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Physical growth patterns and body composition of Rajbanshi adolescent boys of Eastern India

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ABSTRACT

Background: *Poor nutrition status causes delay in process of growth and development by increasing susceptibility to infectious diseases and relative risk of mortality.* ***Aim:*** *The present cross-sectional study was undertaken to assess physical growth patterns and body composition among adolescents belonging to an indigenous ethnic population of West Bengal, India.* ***Subjects and methods:*** *The present study was conducted among 964 boys aged 10-18 years belonging to the indigenous Rajbanshi population of Darjeeling district, West Bengal, Eastern-India. A total of 19 anthropometric variables were used to evaluate physical growth and body composition. Anthropometric measurements were obtained using standard procedures. The statistical analyses include descriptive statistics, Kolmogorov-Smirnov test, ANOVA, percentile conversion and least mean square (LMS) model.* ***Results:*** *Several anthropometric variables (such as height, weight and BMI) have shown increases with age among the boys. The boys however, showed poor growth and body composition when compared with their NCHS/NHANES counterparts. Height, weight, TSF and BMI were below 50th percentile of the reference.* ***Conclusion:*** *These adolescent boys exhibit poor physical growth and body composition. In-depth studies are necessary for identifying the factors responsible for such retardations reflected in both growth and body composition variables.*

Keywords: Physical Growth, Body Composition, Anthropometry, Adolescents, Rajbanshi, India

INTRODUCTION

The scenario of nutritional status and health in many of the low-to-middle income countries including India has changed drastically during the past few decades. This change was primarily due to changes in dietary habits, socio-economic conditions and lifestyle habits. Extreme poverty is concentrated in rural areas while income growth has been dynamic in urban areas (Antony and Laxmaiah, 2008; Kapil and Sachdev, 2012; Ramachandran, 2013). Nutritional studies have highlighted that prevalence of under-nutrition still remains a major public health concern in India (Singh et al., 2006; Som et al., 2006; Antony and Laxmaiah, 2008; Kapil and Sachdev, 2012; Ramachandran, 2013; Bhutia, 2014). Recent studies have also identified a sizable proportion of children and adolescents residing in urban regions suffering from overweight-obesity (Chhatwal et al., 2004; Sidhu et al., 2006; Sharma et al., 2007; Panjikkaran and Kumari, 2009; Mondal et al., 2015). Hence, the populations are currently experiencing situation of both under- and over-nutrition; otherwise referred to as “double burden of malnutrition”. The anthropometric indices used to measure various aspects of growth and development are also frequently used to assess not only well-being of children and/or adolescents, but also that of the society to which they belong (Eveleth and Tanner, 1990; WHO, 1995). Most of the studies on nutritional status in the developing countries have concluded that growth differences between urban and rural populations primarily relate to improve the socio-economic status (Bogin, 1988; Dapi et al., 2007; Olivieri et al., 2008). The relationship between malnutrition and socio-economic status is also well established and the World Health Organization (WHO) has proposed growth retardation to be a measure of overall social deprivation (WHO, 1995).

Growth parameters are widely used in the assessment of health, nutrition and physical characteristic attainments of population. The period of adolescence is characterized as period of exceptionally rapid growth rate and maturation of human development (Tanner, 1978; WHO, 1995). Poor nutrition status has been observed to cause delay in growth and development, increase susceptibility to infectious disease, decrease cognitive functioning and increase relative risk of mortality among adolescents. However, this group has received less importance in terms of growth and nutritional assessment. Typically, the model of nutritional status used in developing countries include the determinants of socio-economic status, poverty, heavy workload, lesser access to food and health care facilities (Bogin, 1998; Dapi et al., 2007; Kapil and Sachdev, 2012; Ramachandran, 2013; Rengma et al., 2016). Moreover, due to rapid growth in stature, muscle mass and fat mass during the peak of adolescent growth spurt, the requirements for some nutrients is high and/or higher than any other age group (WHO, 1995).

India is composed of a number of indigenous populations and has an enormous amount of ethnic diversity (Beiteille, 1998; Majumder, 1998). The country has the largest number of indigenous people in the world and that include diverse tribal, non-tribal and caste populations. Little is known about the growth and nutritional status of such indigenous ethnic populations of the country. Studies have reported physical growth patterns and body composition among adolescents using various anthropometric measurements (Aggarwal et al., 1992, 2011; Chatterjee and Mandal, 1994; Begum and Choudhury, 1999; Rao et al., 2000; de Onis et al., 2001; Mitra et al., 2002; Khongsdier and Mukherjee, 2003; Singh and Mondal, 2014; Mamidi et al., 2016; Debnath et al., 2017). Low nutritional status and body composition have also been reported in some studies among Indian children and adolescents (Rao et al., 2000; Venkaiah et al., 2002; Mukhopadhyay et al., 2005; Deshmukh et al., 2006; Das et al., 2007; Medhi et al., 2007; Bisai and Bose, 2009; Mondal and Sen, 2010a,b; Singh and Mondal, 2014; Rengma et al., 2016; Debnath et al., 2017). It becomes necessary to examine changes of various physical dimensions especially in relation to age-specific growth spurt has a significance in assessment of adolescent growth.

Objectives of the present study were to assess physical growth patterns and body composition among adolescent boys belonging to one such population of Eastern India. The study aimed to estimate physical growth patterns and compare the same with the reference population of National Centre of Health Statistics (NCHS) and National Health and Nutrition Examination Survey (NHANES). The findings of the present study would be helpful to compare and develop growth references for future evaluation of physical growth and body composition among adolescents.

MATERIAL AND METHODS

The eastern region of India comprises of the eight sister states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura, Sikkim and a few districts of northern part of West Bengal. The region is considered to be one of the most ethnically and linguistically diverse regions of the country and consists of numerous heterogeneous, endogamous ethnic groups including tribes and castes, each having its own distinct social, linguistic and biological identity (Kumar et al., 2004). All these groups belong to the Mongoloid and Caucasoid groups and show certain degrees of variations in anthropometric measurements, genetic markers and dermatoglyphic traits (Das and Das, 1981; Roychoudhury, 1992; Bhasin and Walter, 2001; Sen et al., 2011; Dorjee et al., 2016). These populations have co-habited for long periods and presumably there was also gene flow between them (Das 1977; Das et at., 1980). A number of tribal communities (e.g., Lepcha, Rabha, Meche, Toto, Oraon, Santal and Munda) and non-tribal communities (e.g., Rajbanshi, Bengali Caste and Bengali Muslim) reside in North Bengal. Given the region's general backwardness, these communities are very vulnerable to under-nutrition. The existing literature showed that these populations are very vulnerable to nutritional status and high proportions of the individuals are suffering from both moderate and severe grades of under-nutrition (Mittal and Srivastava, 2006; Banik et al., 2007; Mondal and Sen, 2010a,b; Sen et al., 2011; Mondal, 2014; Roy et al., 2016; Debnath et al., 2017). Among these indigenous ethnic populations, the most widely distributed is Rajbanshi. Presently, they constitute a majority (18.40%) of the Scheduled Caste population of West Bengal. They are chiefly distributed in the North-eastern part of India that includes Assam and few districts of North Bengal (Sanyal, 1965). It is generally agreed that the Rajbanshi shows resemblances with the Koch population of the neighboring state of Assam and it is been conjectured that they belong to a mixed race of Austroasian/Dravidian and Mongolian (Risley, 1891). Researchers have opined that they belong to a Dravidian stock that came in contact with the heterogeneous Mongoloid populations (Dalton, 1872; Waddel, 1975). A recent study on genetic markers among the populations of North-eastern India reported that the Rajbanshi was a semi-Hinduized caste group located in-between the clusters between Caucasoid caste and Mongoloid tribal populations (Kumar et al., 2004).

The data for the present study were collected from 5 different government secondary schools situated in sub-urban and rural areas under Siliguri sub-division of Darjeeling district, West Bengal, India. The selection was done on the basis of the predominance of Rajbanshi boys in these schools. The physical features and surnames of the boys were utilized to identify them and subsequently their ethnicity was verified from the official records. Students from the 5^{th} to12^{th} standard were enrolled for the study. They were selected using a multi-stage stratified random sampling method. A total of 1127 adolescent boys in the age group 10 years to 18 years were initially identified. Of them, 1064 boys were approached for participating in the study and finally 1016 boys (95.49%) agreed to participate in the same. Out of these 1016 boys, 52 boys (5.12%) were excluded due to absence of the dates of birth from the official records. Hence, the final sample consisted of 964 boys aged from 10 to 18 years. Special care was taken so that each age had a minimum of 100 boys. All the boys were free from any physical or limb deformities and not suffering from any form of disease at the time of examination. Any previous histories related to their medical and surgical episodes were also taken into consideration during the selection and data collection.

Data Collection

The data was collected during the period from July 2010 to December 2012. Necessary consents and permissions were obtained from the local and school authorities prior to the commencement of the study. The protocol of the study was also approved by the concerned authorities and the study was conducted in accordance with the ethical guidelines of human experiments as laid down in the Helsinki Declaration of 2000 (Touitou et al., 2004). A verbal consent was taken from each participant and their parents before commencing the study. The socio-economic status of the boys was ascertained using a structured schedule. Relevant data on socio-economic and demographic variable (ethnic group, family size, parents' education, occupation, family income and dependent children in family) were recorded for this purpose. Based on the modified scale of Kuppuswamyas (Mishra and Singh, 2003; Kumar et al., 2007), it was observed that, these adolescent boys belonged to lower to middle socio-economic class.

Anthropometric Measurements Obtained

Measurements of height, sitting height, weight, mid upper arm circumference (MUAC), waist circumference (WC), hip circumference (HC), anterior thigh circumference (ATC), medial calf circumference (MCC), biceps skinfold (BSF), triceps skinfold (TSF), sub-scapular skinfold (SSF), supra-iliac skinfold (SISF), anterior thigh skinfold (ATSF) and medial calf skinfold (MCSF) were recorded following standard methods of Weiner and Lourie (1981) and Singh and Bhasin (1989). The boys were wearing minimum clothing and were without any footwear at the time of recording the measurements. The height and sitting height were measured by using an anthopometer rod to the nearest 1 mm, while the circumferences were recorded using a non-stretchable plastic-coated measuring tape on the left side of the body to the nearest 1 mm. Weight was measured using a portable weighting machine and to the nearest 0.1 kg. The skinfolds measurements were recorded to the nearest 0.1 mm using a Holtein skinfold caliper.

The intra-observer and inter-observer technical error measurements (TEM) were calculated to improve the precision of anthropometric measurements by utilizing the standard procedure of Ulijaszek and Kerr (1999) and the coefficient of reliability (R) of the measurements was calculated for testing the reliability of the collected measurements.

To calculate TEM, total of 50 children, other than those covered in the present study was measured by two of the authors (PG and NM). The TEM was calculated using the following formula:

$TEM=\sqrt{(\Sigma D^2/2N)}$ [D=difference between the measurements, N=number of individuals measured].

The co-efficient of reliability (R) was subsequently calculated using TEM by the following equation:

$R= \{1- (TEM)^2/SD^2\}$, SD= standard deviation of the measurements.

The intra-observer and inter-observer TEM values were observed to be within the cut-off value (R=0.95) as recommended by Ulijaszek and Kerr (1999). Hence, the anthropometric measurements recorded by both PG and NM were reliable and reproducible. All the measurements in the course of the present study were subsequently recorded by one of the authors (PG).

Assessment of Body Composition

The following derived anthropometric indices were calculated from the measurements:

a) BMI {BMI= weight (kg)/height (m^2)}

b) Rohrer index {weight (kg)/ height (m^3)}

c) Waist-hip ratio (WHR= WC/HC)

The centripetal fat ratio {CFR= SSF/ (SSF+TSF)} and sub-scapular triceps ratio (STR= SSF/TSF) were calculated to document central and peripheral adiposity and trunk and limb skinfold ratio respectively. The sub-scapular triceps ratio (STR= SSF/TSF) also calculated to estimate trunk and limb skinfold ratio.

Assessment of Physical Growth

For assessment of growth patterns, the following standards have been utilized:

- The age-specific percentile values of National Center of Health Statistics (NCHS) for height and weight.
- The age and sex specific percentiles of NHANES-I references values for BMI and TSF.

Statistical analysis

Statistical analysis was done by utilizing SPSS (version 17.0) for Windows. The results were considered to be significant at $p< 0.05$ level. The One-Sample Kolmogorov-Smirnov test was used to compare in the observed cumulative distribution functions for each anthropometric variable with respect to a specified theoretical distribution. One-way analysis of variance (ANOVA) was applied to identify the variability among all the anthropometric variables among the age groups. The post hoc test using Scheffe procedure was done to compare the multiple comparisons between the anthropometric variables when applicable within the age groups. The age-specific percentiles (3rd, 10th, 25th, 50th, 75th, 90th and 97th) values of height, weight and BMI have also derived using appropriate statistical procedures.

The least median square (LMS) model analysis was used by taking into the account the degree of skewness (L), central tendency (M; Median) and dispersion or the generalized coefficient of variation (S) for the calculation of reference percentiles curves, which is the concept of an age varying adjustment for skewness based on the Box-Cox transformation. The method converts measurements for a subject of known age and sex to evaluate percentile and standard deviation score or z-score (Cole and Green 1992; Cole et al. 1998). The LMS method software computer program fits smooth percentile curves to reference data using the LMS method as described by Cole and Green (1992). The age-specific height, weight and BMI percentile curves with 3^{rd}, 10^{th}, 15^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 97^{th} smoothed percentile lines for the Rajbanshi boys were plotted separately for further evaluation of nutritional status.

RESULTS

Appling the One-Sample Kolmogorov-Smirnov test, it was observed that for the anthropometric variables, the values were observed to be statistically not significant in most cases ($p>0.05$). The age-specific subject distributions and means (±standard deviation) of the recorded anthropometric variables among the Rajbanshi boys is summarized in **Table 1**. The age-specific mean height and weight increased with age from early adolescence but height decreased in the ages from 17 to 18 years. Boys belonging to the ages of 10 to 14 years have experienced greater acceleration in growth patterns in height and weight. The age-specific highest positive attainment of growth spurt was observed in height (7.19 cm) and weight (4.58 cm) among adolescent boys aged 13 years. A similar trend of increase was observed in age-specific mean values of MUAC, WC, HC, ATC and MCC with exception in MUAC, WC, HC, ATC and MCC in ages of 15-16 years. The age-specific mean values of skinfold thicknesses (e.g., BSF. TSF, ATSF, SISF, SSF and MCSF) were also observed to vary in relation to age and did not exhibit any age-specific trends but exceptions were observed in SISF and SSF. Age-specific mean BSF, TSF, SSF, ATSF was observed to be higher among 18 years, while SISF and MCSF were observed to be higher in

17 years and 16 years boys, respectively. The age-specific higher positive attainment growth spurt of BSF, TSF, SSF, SISF, ATSF and MCSF was observed to be 0.60 mm (in 15 years), 0.80 mm (in 18 years), 1.40 mm (in 17 years), 1.38 mm (in 17 years), 1.37 mm (in 11 years) and 0.72 (in 11 years), respectively. Using ANOVA, statistically significant ($p>0.05$) differences were observed in all anthropometric variables with respect to age **(Table 1)**.

The age-specific means (±standard deviation) of the derived anthropometric body composition characteristics among the adolescent boys are presented in **Table 1**. The BMI gradually increased from age of 10 years to 14 years, followed by a slight decrease in 16 years and then values continued to rise reaching its highest peak in age of 18 years (20.21 kg/m^2). The age-specific mean values of the Rohrer index and WHR did not show any general increase with respect to age. The age-specific highest positive attainment of growth spurt was observed in BMI (1.39 kg/m^2) and Rohrer index (0.89) among boys aged 17 years. The age-specific mean values of STR and CFR were observed to vary with the ages and a sudden acceleration was observed in 13 years and the highest mean value was reached in 18 years but in CFR the highest and lowest mean values were observed in 17 years and 12 years respectively. Using ANOVA, statistically significant differences were observed in derived anthropometric and body composition variables among age groups ($p<0.05$) **(Table 1)**. Age-specific selected percentile of 3rd, 10th, 25th, 50th, 75th, 90th and 97th values for height weight and BMI were derived separately among the boys and shown in **Table 2**. There appears to be an existence of significant age-specific variation in anthropometric measurements of height, weight and BMI measurements among adolescent boys' as the boys approached higher ages. Age-specific smooth percentile curves were also derived using LMS procedures for height, weight and BMI among Rajbanshi boys for future evaluation of physical growth status **(Figure 1)**.

Comparison with the Reference Population

Age-specific mean values of height and weight of Rajbanshi boys were compared with the NCHS references data, it was observed that the boys were generally below the 50th percentile of the reference values **(Figure 2)**. The mean age-specific heights were well above the 5th percentile but considerably below the 20th percentile of the reference values of boys aged 10 to14 years and then decrease thereafter to 3rd percentile in ages 17-18 years. The age-specific mean weight was found well above the 5th percentile but below the 20th percentile of the reference in ages 10 to 15 years and thereafter mean values shifted below the 3rd percentile among those aged 16 to18 years.

The comparison of age-specific mean BMI and TSF values of the present study with the NHANES-I reference population is shown in **Figure 3**. The age-specific mean values of BMI and TSF were observed to be below the 50^{th} percentile while age-specific mean BMI values were found to be below the 15^{th} percentile in ages 11 to16 years. Age-specific mean TSF values were observed to be well above the 10^{th} percentiles with only exception in 10 years but the values were observed to be below the 25^{th} percentile in ages of 11 to 15 years.

DISCUSSION

Physical growth measurements provide an important basis of assessment of nutritional status using anthropometric measurements especially among the vulnerable segments of the population (e.g., children and adolescents). The interpretation of anthropometric changes during adolescence is considered to be a complex issue due to puberty and maturation. The present study provides a set of valuable anthropometric data on physical growth and body composition parameters that may be used as reference for growth monitoring and interventions in the future. The results of the present study showed that the age-specific greater growth spurts in anthropometric variables (such as height and weight) were seen among adolescent boys as they approached to puberty (i.e., 13 years) **(Table 1)**. Similar studies have reported greater acceleration in physical growth measurements among adolescents during puberty (e.g., Hauspie et al., 1980; Rao et al., 2000; Mondal and Sen, 2010a; Sen and Mondal, 2013; Rengma et al., 2016). Adolescence is a period of increased nutritional requirements and a large proportion of the growing children in the developing countries are deprived of good quality nutrition on account of poor socio-economic status, ignorance and lack of health promotional facilities. This in turn may leads to nutritional deprivation and results in physical growth retardation and body composition (Rao et al., 2000; Medhi et al., 2007; Mondal and Sen, 2010a,b; Wells, 2010; Sen and Mondal, 2013; Singh and Mondal, 2014; Rengma et al., 2016; Debnath et al., 2017).

The importance of assessing physical growth and prevalence of malnutrition in a population is to provide appropriate nutritional intervention (WHO, 1995; de Onis and Blossner, 1997). Results of the present study suggest that adolescent boys were observed to be well below the 50^{th} percentiles of the reference populations in height, weight, BMI and TSF **(Figures 2-3)**. Several studies have reported poor attainment of physical growth and body composition parameters as compared to growth references (e.g., WHO and National Centre of Health Statistics) among Indian children and adolescents (Begum and Choudhury, 1999; Medhi et al., 2000; Rao et al., 2000; Mitra et al., 2002; Bisai and Bose, 2009; Sen et al., 2011; Mondal, 2014; Roy et al., 2016; Debnath et al., 2017). The poor attainments in physical growth dimensions among Rajbanshi adolescents can be attributed due to their poor living conditions, lower socio-economic status and prevalence of undernutrition or the fact that they do not have the access to better food, basic amenities and also as they belong to a large family size. This fact supports that low percentiles of height and weight in early age reflects the adaptive mechanisms to the low food intake and the subjects usually shows compensatory growth during puberty (Eveleth and Tanner, 1990; Olivieri et al., 2008). Studies have also confirmed that growth retardation (e.g., low-height-for- age) early in life results in adaptations in energy metabolism that favour fat deposition, increasing the risk of children becoming overweight or obese and metabolic disorder later in life (Sawaya et al., 2004; Lee et al., 2015).

The effect of living conditions and environmental variations can influence physical growth patterns as results that have been manifested in age-specific growth retardations and body composition in the population (Olivieri et al., 2008; Medhi et al., 2007; Wells, 2010; Rengma et al., 2016; Debnath et al., 2017). Therefore, an increase in the requirement of nutrients due to the rapid growth during adolescence is also not realized and their dietary intake was observed to be below the recommended dietary level among the boys. As a consequence, these boys were struggling to achieve their growth potential and fell shorter and/or lighter than their reference counterparts. Data suggested that adolescents belonging to the middle and higher socio-economic group nearly in countries are on average larger body size as compared to the lower socioeconomic counterpart (Eveleth and Tanner, 1990; Wells, 2010). The present study showed lean body composition is associated with adolescent boys belonging to a lower to middle socio-economic groups. Individuals belonging to the lower and medium socio-economic status did not have access to food, basic amenities and many individuals live in the same household (e.g., Olivieri et al., 2008; Dapi et al., 2009). However, considerable lower socioeconomic status and nutritional status unlikely plays a major role in attainment of optimum growth and maturation during the period of adolescence among the Rajbanshi boys.

Conclusion

Results of the present study may be useful to implement various nutritional programmes through nutrition supplementation. The study provides valuable anthropometric data on physical growth and body composition reference data among Rajbanshi adolescent boys. The age-sex specific variability in physical growth and body composition may be attributed several exogenous factors (e.g., socio-economic status, genetic, environment factors, food and nutrition and exposed to diseases) which may be refer to overall physical developmental exposure manifested in successive generation of population. In depth studies are necessary for identifying the factors responsible for such retardation reflected in both growth and body composition variables among adolescents.

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Table I: Age-wise mean ± standard deviation (SD) of the anthropometric variables and within age differences among the boys

Variables (N= 964)	10 year (N=105)	11 year (N=104)	12 year (N= 107)	13 year (N= 108)	14 year (N= 105)	15 year (N= 104)	16 year (N= 106)	17 year (N= 110)	18 year (N=115)	F-value
Weight (kg)	26.13±4.31	29.17±6.33	31.83 ±6.76	36.41 ±8.23	39.30 ±8.39	43.59 ±7.59	44.27 ±8.35	47.50 ±7.25	50.35 ±7.81	138.10*
Height (cm)	131.10 ±8.35	136.58 ±9.95	140.07 ±10.14	147.26 ±9.75	151.42 ±9.17	154.15 ±8.41	159.22 ±7.40	158.99 ±5.38	157.98 ±5.57	165.19*
Sitting Height (cm)	66.11 ±4.99	68.46 ±5.43	69.59 ±5.48	73.63 ±6.88	75.52 ±6.74	77.79±6.70	79.55±3.82	79.49±5.14	79.73±4.81	93.34*
WC (cm)	56.73±4.80	58.90±5.48	60.62±5.46	63.24±5.66	63.30±5.00	66.34±7.05	66.17±7.39	68.38±5.29	71.70±7.05	68.32*
HC (cm)	65.38±5.74	67.35±6.07	69.14±5.83	73.02±7.01	75.05±6.25	78.14±6.77	77.95±6.63	80.28±5.28	82.51±6.82	98.00*
MUAC (cm)	18.52±2.03	19.07±2.25	19.16±1.93	20.31±2.54	21.34±2.37	21.14±2.49	21.57±2.11	22.13±1.94	23.03±2.93	47.48*
ATC (cm)	34.01±4.55	35.91±5.37	37.20±5.48	39.02±4.57	40.20±4.03	41.03±4.55	39.95±4.72	42.96±5.21	42.76±5.58	40.64*
MCC (cm)	24.65±2.37	26.34±2.92	26.87±2.96	28.07±3.78	29.20±2.88	29.55±3.35	28.69±3.24	31.25±3.75	31.30±4.13	48.22*
BSF (mm)	3.64±1.43	4.15±1.64	4.52±1.54	4.27±1.56	3.78±1.46	4.38±1.59	4.15±1.73	4.65±1.94	4.66±1.75	5.20*
TSF (mm)	5.57±1.62	6.06±1.99	6.47±1.77	5.90±1.64	5.76±1.66	6.37±2.25	5.81±1.92	6.17±2.28	6.97±2.27	5.31*
SSSF (mm)	5.02±1.26	5.44±1.36	5.61±1.57	5.96±1.73	6.21±1.62	6.62±2.01	6.66±2.07	8.06±5.79	8.14±3.32	17.90*
SISF (mm)	6.29±1.68	6.77±1.78	7.11±2.15	7.40±2.45	7.55±2.03	8.21±2.44	7.99±2.52	9.37±3.27	9.19±3.48	18.71*
ATSF (mm)	6.90±1.86	8.27±1.84	8.62±2.09	8.72±2.12	8.44±2.02	8.49±2.76	8.45±2.75	8.40±2.41	8.78±2.98	6.06*
MCSF (mm)	6.19±1.71	6.91±1.86	6.84±1.59	6.86±1.83	6.93±1.92	6.91±2.27	7.01±1.91	6.95±2.20	6.57±2.70	6.06*
BMI (kg/m^2)	15.34±3.04	15.72±3.43	16.45±4.12	16.81±3.53	17.23±4.17	18.44±3.52	17.48±3.32	18.87±3.25	20.21±3.19	21.49*
Rohrer Index	11.83±2.89	11.61±2.85	11.92±3.55	11.50±2.69	11.48±3.10	12.04±2.68	11.02±2.30	11.91±2.31	12.83±2.21	3.64*
WHR	0.87±0.09	0.88±0.11	0.88±0.11	0.87±0.11	0.85±0.09	0.85±0.09	0.85±0.09	0.85±0.08	0.87±0.08	2.04*
STR	0.95±0.34	0.96±0.36	0.97±0.38	1.13±0.73	1.08±0.33	1.06±0.38	1.15±0.42	1.17±0.42	1.18±0.48	4.55*
CFR	0.48±0.09	0.48±0.09	0.47±0.11	0.50±0.11	0.51±0.08	0.50±0.13	0.53±0.12	0.55±0.14	0.53±0.12	7.30*

*$p < 0.05$

Table 2: Age-specific percentile values for height (HT), weight (WT) and body mass index (BMI) among the boys

Age (year)	3rd			10th			25th			50th			75th			90th			97th		
	HT	WT	BMI	HT	WT	BMI	HT	WT	BMI	HT	WT	BMI	HT	WT	BMI	HT	WT	BMI	HT	WT	BMI
10	114.0	18.5	10.1	120.7	21.0	10.8	126.5	23.0	13.2	130.6	26.0	14.9	136.2	29.0	17.1	140.9	32.0	19.3	149.8	36.0	21.6
11	122.1	20.1	10.5	126.3	22.0	11.5	129.5	25.0	13.6	135.7	27.5	15.1	142.5	34.0	17.4	147.7	37.5	20.4	156.1	44.9	25.5
12	120.9	20.5	10.1	127.9	24.8	11.6	134.0	27.0	13.4	139.0	30.0	15.7	147.0	36.0	19.1	154.0	42.1	22.7	160.2	45.0	25.4
13	127.9	20.0	10.3	134.7	25.0	11.8	141.1	31.0	14.7	147.5	37.0	17.0	155.4	42.0	18.8	160.0	46.1	22.1	164.1	52.9	23.6
14	130.7	21.5	10.8	138.5	26.6	12.3	144.8	31.5	14.6	152.9	40.0	17.5	158.4	45.0	19.7	161.7	49.4	22.3	167.4	59.6	25.4
15	136.3	29.1	11.7	140.7	33.6	13.5	148.6	39.0	16.4	155.5	45.0	18.7	160.0	48.9	20.9	164.3	53.0	22.5	168.1	57.8	25.6
16	137.1	27.0	11.1	148.8	34.4	13.3	157.3	38.0	15.0	160.4	45.0	17.7	164.2	50.0	19.3	167.0	53.3	21.4	168.8	59.8	26.2
17	146.6	29.3	12.6	150.9	38.1	14.5	157.0	44.8	17.6	160.0	48.0	18.9	162.6	51.0	20.2	165.0	55.0	22.8	167.5	61.3	26.7
18	145.6	34.5	13.3	148.4	39.7	15.9	155.0	46.5	18.2	158.7	50.5	20.6	161.4	55.5	22.1	164.8	60.3	23.9	167.7	64.0	26.1

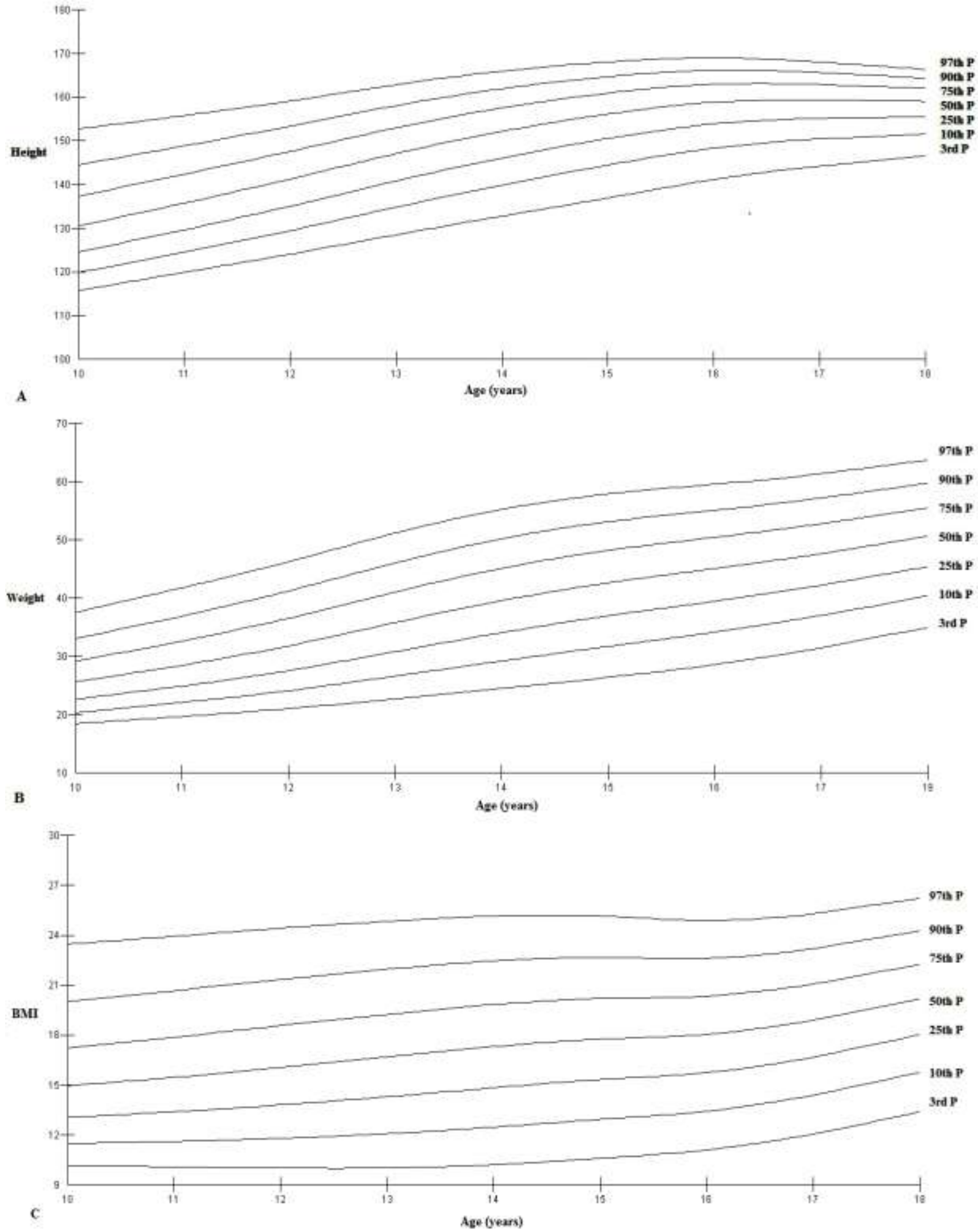

Figure 1: Age-specific percentile curve of height (A), weight (B) and BMI (C) using L, M and S method among the boys

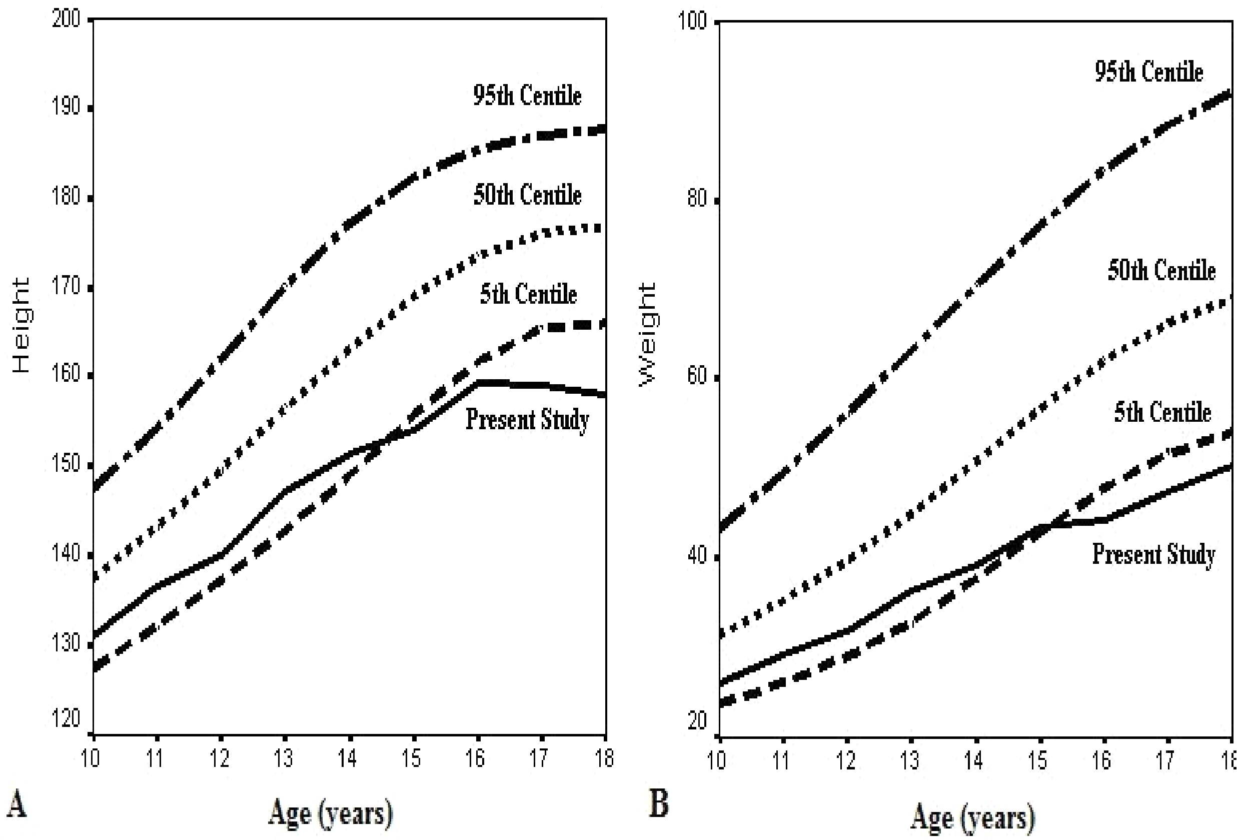

Figure 2: Sex-specific mean height (A) and weight (B) comparison of NCHS reference among the boys

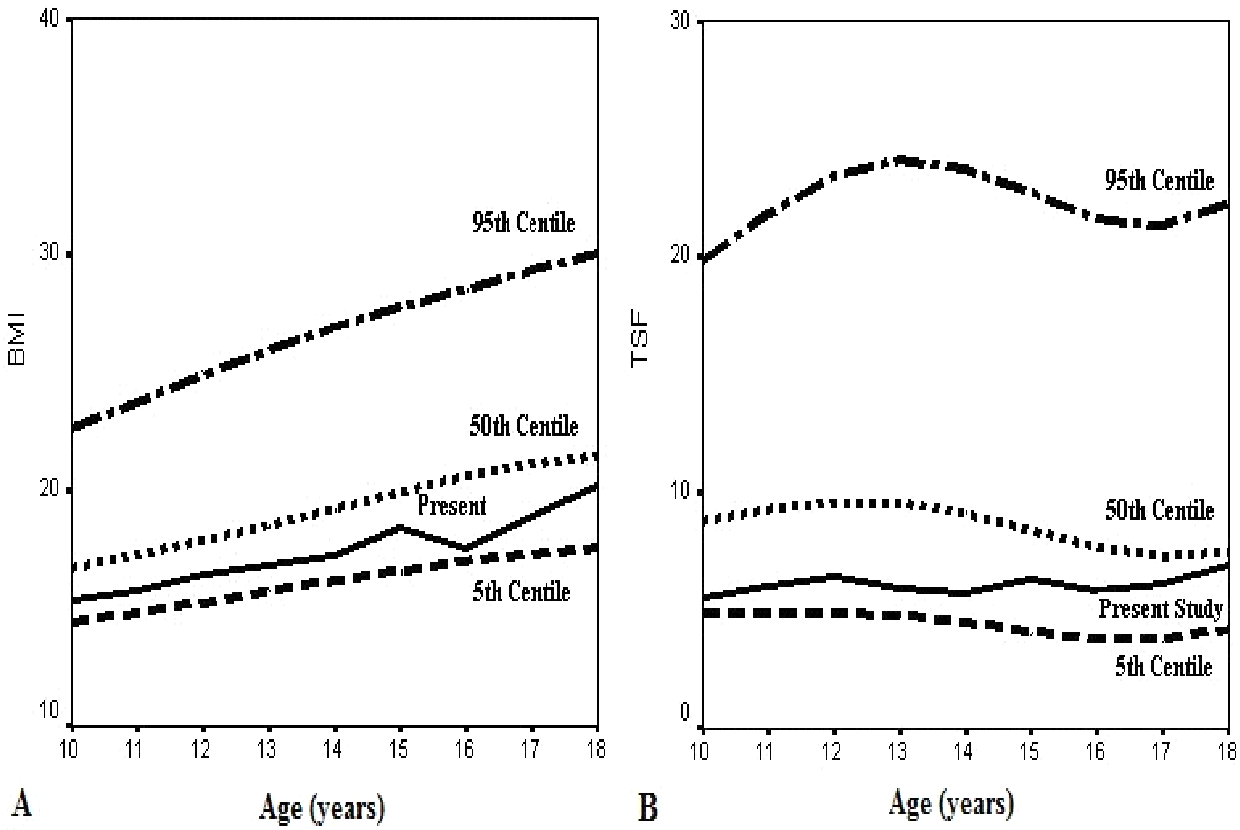

Figure 3: Age-specific mean comparison of BMI (A) and TSF (B) with NFHANES-1 references among the boys