Subcutaneous Adiposity and Nutritional Status Among Children of Eastern-India

Debnath S[1], Mondal N[2], Sen J[3]

Abstract

Introduction: Skinfold thickness is now considered to be an important indicator of body composition and nutritional status. Assessment of subcutaneous adiposity is becoming very important due to increasing trend of overweight and obesity. The objectives of the present study were to determine age-sex specific subcutaneous adiposity using skinfold thicknesses and its use in assessment of nutritional status among children of Eastern-India. **Material and Methods:** The investigation was carried out among 1262 children (619 boys; 643 girls) aged 5–12 years of Darjeeling district, West Bengal. Anthropometric measurements of skinfold thickness were recorded using standard procedures. Age-sex specific smooth percentile curves of skinfold thickness were derived using the L, M and S model. **Results:** Sexual dimorphism was observed in TSF, SSF, SISF, PBF, ∑2SKF and ∑4SKF measurements between sexes in children ($p<0.05$). Age-sex specific mean values of skinfold thicknesses of TSF, SSF, SISF and PBF of girls were observed to be significantly higher than boys ($p<0.05$). The age-sex specific mean values of BSF, TSF, SSF, SISF, ∑4SKF and PBF did not show any age-specific trend in children. Comparison with the NHANES-III data showed poor attainment of subcutaneous adiposity and nutritional status. **Conclusion:** Results of the present study showed the age-sex specific variations in subcutaneous adiposity pattern in children. The comparisons of skinfold thicknesses with references showed unsatisfactory nutritional status among children. These findings are important for future investigations in field, epidemiological and clinical settings.

Key words: Anthropometry, Body Composition, Nutritional Assessment, Skinfold thickness, Sexual Dimorphism, Subcutaneous Adiposity

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Introduction

Anthropometric measures are still considered to be reliable, non-invasive, and inexpensive and widely used technique to assess physical growth and nutritional status. The measures mostly comprise of height, weight and skinfold thickness measurements[1]. Body mass index (BMI, kg/m^2) is also widely used as an index of body fatness and is a measure of weight relative to height rather than of adiposity. It is used as a global proxy of nutritional status and highly correlated with different components of weight (e.g., lean mass or fat free mass, fat mass, skeletal muscle mass and bone mass), however, it is unable to provide differentiation between them[2]. The increase in BMI levels during puberty seems to be largely the result of increase in fat-free mass (e.g., muscle mass) rather than body fatness (e.g., adiposity) which further complicates the interpretation of physical growth among children and adolescents[3,4,5,6,7]. Variations in relative distribution of adipose tissue in the human body is an important area of research and it can be related with several preventable non-communicable diseases (e.g. cardiovascular diseases, metabolic disorders and gastrointestinal abnormalities, hyperlipidaemia, sleep apnoea, hepatic steatosis, polycystic ovary disease, and glucose intolerance)[2,6]. The distribution of adipose tissue is also associated with physical growth and maturation[8,9,10,11]. Epidemiologic evidence supports the theory that relation between excess adiposity (e.g., obesity) and relative risk of disease burden begins early in life[8,11]. Accumulation of higher adiposity levels tend to advance bone ages and early physical growth attainment and maturation in children[12,13].

Skinfold measurements of subcutaneous adiposity have a long history in human nutrition and body composition assessment related research[9,14] and have been widely used to determine the population specific body composition and relative subcutaneous adiposity distribution[3,15,16]. Amount of subcutaneous body adiposity is very specific to adipose tissue and can be determined using non-invasive techniques (e.g., anthropometry)[1,3,5]. Therefore, skinfold thickness is an important, useful and valid anthropometric measure of regional and total body adiposity in clinical or epidemiological research settings[1,11,15,16,17]. Skinfold thickness has been used extensively for estimating the changes in subcutaneous adiposity and body composition, and observed to be very useful technique due to its easy-to-use and non-invasive nature in research studies[3,9,14,15,18,19]. Adipose tissue accumulation is mostly dependent on nutritional status, age-sex specific and ethnic variation, and skinfold thicknesses are widely used as a practical tool for assessment of nutritional status in field, epidemiological or clinical settings[2,3,5,8,17]. Several researchers have reported age-sex variations in subcutaneous adiposity pattern, nutritional status and body composition using skinfold thicknesses among children[3,9,17,19,20]. The objectives of the present study were to determine the age-sex specific subcutaneous adiposity and assessment of nutritional status using skinfold thickness among rural children of Eastern-India.

Material and Methods

The present cross-sectional investigation was carried out among 1262 school-going children (boys: 619; girls: 643) aged 5-12 years residing in rural areas of Phansidewa Block, Darjeeling district, West Bengal, India. This community block (Latitude 26º 34´59´´ N, Longitude 88º 22´00´´ E) is situated near the Indo-Bangladesh border region and ~35– 40 km from the sub-divisional town of Siliguri and covers an area of 308.65 km^2. The community block has availability of all the basic amenities, such as hospitals, schools, markets, post office and government offices[3].The minimum number of participants required for the present investigation was estimated following the standard sample size estimation method[21]. In this method, the expected population proportion of 50%, absolute precision of 3% (≤5%; i.e., the lower margin of error) and confidence interval of 95% were taken into consideration. The minimum number of sample size estimated for the present investigation was 1068 individuals. Finally, 1262 children (619 boys; 643 girls) aged 5–12 years were selected to take part in the investigation. The socio-economic data on age, sex, parents' occupation and nature of occupation, parents' education, monthly family income, family size, family types, house-conditions, electricity facility, and drinking water and toilet facilities were collected using a structured schedule. A modified version Kuppuswamy's socio-economic scale was used to evaluate the socio-economic status (SES) of the children[22]. The determination of SES showed that all the children belonged to lower-middle SES. The data of the present investigation was collected during the period from September 2014 to November 2015.

Anthropometric measurements recorded: Anthropometric measurements were recorded using standard anthropometric procedures[1]. The skinfold measurements of biceps (BSF), triceps (TSF), sub-scapular (SSF) and supra-iliac (SISF) were measured using a Holtain skinfold calliper (London University Institute of Child Health, UK) on the left side of each child to the nearest to 0.2 mm. For calculating intra-observer and inter-observer technical errors of the measurements (TEM)[23], BSF, TSF, SSF and SISF were recorded from different data set of 50 children other than those selected for the investigation by SD and JS. Very high values of coefficient of reliability (R >0.975) were obtained for BSF, TSF, SSF and SISF and these values were observed to be within the recommended cut-off of 0.95[23]. Hence, the measurements recorded by SD and JS were considered to be reliable and reproducible. All the measurements in course of the present investigation were recorded by SD. The sum of two skinfolds (∑2SKF) and sum of four skinfolds (∑4SKF) were calculated using the following standard equations:

∑2SKF (mm)= TSF+SSF

∑4SKF (mm)= BSF+TSF+SSF+SISF

The body density (D) was calculated for the evaluation of peripheral adiposity or percent of body fat (PBF) using the standard equations of Deurenberg et al.[24]:

D_{Boys}= 1.1133−0.0561(log ∑4SKF) + 1.7(age*10^{-3})

D_{Girls}= 1.1187−0.0630 (log ∑4SKF) + 1.9(age*10^{-3})

The assessment of peripheral adiposity or PBF of the children was calculated using the standard equation of Westrate and Deurenberg[25]:

PBF=[562−4.2(age−2)]/D− [525−4.7(age−2)]

The data were statistically analysed using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, IL; version 17.0). Descriptive statistical analysis of the data obtained was depicted in terms of mean and standard deviation (±SD). One-way analysis of variance (ANOVA) was performed to assess age-specific mean differences in anthropometric variables of the groups using Scheffe procedure. Independent sample t-test was done to assess sex-specific mean differences in anthropometric variables. The LMS model was utilized to convert the measurements for children of known age-sex to evaluate the centiles[26,27]. The LMS Chart Maker software program (The Institute of Child Health, London) was used to obtain the smooth centile curves. The method summarizes percentiles at each age based on the power of age-specific Box-Cox power transformations used to normalize data. The centile curves (3^{rd}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 97^{th}) were derived as reference data for further evaluation of body composition. A p-value of <0.05 was considered to be statistically significant.

Results

Age and sex-specific subject distribution, means and standard deviations of BSF, TSF, SSF, SISF, ∑2SKF and ∑4SKF among the boys and girls are depicted in Table 1. Age-specific mean skinfold value was observed to be slightly higher among girls than boys, especially in TSF and SSF in older age groups (e.g. 10-12 years). Age-specific mean BSF and SISF were observed to be higher in younger age groups (e.g., 5-8 years). The mean values of ∑4SKF were observed to be higher among boys than girls of younger age groups (e.g. 5-8 years) and higher among girls than boys in older age groups (9-12 years). The age-specific PBF ranged from 13.24% (in 11 years) to 15.29% (in 5 years) (in boys) and 14.91% (in 8 years) to 17.22% (in 10 years) (in girls). The age-specific mean differences were observed to be statistically significant using ANOVA for all the variables of boys and girls (p<0.05) except in case of boys in TSF, SSF, ∑2SKF and ∑4SKF (p>0.05). The results of the independent sample t-test showed statistically significant (p<0.05) sex-specific differences in overall mean values of TSF (F-value= 48.81, d.f.,1,1261), SSF (F-value= 73.58, d.f.,1,1261), SISF (F-value= 32.15, d.f.,1,1261), PBF (F-value= 53.91, d.f.,1,1261), S2SKF (F-value = 65.46, d.f.,1,1261) and ∑4SKF (F-value= 28.06, d.f.,1,1261) (p<0.05). Age-specific LMS percentile curves of BSF, TSF, SSF and SISF for girls showed an ascending trend which is absent in boys. Sexual dimorphism appeared to be in TSF, SSF, SISF, PBF, ∑2SKF and ∑4SKF measurements between sexes (p<0.05). Age-sex specific percentile curves of BSF, TSF, SSF and SISF using LMS for assessment of nutritional status is depicted in Figure 1.

Assessment of nutritional status: The assessment of nutritional status was done by comparing the age and sex specific mean values of TSF, SSF and ∑TSF+SSF using the reference values of NHANES-III reference[28] (Figure 2). The comparison of the present investigation with reference population showed that the age-sex specific mean TSF values of the boys and girls were<25^{th} percentile which were below normal mean values of TSF. The mean SSF values were found to be <50^{th} percentile among boys and girls, respectively. The age-sex specific mean values of SISF of majority of boys and girls were <50^{th} percentile of the reference. The mean values of sum of ∑2SKF of boys and girls were <50^{th} percentile. Therefore, poor nutritional status of the children was observed with reference to the NHANES-III reference population[28]. Age-specific mean values were observed to be <50^{th} percentile (e.g., TSF, SSF, SISF and ∑2SKF) in age groups of 5-7 years in both sexes, but the mean values were observed to be almost on <25^{th} percentile values of reference in 10-11 years in TSF, SSF, SISF and ∑2SKF. Exceptions were observed in 12 years where TSF and SSF values of girls were in <25^{th} percentile, TSF and SSF values on 25^{th} percentile, SISF values were on 25^{th} percentile (in boys) and on 5^{th} percentile (in girls) and ∑2SKF values were on 25^{th} percentile for boys and in <25^{th} percentile in girls (Figure 2).

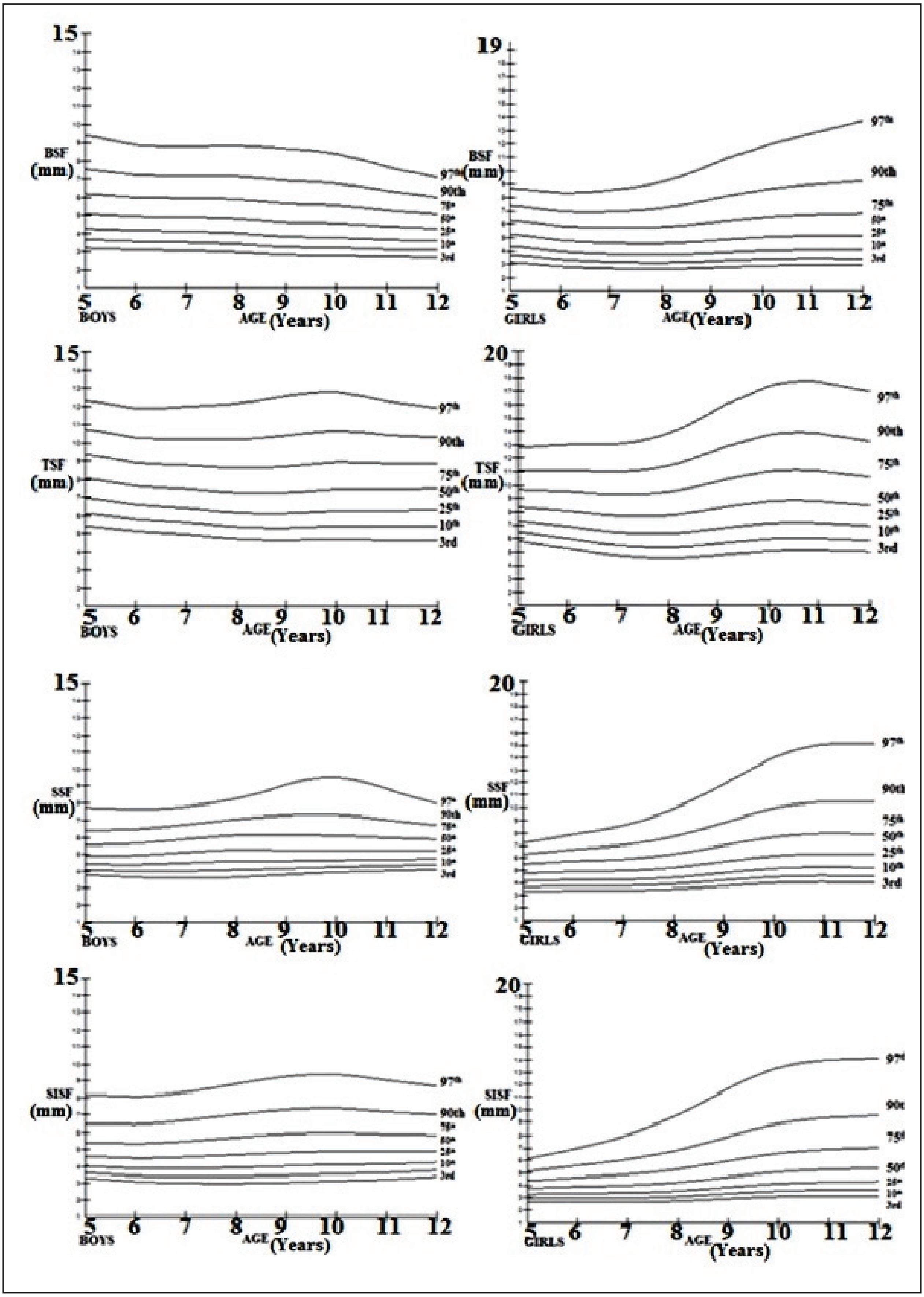

Fig. 1: Age-sex specific LMS graphs of BSF, TSF, SSF and SISF among the children

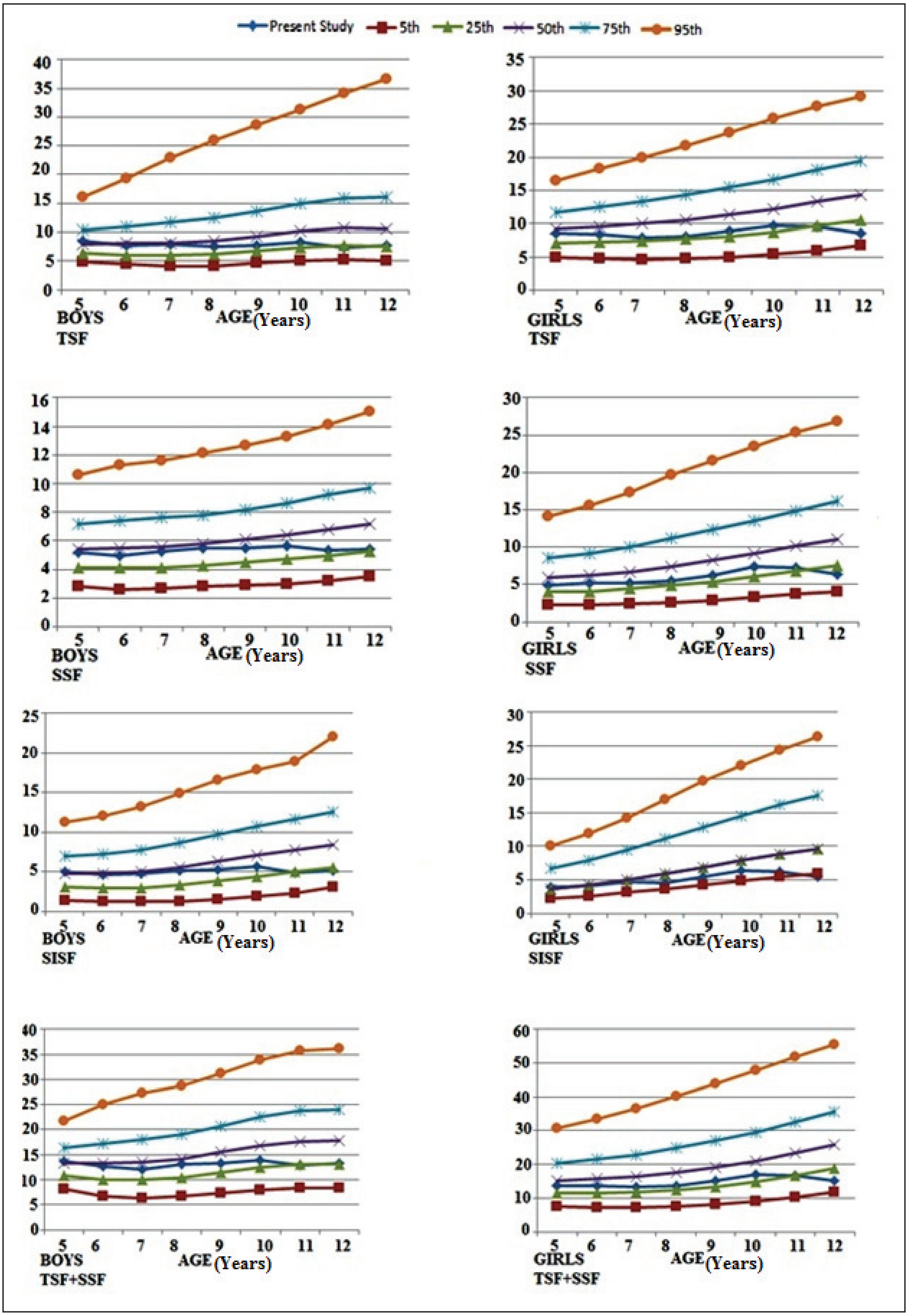

Fig. 2: Comparison of TSF, SSF and ∑TSF+SSF with NHANES-III reference[28] population among the children

Table 1: Age-sex specific mean and standard deviation of anthropometric variables among the children

Age Group	BSF (mm)		TSF (mm)		SSF (mm)		SISF (mm)		∑2SKF (mm)		∑4SKF (mm)		PBF	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
5 Years	7.36 ±1.74	5.54 ±1.58	8.46 ±2.22	8.59 ±1.90	5.23 ±1.83	4.89 ±1.07	5.07 ±2.00	3.93 ±1.00	13.69 ±3.76	13.53 ±2.69	26.12 ±16.37	22.98 ±4.41	15.29 ±4.10	15.89 ±2.63
6 years	5.03 ±1.21	4.88 ±1.30	7.67 ±1.51	8.47 ±2.07	5.00 ±0.95	5.21 ±1.26	4.69 ±1.19	4.07 ±1.00	12.67 ±2.13	13.68 ±3.08	22.39 ±3.90	22.63 ±4.50	13.98 ±2.06	15.41 ±2.61
7 years	5.17 ±1.41	4.97 ±1.56	7.85 ±1.75	7.98 ±2.19	5.29 ±1.02	5.16 ±1.41	4.82 ±1.32	4.67 ±3.33	12.13 ±2.40	13.22 ±3.42	23.13 ±4.45	22.80 ±5.97	14.19 ±2.25	15.10 ±3.25
8 years	5.20 ±1.46	4.85 ±1.62	7.53 ±2.00	8.00 ±2.30	5.50 ±1.40	5.52 ±1.72	5.11 ±1.66	4.50 ±1.51	13.02 ±3.07	13.57 ±3.74	23.33 ±5.39	22.86 ±5.84	14.07 ±2.68	14.91 ±3.20
9 years	4.98 ±2.30	5.48 ±2.54	7.73 ±2.89	8.88 ±3.21	5.52 ±1.90	6.29 ±2.36	5.26 ±2.10	5.41 ±2.76	13.25 ±4.32	15.21 ±5.31	23.48 ±8.18	26.06 ±9.16	13.85 ±3.18	16.17 ±4.01
10 years	5.09 ±1.45	5.54 ±2.30	8.27 ±2.44	9.75 ±3.59	5.65 ±1.25	7.38 ±3.83	5.66 ±2.04	6.34 ±3.95	13.92 ±3.27	17.13 ±7.10	24.67 ±6.04	29.01 ±11.48	14.47 ±2.76	17.22 ±4.40
11 years	4.45 ±1.23	5.95 ±2.77	7.42 ±1.75	9.56 ±3.52	5.38 ±1.15	7.27 ±3.24	4.92 ±1.16	6.17 ±2.82	12.80 ±2.62	16.80 ±6.53	22.17 ±4.57	28.94 ±10.18	13.24 ±2.31	17.06 ±4.16
12 years	4.44 ±1.08	5.82 ±2.97	7.78 ±1.81	8.55 ±2.13	5.43 ±0.95	6.41 ±2.08	5.19 ±1.37	5.53 ±2.15	13.21 ±2.42	15.03 ±3.80	22.85 ±4.12	26.31 ±7.11	13.57 ±2.00	15.91 ±3.11
Total	5.22 ±4.52	5.36 ±2.18	7.80 ±2.12	8.82 ±2.93	5.36 ±1.38	6.17 ±2.68	5.06 ±1.67	5.22 ±2.88	13.17 ±3.12	15.01 ±5.31	23.45 ±7.36	25.57 ±8.72	14.10 ±2.76	16.07 ±3.73
F-value*	2.36	2.90	1.83	4.88	1.73	12.49	2.39	9.12	1.19	8.29	1.92	9.66	2.81	5.08
p-value	0.02	0.00	0.08	0.00	0.09	0.00	0.02	0.00	0.31	0.00	0.06	0.00	0.007	0.00

*Age-specific mean differences, ± SD= standard deviations

Discussion

Human adiposity in body composition assessment is a resource for the energy cost required for growth, reproduction, immune function, heritability and hormonal secretions of adipose tissue which play a key regulatory role in these functions[2]. Population/ ethnic variations in adiposity and nutritional status can be attributed to several associated factors (e.g. sex, ethnicity, diet, physical exercise patterns, socio-economic status, environment and burden of infectious disease)[3,5,16,19,29,30,31,32,33,34]. Age-specific body adiposity increase has significant influence on the variation of subcutaneous adipose tissue[3,16,19,20,33,34,35]. However, the pronounced sex-specific difference was absent in the subcutaneous adipose tissue before puberty. Studies conducted among children of US[8,36], Netherlands[37] and Japan[38] showed insignificant sex-difference in abdominal and subcutaneous adipose tissue measured by skinfold thicknesses. Studies also showed that the attainment of puberty in girls tend to accumulate significantly higher adipose tissue than boys[3,16,19,29,35]. Several studies have reported sexual dimorphism in subcutaneous adiposity patter among children[3,9,16,19,18,33,35]. There were significant age-sex specific differences in subcutaneous adiposity pattern and PBF in children (Table 1). Several researchers have reported that the absolute skinfold thicknesses were higher in girls[3,16,18,19,29,35] but the demarcation in relative skinfold thickness were observed during puberty due to the increase in peripheral adipose tissue deposition in girls[5,9,29]. Such variation in subcutaneous adiposity can be attributed to sex-specific and genetic variations, sex-steroid hormones and environmental factors and it also serves as a good indicator of nutritional status of children[5,3,19,32].

Sexual dimorphism in adiposity levels primarily attributed to the action of sex steroid hormones[3,5]. Estrogen increases the fat storage, resulting in higher adipose tissue storage in females than in males. Moreover, the skinfold thicknesses directly measure subcutaneous adiposity and contributes to PBF[17,36]. Therefore, lower levels of adipose tissue gives rise to low levels of PBF or body composition indicating the poor nutritional conditions in children (Figure 2). However, several studies have provided the usefulness and validity of skinfold thickness in assessing body composition and nutritional status[10,16-20,29,35]. Population/ ethnic differences are observed in the accumulation of adipose tissue among children[8,10,33]. The results of the present investigation showed significantly higher adiposity among girls than boys (Table 1). The higher age-groups reaching puberty showed higher differences and higher values of skinfold thicknesses than the lower age groups. Comparison with NHANES-III reference population[28] showed very unsatisfactory nutritional status and also sex-specific differences in mean values were observed in children (Figure 2). Undernutrition is a major cause of concern in children and there is a scarcity of growth reference values for skinfold thickness (e.g. TSF, SSF, SISF and ∑TSF+SSF) except the reference values published by Frisancho[28] using NHANES-III data. This was why the results of the present investigation were compared to assess nutritional status and body composition. Several studies have reported that the children residing in rural areas were observed to be more vulnerable to unsatisfactory nutritional status than their urban counterparts where prevalence of overweight-obesity has become a cause of concern[3,30,32]. The lower adiposity levels among children could be the major indicator of undernutrition, which is actually being more frequent than overweight-obesity among Indian children[3,19,20,30,32]. The results of the present investigation will be useful for nutritionist, paediatrician and policy makers in their endeavour to formulate nutrition sensitive developmental and/or intervention strategies related to nutritional status and subcutaneous adiposity (i.e., body composition). Further studies should be conducted to formulate new ethnic specific standards and to identify the population specific undernutrition and body composition using skinfold among vulnerable segments of population.

Conclusion

Results of the present investigation showed the age-sex specific variations in subcutaneous adiposity pattern and subcutaneous adiposity was significantly greater among girls than boys. The comparisons of skinfold thicknesses with references showed unsatisfactory nutritional status among children. Hence, appropriate nutrition sensitive intervention programmes are necessary to ameliorate the nutritional situation. These findings are also important for future investigations in field, epidemiological and clinical settings.

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