses (40.5%) and families of labourers (40.3%). The extent of stunting decreased with increasing size of land holdings and increasing per capita income. The prevalence of underweight as assessed by weight=age was significantly associated with all the variables ($P < 0.05$) except with ownership of house.

There is a significant ($P < 0.05$) association between CED (BMI < 5th percentile of NHANES) and religion, community, family size, type of house, occupation and per capita income.

Table 1: Socio-economic status

Variable	Description	Percentage
Religion	Hindu	90.8
	Muslim	5.6
	Christian	2.1
	Others	1.4
Community	ST	12.1
	SC	27.2
	BC	29.6
	Others	31.1
Type of family	Nuclear	62.9
	Joint	16.9
	Extended	20.3
Family size	1 – 4	16.0
	5 – 10	77.2
	> 10	6.8
Literacy	Illiterate	41.9
	Literate	2.6
	≥ Primary	55.5
House	Own	97.9
	Tenant	2.1
Type of house	Kutcha	60.8
	Semi-pucca	31.1
	Pucca	8.1
Land holdings (acres)	Nil	37.3
	0 – 5	8.6
	> 5	54.1
Occupation	Labourer	27.0
	Agriculturist	45.5
	Artisans=business=service	24.1
	Others	3.4
Per capita income in Rs (percentile)	< 25	77
	26 – 50	141
	51 – 75	228
	≥ 76	626

Table 2: Heights and weights (mean± s.d.) of adolescent girls

	Married			Unmarried		
'Age (y)'	Number	Height	Weight (kg)	Number	Height (cm)	Weight (kg)
14	49	149.5±5.8	37.6±5.2	699	147.8±6.5	35.9±5.5
15	99	149.9±5.5	39.7±5.6	541	149.8±6.2	38.7±5.7
16	142	150.0±5.7	41.2±4.5	497	151.5±5.7	41.3±5.4
17	115	152.1±6.3	43.2±5.5	354	152.3±6.3	42.8±5.6

Table 3: Food intakes (g/day) by age groups

Age group (y)		Millets	Cereals	Pulses	Green leafly vegetables	Other vegetables	Roots and tubers	Nuts and oil seeds	Condiments	Fruits	Fish	Other flesh foods	Milk and milk products	Fats and oil	Sugar and Jaggery
Boys															
10-12	Mean	97.77	272.61	26.04	14.99	34.52	39.37	10.46	11.71	19.90	14.48	2.61	65.99	10.56	18.57
	s.d.	166.70	159.14	28.70	40.22	48.82	53.00	21.98	10.98	47.11	42.51	13.98	102.46	15.33	22.41
13-15	Mean	119.73	308.31	28.14	12.12	46.88	48.66	14.75	12.75	35.26	18.43	3.61	64.68	10.91	18.56
	s.d.	206.85	185.46	30.58	35.47	71.72	65.69	28.38	12.46	254.26	45.11	18.64	105.45	10.27	19.30
16-18	Mean	117.53	397.24	32.23	22.73	57.77	52.46	20.07	15.69	24.12	24.40	4.61	67.64	13.06	18.88
	s.d.	229.70	210.86	35.01	61.84	73.42	61.98	42.64	31.65	50.11	55.05	26.10	100.83	14.58	19.00
Boys															
10-12	Mean	99.17	249.02	24.54	13.56	37.64	40.68	10.60	10.57	21.50	11.96	2.77	52.96	9.20	18.51
	s.d.	154.30	150.23	27.86	46.57	54.20	53.42	22.58	10.55	52.25	35.82	17.38	83.40	9.52	20.10
13-15	Mean	92.25	307.22	26.04	16.41	44.11	54.04	10.81	10.50	15.92	14.22	3.41	56.37	9.62	18.34
	s.d.	161.54	168.74	31.25	41.67	58.95	153.52	23.09	9.90	30.75	45.22	21.80	89.32	9.04	23.49
16-18	Mean	88.11	354.71	26.94	13.46	49.68	57.03	17.75	12.92	22.43	17.70	3.68	71.12	11.17	19.23
	s.d.	169.12	183.12	28.92	36.04	64.08	67.03	34.94	14.56	47.97	47.37	21.45	110.08	9.74	19.71

Table 4: Distribution (%) of adolescents according to intake of nutrients (Y. RDA)

Nutrients	Percentage of RDA	Boys	Girls
Protein	<50	2.5	3.7
	<70	12.9	15.4
Total fat	<50	18.2	23.0
	<70	31.6	37.7
Energy	<50	9.3	5.3
	<70	34.0	24.8
Calcium	<50	36.9	43.2
	<70	54.2	59.6
Iron	<50	41.5	10.8
	<70	73.2	35.5
Vitamin A	<50	75.4	79.0
	<70	82.2	83.8
Thiamin	<50	19.0	16.2
	<70	41.4	39.5
Riboflavin	<50	43.1	37.8
	<70	73.6	64.5
Vitamin C	<50	36.5	37.2
	<70	49.7	49.6

Table 5: Heights (cm) weights (kg) of boys and girls according to age

		Boys		Girls	
Age (y)		Height	Weight	Height	Weight
10+	Mean	128.1	23.1	128.1	23.2
	s.d.	7.0	3.9	7.2	3.8
	Median	127.3	22.8	128.0	22.9
11+	Mean	133.1	25.1	133.1	25.7
	s.d.	6.6	3.9	7.3	4.4
	Median	133.0	24.9	133.2	25.0
12+	Mean	137.4	27.3	138.4	28.7
	s.d.	7.5	4.7	7.5	5.4

	Median	137.4	26.6	138.7	28.1
13+	Mean	143.0	30.8	144.1	32.6
	s.d.	8.0	5.8	6.8	5.6
	Median	142.6	30.2	144.3	32.5
14+	Mean	148.6	34.8	147.9	36.0
	s.d.	8.4	6.4	6.5	5.5
	Median	149.1	34.0	148.2	36.0
15+	Mean	153.0	38.6	149.8	38.9
	s.d.	8.6	6.4	6.1	5.8
	Median	153.3	38.5	150.4	39.0
16+	Mean	158.0	42.3	151.2	41.3
	s.d.	8.4	6.8	5.8	5.2
	Median	159.0	42.1	151.3	41.0
17+	Mean	161.2	46.0	152.1	42.8
	s.d.	7.0	6.2	6.3	5.6
	Median	161.5	45.8	152.5	42.8

Table 6: Prevalence of stunting and underweight in adolescents

	Boys				**Girls**			
	Stunting (< median-2 s.d.)		**Underweight (< median-2 s.d.)**		**Stunting (< median-2 s.d.)**		**Underweight (< median-2 s.d.)**	
Age (y)	Prevalence (%)	Confidence interval	Prevalence (%)	Confidence interval	Prevalence (%)	Confidence interval	Prevalence (%)	Confidence interval
10+	34.7	31.8-37.6	41.6	38-6-44.5	32.5	29.5-35.4	37.8	34.7-40.8
11+	31.2	27.6-34.7	42.1	38.3-45.9	37.4	34.0-40.8	42.4	38.9-45.8
12+	32.8	30.6-35.6	51.6	48.6-54.6	44.7	41.5-47.9	45.3	42.1-48.5
13+	32.1	28.6-35.6	51.2	47.4-54.9	46.7	43.3-50.0	37.6	34.3-40.9
14+	36.3	32.8-38.8	55.8	52.1-59.4	41.2	37.7-44.7	35.7	32.3-39.1
15+	48.9	45.0-52.7	58.5	54.7-62.3	37.9	34.1-41.6	39.0	35.2-42.8
16+	51.8	48.0-55.6	66.1	62.5-69.7	34.1	30.5-37.7	39.0	35.3-42.7
17+	59.7	55.5-63.9	68.6	64.6-72.6	37.2	32.9-41.1	37.6	33.3-41.9
	223.85 (P<0.01)		195.8 (P<0.01)		60.9(P<0.01)		23.3(P<0.01)	

Table 7: Median body mass index (BMI) of adolescents

	Present Study		**NHANES**	
Age (y)	**Boys**	**Girls**	**Boys**	**Girls**
10+	13.7	13.9	16.7	17.0
11+	13.9	14.2	17.3	17.7
12+	14.3	14.7	17.9	18.4
13+	14.8	15.5	18.5	18.9
14+	15.4	16.5	19.2	19.3
15+	16.0	17.3	19.9	19.7
16+	16.8	17.9	20.6	20.1
17+	17.6	18.5	21.1	20.4

Table 8: Distribution (%) of adolescents above 5th percentile of NHANES

Age (y)	**Boys**	**Girls**
10+	72.7	62.7
11+	77.6	61.0
12+	76.9	57.1
13+	72.2	47.2
14+	70.5	32.2
15+	64.6	25.0
16+	56.9	19.2
17+	43.9	16.4

Conclusion

For the first time, a large database on the diet and nutritional status of adolescents of rural areas representing most of the large eight Indian States is presented. The food intakes were highly skewed. Hence, in the case of green leafy vegetables, fruits, nuts and flesh foods, the median values were nil, indicating that at least 50% did not consume these foods. In view of higher cereal intakes, the consumption of energy and pro- tein was better. This, perhaps, resulted in a higher proportion of adolescents consuming inadequate amounts of micronu- trient such as iron, vitamin A, niacin, vitamin C and ribo- flavin. As in the case of children of other ages from rural areas, the adolescents were shorter and lighter than their American counterparts. On the other hand, they

were comparable to the apparently normal adolescents from the rural areas studied earlier (ICMR) with respect to both height and weight in the case of girls, while the males were slightly shorter. Contrary to the common impression, the extent of under- nutrition was higher among boys than among girls, particu- larly after the age of 12 y. Similarly, the extent of thinness (< 5th percentile of American values) was less among girls than boys in all age groups. An important observation is that about a quarter of adolescent girls get married early and more importantly at least a quarter of them conceive. There is, therefore, a need to develop strategies to improve the nutritional status of adolescent boys and girls to achieve their maximum growth potential. This calls for behaviour changes in the community so that early marriages are not practised. Direct nutrition interventions, particularly tackling high prevalence of anaemia, are required. Consequently, a significant proportion of the adolescent girls could be considered to be at risk due to short stature and underweight. Several studies have shown that girls, when compared to sex-specific standards, are nutritionally better off. This could be the reason for lack of increase in stunting in eight states (provinces) of Andhra Pradesh, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Uttar Pradesh and Tamil Nadu of India.

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