Acta Scientific NUTRITIONAL HEALTH (ISSN:2582-1423)

Volume 10 Issue 8 August 2026

Research Article

Assessment of Dietary Nutrient Intake among Adolescent Girls in Purba Bardhaman District, West Bengal: A Cross-Sectional Study

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Received: August 13, 2026

Published: August 31, 2026

Abstract

Adolescence is an important period of life marked by various aspects of development including physical, physiological, cognitive and psychological changes, where nutrition plays an important role in ensuring proper growth and health in the future. Adolescent girls are especially prone to nutritional deficiencies because of rapid physical growth and the onset of menstruation. The current study aims to assess the physical features and dietary nutrient intake of adolescent girls living in the Purba Bardhaman district of West Bengal. The subjects were divided into three categories of early, middle and late adolescence to investigate the differences in their nutrient intake according to the stages of development. Anthropometric measurements such as height, weight and body mass index were recorded, and daily intake of energy, macronutrients, iron, calcium and certain vitamins were assessed. It was noted that the total energy intake progressively increased with age but failed to meet the recommended values for all adolescents. The intake of protein, niacin, and vitamin C was adequate; however, the intake of fat, iron, calcium, riboflavin, vitamin B6, and folic acid was insufficient. There were statistically significant differences in the intake of some nutrients by age; however, an increase in food intake with age failed to ensure nutrient sufficiency. The results suggest the presence of a high risk of nutrient deficiency in adolescent girls and highlight the need for nutritional diversification, nutritional education, regular evaluation of nutritional status, and targeted interventions through nutrient-dense foods.

Keywords: Adolescent Girls; Nutritional Status; Dietary Intake; Micronutrient Deficiency

Introduction

Adolescence, which involves the age range between 10 and 19 years, is a very significant stage in the life course that experiences significant physical, physiological, cognitive, psychological, and social developments [1]. This period witnesses remarkable alterations in physical growth, body composition, puberty, bone growth, and behaviour, thus, becoming very crucial in forming proper dietary habits and preventing nutritional problems that have effects at different stages of life [2]. With the high energy requirements of this period, it becomes necessary to take enough

nutrients and energy. Nutritional deficiencies in this phase can cause negative impacts on growth, physical ability, cognition, immunity, and reproduction [3].

Nutritional needs of adolescent girls are especially critical since they are experiencing rapid growth and maturation along with the onset of menses. The accelerated development of bones, increase in blood volume, maturation of reproductive organs and lean body mass raise their need for energy, protein, iron, calcium, folate, and many other micronutrients [4,5]. Iron is particularly important since there is an additional loss due to menses along with the heightened need associated with growth and development. Iron deficiency and iron deficiency anaemia may impair oxygen carriage, physical activity, ability to concentrate and learn, and overall quality of life [3]. Therefore, proper nutrition in adolescence plays an important role in future reproductive and maternal health as well.

Nutritional status among adolescents is affected by biological, dietary, socioeconomic, cultural and environmental determinants. Household food supply, economic situation, parental education, family type, food preferences, cultural beliefs and food allocation are some of the factors that might determine the amount and types of foods eaten [6]. Moreover, growing access to processed foods, energy-dense snacks, sugar-sweetened drinks and food marketing might lead to dietary change as well as poor diversity in diet when the nutrient-rich foods are substituted by energy-dense foods that contain relatively low amounts of micronutrients. As adolescent dietary behaviours are likely to be maintained in the future, this is a good time to promote healthy diets among adolescents.

Nutrition in adolescence becomes especially difficult in LMICs due to the presence of undernutrition, micronutrient deficiencies, obesity, and overweight at the same time, which reflects the double burden of malnutrition linked to the process of socioeconomic development, urbanization, and food transition [7]. The population of South Asia demonstrates the existence of problems like undernutrition and micronutrient deficiencies alongside with the emergence of nutritionally poor foods rich in calories [4].

The consumption of energy and macronutrients is vital for the growth and development process. Energy is needed for basal metabolism, physical activities, tissue production, and growth, whereas proteins are needed for tissue production and repair, production of enzymes and hormones, and lean tissue mass. Fats supply energy and essential fatty acids, and facilitate absorption of fat-soluble vitamins, however, the quality and amount of fats matter**.** Carbohydrate nutritional quality also depends on the variety of foods containing carbohydrates, such as whole grains, cereals, pulses, fruits, and vegetables. Micronutrients are also important, especially iron and calcium that aid in the synthesis of hemoglobin, transportation of oxygen, metabolism of energy, cognitive functioning, bone development, and peak bone mass formation [5]. Folate, vitamins A, C, thiamine, riboflavin, niacin, and B6 are also important for the cell division process, erythropoiesis, immune function, and energy metabolism.

It is clear that dietary assessment is a very important way of assessing nutrition adequacy as well as ensuring that intake meets age- and sex-specific nutritional needs [8]. The comparison of nutrient intake and dietary reference intakes may allow establishing nutrients that need to be improved and/or intervened through dietary measures. As it is known that there are different nutritional requirements depending on age, sex, body size, growth, etc. assessment of dietary intake at various stages of adolescence is especially important. Assessment of anthropometrics such as height, weight, and BMI could provide additional information about growth and nutrition; however, growth references for age and sex should be preferred for adolescents over adult cut-offs for BMI.

Adolescent nutrition continues to be a significant public health issue in India, with several studies having documented insufficient food consumption, malnutrition, and lack of micronutrients, especially amongst girls and socioeconomically disadvantaged populations. Cultural practices concerning food consumption by gender, food distribution within households, eating habits, dietary restrictions, and beliefs can also impact adolescent girls' nutrition. In some cultures, menstrual periods may be connected to food consumption restrictions or modifications in eating habits that could impact nutrient consumption [4].

West Bengal constitutes an important area to study the status of nutrition adequacy of the adolescents since there are some previous studies showing inadequacies of nutrition and diets among adolescents in West Bengal [9,10]. On the other hand, there have been the transitions in nutrition of India resulting in the presence of undernutrition as well as emerging cases of overweight and obesity, making it pertinent to study the dietary pattern and

nutrient adequacy of that particular region [6,7]. However, there is scant information available on the energy, macronutrient, and micronutrient intake of adolescent girls in some districts of West Bengal.

Therefore, assessing the nutritional intake of adolescents in Purba Bardhaman district is crucial for determining nutritional inadequacies as well as the degree of adequacy of the nutritional intake according to recommended levels. This would provide information that will be used to determine the specific nutrients that should receive more focus as well as developing nutrition education programs and interventions for adolescents. This study was undertaken to assess the nutritional status of adolescents in Purba Bardhaman district of West Bengal with a special focus on physical attributes and mean intake of energy, macronutrients and certain micronutrients in adolescents at various developmental stages.

Methodology

Study design and participants

This study was carried out among 300 adolescent girls living in Purba Bardhaman, West Bengal. Cross-sectional study design was adopted in order to know about their physical attributes and nutrient intake in their diet. The participants were divided into various age groups to see the differences in their nutrient intake at different levels of adolescence. Before the start of the study, ethical approval (HMC/IEC/DEPT/AKS/2024/4, date 03/07/2024) was taken from the Institutional Ethical Committee (IEC) for Research on Human Subjects, Hooghly Mohsin College, Chinsurah.

Assessment of physical characteristics

The physical parameters under evaluation are age, height, weight, and Body Mass Index (BMI). Age is expressed in years, height in centimetres, and weight in kilograms. Body Mass Index is computed as follows: BMI (Kg/m^2) = Weight (kg) / $Height^2$ (m^2)

Anthropometric data have been widely employed to evaluate growth and nutritional status among adolescents and measured according to standard method [11].

Assessment of dietary intake

Energy and nutrient intakes per day were analyzed for the adolescent girls [12]. The nutrients evaluated for intake were energy, carbohydrates, protein, fat, iron, calcium, vitamin A, thiamin, riboflavin, niacin, vitamin B6, folic acid, and vitamin C. The subjects were grouped into three age groups which include early adolescence (10 - 13 years), middle adolescence (14 - 15 years), and late adolescence (16 - 21 years).

The average daily intake of all nutrients was reported as mean ± standard deviation (SD). Comparison between the actual intake and the corresponding RDA/EAR was carried out to determine the adequacy of the diet. The proportion of nutrient intake with respect to their RDA/EAR was also determined for each nutrient. Nutrient requirements were based on the guidelines of the Indian Council of Medical Research (ICMR).

Statistical analysis

Data obtained from analysis were systematically tabulated and subjected to statistical analysis. Numerical variables such as age, height, body weight, Body Mass Index (BMI), and nutrient intake were presented in terms of mean ± standard deviation (SD). Analysis of variance (one way ANOVA) was carried out for the mean nutrient consumption among the three groups of adolescents to establish if the difference between them was statistically significant. This involved calculating the F-ratio and comparing it to the p-value. A p-value of 0.05 or less was taken as statistically significant.

Results

The physical parameters of the adolescent girls (n = 300) are shown in table 1 along with their standard deviation. The average age of the adolescent girls is 15.52 ± 3.45 years. The average height of adolescent girls is 146.86 ± 10.38 cm, and their average body weight is 38.91 ± 11.17 kg. The average BMI of the adolescent girls is 17.74 ± 3.79 kg/m^2.

Parameters	Mean ± SD
Age (Years)	15.52 ± 3.45
Height (cm)	146.86 ± 10.38
Weight (kg)	38.91 ± 11.17
BMI (kg/m^2)	17.74 ± 3.79

Table 1: Mean ± SD of physical characteristics of the adolescent girls (n = 300).

Nutrient intakes	Early Adolescence (Ages 10 to 13) (n = 97)			Middle Adolescence (Ages 14 to 15) (n = 51)			Late Adolescence (Ages 16 to 21) (n = 152)			F ratio (p)
	Mean ±SD	RDA/ EAR	% of RDA/ EAR	Mean ±SD	RDA/ EAR	% of RDA/ EAR	Mean ±SD	RDA/ EAR	% of RDA/ EAR	
Energy (Kcal/d) $	1635.54 ±470.73	2060	79.4	2050.39*** ±525.86	2400	85.4	2300.10***## ±347.75	2500	92.0	72.787 (0.000)
Carbohydrate (g/d)	334.84 ±96.60	-	-	434.09*** ±122.60	-	-	472.83***# ±77.36	-	-	66.193 (0.000)
Protein (g/d)	42.70 ±19.59	33	129.4	47.72 ±15.40	43	111.0	60.15***### ±15.71	46	130.8	33.469 (0.000)
Fat (g/d)	25.68 ±9.53	35	73.4	24.35 ±7.34	40	60.9	28.27## ±11.61	35	80.8	3.529 (0.0305)
Iron (mg/d)	16.84 ±11.11	28	60.1	15.94 ±8.99	30	53.1	21.81**### ±13.03	32	68.2	7.572 (0.001)
Calcium (mg/d)	429.34 ±338.33	850	50.5	450.95 ±292.87	1000	45.1	555.70**# ±325.63	1050	52.9	5.106 (0.006)
Vit-A (IU/ d)	580.64 ±1423.99	790	73.5	775.64 ±1698.15	890	87.2	830.64 ±1638.38	860	96.6	0.753 (0.471)
Thiamine (mg/d)	1.14 ±0.44	1.4	81.4	1.31* ±0.41	1.6	81.9	1.52***## ±0.35	1.7	89.4	27.995 (0.000)
Riboflavin (mg/d)	0.46 ±0.24	1.9	24.2	0.46 ±0.20	2.2	20.9	0.57***### ±0.21	2.3	24.8	9.147 (0.001)
Niacin (mg/d)	16.11 ±6.14	14	115.1	19.76*** ±5.97	16	123.5	22.66***## ±4.50	17	133.3	44.752 (0.000)
B6 (mg/d)	0.62 ±0.31	1.9	32.6	0.82*** ±0.25	2.2	37.3	0.89*** ±0.27	2.3	38.7	27.009 (0.000)
Folate (µg/d)	94.76 ±49.80	225	42.1	93.51 ±37.76	245	38.2	117.92***### ±49.80	270	43.7	9.074 (0.001)
Vit C (µg/d)	68.32 ±60.97	50	136.6	69.79 ±66.14	65	107.4	98.70***# ±82.09	70	141.0	6.244 (0.002)

Table 2: Average daily nutrient intake by the adolescent girls (n = 300).

EAR: Estimated Average Requirement; RDA: Recommended Daily Allowance; $- compare with EAR.

With reference to Early Adolescence: * P < 0.05; ** P < 0.01; *** P < 0.001.

With reference to Middle Adolescence: # P < 0.05; ## P < 0.01; ### P < 0.001.

Average daily nutrient intake of the adolescent girls

The mean daily nutrient intake of the adolescent girls has been presented separately under the three stages of adolescence - early (10 - 13 years; n = 97), middle (14 - 15 years; n = 51), and late (16 - 21 years; n = 152). The mean nutrient intake has been compared to the corresponding RDA/EAR values, and the difference in nutrient intake among the three adolescent groups has been measured using one-way ANOVA.

The mean daily energy intake rises steadily with increasing age, from 1635.54 ± 470.73 kcal/day for early adolescents to 2050.39 ± 525.86 kcal/day for middle adolescents and 2300.10 ± 347.75 kcal/day for late adolescents. The adequacy levels for these ages are 79.4%, 85.4% and 92.0%, respectively. This indicates that energy intake falls below the recommended level for all three age groups, but the requirement fulfilment percentage is highest among late-adolescents.

The mean daily carbohydrate intake of the adolescent girls is 334.84 ± 96.60 g/day for early adolescents, 434.09 ± 122.60 g/day for middle adolescents, and 472.83 ± 77.36 g/day for late adolescents. These differences among the three groups are highly significant ($F = 66.193$, $p < 0.001$). The average daily intake of protein is 42.70 ± 19.59 g/day in early adolescence, 47.72 ± 15.40 g/day in middle adolescence, and 60.15 ± 15.71 g/day in late adolescence. It is higher than the recommended one for all three groups and equals 129.4%, 111.0%, and 130.8% of the recommended level, respectively. There is a statistically significant difference in protein intake among three groups ($F = 33.469$, $p < 0.001$).

The average daily intake of fat is 25.68 ± 9.53 g/day, 24.35 ± 7.34 g/day, and 28.27 ± 11.61 g/day among girls in early, middle, and late adolescence, respectively. The fat intake corresponds to 73.4%, 60.9%, and 80.8% of the recommended level. It means that it is lower than the recommended one in all three groups. There is a statistically significant difference in fat intake among the three groups ($F = 3.529$, $p = 0.0305$).

The average daily intake of iron is 16.84 ± 11.11 mg/day in early adolescence, 15.94 ± 8.99 mg/day in middle adolescence, and 21.81 ± 13.03 mg/day in late adolescence. Adequacy levels for these groups are 60.1%, 53.1%, and 68.2%, respectively. It means that it is considerably lower than the recommended one in all three groups. The average calcium intake per day is 429.34 ± 338.33 mg/day for early adolescents, 450.95 ± 292.87 mg/day for middle adolescents, and 555.70 ± 325.63 mg/day for late adolescents. This accounts for 50.5%, 45.1%, and 52.9% of the recommendation, respectively. Therefore, there is no change in terms of calcium intake throughout the stages of adolescence where calcium intake is approximately half of the recommended level. The difference among the three groups is statistically significant ($F = 5.106$, $p = 0.006$).

With regard to vitamin A, the average daily intake is 580.64 ± 1423.99 IU/day among early-adolescent girls, 775.64 ± 1698.15 IU/day among middle-adolescent girls, and 830.64 ± 1638.38 IU/day among late-adolescent girls. Adequacy level of each group is 73.5%, 87.2%, and 96.6%, respectively, but there is no statistical significance in the differences. For thiamine intake, the mean daily intake varies from 1.14 ± 0.44 mg/day in early adolescents to 1.31 ± 0.41 mg/day in middle adolescents.

The mean daily riboflavin intake is 0.46 ± 0.24 mg/day in early adolescence, 0.46 ± 0.20 mg/day in middle adolescence, and 0.57 ± 0.21 mg/day in late adolescence showing significant inadequacy of riboflavin intake in the adolescent girls. The difference between the three groups is statistically significant ($F = 9.147$, $p = 0.001$).

The mean daily niacin intake is 16.11 ± 6.14 mg/day in early adolescence, 19.76 ± 5.97 mg/day in middle adolescence, and 22.66 ± 4.50 mg/day in late adolescence. The intake surpasses the recommended level. There exists highly significant difference in niacin intake between the three adolescent groups ($F = 44.752$, $p < 0.001$).

The mean daily vitamin B6 intake is 0.62 ± 0.31 mg/day, 0.82 ± 0.25 mg/day, and 0.89 ± 0.27 mg/day in early, middle, and late-adolescence, respectively indicating considerable deficiency in vitamin B6 intake in all the three groups. The difference in vitamin B6 intake is statistically significant ($F = 27.009$, $p < 0.001$). The mean daily folate intake is 94.76 ± 49.80 µg/day in early-adolescent girls, 93.51 ± 37.76 µg/day in middle-adolescent girls, and 117.92 ± 49.80 µg/day in late-adolescent girls. The folate intake is considerably below the recommended level.

The mean vitamin C consumption per day for early adolescents is 68.32 ± 60.97 µg/day, for middle adolescents, it is 69.79 ± 66.14 µg/day, and for late adolescents, it is 98.70 ± 82.09 µg/day. These

values represent 136.6%, 107.4%, and 141.0% of the recommended levels, respectively, meaning that the consumed amount of vitamin C in all three groups is above the recommended level. There is a statistically significant difference is found.

Discussion

Adolescence is characterized by rapid growth and development, which leads to an increased need for energy and important nutrients. Malnutrition in this stage of life can negatively impact growth and development, physical fitness, and the ability to reproduce in the future. The current research has found that adolescent girls suffer from poor nutrition, as their intake of some nutrients increases with age, but significant deficiencies remain, such as lack of energy, fats, iron, calcium, riboflavin, vitamin B6, and folate. Similar findings have been discovered concerning the nutrition of adolescent girls in India [13-15].

These results point to a possible issue of undernutrition in the study group. This could be due to the lower BMI along with insufficient intake of energy, which might have led to insufficient intake of energy for supporting the process of growth. In another study conducted by Radhika., *et al*. (2018), it was seen that a large number of Indian adolescent girls were undernourished [15]. Nutritional status depends not only on dietary but on non-dietary factors as well. Similarly, Nair., *et al*. (2017) observed a high rate of undernutrition among rural adolescent girls from Maharashtra [13].

Energy intake also showed significant improvement with increased age of the adolescents; however, energy intake was still inadequate in all three groups, which shows that despite the increased energy intake, the increased demands were not met by the increased intake. Radhika., *et al.* (2018) also found that the energy intake among adolescent girls was inadequate and varied based on the age and nutrition status of the adolescent girls. Reddy., *et al*. (2019) have also found that rural adolescent girls were experiencing inadequate energy intake along with a high prevalence of thinness and stunting [15,16].

Carbohydrate intake was found to increase with age, which could be attributed to the dominant presence of cereal-containing foods in the diet of Indians. However, while cereals and pulses may be commonly consumed by adolescent girls, the consumption of fruits, vegetables, and iron and calcium containing foods may be less. According to Chandar., *et al*. (2018), in their study on a rural population of Puducherry, satisfactory intake of cereals and pulses was reported, but low intake of fruits, vegetables, and iron and calcium containing foods was reported [17].

There were considerable increases in the amount of protein consumed by the adolescents, and the consumption was sufficient based on the guidelines. Adequate consumption of protein is essential for teenagers to facilitate the development of their tissues and muscles. This positive consumption of proteins can be attributed to the role of cereals, pulses, and other foods with proteins that form part of their usual diets. However, it is important to note that adequacy in total protein does not mean that there is adequate quality in their diets since the quality of proteins differs. Reddy., *et al*. (2019) made a similar recommendation in improving the diets of adolescent girls [16].

Consumption of fat among all three groups was still inadequate, but the difference between them was statistically significant. Insufficient fat consumption may lead to low dietary energy density and reduced absorption of vitamins that are fat-soluble. Patil., *et al.* (2018) stated about a considerable insufficiency in both macronutrients and micronutrients among adolescent girls in rural western India [14]. Therefore, it will be important to include healthy fats from nuts, seeds, and good vegetable oils in the diets of adolescents, while avoiding the consumption of too much fried food.

Iron has been one of the primary nutritional issues in the current research. Despite the significant increase in iron consumption by late adolescents, iron consumption has been insufficient at all ages. Adolescent females are especially at risk of iron deficiency due to their fast growth and the loss of blood through menstruation. Ahankari., *et al*. (2017), in a large study of rural adolescent females in Maharashtra, found that the prevalence of iron-deficiency anaemia was high and that age, poor nutritional status, and insufficient fruit consumption were among the key risk factors [18]. Ghatpande., *et al*. (2019) have also found a relationship between the consumption of fruits and vegetables and iron status in adolescent females [19].

Calcium intake was insufficient all through the adolescent age group except that there was a marked improvement in late

adolescents. This is worrisome because during adolescence, the process of bone mineralization and peak bone mass acquisition occurs. According to Chandar., *et al*. (2018), the consumption of food rich in calcium was insufficient among rural adolescent females [17]. Similarly, calcium deficiency was common among rural adolescents as found by Patil., *et al*. (2018) [14]. Therefore, more consumption of dairy products and calcium rich locally available foods like ragi, sesame, and green leafy vegetables might help.

Intake of vitamin A rose with age but did not have statistical significance, indicating that there was a minimal change in intake associated with age. On the other hand, there was a significant increase in thiamine intake but it was still below the recommended intake. Riboflavin intake was insufficient but had a significant improvement among late adolescents. Insufficient intake of certain B-group vitamins could be due to poor variety of foods. Gonmei and Toteja (2018) pointed out the ongoing problem of micronutrient deficiencies in India [20].

Intake of niacin was relatively good and increased significantly with age, showing that the nutritional deficiency in this sample group was specific to nutrients rather than general in nature. On the other hand, intake of vitamin B6, though it increased significantly, was inadequate in all groups. Intake of folate was also relatively low compared to recommended levels, but there was a significant increase in late adolescents. Folates are particularly crucial for young girls at an age where they are nearing reproductive age, since folate helps in DNA synthesis and division.

The intake of vitamin C was quite sufficient and also showed a marked increase among late adolescents. This is beneficial from a nutritional point of view since vitamin C is known to improve the absorption of non-haem iron. Ghatpande., *et al*. (2019) also found associations of fruit and vegetable intake with indicators of iron. Hence, the consumption of vitamin-C rich fruits and vegetables on a regular basis would also be beneficial in this respect [19].

In general, the results represent that while nutrient consumption did increase with age advancement, this was not sufficient to fulfil the need for some nutrients. It can be noticed that the adequate consumption of protein, niacin, and vitamin C is in contrast to the inadequate consumption of energy, fat, iron, calcium, riboflavin, vitamin B6, and folic acid. This trend is supported by the findings that adolescent girls in India face the risk of several micronutrient deficiencies [15,20].

These results indicate that there is an urgent need for a holistic approach to nutritional interventions among adolescents. Education on nutrition should focus not only on increased food intake but also on diverse nutrients. Increased intake of foods rich in iron, calcium, and folic acid, legumes, milk and dairy products, fruits and vegetables, nuts and seeds can be encouraged. Nutritional assessment and iron folic acid supplementation must be added to the existing food-related interventions. According to Reddy., *et al*. (2019), effective implementation of nutrition programs among adolescents combined with information on nutritious foods that are locally available must be ensured [16].

Conclusion

This research shows a mixed nutritional status among the adolescent girls, whereby there was increase in the intake of nutrients with age; however, there was still inadequacy of many vital nutrients. There was lower energy and fat intake compared to the recommendation, but there was marked inadequacy of many nutrients such as iron, calcium, riboflavin, vitamin B6 and folate in addition to protein, niacin and vitamin C adequacy. These results reveal that the increase in the quantity of food intake with age does not automatically result into nutritional adequacy, where nutritional diversity remains an issue. These nutritional deficiencies might have many health implications in relation to growth, bone development, and micronutrient deficiency as well as reproductive well-being. Thus, there is a need for adolescent nutrition intervention programs, which include nutritional diversity and food intake of nutrient-rich foods along with nutrition education and assessment.

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