## Original Article

# Exploring Body Composition of Pre-adolescent Schoolers based on Skinfold Thickness and Arm Girth for Assessing Anthropometry

Sharmin Rahman[1], Rokhsana Tanjin[2], Nazia Binte[3], Nurun Naher[4], Mohammad Adnan Khan[5], Sanjida Amin[6],

**Abstract:**

**Background**: Early nutrition plays a pivotal role in shaping long-term health and well-being during adulthood and beyond. Nevertheless, there has been limited exploration into methods for assessing the nutritional status of Bangladeshi pre-adolescent schoolers through anthropometric measurements, encompassing weight, height, skinfold thickness, circumferences (such as head and waist), and limb lengths (including shoulder and wrist). Evaluating nutritional conditions using these measurements reveals variations among different groups, such as boys versus girls and distinctions between rural and urban areas. Part of this study have been adopted from earlier 4 studies but on extrapolating data from the database of Anthropometric Somatotype of Government Primary School Children in Dhaka City.

**Materials & Methods:** A descriptive cross-sectional study was conducted among 400 government elementary school students aged between 9 and 12 years. Data was collected using a semi-structured questionnaire and analyzed using SPSS.

**Findings**: Percentage of body fat, total body fat & skinfold thickness of the groups of boys were higher than same age group of girls. Girls BMI ranges are higher than the same age group of boys. In the matter of Body Surface Area, girl child of 9 year has less BSA than 9year age boys, as age goes up the scenario changes gradually. 9-10-year-old boys have higher Arm grith than those age of girls, 10-12 years old girls tend to have higher calf grith than boys of same age group.

**Keywords:** Triceps, subscapular, suprailiac, anthropometry, calf girth, arm girth, total fat percentage.

## Introduction

The assessment of body composition in childhood can be performed with several sophisticated techniques, but in many circumstances, it is more desirable to utilize widely available and simple techniques such as anthropometry.[1]

1. Associate Prof, Anatomy, Ad-din Women's Medical College, Dhaka.
2. Assistant Prof, Anatomy, Ad-din Women's Medical College, Dhaka.
3. Assistant Prof, Anatomy, Ad-din Women's Medical College, Dhaka.
4. Assistant Prof, Anatomy, Ad-din Women's Medical College, Dhaka.
5. Assistant chief (Medical), MIS, Directorate General of Health Services.
6. Associate Prof, Anatomy, Universal Medical College.

**Correspondence:** Dr. Sharmin Rahman, Associate Professor, Department of Anatomy, Ad-din Women's Medical College, Dhaka. Phone Number: 01732646777, E-mail : sharminhf3@gmail.com

**Received Date** : 17 September, 2023
**Accepted Date** : 26 November, 2023

Anthropometry has a long history of measuring individual nutritional and health condition since it is a low-cost, non-invasive technology that offers extensive information on various body structure components, particularly muscle and fat components.[2,3] Furthermore, anthropometric measures are very sensitive to a wide range of nutritional status, whereas biochemical and clinical indicators are only relevant in cases of severe nutrition. Anthropometry is the science of measuring the human body in respect of bone, muscle, and adipose tissue measurements.[4] In a word, it is a scientific discipline that deals with the measuring of the human body.[5] Anthropometric measurements include

1. Weight
2. Height (Standing height, recumbent length)
3. Skinfold thickness
4. Circumferences (head, waist, arm)
5. Limb length (shoulder, wrist)[5]

Body mass index (BMI) and mid-upper-arm-circumference (MUAC) are one of the most important and trustworthy of the regularly used anthropometric measure. Anthropometric measures may be used to calculate a variety of indices and ratios. The body mass index, or "BMI is perhaps the most well-known metric of body fat and is widely regarded as a triable metric for determining chronic energy shortage in people particularly in underdeveloped nations[2,4]. It has strong relationship with fat and fat-free mass, therefore it may be used to assess the body's protein and fat stores[2] .The ratio is roughly constant in normal individuals and someone with a low BMI is underweight for their height.[1] However, there are several drawbacks to relying just on BMI, for example, the ratio of sitting to standing height or the cormic index might affect BMI. The cormic index varies across and among populations.[6]

As a result, without using the cormic index as a correction factor, the sensitivity and specificity of BMI as a nutrition indicator may be poor. Because humans tend to lose fat free mass and gain fat mass as they get older, ageing can affect the functional import BMI at various ages[6]. The importance of BMI can also be influenced by oedema. When adults are extremely undernourished, they may develop oedema, which falsely mises their weight, making their BMI look more normal than it is [7]. Furthermore, the BMI's universal cut-off cannot be used across diverse populations. As a result, BMI's use as an accurate screening tool for assessing adult undernutrition is limited. Body surface area was designed as a metric for modulating different pharmacological therapies as well as a standard tool for indexing various physiologic parameters including glomerular filtration rate and cardiac output.[8] There are several methods for calculating an individual's body surface area (BSA).

Skinfold thickness is a simple means of estimating body composition which is widely used in children[9]. Now a days childhood obesity is a common health problem in Bangladesh because of its association with increased risk of hypertension, coronary heart disease, diabetes and certain types of cancer. Skinfold thickness is also a good method to measure level of fatness because it directly measures subcutaneous fat layers.[10] Very low values of skinfold thickness indicate the depleted calorie reserves of the body and are correlated with malnutrition. So, this is a good predator of health and chronic disease.[11] Skinfold thickness is also used to calculate anthropometric somatotype.

Assessment of total body fat and percentage of body fat is important in the management of diseases like obesity, cardiovascular diseases and type 2 diabetes mellitus.[12] It is also a good method to measure level of fatness because it directly measures subcutaneous fat layers by measuring skinfold thickness[11]. Different body size, shape and proportions are beneficial in different physical activities. Physical abilities of the players have marked effects on the skill of players and the tactics of the team. To evaluate these physical abilities parameters of the body composition such as the percent body fat and somatotype components are often used.[13]

Measurements of upper arm girth and calf girth can be performed to detect alterations from physiological growth. It reflects inadequate or excess food intake, insufficient exercise and disease. Upper arm girth and call girth measurements are also used in determination of somatotype[14] which has a relatively long tradition in human biology, including changes during growth and maturation[15]. There is limited study specifically looking at anthropometric measurements including height, weight, bi-epicondylar breadth of the humerus and femur, BMI and BSA, despite the fact that anthropometric measurements are often used to assess nutritional status across the world, including Bangladesh. Therefore, the purpose of this study was to determine whether primary school pupils had the aforementioned anthropometric measures.

## Materials& Methods:

### Study Type

The study was cross sectional study.

### Study Place

This present study was conducted in the department of Anatomy, Dhaka Medical College, Dhaka & was performed on government primary school children.

### Study Population

Study population was primary school children, age range 9-12 years. Among 580 students, 400 participated in the study. Half of the population were boys and half were girls. The study population was divided into three groups A, B, C according to age and sex of the subject. Group A include age 9-10 years, group B include age 10-11 years and group C include age 11-12 years old children. Each group was subdivided into A1, B1, C1, for boys and A2, B2, and C2, for girls.

### Study Period

The study was conducted from January 2012 to December 2012.

### Selection of Criteria

#### A. Inclusion Criteria

The subjects were from 9 years to 12years, the students of class III to class V.

#### B. Exclusion criteria

Children with any disabilities or chronic condition were excluded from the study.

### Sample Size

Study population was 400 government primary school children. Out of 400 children, 200were boys and 200 were girls.

### Sampling techniques

Convenient sampling technique was followed to select the needed sample.

### Study instrument and study tool

Data was collected using a semi-structured questionnaire. This questionnaire was adapted from earlier research and modified to fit the needs and circumstances of the study purpose. This questionnaire was approved by faculty members of Dept. of Anatomy & MRU in DMC. The developed tool was pretested with 20 students to test the feasibility of the proposed study.

### Interview procedure

Students were contacted in their classroom before or after lectures for data collection after obtaining students assent and parental or legal guardian consent. Study objectives was explained before data collection.

### Anthropometric measurements

Anthropometric measurements were taken following standard protocol and instrument[16]. The height of the body was measured by stadiometer in centimeters (cm) and the weight was measured by weighing scale in kilogram (kg). Bi-epicondylar breadth of the humerus and femur was measured by a digital slide caliper in centimeters (cm). Bi-epicondylar breadth of the humerus was determined by measuring the distance between the medial and lateral epicondyles of the humerus, with the shoulder and elbow flexed to 90 degrees and bi-epicondylar breadth of the femur was determined by measuring the greatest distance between the lateral and medial epicondyles of the femur. Body Mass Index (BMI) has been calculated using the formula mentioned below and Body Surface Area (BSA) was calculated by following Du Bois's formula as mentioned in introduction section.

BMI = weight in Kg / (height in meter) $^2$

BSA = 0.007184xHeight(m)^0.725xWeight(kg)^0.425

Skinfolds were measured by skinfold caliper in mm. A fold of skin and subcutaneous tissue was firmly pinched between thumb and forefinger and away from the underlying muscle at the marked site. Then the skinfold caliper was placed 1cm below the fingers of the left hand to measure thickness of the fold. During measurement the subject was asked to stand relaxed, except for the medial calf skinfold which was taken with the subject seated .[17]

Triceps skinfold was taken with the subject's arm hanging loosely in the anatomical position. A line was drawn at the back of the arm connecting the acromion and the olecranon processes. A midpoint of the line was determined. Then a fold was raised at the determined site and measurement was taken.[17]

Subscapular skinfold was taken by raising the fold on a line from the inferior angle of the scapula in a direction that was obliquely downwards and laterally at 45 degrees[17].

A point was taken 5-7 cm above the anterior superior iliac spine at the junction of a line to the anterior axillary border and a diagonal line going downwards and medially at 45 degrees. Then suprailiac skinfold was measured by raising the fold at the point[17].

Percentage of body fat (BF%) was calculated by Slaughter et al equations[9].

Boys = 1.21 (sum of 2 skinfolds) – 0.008 (sum of 2 skinfolds)$^2$ – 1.7

Girls = 1.33 (sum of 2 skinfolds) – 0.013 (sum of 2 skinfolds)$^2$ – 2.5

[BF% for children with triceps and subscapular skinfolds <35 mm]

Boys = 0.783 (sum of 2 skinfolds)– 1.7

Girls = 0.546 (sum of 2 skinfolds) + 9.7

[BF% for children with triceps and subscapular skinfolds >35 mm]

Total body fat was calculated by following formula[13].

Total body fat (kg) = (Percentage of body fat / 100) x Body mass (kg)

Upper arm girth was measured by a standardized flexible ribbon tape in cm. The subject was asked to flex the shoulder to 90 degrees and the elbow to 45 degrees. Then the children were asked to clasp the hand and maximally contract the elbow flexors and extensors. Then midpoint of upper arm was determined and upper arm girth was measured.[17]

Calf girth was measured by a standardized flexible ribbon tape in cm. The children were asked to stand with feet at a distant. Then maximum calf girth was measured around the calf.[17]

### Statistical analysis

All data were checked and edited after collection. Later on, the data were inputted and analyzed using SPSS version 17.0 for windows. Statistical analyses were done by unpaired student's 't' test.

### Result

Percentage of body fat and total body fat of group A2, B2 and C2 were significantly greater than group A1, B1 and C1(P<0.001). In the present study, total body fat of $A_2$, $B_2$ and $C_2$ were higher than $A_1$, $B_1$ and $C_1$ (P<0.001).

**Table-1: Percentage of body fat and total body fat of boys and girls of Government primary school (n=400)**

| Group | Percentage of body fat (Mean ± SD) | Total body fat (kg) (Mean ± SD) | P value |
|---|---|---|---|
| $A_1$(n=68) | 10.10±2.47(6.37-20.18) | 2.55±0.75 (1.28-5.85) | 0.0001*** |
| $A_2$(n=68) | 13.30±4.37(6.17-25.70) | 3.32±1.30 (1.1-7.96) | |
| $B_1$(n=66) | 10.69±3.72(3.87-21.04) | 2.85±1.27(1.04-6.63) | 0.0001*** |
| $B_2$(n=66) | 14.28±3.99 (7.58 -29.35) | 4.41±2.12 (1.59-14.38) | |
| $C_1$(n=66) | 11.71±3.55(6.37-22.73) | 3.38±1.35(1.53-8.07) | 0.0001*** |
| $C_2$(n=66) | 15.71±4.65 (4.33-26.23) | 5.35±2.47 (1.68-12.27) | |

Triceps', subscapular, suprailiac and medial calf skinfold of group A2, B2 and C2 were significantly greater than group A1, B1 and C1.

**Table-2: Subscapular skinfold, suprailiac skinfold, Medial calf skinfold of boys and girls of Government primary school (n=400)**

| Group | Subscapular skinfold (mm) (Mean ± SD) | Suprailiac skinfold(mm) (Mean ± SD) | Medial calf skinfold(mm) (Mean ± SD) |
|---|---|---|---|
| $A_1$(n=68) | 4.51±1.15(2.00-9.00) | 4.29±1.44(2.00-9.00) | 6.01±1.78(3.00-12.00) |
| $A_2$(n=68) | 5.85±2.27 (3.00-14.00) | 6.11±2.28(2.25-14.00) | 7.98±2.37(3.00-12.00) |
| P value | 0.0001*** | 0.0001*** | 0.0001*** |
| $B_1$(n=66) | 4.64±1.73(2.00-10.00) | 4.32±2.12(2.00-10.50) | 7.16±2.26(2.25-14.00) |
| $B_2$(n=66) | 6.95±2.51(2.50-16.00) | 6.73±2.35 (3.00-14.00) | 8.15±2.76(3.00-18.00) |
| P value | 0.0001*** | 0.0001*** | 0.026* |
| $C_1$(n=66) | 5.10±1.71(3.00-11.00) | 5.23±2.24(2.00-12.00) | 7.66±2.49(4.00-14.00) |
| $C_2$(n=66) | 7.53±2.67(3.75-16.00) | 7.64±3.01 (3.00-16.00) | 8.73±3.15(3.00-18.00) |
| P value | 0.0001*** | 0.0001*** | 0.031* |

Body mass index of A1 and A2 groups ranged from 11.60-16.60 kg/m² and 10.90-17.60 kg/m2, respectively and the mean (SD) BMI were 13.66±1.09 kg/m² and 13.80 1.34 kg/m³, respectively. No significant difference in BMI was observed between A1 and A2 study groups (p-0.517). The BMI of B1 and B2 groups ranged from 10.40-18.30 kg/m2 and 10.70-22.60 kg/m², respectively and the mean (SD) body mass index were 13.92+1.51 kg/m² and 14.65+2.26 kg/m², respectively.

Body mass index of B2 was greater than B1 study group (p<0.05). Body mass index of C1 and C2 groups ranged from 12.30-18.00 kg/m² and 11.10-23.10 kg/m², respectively and the mean (SD) body mass index were 14.29+1.28 kg/m² and 15.57+2.42 kg/m², respectively. The BMI of C2 was greater than C1 study group (p<0.001).

Body surface area (BSA) of boys and girls government primary school of Body surface area of A1 and A2 groups ranged from 0.87-1.13 m² and 0.84-1.31 m², respectively and the mean (±SD) body surface area were 0.99±0.05 m² and 0.97 0.08 m², respectively. No significant difference in body surface area was observed between A1 and A2 study groups (p=0.264). The BSA of B1 and B2 groups ranged from 0.89-1.25 m² and 0.89-1.41 m², respectively and the mean (SD) body surface area were 1.02+0.08 m² and 1.10+0.12 m², respectively. Body surface area of B2 group was greater than B1 study group (p<0.001). The BSA of C1 and C2 was ranged from 0.91-1.30 m² and 0.97-1.47 m², respectively and the mean (SD) body surface area were 1.07 0.08 m² and 1.17±0.11 m², respectively. Body surface area of C2 group was greater than Cl study group (p<0.001). B1 group's bi-epicondylar femur width was higher than B2 group. B2 group's body surface area was larger than B1 group. Body surface area of the C2 group was greater than C1 group. (p<0.001).

**Table-3: Body Mass Index of boys and girls of Government primary school (n=400)**

| Group | Boys | | Group | Girls | | P value |
|---|---|---|---|---|---|---|
| | N | Body Mass Index (BMI)Kg/$m^2$ (Mean ±SD) | | N | Body Mass Index (BMI)Kg/$m^2$ (Mean ±SD) | |
| Group $A_1$ | 68 | 13.66±1.09 | Group A2 | 68 | 13.80±1.34 | <0.517 |
| Group $B_1$ | 66 | 13.92±1.51 | Group B2 | 66 | 14.65±2.26 | <0.033 |
| Group $C_1$ | 66 | 14.29±1.28 | Group C2 | 66 | 15.57±2.42 | <0.001 |
| Total | 200 | | Total | 200 | | |

**Table-4: Body surface area of boys and girls of Government primary school (n=400)**

| Group | Gender | Body surface area (m²) (Mean ± SD) | P value |
|---|---|---|---|
| Group A1 (n=68) | Boys | 0.99±0.05 | 0.264 |
| Group A2(n=68) | Girls | 0.97±0.08 | |
| Group B1(n=66) | Boys | 1.02+0.08 | <0.001 |
| Group B2(n=66) | Girls | 1.10±0.12 | |
| Group C1(n=66) | Boys | 1.07±0.08 | <0.001 |
| Group C2(n=66) | Girls | 1.17±0.11 | |

Gender percentage as per age shown in figure 1

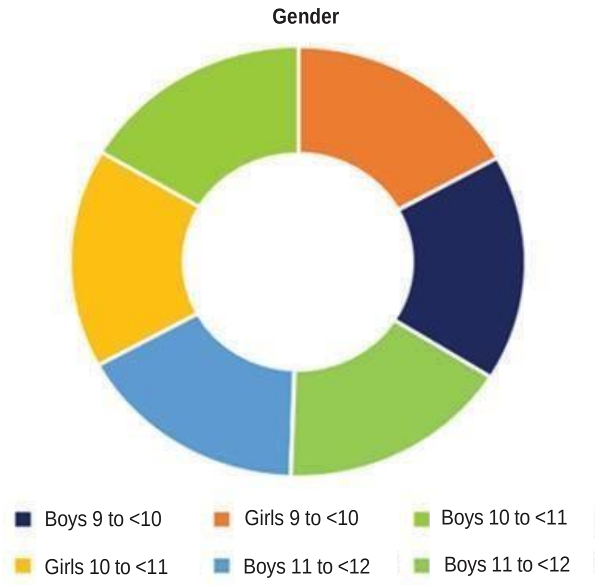


**Figure-1** Gender Percentage of Study Populations

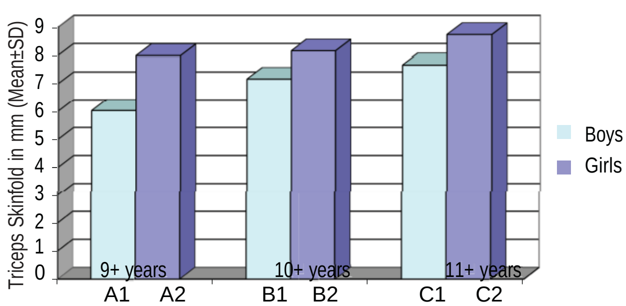


**Figure-2** Triceps skinfold of boys and girls of government primary school

Triceps' skinfold of group A2, B2 and C2 were significantly greater than group A1, B1 and C1

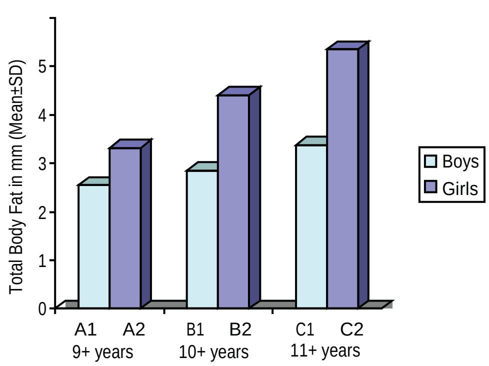


**Figure-3:** Total Body Fat of boys and girls of government primary school

Total Body Fat of group A2, B2 and C2 were significantly greater than group A1, B1 and C1

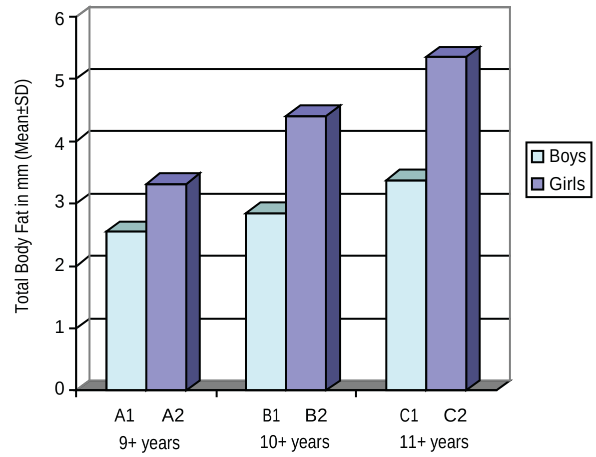


**Figure-4** Upper arm girth of boys and girls of government primary school

Upper arm girth of group A1 were significantly higher than group A2, B2 were significantly higher than B1. No significant up difference in upper arm in girth between group C1 gr and C2. A Calf girth of group B2 and C2 were significantly higher than group B1 and C1. No significant difference in calf girth between group A1 and A2. B2 group had a greater weight than B1 group ($p<0.001$), where C2 was heavier than the C1 group. A1 group's bi-epicondylar width of the humerus was greater than the A2 group ($p<0.05$) and B2 group was higher than B1 group.

## Discussion

An anthropometric examination of nutritional status was done in the current study. A cohort of children (9-12 years old) from four public primary schools in the city of Dhaka that was diverse in terms of gender, family income, and age were specially chosen. It can give a picture of health and nutritional situation of Bangladeshi school going children.

Boys and girls aged 9 to 10 exhibited average heights of 135.01±3.70 cm and 133.43±6.62 cm, along with average weights of 24.88±2.27 kg and 24.65±3.39 kg, respectively. In the 10–11 age group, boys had mean heights and weights of 136.89±5.04 cm and 26.14±3.57 kg, while girls had mean heights and weights of 141.89±6.64 cm and 29.49±5.78 kg, respectively. Notably, in this age group, girls surpassed boys in both height and weight. As participants progressed to the

11–12 age group, mean heights were 140.70±5.24 cm for boys and 145.42±5.86 cm for girls, with mean weights of 28.39±3.54 kg and 32.90±6.04 kg, respectively.

According to South Indian study, Boys become taller than girls from 14 years and girls become heavier than boys from 10 years; however, there is a crossing over (no difference) in weight at 15 years and from 16 years of age, the boys become heavier [18]

In terms of skinfold measurements, group A2, B2, and C2 demonstrated significantly higher subscapular skinfold compared to group A1, B1, and C1 (P<0.001). Similarly, suprailiac skinfold measurements in group A2, B2, and C2 were significantly elevated compared to group A1, B1, and C1 (P<0.001). The medial calf skinfold in group A2, B2, and C2 was significantly higher than in group A1 (P<0.001), as well as in comparison to group B1 and C1 (P<0.05).

Our study used both skinfold thickness and BMI to measure fat mass, fat-free mass, and % body fat. However, Astrid CJ Nooyens et al. (2007) suggests skinfold thickness over BMI to measure body fatness [19]

Total body fat of $A_2$, $B_2$ and $C_2$ were higher than $A_1$, $B_1$ and $C_1$ (P<0.001) which express girls had more fat in body then boys. Percentage of body fat also shows same kind of result.

A higher fat mass among girls than boys and higher % body fat in girls than boys were observed in the current study. However, Soledad Aguado-Henche et al. (2011) observed no gender-specific difference [20]. However, Jaydip Sen & Nitish Mondal (2013) reported a sex-specific significant difference in FM and FFM among children 5–12 years in West Bengal, India [21]. Zhang Ying-Xiu, Wang Shu-Rong et al found percentile values for triceps and subscapular SFs of Chinese and American children were lower than the per-centiles of boys and girls in the present study, performed in 8568 Chinese ,783 North-American children and adolescents .[22]

Body mass index values for boys and girls aged 9 to 10 were 13.66±1.09 and 13.80±1.34 kg/m$^2$, respectively, in the current study. These two groups had no significant statistical difference between them. Boys and girls aged 10 to 11 had mean body mass indices of 13.92±1.51 kg/m$^2$ and 14.65±2.26 kg/m$^2$, respectively. Statistics showed that this difference was not significant. Boys and girls between the ages of 11 and 12 had mean BMIs of 14.29±1.28 kg/m$^2$ and 15.57±2.42 kg/m$^2$, respectively. BMI values were higher in girls than boys and increased as the age of the participants increased. The BMI values for different age categories in the present study were smaller than similar studies conducted in Bangladesh and India.[23,24] Observed results were found to be similar in a study conducted among vegetarian and non-vegetarian Nepalese children.[25] According to World Health Organization's (WHO) growth reference for 5-19 years, the present study populations, the students are found to be underweight.

Boys and girls aged 9 to 10 showed calculated mean body surface areas (BSAs) of 0.99±0.05 m² and 0.97±0.08 m², respectively, with no discernible correlation between the two groups. In the 10–11 age group, boys had mean BSAs of 1.02±0.08 m², while girls exhibited a slightly higher value of 1.10±0.12 m². This variation was statistically noteworthy. 1.07±0.08 m$^2$ and 1.17±0.11 m$^2$ was mean BSAs respectively of boys and girls between the ages of 11 and 12. Additionally, this distinction was statistically significant.

## Limitations

The present study has certain limitations. Firstly, no information was collected on parental education, lifestyle-related variables. Hence, it was not possible to explore the dietary habits or physical activity behavior of children. Secondly, data were collected from students of four schools in the Dhaka district. Hence, the present results might not be generalizable to all school children in Bangladesh. The study was performed based upon earlier 4 published reports.[26-29]

## Recommendation

It could be beneficial to conduct more research with a larger sample size and a proportionate number of samples from various categorical variables to comprehend the children's nutritional status and its predictive factors. Studies with different categories like industrial workers, job holders, day laborers, and sportsmen are recommended. Recording the medical history of children and families can help us know the roots of the problems.

## Conclusion

Analyses of body composition and anthropometric measurements indicated that children's nutritional status was below the standard requirement. This study represents a summary of 4 published papers only because we intended to publish summarized zest or extracts from each of those morphometric studies to show in one place or study. This will assist our postgraduate or graduate students not only doctors but also for nutritionists. Findings of this study remains more prudent method or technique to yield better findings which remains more valuable in terms of digging out integrated anthropometric values yet being more useful and valuable an approach to show children's nutritional status & /or morphometric assessments.

## References


1. Dezenberg, CV. et. al, Predicting body composition from anthropometry in preadolescent children. International Journal of Obesity, 1999; 23: 253-259.
2. Bhattacharya A, Pal B, Mukherjee S, Roy SK. Assessment of nutritional status using anthropometric variables by multivariate analysis. BMC Public Health. 2019;19:1-9.
3. Misra A, Pandey RM, Rama Devi J, Sharma R, Vikram NK, Khanna N. High prevalence of diabetes, obesity and dyslipidaemia in urban slum population in northern India. Int J Obes. 2001;25:1722-9.
4. Anthropometry procedures manual.: https:// www.cdc.gov/ nchs/data/ nhanes/ nhanes_03_04 / BM .pdf, Accessed on 20 November 2021.
5. Norgan NG. Body mass index and nutritional status: the effect of adjusting body mass index for the relative sitting height on estimates of the prevalence of chronic energy deficiency, overweight and obesity. Asia Pac J Clin Nutr. 2014;4(1):137-145.
6. Norgan NG. Population differences in body 4-5 composition in relation to the body mass index. Eur J Clin Nutr 1994;48(3):S10-25.
7. Woodruff BA, Duffield A. Anthropometric assessment of nutritional status in adolescent populations in humanitarian emergencies. Eur J Clin Nutr. 2002;56: 1108-18.
8. Nishida C, Barba C, Cavalli-Sforza T. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363:157-63.
9. Reilly JJ, Wilson J, Durnin JVGA. Determination of body composition from skinfold thickness:a/validation study. Archives of Diseases in Childhood, 1995; 73: 305-10.
10. Widiyani T, Suryobroto B, Budiarti S, Hartana A. The growth of body size and somatotype of Javanese children age 4 to 20 years. Hayat Journal of Biosciences, 2011; 18(4): 182-92.
11. Bhasin MK, Jain S. Biology of the tribal groups of Rajasthan, India. 2. Physical growth and anthropometric somatotypes. Anthropologist, 2007; 9(3): 177-87
12. Wickramasinghe, VP, Lamabadusuriya S.P. Cleghorn, G.J. and Davies, PS.W. Assesment of body composition in S Lankan children: va Tation of a skinfold thickness equation. Ceylon Medical Journal, 2008; 53(3): 82-88.
13. Gaurav V., Singh and Singh, S. Anthropometric characteristics, on itotyping and body composition of volleyball and beatball players. Journal of Physical Education and Spots Management, December, 2010; 1(3): 28-32.
14. Rahmawati NT (Somatotypes of Javanese soccer and volleyball players in Yogyakarta. Berkala Limu Kedokteran. 2003; 35(3): 157-64.
15. Raudsepp L, Jurimae T. Somatotype and physical fitness of prepubertal children. Collegium Antropologicu. 1996; 20(1): 53-59.
16. Weiner, J.S. and Lourie, J.A., Eds, Age changes in the anthropometric and body composition characteristics of the Bishnupriya Manipuris of Cachar district, Assam Practical human biology. Academic Press, London. (1981).
17. Carter, J. Prevailing Somatotypes and Their Contribution Rate to the Coordination Abilities among the Students of the Physical Education College The Heath-Carter Anthropometric Somatotype-Instruction Manual. Surrey TeP and ROSSCRAFT. (2002).
18. Kumaravel V, Shriraam V, Anitharani M, Mahadevan S, Balamurugan AN, Sathiyasekaran B. Are the current Indian growth charts really representative? Analysis of anthropometric assessment of school children in a South Indian district. Indian J Endocr Metab 2014;18:56-62.
19. Kamruzzaman M, Rahman SA, Akter S, Shushmita H, Ali MY, Billah MA, Kamal MS, Elahi MT, Paul DK. The anthropometric assessment of body composition and nutritional status in children aged 2-15 years: A cross-sectional study from three districts in Bangladesh. PLoS One. 2021 Sep 9;16(9):e0257055. doi: 10.1371/journal.pone.0257055. PMID: 34499671; PMCID: PMC8428712.
20. Addo OY, Himes JH. Reference curves for triceps and subscapular skinfold thicknesses in US children and adolescents. Am J Clin Nutr. 2010 Mar;91(3):635-642. doi: 10.3945/ajcn.2009.28385. Epub 2010 Jan 6. PMID: 20053877.

21. Mukhopadhyay A, Bhadra M, Bose K. Regional adiposity, body composition and central body fat distribution of 10-16 years old Bengalee boys of Nimta, North 24 Parganas, West Bengal, India. Coll Antropol. 2005 Dec;29(2):487-92.

22. Sen J, Mondal N. Fat mass and fat-free mass as indicators of body composition among Bengalee Muslim children. Ann Hum Biol. 2013 May;40(3): 286-93. doi: 10.3109/03014460.2013.764014. Epub 2013 Feb 11. PMID: 23398370.

23. Anam MR, Akter S, Hossain F. Association of sleep duration and sleep quality with overweight/obesity among adolescents of Bangladesh: a multilevel analysis. BMC Public Health. 2022;22:1-9

24. Salvi S, Kumar A, Puri H. Association between air pollution, body mass index, respiratory symptoms, and asthma among adolescent school children living in Delhi, India. Lung India. 2021;38:408

25. Acharya U, Nakanishi J. Body mass index (BMI) of vegetarian and non-vegetarian children in Nepal. J Heal Promot. 2021;9:55-64.

26. Rahman S, Ara S, Begum M, S, Akhtar M B Skinfold thickness of government primary school children in Dhaka city. Bangladesh Journal of Anatomy, January 2015;13.2:41-45

27. Rahman S, Ara S, Khan MA, Akter M B Arm girth and calf girth of government primary school children in Dhaka city. Bangladesh Journal of Anatomy, January 2018;15.1:5-8

28. Rahman S, Ara S, Khan MA, Ahmed A, Rahman S, Akter R Assessment of body composition of government primary school children in Dhaka city. The Journal of Ad-din Women's Medical College, Jan 2016;4.1: 13-15.

29. Rahman S, Khan MA, Anam MR, Nahar Y, Ara S. Anthropometric measures in Bangladeshi school children to determine body composition and nutritional status: a descriptive cross-sectional study. Int J Community Med Public Health 2023;10: 57-62.