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Nutritional status and body composition of adolescent girls of district Udham Singh Nagar (Uttarakhand)

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■ **ABSTRACT :** The present study was conducted to assess the nutritional status and body composition of adolescent girls of the age group 13-17 years using bioelectrical impedance analyzer and to find out the correlation of age, family size and per capita income with the body composition parameters of the adolescent girls. A cross-sectional study was conducted among school going adolescent girls of district Udham Singh Nagar of Uttarakhand in the year 2012-13. Subjects were selected using stratified random sampling technique, taking age as a stratum, to obtain a sample size of 440 girls. Adolescent girls suffering from any chronic disease were excluded from the study. General information regarding age, education, religion, caste, family type, family size and family income was collected with the use of pre-tested interview schedule. Anthropometric measurements were taken as per standard methods. Body composition analysis was done with the use of bio scan analyzer based on BIA. Subjects were assessed for different categories of malnutrition using BMI-for-age and body fat-for-age percentile values. On the basis of BMI-for-age percentiles, 73.86 per cent subjects were found normal and 19.55 per cent girls were underweight. About 4.78 per cent girls fell in the category of overweight whereas obesity was prevalent only in 1.82 per cent girls of the present study. Per cent body fat of subjects varied from 8.68 to 44.35 with the mean value of 24.50±7.97 per cent and was found positively and significantly correlated with weight (r=0.463) and BMI (r=0.565) at p=0.01. Age was found to have significant positive correlation with per cent fat free mass (r=0.416) and significant negative correlation with per cent body fat (r=-0.416, p=0.01) which indicates that with the advancement in age, the muscle mass of the girls increased with proportionate decrease in per cent body fat. Growth spurt in the adolescent girls of district Udham Singh Nagar was found at the age of 13 years. On the basis of body fat-for-age percentiles, 14.77 per cent subjects were found overweight and 3.64 per cent were obese. Underweight was found as an emerging health problem in adolescent girls of district Udham Singh Nagar which tend to increase with age.

■ **KEY WORDS:** Adolescents, Body composition, Body mass index, Obesity, Body fat

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Adolescents (10-19 years) constitute about 20 per cent of the total Indian population (UNICEF, 2010). Adolescents have been considered to have the lowest mortality among different age groups and have, therefore, received low priority in terms of nutritional status assessment (Woodruff, 2000). However, because of rapid growth in stature, muscle mass and fat mass during the peak of the adolescent growth spurt, the requirements for some nutrients is higher in adolescence than in any other age group (ICMR, 2010). Health and nutritional status of adolescent girls are direct reflection of the cumulative effects of physical growth, the onset of menarche and increase in fat and muscle mass which place extra nutritional requirements on them (Choudhary *et al*., 2009).

Body composition during puberty is a marker of metabolic changes that occur during this period of growth and maturation, thus, holds key information regarding current and future health. It is affected by number of factors including age, gender, heredity, physical activity and dietary intake etc. Obesity during childhood and adolescence increases the risk

for many chronic diseases including diabetes mellitus, cardio-vascular disease and non-alcoholic fatty liver disease. Therefore, it is imperative to identify at risk individuals at an early stage (Kapil *et al*., 2002).

Scanty information is available on body composition of Indian adolescent girls, therefore, this study was taken as an initiative with the primary objective to assess the nutritional status and analyze body composition of the adolescent girls of district Udham Singh Nagar, so that, the information collected in this study can be used for the formulation of health and developmental policies for adolescent girls in the state.

■ RESEARCH METHODS

Selection of the samples:

The present cross-sectional study was conducted among school going adolescent girls of Pantnagar and Rudrapur areas of district Udham Singh Nagar of Uttarakhand in the year 2012-13. Assuming a prevalence of underweight among 13-17 year girls as 50 per cent (Saxena and Saxena, 2011), with 95 per cent confidence level and 5 per cent relative precision, the sample size required for the proposed study was computed using the formula given below:

$$n = \frac{(1.96)^2 P_{exp}(1 - P_{exp})}{d^2}$$

where,

n = required sample size,

P_{exp} = expected prevalence,

d = desired absolute precision.

Using the above formula, sample size was estimated as 384 *i.e.* about 77 girls from each age group. Ten more subjects were added to each age group and finally, the total figure (435) was rounded off to ten multiple number *i.e.* 440. Subjects were selected using stratified random sampling technique, taking age as a stratum, to obtain a sample size of 440 adolescent girls between 13-17 years of age. Girls suffering from any chronic disease were excluded from the study.

Socio-demographic profile:

Information on socio-demographic profile (age, religion, caste, family size and type, family income) was collected using a pretested interview schedule.

Anthropometric measurements and body composition analysis:

Anthropometric measurements including height, weight, waist and hip circumference were taken as per standard methods (Jelliffe, 1966) and further, waist-to-hip ratio (WHR) and body mass index (BMI) were calculated. Body composition analysis (body fat %, total body water %, body density, body cell mass) was performed on the subjects using bioscan analyzer which works on the principle of bioelectrical impedance analysis (BIA) technique.

The BMI-for-age values of CDC growth charts (CDC growth charts, 2000) (Table 1) were used for comparing the BMI-for-age of subjects in the present study. Body fat per cent-for age of subjects was estimated and subjects were categorized as underweight, normal, overweight and obese by comparing their body fat per cent with the percentile values of body fat (WHO, 1995) (Table 2).

Statistical analysis:

All results of quantitative parameters were expressed as mean, standard deviations, percentage and percentiles. One way classified model of ANOVA was used to find out the variations present among the subjects for anthropometric data and body composition parameters. Correlation analysis between variables was also done.

■ RESEARCH FINDINGS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

General information:

In the present study, 77.50 per cent subjects belonged to nuclear families. Family size ranged from 2-16 members. Majority of the subjects under study were Hindu (89.32%) and belonged to general category (75.23%). Monthly income of the families of subjects ranged from Rs. 7,000 to Rs. 2,50,000 with an average of Rs. 46,746± 36,551. Majority *i.e.* 44.32 per cent subjects had per capita income in the range of Rs. 5,001-10,000/month, followed by 27.73 per cent having per capita income below Rs. 5,000/month. About 21 per cent subjects were having per capita income in the range

Table 1: BMI-for-age percentiles for adolescent girls (CDC growth charts, 2000)

Age	BMI-for-age percentile values			
	<5th	5th-84th	85th-95th	>95th
13 years	<15.40	15.40-22.60	22.61-26.40	>26.40
14 years	<15.80	15.80-23.30	23.31-27.20	>27.20
15 years	<16.30	16.30-24.00	24.01-28.00	>28.00
16 years	<16.80	16.80-24.80	24.81-28.70	>28.70
17 years	<17.30	17.30-25.00	25.01-29.60	>29.60

of Rs. 10,001-20,000/month whereas 6.9 per cent subjects had per capita income more than Rs. 20,000/month.

Anthropometric assessment:

Data on anthropometric measurements (Table 3) revealed a gradual increase in the height and weight of subjects with the advancing age which showed a positive growth pattern. In the present study, average height of girls ranged from 138 cm to 176 cm during 13 to 17 years with the mean height of 155.46 ± 6.79 cm and weight ranged between 28 kg to 80 kg with the mean value of 45.33±8.70 kg. The values for height and weight of girls in the present study were found lower than the values reported for Nigerian girls by Ogechi *et al.* (2007) but higher than the values *i.e.* height (154.7± 6.10 cm) and weight (43.6± 10.7 kg) reported by Tharkar and Viswanathan (2009) for adolescent girls of Chennai.

Body mass index (BMI) of subjects was calculated using the formula *i.e.* weight (kg)/height (m^2). The average BMI of the subjects in 13, 14, 15, 16 and 17 years age group was found to be 18.01 ± 3.07 kg/m^2, 18.39 ± 3.26 kg/m^2, 19.26 ± 3.28 kg/m^2, 18.95 ± 6.52 kg/m^2 and 19.26 ± 2.10 kg/m^2, respectively, ranging from 12.26 to 32.87 kg/m^2 (Table 3). The average BMI of the girls in present study *i.e.* 18.71±3.03 kg/m^2 was found almost similar *i.e.* 18.8±3.1 in the study reported by Tharkar and Viswanathan (2009) but lower than the BMI of adolescent girls of Nigeria. BMI was found to be positively and significantly correlated with age (r=0.147), per capita monthly income (r=0.157) and weight (r=0.890) at p=0.01.

Using the BMI-for-age percentile values, subjects were assessed for the prevalence of underweight, overweight and obesity. Majority (73.86%) of subjects were found healthy (Fig. 1). About 5 per cent and 2 per cent of the girls were found overweight and obese, respectively. At the same time

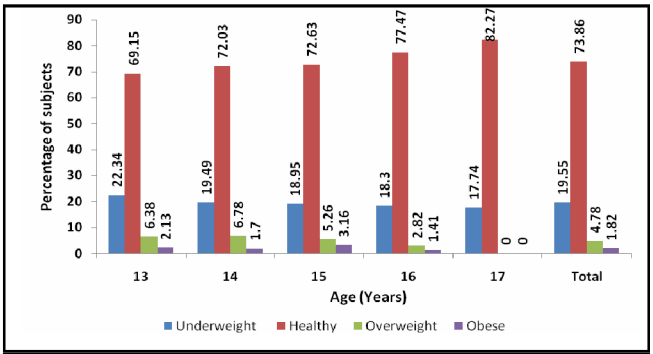

Fig. 1: Classification of subjects based on BMI- for-age (kg/m^2) percentiles

Table 2: Body fat -for-age percentiles for adolescent girls (WHO, 1995)

Age	Body fat-for-age percentile values			
	<5th	5th-84th	85th-95th	>95th
13 years	<10.9	10.90-32.10	32.11-37.8	>37.8
14 years	<12.5	12.50-33.20	33.21-38.6	>38.6
15 years	<14.6	14.60-33.50	33.51-39.5	>39.5
16 years	<16.8	16.80-33.70	33.71-40.3	>40.3
17 years	<18.8	18.80-33.90	33.91-41.0	>41.0

Table 3: Anthropometric measurements and body composition parameters of subjects

Parameters	13 years	14 years	15 years	16 years	17 years	Total (Range)
Height (cm)	152.04±6.09	154.58±5.69	156.42±6.46	157.38±7.30	157.90±7.63	155.46±6.79(138.7-176.4)
Weight (kg)	41.94 ± 9.18	44.08±8.89	47.14±8.54	47.96±7.33	48.19±7.30	45.33±8.70 (28.3-80.50)
BMI (kg/m^2)	18.01±3.07	18.39±3.26	19.26±3.28	18.95±6.52	19.26±2.10	18.71±3.03(12.26-32.87)
Waist cir.(cm)	68.06± 8.98	66.81 ±7.94	68.08 ±6.77	68.70± 6.52	69.09± 5.66	67.98 ±7.46 (50-99)
Hip cir. (cm)	84.23±8.81	84.98±7.99	86.71±7.87	88.39±6.96	89.39±6.31	86.36±7.97 (60-110)
Waist/hip ratio	0.81±0.06	0.76±0.05	0.79±0.05	0.78±0.05	0.77±0.03	0.79±0.05 (0.68-0.94)
Fat (%)	27.53±7.60	26.44±6.98	27.71±6.42	18.14±6.99	18.61±6.01	24.50±7.97 (8.68-44.35)
FFM (%)	72.46± 7.61	73.58±7.01	72.29±6.42	81.87±6.99	81.39±6.01	75.49±7.97(55.65-91.90)
TBW (%)	55.46±4.00	55.61±3.48	54.69±3.12	57.29±5.15	56.63±4.51	55.79±4.06(46.22-69.03)
ECW (%)	38.22±4.15	38.24±4.06	37.36±3.88	44.61±3.46	44.16±3.05	39.91±4.83(22.87-50.72)
ICW (%)	61.76±4.15	61.80±4.06	62.63±3.88	55.38±3.46	55.83±3.05	60.09±4.84(49.27-77.12)
ECW/ICW	0.63±0.11	0.62±0.10	0.60±0.10	0.81±0.11	0.80±0.09	0.67±0.13 (0.30-1.03)
Body density (kg/l)	1.04±0.02	1.04±0.02	1.03±0.02	1.06±0.02	1.06±0.02	1.04±0.02 (1.00-1.09)
BCM (kg)	16.81±3.06	18.09±2.99	19.38±2.93	20.12±2.06	20.58±2.21	18.77±3.06(11.37-30.06)

19.55 per cent of the subjects were less than the 5th percentile indicating underweight. The prevalence of overweight and obesity in the present study was lower than the study done amongst affluent adolescent girls (10 to 15 years) of Chennai in 1981 and 1998. The prevalence of overweight and obesity denoted by BMI above 85th and 95th percentile at Chennai showed that 9.6 per cent of the girls were overweight and 6 per cent were obese (Vedavati *et al*., 2003).

Various other studies (Ramachandran *et al*., 2002, Chatwal *et al*., 2004; Mehta *et al*., 2006 and Bose *et al*., 2007) reported higher magnitude of overweight from 9 to 27.5 per cent and that of obesity from 1 to 12.9 per cent compared to the present study.

Waist and hip circumferences ranged from 50 to 99 cm and 60 to 110 cm, respectively, with the mean values of 67.98 ±7.46 cm and 86.36 ± 7.97 cm (Table 3). Waist-to-hip ratio (WHR) was also calculated in this study. WHR varied from 0.68 to 0.94 with the mean WHR of 0.79±0.05 and was found positively and significantly correlated with weight (r=-0.168) at p=0.01.

Body composition:

Bioelectrical impedance analysis (BIA) is a simple, cheap, non-invasive, reliable, repeatable and valid estimation for human body composition, both in field and clinical applications (Gropper *et al*., 2009). In the present study, body fat (kg) among subjects varied from 2.82 kg to 30.60 kg with the mean value of 11.41±5.23 kg. In percentage, body fat of subjects varied from 8.68 to 44.35 with the mean value of 24.50±7.97 per cent (Table 3) and was found to have significant positive correlation with weight (r=0.463), WHR (r=0.375) and BMI (r=0.565) at p=0.01. Khadgawat *et al*. (2013) also reported the significant positive correlation between per cent body fat and BMI in adolescent girls of Delhi Public Schools.

Using the reference per cent body fat-for-age percentile cutoffs, majority (63.41%) of subjects were found in healthy range (Fig. 2). In the age groups of 13 and 14 years, none of the subjects was found underweight whereas in 16 and 17 years age group, majority *i.e.* 54.93 per cent and 61.29 per cent

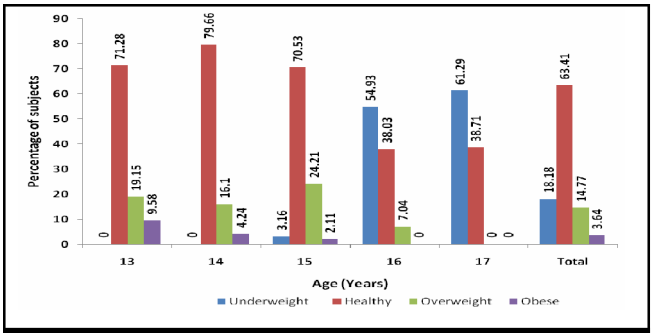

Fig. 2: Classification of subjects based on body fat- for-age (kg/m²) percentiles

subjects, respectively, were found underweight.

The findings indicate that body fat of the girls did not increase with increasing ages as expected with normal health. The reason for this might be the increase in height and energy requirement of the girls at this age. To meet the extra demand of energy, the stored fat is used in absence of additional dietary intake of energy, which might have lead to the decline in fat percentage. Findings of this study also revealed that 14.77 per cent of the girls had per cent body fat-for-age between 85th and 95th percentile indicating overweight. About 4 per subjects had body fat values equal to or above 95th percentile indicative of obesity.

In the present study, fat free mass of subjects varied from 20.6 kg to 49.42 kg. In percentage, fat free mass of subjects varied from 55.65 to 91.90 per cent with the mean of 75.49±7.97. Highest fat free mass per cent (81.87±6.99) was recorded in the girls of 16 years age and lowest value was recorded in the girls of 15 years of age (72.29±6.42) (Table 3). Fat free mass is related with health as it is found to have a strong correlation to morbidity, mortality, caloric requirement and physical performance. Muscles, vital organs, bones and extracellular fluid are the major components of fat free mass.

A statistically significant difference (p=0.01) was found using ANOVA in fat free mass content between girls of 13 and 16 years; 13 and 17 years; 14 and 16 years; 14 and 17 years; 15 and 16 years and 15 and 17 years. These findings suggest that there was no significant difference in fat free mass content of 13, 14 and 15 years old girls. In the present study, age was found to have significant positive correlation with per cent fat free mass (r=0.416) and significant negative correlation with per cent body fat (r=-0.416, p=0.01) which indicates that with the advancement in age, the muscle mass of the girls increased with decrease in per cent body fat.

Water accounts for about 60 per cent of the total body weight in a normal adult, making it the most abundant constituent of the human body. Out of which, 67 per cent is present in the intracellular compartment and rest 33 per cent in the extracellular compartment. Total body water (TBW) per cent among the subjects of the present study ranged from 46.22 to 69.03 with an average of 55.79±4.06 per cent (Table 3). It was found positively and significantly correlated with per cent fat free mass (r=0.876) and age (r=0.128) but negatively significantly correlated with weight (r=-0.676) and per cent body fat (r=-0.876) at p=0.01.

The ratio of ECF to ICF, known as ECF/ICF has been used as a single index of health. This ratio is used as an indicator to monitor several clinical and physiological conditions such as enlargement of the ECW compartment compared to ICW compartment associated with obesity and the regulation of fluids prior to and after weight reduction and maintenance (Turna *et al*., 2006). In the present study, extracellular water (ECW) to intracellular water (ICW) ratio ranged from 0.30 to 1.03 with

the mean ratio of 0.67±0.13 (Table 3).

Body density is used to indirectly estimate total body fat and fat free mass. It is the density of human body, derived from body weight and volume. In the present study, body density of subjects ranged from 1.00 to 1.09 kg/l with an average of 1.04 ± 0.02 (Table 3).

Body cell mass is a "cellular level" component of body composition which is considered the actively metabolizing portion of the body. BCM represents protoplasm, a portion of the body that generates energy and is associated with all major functions. BCM is used for normalization of energy expenditure and other metabolic measures. The findings of the present study revealed that body cell mass (BCM) varied from 11.37 kg to 30.06 kg (Table 3) with an average of 18.77±3.06 kg. BCM content was found in increasing manner with the advancing age *i.e*. lowest BCM was recorded in 13 years age group (16.81 ± 3.06) and highest BCM was found in 17 years aged girls (20.58 ± 2.21). BCM was found to significantly and positively correlated (r=0.193) with the fat mass of the subjects at 1 per cent level of significance.

Conclusion:

On the basis of the findings of this study, it can be concluded that anthropometry and body composition of adolescent girls are influenced by number of factors like age, family size and per capita income. Income has a great impact on the body composition of individuals as it greatly influences the dietary pattern and eating habits. Growth spurt in the adolescent girls of district Udham Singh Nagar was found at the age of 13 years. A gradual increase in the height and weight of subjects was recorded with the advancing age which showed a positive growth pattern among the girls.

In the present study, different degrees of malnutrition were assessed among the subjects using two indices *i.e*. BMI-for-age percentiles and body fat-for-age percentiles. The percentage of underweight girls was almost similar *i.e*. 19.55 per cent and 18.18 per cent by using BMI-for-age percentiles and body fat-for-age percentiles, respectively. Higher percentage of subjects was found overweight (14.77%) and obese (3.64%) using body fat-for-age percentiles in comparison to BMI-for-age percentiles (4.78% overweight and 1.82% obese).

Body fat per cent of the subjects in this study was found positively correlated with body mass index but prevalence of different degrees of malnutrition on the basis of BMI-for-age percentiles and per cent body fat-for-age percentiles were not found similar. Thus, it is recommended that future studies on body composition analysis of adolescents should not rely solely on BMI cut-points of obesity but should be based on the relationship of BMI with per cent body fat.

As information regarding the body composition and nutritional status of adolescents in Uttarakhand is scarce, the information collected in this study can further be used for the formulation of health and developmental policies for adolescents in the state.

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