RESEARCH PAPER

Evaluation of Triceps Skin fold thickness as an indicator of Nutritional Status Among BMI classifications

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Abstract:

Purpose: Altered nutritional status such as Malnutrition, overweight and obesity has significant health risks. Body Mass Index (BMI) is a commonly used screening tool for nutritional status, while triceps skinfold thickness (TSFT) is an important measure of subcutaneous fat and body composition.

Aims & Objectives: To evaluate the Triceps skin fold thickness in underweight, normal and overweight among adoloscents.

Methodology: This cross-sectional study was carried out among adoloscents males and females to assess BMI and TSFT in underweight, normal, overweight and obese individuals aged 18–25 years. Anthropometric measurements, including height, weight, and TSFT, were recorded using standard protocols. Subjects were recruited based on inclusion and exclusion criteria.Participants were classified according to World Health Organization (WHO) BMI criteria, and TSFT was compared between groups.

Findings: Mean TSFT was significantly lower in underweight subjects, reflecting reduced fat stores, while obese participants exhibited substantially higher TSFT, indicating increased subcutaneous adiposity. All the variables were found to be statistically significant. BMI showed a strong positive correlation with TSFT ($P < 0.01$).Variations in TSFT provided more nuanced insights into body fat distribution that BMI alone could not capture.

Originality: Triceps Skin Fold Thickness (TSFT) offers valuable additional information on fat reserves. Combining BMI with TSFT measurements may improve the accuracy of nutritional assessments and effective interventions for under- and over-nutrition.

Keywords: Body Mass Index, Body fat content, Triceps Skinfold thickness, Nutrition, Adoloscents.

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Background:

Body Mass Index (BMI) is also known as the Quetelet Index {BMI = weight (kg)/[height (m)]^2}, is considered the preferred method for evaluating health status over other indices like the Ponderal and Broca indices due to its strong correlation with body fat percentage (Bray G.,1983). BMI helps to categorize the individuals into various groups that includes underweight, normal weight, overweight, obesity class I and II, and extreme or class III obesity (Bray G, 1998). It is the most commonly used tool for assessing body weight across large populations and widely employed in clinical settings to identify obesity (Burton W, 1998). Additionally, measuring the thickness of skinfolds is another widely accepted technique for determining the body fat. BMI and skinfold measurements are used frequently for assessing overweight and obesity. Some of the techniques are used to assess anthropometric parameters in obesity, including Body Mass Index (BMI), waist circumference, waist-to-hip ratio, waist-to-height ratio, skinfold thickness, and body fat percentage estimated through bioelectrical impedance analysis or DEXA.It provides critical tools for diagnosing and tracking obesity for guiding clinical decision and public health intervention. Triceps skin fold thickness is one of the most common method employed to assess obesity especially in clinical, nutritional and fitness assessment. It reflects the amount of subcutaneous fat that correlates with total body fat (Must A, 1991).It is reliable, very economic, suitable for field survey and easy to measure as it is noninvasive method (Colley JRT, 1974). Triceps skinfold thickness (TST) is used as a measure of body fat mass in children (Sarri A, 2001). Many studies have shown a strong correlation between fat mass and BMI (Sarri A, 1998).

Obesity is commonly prevalent in the Asian subcontinent, especially in South Asian countries (Wang, S.; 2015). Genetically, Asians are more prone to accumulate fat around the abdomen compared to other ethnic groups (Wang, S.; 2015). Economic development and urbanization have led to a shift from traditional nutritious diets to Western-style diets high in saturated fats, refined sugars, and preservatives. Additionally, high intake of white rice and low levels of physical activity were thought to contribute to abdominal fat accumulation in South Asians (Williams R., 2020; Das Gupta R, 2022). India, the most populous country in South Asia with 1.2 billion residents, is estimated to have around 350 million individuals affected by obesity (Ahirwar, R.; 2019). More recently, BMI has been suggested as the most appropriate indicator of body fat in children and adolescents, as it is both reliable (Bellizi MC, 1999). Triceps skinfold thickness shows a positive correlation with the arteriosclerosis index and systolic blood pressure, while it is negatively associated with high-density lipoprotein (HDL) cholesterol (Kanda A, 1997).

In individuals with underweight, triceps skinfold thickness is typically low, often below established reference values for age and sex. A triceps skinfold measurement of less than 5 mm is a strong indicator of low body fat stores and severe malnutrition (Ruth M. Ayling, 2014). The current study was conducted to assess BMI, skinfold thickness and body fat percentage in underweight and obese adoloscents and to compare these measurements with non-obese peers.

Methods:

The prospective cross sectional study was performed in 200 subjects among both males and females in the age group of 18 - 25 years. Written consent from each study participants was obtained for carrying out the study after explaining to them the protocol of the study and the benefits of the study. This study was approved by the institutional ethical committee The detailed medical history of the participants were collected using questionnaire that includes name, age, occupation , H/O of co-existing disease and personal habits like H/O of smoking , alcohol and anthropometric measurements (Height and Weight) . The subjects were selected based on inclusion and exclusion criteria. Healthy subjects were included in this study whereas subjects with history of chronic illness, diabetes, hypertensive, neuromuscular disease and neurological disorder were excluded from this study.

The triceps skin fold thickness was measured by skinfold caliper over the triceps muscle at a point midway between the lateral projection of the acromion process of scapula and the inferior margin of the olecranon process of ulnar. The body weight (Wt) was recorded bare footed to the nearest 0.1 kg. The height was measured using meter scale without footwear to the nearest 0.1 cm. BMI was calculated by Quetelet's index: Weight (kg) divided by the square of Height (m2). According to the Method of Deurenberg P et al, Fat mass and free fat mass was estimated using the formula (Deurenberg P, 1991).

Men: (1.20 x BMI) + (0.23 x Age) – 16.2,

Women: (1.20 x BMI) + (0.23 x Age) – 5.4.

According to Kenneth J. Ellis et al 2001

Fat Mass (kg) = Body Weight (kg) * (Body Fat Percentage / 100)

Fat-Free Mass (kg) = Body Weight (kg) - Fat Mass (kg)

The Datas were expressed as mean ± S.D. ANOVA test was conducted to compare the triceps skin fold thickness among normal, underweight, obese and overweight.

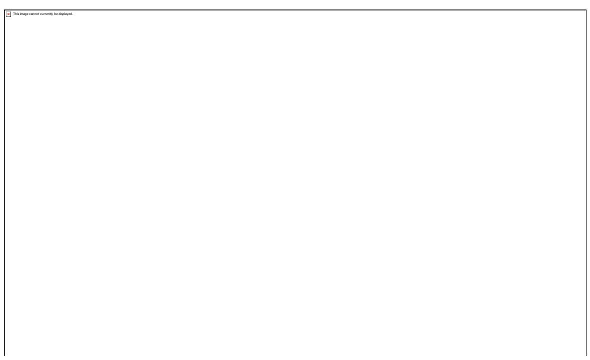
Results:

Table 1: **Descriptive characteristics of the study population**

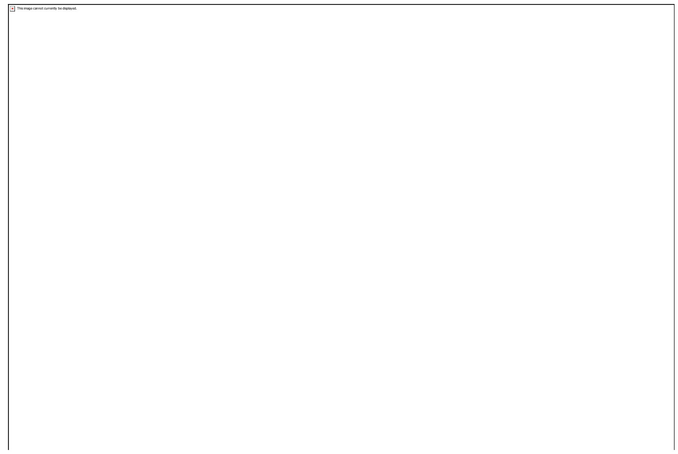
Parameters	Normal (18-25)		Under weight (<18)		Overweight (25-30)		Obese (> 30)		P value
	Male	Female	Male	Fem	Male	Female	Male	Female	

				ale					
Height(CM)	167.17±8.8	156.68±7.3	167.9±8.4	155.7±6.7	168.85±8.5	155.82±9.3	165.19±8.6	154.9±4.1	<0.05
Weight(KG)	59.62±8.2	52.4±7.9	67.9±16.7	60.6±17.1	77.7±8.3	66.3±8.4	89.17±7.8	82.50±7.04	<0.05
BMI(Kg/m2)	22.11±3.16	21.59±2.25	24.2±6.05	24.9±6.89	27.5±3.44	25.93±2.8	30.88±4.07	30.08±4.97	<0.05

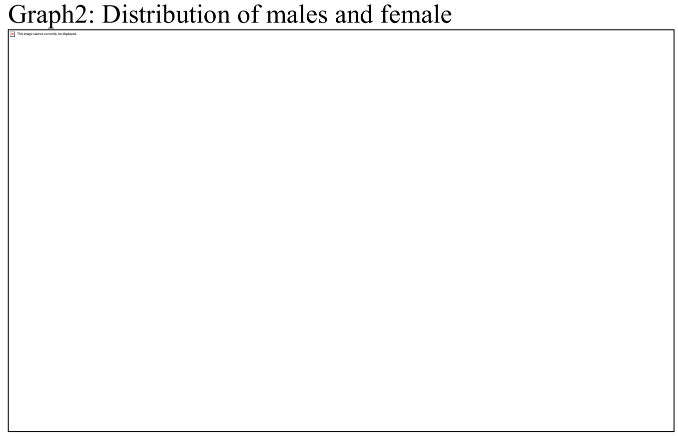
Values indicate Mean ± SD, *P<0.05, **P<0.01, ***P<0.001



Graph 1- Distribution of underweight, normal and obese subjects among males subjects.



Graph2: Distribution of males and female



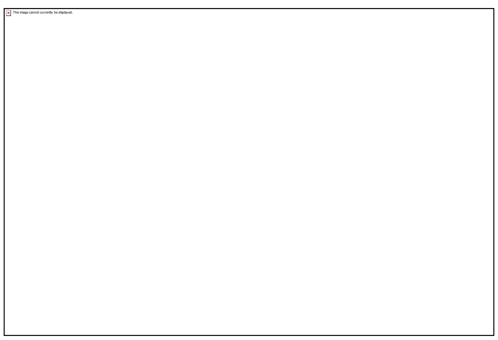
Graph 3- Distribution of underweight normal and obese subjects among Females subjects

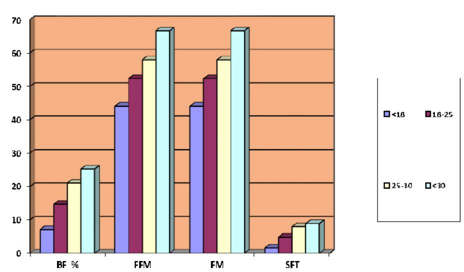
Table 2: comparison of skin fold thickness and distribution of fat among Underweight, Normal, overweight and Obese subjects.

Parameters	**Normal (18-25)**		**Underweight (<18)**		**Overweight (25-30)**		**Obese (> 30)**		**P value**
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	
Body fat %	14.66±3.87	24.91±2.9	7.08±1.89	17.66±3.04	21±4.1	30.15±3.34	25.22±4.84	34.8±6.72	<0.05
Free fat mass	52.3±6.5	38.99±4.03	44.06±8.79	33.77±3.64	57.9±5.9	45.19±5.53	66.68±4.2	49.8±1.9	<0.01

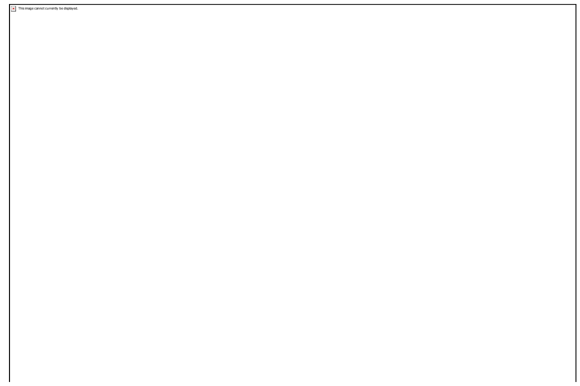
Fat Mass	52.3±6.5	13.14±3.09	44.06±8.8	7.29±1.7	57.9±5.9	19.69±4.07	66.68±4.2	33.7±4.96	<0.01
Skin Fold Thickness (MM)	**4.79±1.69**	**5.23±1.86**	1.56±0.37	1.56±0.47	7.95±2.2	6.8±1.3	8.88±0.98	8.7±0.98	<0.01

Values indicate Mean ± SD, *P<0.05, **P<0.01, ***P<0.001





Graph 4-Skin fold thickness and distribution of fat among Underweight Normal overweight and Obese in male subjects



Graph 5- Skin fold thickness and distribution of fat among Underweight Normal overweight and Obese in Female subjects

The data was expressed as mean ± SD and ANOVA were performed for all the variables. Datas were analysed using SPSS version 19.Gender distribution of study participants were found to be equally distributed (50.25% in males and 49.75% in female subjects). Mean and standard error mean of height, weight and BMI is given in table 1. Height and weight of the study participants shows significant statistically among underweight, normal, overweight and obese (P<0.05).Also observed significant difference among males and females. Males were found to be higher than females. Among males 46.5% were overweight,24 % as underweight and 29.5% fall within the normal BMI range which was statistically significant (P<0.05).In case of female participants 42.57% were found to be overweight,20.79% as underweight and 36.63% as normal which was found to be statistically significant (P<0.05). The Distribution of underweight, normal and obese subjects among study participants is shown in fig 1 & 2. Body fat %, were found to be higher in female population than males among all the three groups which was found to be statistically significant (P<0.05) (Table 2).The distribution of body fat % were less in underweight (M= 7.08±1.89 & F= 17.66±3.04) while more in overweight (M=21±4.1 & F=30.15±3.34) and obese (M=25.22±4.84 & F=34.8±6.72) than the normal group (M=14.66±3.87&F=24.91±2.9). Predominantly Free fat mass were found to be more in males when compared to females which was statistically significant (P<0.01) (Table 2).It is graphically represented in fig 3 & 4. Free fat mass were found to be decreased in underweight (M=44.06±8.79&F=33.77±3.64) and increased in overweight (M=57.9±5.9&F=45.19±5.53) and obese (M=66.68±4.2&F=49.8±1.9) compared to normal group (M=52.3±6.5&F=38.99±4.03).Similar results were observed in Fat mass which was statistically significant (P<0.01).Triceps skin fold thickness does not show much difference among males and females among all the groups comprehensively. Skin fold thickness were found to be reduced in underweight group (M=1.56±0.37&F=1.56±0.47) and increased in overweight (M=7.95±2.2 &F=6.8±1.3) and obese (M=8.88±0.98 & F=8.7±0.98) when compared to normal group (M=4.79±1.69&F=5.23±1.86) which was statistically significant ($P<0.01$).All the variables were found to be statistically significant and positively correlated.

Discussion:

Nutritional status during adolescent age is a major concern of nutritional and health status in adult life. Globally, including India, health hazards associated with undernutrition and micronutrient deficiencies remain major public health problems. The past three decades have witnessed the emergence of over nutrition as a problem in adolescent children in developed countries and in affluent urban segments in developing countries. Overweight adolescent children are at higher risk of becoming over nourished adults and thereby incurring a higher risk of developing non-communicable diseases. Studies also suggest that during nutrition transition, under nutrition in childhood and adolescence may increase the risk of over nutrition, diabetes and hypertension in adult life, thereby resulting in “dual nutrition burden”. In India, undernutrition and obesity present a dual burden, with both conditions occurring simultaneously that exist across demographic groups. Although underweight persists as a significant issue, especially in rural populations and specific age categories, obesity is steadily increasing, particularly in urban areas among children and women. According to Smitha Asthana, overall prevalence of underweight among Indian women decreased to 22.9%, while rates of overweight (15.5%) and obesity (5.1%) increased. Among illiterate women, underweight declined by 17.1%, whereas overweight increased by 7.3% and obesity by 2.3%. Urban areas had a greater obesity burden (9.1%) than rural areas (3.1%), with little change over time (ranging from 4.8% to 6%). In contrast, underweight was more common in rural areas (26.7%), despite an evident 13.8% decrease. The Central (25.3%–28.3%) and Eastern (21.3%–31.5%) regions of India and their states/UTs had notably higher rates of underweight (Smita Asthana, 2019).

Balanced diet is essential during adolescence to support the physical growth and development that occurs in the later stage of life. A well-balanced diet rich in calories, protein, calcium, iron, and other key nutrients is essential. Adolescent girls are especially at risk of developing malnutrition and obesity because of their heightened nutritional requirements during growth spurts and menstruation. Lack of physical activity and imbalanced diet could leads to abnormal alteration in body fat mass.According to WHO, Adolescent is a period where they require increased nutrition for the development and growth (WHO, 1995). However relative weight is a simple to measure, it represents not only fat but also bone and muscle mass (Garn SM, 1986). Body mass index (BMI) shows a moderate association with height during growth (Flegal KM, 1990). In comparison, skinfold thickness provides a direct effect of body fat. Due to the complex relationships between energy intake, growth, and fat accumulation, discrepancies between being overweight and having excess body fat are more common in children than in adults. Griffiths et al. (1985) reported that less than half of the boys with a weight-for-height above the 90th percentile also had triceps skinfold thickness greater than the 75th percentile. Similarly, Bahaa Abalkhail (2002) found elevated BMI and TSF values in both males and females, aligning with the findings of the present study. Furthermore, BMI was significantly higher among overweight and obese individuals compared to those who were not obese ($P < 0.01$), consistent with the results reported by Satipati Chatterjee et al. (2006).

Watanabe K et al. reported that triceps skinfold thickness was significantly greater in obese individuals, and the percentage of body fat was markedly higher among obese and overweight participants compared to their non-obese counterparts. These findings are consistent with the results of the present study (Watanabe K, 1994). Skinfold measurements, especially triceps skinfold thickness, have been widely studied in both Indian and international child populations, with findings that align closely with those of the present study (Chatterjee P, 2002).

Fat mass denotes the body's total fat content, whereas fat-free mass comprises of muscles, bones, water, and internal organs. In essence, fat mass serves as the body's energy reserve, while fat-free mass comprises the functional and structural elements of the body. Accumulation of adipose tissue mass or fat mass for a given body weight determines the obesity or underweight. During periods of negative energy balance, both fat mass and fat-free mass (FFM) are reduced. The ratio of fat to FFM loss is influenced by various factors such as the size of the calorie deficit, the diet’s macronutrient composition and the initial levels of fat and FFM before weight loss begins (Hall KD., 2007). Research suggests that underweight individuals tend to lose a higher proportion of FFM compared to those with obesity (Forbes, GB., 1987). In this present study, Free fat mass (FFM) were found to be reduced in underweight individuals when compared to subjects with normal BMI where the same observation was given by Anura V Kurpad et al (Anura V Kurpad et al,2003).BMI and Skin fold thickness is an appropriate tool measure the body fat mass for pre evaluation. Hence, our findings suggest that BMI-for-age is a useful screening tool for identifying children and adolescents who may require further assessment and monitoring. However, BMI-for-age should not be viewed as a definitive measure of body fatness, especially in cases where BMI-for-age falls between the 85th and 94th percentiles. While about 70% of adoloscents within this BMI range had body fat levels that matched or exceeded what their BMI-for-age would indicate, 30% had body fat comparable to that of adoloscents with normal weight.

Conclusion:

BMI and Skin Fold Thickness were found to be significantly altered in underweight and obesity when compared to individual with normal BMI.Altered nutrition status is known to affect several physiological functions of the body. Both obesity and underweight leads to various health problems. Obesity primarily raises the burden of chronic non-communicable diseases while underweight leads to malnutrition, infections, and developmental impairments. Targeted public health and clinical strategies are needed to address both ends of the nutritional spectrum to prevent the risk of non-communicable diseases. BMI and triceps skin fold thickness provides simple, cost effective and noninvasive technique to assess the body fat percentage. Future research work on body fat (adiposity) is required using modern techniques rather than relying only on BMI cut-off points to define obesity.

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Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Consent for publication

Informed consent for the study publication was provided by all participants upon recruitment.

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