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Assessment Of Nutritional Status And Its Correlates Among Adolescent Girls Of Meerut City, India: A Cross-Sectional Study

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Abstract
The present study aimed to assess the nutritional status and its impact or correlation with the health of adolescent girls. The cross-sectional sample consisted of 200 adolescent girls aged 10 to 21 years of Meerut City and attached rural area, District Meerut, Uttar Pradesh, India. Height, weight, body mass index and hemoglobin level were recorded personally. Nutritional status was evaluated with the help of BMI using different standards. All the selected girls were interviewed personally during investigation with the help of questionnaire. A semi structured questionnaire was used to find out information about socio demographic/ economic characteristics, food intake pattern, food and nutritional security status, dietary intake characteristics, morbidity status, physical activity and psychological related questions. The highest body mass index was observed in the participants in late adolescence (25.36 Kg/m^2) and followed by early adolescence (20.90 Kg/m^2) and mid adolescence (19.10 Kg/m^2). The results of the BMI suggested that the obesity was observed in late adolescents. The mid adolescent group was found healthier with a BMI of 19.10 Kg/m^2 in comparison to early adolescent group (20.90 Kg/m^2). The study revealed the prevalence of anemia, stunting and wasting/thinness, overweight and obesity. There is a need to create awareness among adolescents and their families about nutrition and health.

Keywords: Adolescence, Body Mass Index, Food and nutritional security, Anemia, Obesity.

INTRODUCTION

Adolescents constitute one-fifth of the total global population (UNICEF, 2012; WHO, 2021). About 87% of adolescents reside in the developing countries **(**UNICEF, 2012) and only India shares largest adolescent population with about 243 million adolescents, which is almost 21% of the whole Indian population (MHFW, 2014; Sivagurunathan, 2015). This young (10 and 19 years) population is marked with rapid and intense physiological, psychological and sexual growth (WHO, 2020) and requires balanced nutrition comprising of all macro and micronutrients to help in fast growth spurt and increased physical activities (Soliman *et al.,* 2014; Christian *et al.,* 2018; Savarino *et al.,* 2021; Phuljhele *et al.,* 2021). It is also a crucial group for addressing diverse health needs and protecting future generation from possible diseases (Saha *et al.,* 2021). Inadequate nutrition can lead to delayed sexual development and slower linear growth (Jacob and Nair, 2012; WHO, 2018). As a result, adolescents need more nutrients compared to adults (Saha *et al.,* 2021). The National Family Health Survey revealed that about 41.9% of girls were thin and 4.2% of girls were overweight in the age group of 15–19 years (IIPS, 2016) while about 57.2% of women in the age group of 15–49 years (including adolescent girls) were anemic (IIPS, 2021). Thinness (low BMI) is a common problem among adolescent girls in India. However, many girls are also obese and overweight (Sharma and Mondal, 2014). This ensues as a double burden of malnutrition, with some girls not getting enough nutrients and others consuming too much. This is due to nutritional transition (Hasan *et al.,* 2017) which is likely due to changes in dietary patterns and lifestyles.

Good health is essential for a fulfilling life, and it's a basic human right (David *et al*., 2010). Adolescence, spanning from ages 12 to 18, is a crucial period of rapid growth and development for young people. This stage, which marks the transition from childhood to adulthood, is characterized by the emergence of secondary sex characteristics and the completion of physical growth. During this time, adolescents require increased nutrient intake to support their rapid development (Hurlock, 2000). In India, a significant number of the population, approximately 28% in rural areas and 26% in urban areas, live below the poverty line. This means they lack the resources to meet their basic nutritional needs, which are defined as 2400 Kcal per day in rural areas and 2100 Kcal per day in urban areas. Chronic malnutrition can lead to serious health problems, including stunted growth, wasting, chronic diet-related diseases, increased illness and death, and reduced productivity. Nutritional awareness is crucial in India, especially for young girls and women, who are disproportionately affected by malnutrition and anemia. Lack of accurate information and guidance leaves adolescents vulnerable to nutritional deficiencies.

In India, adolescents make up a significant portion of the population, representing over one-fifth of the total. It is important for adolescent girls to maintain a healthy weight (42–64 kg and height 155–169 cm) during this time. Eating a balanced diet is crucial for preventing nutritional deficiencies, particularly iron deficiency, which can have a significant impact on health and well-being. The nutritional status of adolescent girls, who will become the mothers of the future, is particularly important as it has a direct impact on the overall nutritional health of the community. To effectively address

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this issue, it is very crucial to understand the prevalence and contributing factors of these nutritional problems. Addressing malnutrition among adolescent girls is a critical step towards achieving the sustainable development goal of eliminating malnutrition by 2030 (Caleyachetty *et al*., 2018).
The present study was aimed to assess the nutritional status and its correlated factors among a sample of adolescent girls. The study was conducted in the Meerut City and attached rural area of District Meerut, Uttar Pradesh, India and included 200 adolescent girls aged 13–21 years.

MATERIALS AND METHODS:
It was a cross-sectional study conducted in the Meerut City, Uttar Pradesh, India. A total of 200 adolescent healthy girls from the age group of 10-21 years were selected randomly from different areas of the Meerut City (including the immediate attached rural area). They were divided into three groups according to age: 10–13, 14–17 and 18–21. All the selected were interviewed personally during the investigation with the help of a questionnaire. A semi-structured questionnaire was used to find out information about socio demographic/ economic characteristics, food intake pattern, food security status, dietary intake characteristics, morbidity status, physical activity and psychological related questions. Information on actual age was taken from school records. The dietary intake was assessed by the 72 hour recall method using an oral questionnaire for 4 consecutive days. The Type of food consumed was assessed and the quantity of raw food was reported in grams. Care was taken to avoid fasting and festival days while noting the intake.
Anthropometric measurements like 'height' and 'weight' were taken using standardized equipment and by standard technique (WHO, 1995). The weight was measured in kilograms without shoes using a standing weighing machine having a precision of 0.1 kg. Checks on the scales were made routinely before recording the weight of each girl student and the pointer was adjusted to zero using the screw provided. The height was taken barefooted in centimeters using standard measuring tape. A vertical tape fixed perpendicular to the ground on the wall was used as the scale. This tape was non-stretchable; was fixed with transparent adhesive tape and care was taken to see there was no folding or tilting to any side. Height was recorded to the nearest 1 cm. Nutritional status was assessed using age and sex specific cut off points of body mass index (BMI). BMI is a simple index of weight for height that is commonly used to classify underweight, overweight and obesity in humans. It is calculated as follows: Body Mass Index (BMI) = Weight (kgs)/ Height (m^2) X 100. The hemoglobin content was estimated using (a) portable hemoglobin meter. The mean hemoglobin content of the adolescent girls was 8.94 g/dl with (a) range of 6.5-11.5 g/dl among the girls.

RESULTS ADN DISCUSSION:
The collected data on the socio-economic background of the selected girls is presented in Table 1. A total of 200 school/college going adolescent girls were enrolled in the present study. About 18% were early adolescents (10–13 years) while 17% were mid adolescents (14–17 years) and 65% were late adolescents (18–21 years) age group. A maximum of 18% were educated at primary level (up to 8^{th} class), 17% were secondary (up to 10^{th} class), 58% were higher secondary (up to 12^{th} class) and 7% were graduates. Majority 85% of the school/college going adolescent girls who participated in the study belonged to middle income group, only 15% were below socio-economic status and no participants were belonged to high income group. Majority (66%) of the respondents belonged to (the) Hindu religion with a vegetarian food habit and 34% were Muslim religion with a non-vegetarian food habit. The demographic status of the respondents showed that the majority (78%) of the respondents were from nuclear families and about 22% were from joint families. The literacy rate in respondents' parents was found 100% and a maximum number of 13% mother and 4% father were educated at the primary level (up to 8^{th} class), 27% mother and 21% father were secondary (up to 10^{th} class), 41% mother and 36% father were higher secondary (up to 12^{th} class) and 19% mother and 39% father were graduates. It is also clear from the collected data that the mean height of early adolescent girls was 127.23 ± 2.63 cm, weight was 33.80 ± 5.33 kg and mean BMI was 20.90 Kg/m^2 in 10–13 year age group. The mean height of early adolescent girls was 148.59 ± 2.53 cm, weight was 42.14 ± 3.25 kg and mean BMI was 19.10 Kg/m^2 in 14–17 years age group. The mean height of early adolescent girls was 149.85 ± 3.64 cm, weight was 56.97 ± 4.77 kg and mean BMI was 25.36 Kg/m^2 in 18–21 years age group. The highest body mass index was observed in the participants in late adolescence (25.36 Kg/m^2) and followed by early adolescence (20.90 Kg/m^2) and mid adolescence (19.10 Kg/m^2). The results of the BMI suggested that the obesity was observed in late adolescents. The mid adolescent group was found healthier with a BMI of 19.10 Kg/m^2 in comparison to the early adolescent group (20.90 Kg/m^2). Pandurangi *et al.* (2022) analyzed the Indian data related to malnutrition among Indian adolescents and showed 27.4% stunting, 24.4% thinness, 4.8% overweight and 1.1% obesity among adolescents of 10–19 years of age

group. They also concluded that the stunting was higher among girls and older adolescents, while thinness was higher for boys and early adolescents.

Table 1: Demographic Characteristics of Collected Data

Demographic Characteristics	**Respondents Status**
Age	
10-13 (Early Adolescence)	18 %
14-17 (Mid Adolescence)	17 %
18-21 (Late Adolescence)	65 %
Mean Age	17.38 ± 3.12
Education	
Primary	18 %
Secondary	17 %
Higher Secondary	58 %
Graduation	07 %
Social Class	
Lower Income	15 %
Lower Middle	34 %
Middle Income	19 %
Upper Middle	32 %
Religion	
Hindu	66 %
Muslim	34 %
Family Status	
Nuclear	78 %
Joint	22 %
Mother Literacy Rate	
Primary	13 %
Secondary	27 %
Higher Secondary	41 %
Graduation	19 %
Father Literacy Rate	
Primary	04 %
Secondary	21 %
Higher Secondary	36 %
Graduation	39 %
Height	
10-13 (Early Adolescence)	127.23 ± 2.63 cm
14-17 (Mid Adolescence)	148.59 ± 2.53 cm
18-21 (Late Adolescence)	149.85 ± 3.64 cm
Weight	
10-13 (Early Adolescence)	33.80 ± 5.33 kg
14-17 (Mid Adolescence)	42.14 ± 3.25 kg
18-21 (Late Adolescence)	56.97 ± 4.77 kg
Body Mass Index	
10-13 (Early Adolescence)	20.90 Kg/m^2
14-17 (Mid Adolescence)	19.10 Kg/m^2
18-21 (Late Adolescence)	25.36 Kg/m^2

The age-specific nutritional status and physical examination of the adolescents are presented in Table 2. The present study was aimed to assess the nutritional status of early, mid and late adolescents by examining the prevalence of underweight, stunting, thinness, overweight, food habit, meal pattern, food items taken, general appearance, skin test, hair test, lips test, eye test, tongue test, nail test, thyroid test, teeth test, gums test, skeleton test, hemoglobin content, gastro-intestinal test, neurological system test and menstrual cycle age. The Indian traditional three meal pattern was observed among the studied adolescent group.

The majority of plant-based food sources were perceived to be healthy compared to animal-based food sources in the studied area. The consumption rate was found very frequent such as chapati (100%), rice (100%), pulses (88%), vegetables (91%), fruits (85%) and plant-based sugar content (77%). Indigenous communities rely on a wide range of

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plant-based food sources with a wide variety of processing and consumption methods. However, some animal-based products are also equally important, such as milk and milk-based products (96%) and ghee (89%). However, only poultry meat was consumed, only 34% as (a) frequent part of the diet. As observed in the results, the diets of the studied groups were mainly comprised cereals, pulses, vegetables and fruits cultivated locally. Wheat and rice were integral components of the daily diet of the groups studied.

Table 2: Multivariate analysis for different determinants of adolescent girls from (10 to 21 years old)

Food Habit	**Frequency**	**General Appearance**	**Frequency**	**Eye Test**	**Frequency**	**Teeth Test**	**Frequency**	**Hemoglobin**	**Frequency**
a. Vegetarian	66	**a.** Normal	37	**a.** Normal	24	**a.** Normal	55	**a.** Normal	20
b. Non-vegetarian	34	**b.** Dull	25	**b.** Pale	45	**b.** Mottled enamel	11	**b.** Mild	19
c. Ova-vegetarian	0	**c.** Edema	10	**c.** Sensitive to bright light	17	**c.** Dis-pigmented	7	**c.** Moderate	48
Meal Pattern	**Frequency**	**d.** Active	28	**d.** Bitot spot	5	**d.** Dental caries	27	**d.** Severe	13
a. Early morning	35	**Skin Test**	**Frequency**	**e.** Corneal xerosis	9	**Gums Test**	**Frequency**	**Menstrual Cycle Age**	**Frequency**
b. Breakfast	100	**a.** Normal	26	**Tongue Test**	**Frequency**	**a.** Normal	30	**a.** 10-11	20
c. Mid lunch	20	**b.** Dry/ rough	38	**a.** Normal	62	**b.** Swollen	22	**b.** 12-13	35
d. Lunch	100	**c.** Eczema	15	**b.** Pale	18	**c.** Bleeding	21	**c.** 13-14	45
e. Evening meal	45	**d.** Flaky	12	**c.** Scarlet red	9	**d.** Purpish or red	18	**Gastro-intestinal Test**	**Frequency**
f. Dinner	100	**e.** Pinpoint	9	**d.** Magenta	5	**e.** Spongy	9	**a.** Normal	79
Food Items Taken	**Frequency**	**Hair Test**	**Frequency**	**e.** Soreness	6	**Skeleton Test**	**Frequency**	**b.** Anorexia	0
		a. Normal	28	**Nail Test**	**Frequency**	**a.** Normal	65	**c.** Enlarged liver	6
a. Chapati & Rice	100	**b.** Dry/ lusterless	23	**a.** Normal	19	**b.** Pigeon chest	5	**d.** Constipation	8
b. Vegetables	91	**c.** Thin/ sparse	33	**b.** Thin/bright	42			**e.** Increased appetite	7
c. Pulses	88	**d.** Easily pluckable	16	**c.** Ridged	23	**c.** Beading of ribs	2	**Neurological System Test**	**Frequency**
d. Milk & milk products	96	**Lips Test**	**Frequency**	**d.** Koilonychia	7			**a.** Normal	70
e. Ghee	89	**a.** Normal	39	**e.** Flat nail	9	**d.** Bow legs	6	**b.** Nervousness	10
f. Fruits	85	**b.** Dry	28	**Thyroid Gland Test**	**Frequency**	**e.** Knock knees	9	**c.** Depression	15
g. Sugar	77	**c.** Angular stomatitis	15	**a.** Normal	92			**d.** Muscle tremor	0
h. Poultry meat	34	**d.** Cheilitis	18	**b.** Enlarged	8	**f.** Enlarged joints	13	**e.** Mental confusion	5

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At present, India is a food secure country, but there is a major issue with nutritional security. Due to nutritional insecurity, malnutrition is increasing day by day in adolescents and other populations. Malnutrition occurs in both types of people who are either undernourished or over nourished. In India, more children suffer from malnutrition due to improper diet, bad food habits and dietary imbalances than due to nutritional deficiencies. Malnourished children may be short for their age, thin or bloated, listless and have weakened immune systems. Nutritional disorders can affect any system in the body and the senses of sight, taste and smell. Also, this might affect their general appearance and physical looks (pale, thick and dry skin, bruising easily, rashes, changes in skin pigmentation, thin hair that is tightly curled and pulls out easily, achy joints, bones that are soft and tender, gums and teeth that bleed easily, tongue that may be swollen or shriveled and cracked, night blindness, increased sensitivity to light and glare, body language, improper fitness, etc., which in turn develop them as physically and mentally unfit, less confident, anxiety issues, changes in mood and other psychiatric symptoms.

In the present study, general appearance of the 37% girls were normal and only 28% of girls were observed active. Although 25% of girls were observed dull and 10% were observed edema. The skin tone of 26% of girls was normal but 74% of girls were suffering with dry/rough (38%), eczema (15%), flaky (12%) and pinpoint (9%) skin. In children, common causes of hair fall include fungal or bacterial infections, telogen effluvium (stress-related hair loss), and traction alopecia. However, the most common cause of hair loss in children is scalp ringworm, which is a treatable fungal infection. Most of these causes of hair loss are effectively treatable, but no effective remedy is available for the hair loss caused by malnutrition. In the present case, 72% of the girls were facing different hair problems (23% dry hairs, 33% thin or sparse hairs and 16% weak hairs) and only 28% of girls were found with normal hair. Generally, healthy lips should be pink, soft and smooth. Only 39% of girls were reported with healthy lips and 28% of girls reported with dry lips, 15% with angular stomatitis and 18% with cheilitis.

Eye and nail color may signal a predisposition to certain medical conditions and changes in their colour can also indicate an underlying health disorder that needs to be addressed. The eyes and nails of 24% and 19% of girls were found normal and healthy, respectively. However, the change in eye colour of 76% of girls (45% pale, 17% sensitive to bright light, 5% bitot spot and 9% corneal xerosis) and nail colour of 81% of girls (42% thin, 23% ridged, 7% koilonychias and 9% flat nail) reported in the studied groups and these changes in eye and nail colour might be a symptom of some possible health risks.

Oral health is an indicator of health and good oral health is vital to good overall health. Oral hygiene is preventative care. The oral health problems such as cavities, gum disease, bad breath (halitosis) and other issues can be triggered before they start by taking good care of your teeth, gums and tongue. Oral health is also linked to whole-body health. The mouth is both the primary pathway into the body and an ideal environment for bacteria to thrive. There are up to six million bacteria present in a typical person's mouth. Most are harmless, or at least well-controlled by the body's natural defenses– as long as good oral hygiene is practiced. Poor oral health negatively affects growth, development, learning, nutrition, communication and self-esteem for all sections of society; young and old; have and have-nots. In the present study, only 55% of girls reported healthy teeth, 30% of girls reported healthy gums and 62% of girls reported a healthy tongue. Rest of the girls reported having different symptoms of unhealthy teeth (45%), gum (70%) or tongue (38%). A lot of risk was reported regarding gum diseases in comparison to teeth and tongue diseases in the adolescent girls.

Body Mass Index (BMI) is a good indicator for measurements of Bone Mineral Density (BMD), which measures the density of minerals present in the bones. Body mineral density is associated positively with the BMI, but negatively with the age. The higher the BMI (>30 kg/m^2), the higher the BMD and the lesser the risk for developing osteoporosis. However, in the present study, 35% of the girls were primarily reported with deformed/abnormal shape of bones (5% with pigeon chest, 2% with beading of ribs, 6% with bow legs, 9% with knock knees and 13% with enlarged joints). Human female lose a lot of blood during the menstrual cycle and it may end up losing more red blood cells than the body can make. This can reduce the amount of iron in the body. As a result, (the) female body will have a harder time making the hemoglobin that's needed to carry oxygen throughout the body. In the present study, the menstrual cycle of 20% of the girls was started in at the age of 10–11 years, 35% of the girls in at the age of 12–13 years and 45% of the girls in at the age of 13–14 years. The age of the menstrual cycle directly affects the hemoglobin levels and female patients have thyroidism. In the present study, 8% of the girls reported having an enlarged thyroid and more chances of low hemoglobin levels and anemia. Ahmed and Mohammed (2020) reported that people with thyroid abnormalities may have low iron levels, which affect the hemoglobin levels; also they may have reduced levels of both folate and B12, which have been detected in up to 25% of patients, and this eventually affects the blood parameters including the hemoglobin and the RBCs, which in turn cause anemia. The examination results of hemoglobin levels were reported as normal in 20%, mild in 19%, moderate in 48% and severe in 13% of girls. 13% of girls having low hemoglobin levels reported experiencing symptoms of anemia (weakness, tired all the time, pale hands and face, dizziness, breathlessness when resting). Ruhimat *et al.* (2023) examined 31 respondents for the hemoglobin levels and reported an average hemoglobin level of 13.1 g/dL before menstruation cycle and 11.9 g/dL after menstruation cycle. They concluded that the average results showed a decrease in hemoglobin levels when experiencing menstruation.

In case of reported neuro-gastrological disorders, 30% of the girls showed symptoms of neurological (10% Nervousness, 15% Depression, 0% Muscle tremor and 5% Mental confusion) and 21% of the girls showed symptoms of gastrological (0% Anorexia, 6% Enlarged liver, 8% Constipation and 7% Increased appetite) disorders. Camilleri

(2021) reviewed that the nervous system controls the major functions of the gastrointestinal tract. Disorders of the nervous system affecting gastrointestinal tract function. Common gastrointestinal symptoms in neurologic disorders include sialorrhea, dysphagia, gastroparesis, intestinal pseudo-obstruction, constipation, diarrhea, and fecal incontinence. The gut and the brain are highly integrated and the relationship between the brain and gut has been known for a long time. Tiwari *et al.* (2023) reviewed that the gut micro biota of humans is known to play a significant role in the metabolism of nutrients and drugs, immunomodulation, and pathogen defense by inhabiting the gastrointestinal tract. The role of the gut micro biota in the gut-brain axis has been documented for different. The micro biota-gut-brain axis is a bidirectional pathway through which the gastrointestinal tract exerts an influence on cerebral nutrition and function. It regulates different mechanisms and associated pathways. It shows different behaviors with individualized bacteria and change in gut micro biota shows characteristic impact on several neurologic disorders.

CONCLUSION:

The result of the study revealed that the prevalence of anemia, stunting and wasting/thinness, overweight and obesity. This indicates that appropriate intervention and focus should be given to these populations. Understanding the intergenerational effect of malnutrition in the study communities, there is a clear need for carefully designed longitudinal studies to definitively answer the reasons for poor growth throughout the period of adolescence. Strategies addressing the nutritional status of girls are needed in addition to the conventional approach of providing services to pregnant and lactating women through the traditional maternal and child health care programs. Nutritional status of adolescent girl's contributes to the nutritional status of family and further community. So, there is a need to initiate intervention measures to improve the nutritional status of adolescent girls who are the future 'mothers-to-be'. Therefore, there is a great requirement for school-based nutrition education and consistent health education programs to be included in schools to promote healthy nutrition and dietary behaviors.

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