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A Cross-Sectional Study on Physical Growth and Body Composition among Bengali Adolescents of North Bengal, West Bengal (INDIA)

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ABSTRACT

Aim: *Present study aims to assess the physical growth and body composition among the Bengali adolescents of Darjeeling district.**Materials and Methods:** Present community-based cross-sectional study was conducted among the adolescents of Matigara block under Siliguri sub-division of Darjeeling district. Total 392 adolescents (190 boys; 202 girls) under the age groups of 11-17 years were included in this study. Seven anthropometric and six derived variables were considered. All the statistical analyses were performed by SPSS (v.26). **Results:** Significant sexual dimorphism were found in height, weight, sitting height, MUAC, Head Circumference, TSF, SSSF, PBF, FFM and FMI. Higher mean of height, weight, Sitting height, MUAC, head circumference FFM were observed among boys whereas, in case of TSF, SSSF, PBF and FMI higher mean values were found among girls. Age-specific mean differences were found significant for all the anthropometric and body composition parameters. BMI showed a high correlation with all body composition parameters. From Regression analysis, significantassociations of BMI and PBF with the anthropometric and body composition measures were found.**Conclusion:**Comparison showed that the percentile values of height and weight of the present population were almost in the line of IAP (2015, 25th percentile) growth reference but below CDC (2000) and NHANES (1999-2002) references that represents poor growth in comparison to the international cut offs. Females had more fat level whereas; males had more lean mass (in total). There is need to develop regional growth standard for better understanding of growth among adolescents of different ethnic groups.*

Keywords: *Growth, Body composition, PBF, FM, FMI, Skinfolds, Bengali adolescents.*

INTRODUCTION

Assessment of physical growth and body composition has an essential role in nutritional assessment for the effect of age, sex, ethnicity, geographic, socioeconomic status, environment, disease, sedentary behavior, physical activity, genotype, or genetic factors and also a helpful sign for health and nutritional status (Sharma and Mondal, 2018). Body composition refers to the percentage of body organs, muscles, bones, fat, and water content. Body fat is a standard component that accumulates in the adipose tissue and serves as a valuable marker for assessing the adiposity of individuals (Dutta and Sengupta, 2020). The body adiposity proportions vary with different factors such as age, sex, and environmental conditions and are a good indicator of children's health and nutritional status (Rajkumari et al., 2012). For the assessment of body composition, different methods such as total body fat (TBF), fat-free mass (FFM), bone mineral content (BMC), percent body fat (PBF), lean body mass (FFM-BMC), bone mineral density (BMD) and total body water are used (Siervogel et al., 2003) with some new techniques (bioelectrical impedance analysis, dual X-ray absorptiometry, computerized tomography, underweight weighing) (Dutta and Sengupta, 2020). A significant sexual dimorphism can be seen in the timing of pubertal events as well as in body composition, as both sexes experience a rapid increase in TBF, and the proportion of body fat increases more slowly in boys as a result of a simultaneous rapid increase in FFM (Guo et al., 1997; Siervogel et al., 2000; Maynard et al., 2001; Nguyen et al., 2001).

The assessment of body composition is of great importance in children and adolescents for the life and health status of the population as well as its influence on the morbimortality risk (Wells and Fewtrell, 2006; Terres et al., 2006; Cali and Caprio, 2008; Carvalho et al., 2011; Parks et al., 2014). During adolescence, changes in body size and composition are found to be strongly associated with developmental and physical performance characteristics (Fukunaga et al., 2013; Odo et al., 2015). BMI is associated with body composition and nutritional status and is highly correlated with body fatness (Garrow and Webster, 1985; Rolland-Cachera, 1993). At any particular BMI, depending on gender, age, maturity, race, height, and body fat distribution, body composition greatly varies in children (Kuriyan et al., 2018). Evensen et al. (2019) reported that higher BMI and more significant BMI gain at later ages (compared with birth and early childhood) are strong predictors of higher fat mass and central overweight or obesity at 15 to 20 years of age. Though BMI is considered to assess the relationship between risk factors and internal fat (Rolland-Cachera, 1993), it has some limitations such as BMI is calculated by height and weight, which makes it an inaccurate indicator of body fatness (Mandal et al., 2021); it does not reflect changes in body fat content and distribution (Zhao et al., 2023), and the individual contribution of muscle mass and fat mass (FM) to overall body mass cannot be differentiated using BMI alone as obesity may be over-diagnosed (Mastorci et al. 2017).

Skinfold thickness (SFT) is a good measure of body composition as it gives a fair assessment of fat location (Mandal et al., 2021). The subcutaneous fat's thickness reflects body fat (Orphanidou et al., 1994; Mandal et al., 2021) and is storage of energy during nutritional deprivation; lower body fat indicates lower energy intake by children (Mandal et al., 2021). Fat-free mass (FFM) is also an essential component of the body and age-related increase in BMI among children and adolescents (Freedman et al., 2005; Kuriyan et al., 2018), and the increase in Fat-free mass during child growth is of interest for both clinical care and nutritional programming (Wells, 2003; Kuriyan et al., 2018). Two indicators, such as fat mass index and fat-free mass index, proved helpful tools to track obesity in children and identify the predictors of risk and at-risk ethnic groups (Rush et al., 2009). According to WHO (2018), 340 million children and adolescents (10-19 years) and nearly 40 million under-5 children were overweight or obese (WHO, 2018; Kobylińska et al., 2022).Albu and Rada (2014) reported significant changes in anthropometry and body composition among Romanian teenagers. The role of environment in the development of adiposity, along with the significant association of lower socioeconomic status between body composition and impaired growth, obesity, and increased abdominal fat, was also evident among adolescents and adults (Popkin et al., 1996; Patel et al., 2020; Mandal et al., 2021; Long et al., 2021). Anthropometric characteristics and body composition are reliable means to describe the human body and the development of physical growth processes in various age stages, especially adolescence (Saleh, 2020).

Various studies have reported adolescents' physical growth and body composition using anthropometric measurements (Mondal et al., 2017; Sharma and Mondal, 2018). However, determining growth and body composition among adolescents, particularly in the age group of 11-17 years in both sexes from the region selected for this study, is scanty (Mondal et al., 2017). So, the present study aimed to determine the physical growth pattern and body composition and age-sex-specific effect on different anthropometric, physical growth, and body composition variables among the rural Bengali adolescents of Darjeeling, West Bengal.

MATERIAL AND METHODS

Study Area and participants

The state of West Bengal is broadly divided into two parts. The northern part, popularly known as North Bengal, comprises a total of eight districts (viz. Darjeeling, Kalimpong, Jalpaiguri, Alipurduar, Coochbehar, North Dinajpur, South Dinajpur, and Malda), and the southern part is South Bengal comprises rest of the districts. This state is India's most ethnically and linguistically diverse region, with numerous heterogeneous, endogamous ethnic groups with distinct identities (Kumar et al., 2004; Mondal et al., 2017). The residents of this area are mainly various tribal (Rabha, Mech, Toto, Lepcha, santal, Munda, and Oraon) and non-tribal communities (such as Bengalis and Rajbanshis). The present study was conducted among adolescents belonging to the Bengali Hindu caste population (BHCP) who are ethnically a Bengali-speaking endogamous caste group of West Bengal, probably a blend of Dravidian and Mongoloid groups with a strain of Indo-Aryan blood in higher caste groups (Das Choudhury et al., 1993; Debnath et al., 2016).

Data for the present study was collected from 3 different Bengali-medium government higher secondary schools (two co-educational and one girls' school) in the Matigara jurisdiction of Siliguri sub-division, Darjeeling (West Bengal). The data were collected during the period of August-September 2023. Before the data collection, consent was taken from the school authorities, the participants, and one of their parents. The study was conducted by the ethical guidelines of human experiments as laid down in the Helsinki Declaration of 2000 (Touitou et al., 2004). The participants were the students of 5th to 12th standards under the age groups of 11 to 17 years, and they were selected using a multistage stratified random sampling method. 400 students were initially identified, but 392 were eligible for the study. All the participants were healthy and not suffering from any diseases or body deformities.

Anthropometric Measurements

A total of seven anthropometric measurements collected by one of the authors (MD) were Height (HT), Weight (WT), Sitting height (SHt), Mid-upper-arm circumference (MUAC), Head circumference (HdC), Triceps skinfold (TSF) and Sub-scapular skinfold (SSSF) were measured by the standard methods of Weiner and Lourie (1981) and Singh and Bhasin (1989). An anthropometer rod was used to measure the height and sitting height (to the nearest 1 mm), and weight was measured by weighing the machine to the nearest 0.1 kg. A non-stretchable tape was used for circumference, and the Skinfolds were measured by

Holtein skinfold caliper (to the nearest 0.2 mm). The intra-observer and inter-observer technical error measurement (TEM) values were found to be within the cut-off value (R = 0.95) as recommended by Ulijaszek and Kerr (1999).

Assessment of Growth and Body Composition

The growth patterns were assessed by National standards of IAP (2015) (Khadilkar et al., 2015) and International standards of NHANES (1999-2002) (McDowell et al., 2005) and CDC (2000) for the age-specific percentile values of height, weight. Derived Variables for assessment of body composition were calculated by the following equations (Slaughter et al., 1988; VanItallie, et al., 1990):

BMI = Weight (kg)/ Height^2 (m^2) (WHO, 1995).

PBF= 1.21(TSF+SSSF)-0.008(TSF+SSSF)^2-1.7 (for boys)

1.33(TSF+SSSF)-0.013(TSF+SSSF)^2-2.5 (for girls)

FM (kg) = Weight (kg)*[PBF/100]

FFM (kg) = Weight (kg)-FM (kg)

FMI= FM(kg)/Height^2(m^2)

FFMI= FFM (kg)/Height^2(m^2)

Statistical Analysis

The statistical analyses were performed by using statistical package for social science (SPSS, v.26). The mean and standard deviation were computed along with ANOVA to compare the anthropometric data between sexes among the adolescent boys and girls. T-test was performed to evaluate significant sex differences in the measurements taken. Pearson correlation and linear regression were also performed to check the association between various anthropometric and body composition variables. P<0.01 and <0.05 were considered statistically significant.

RESULTS

Table 1 represents the age and sex-specific descriptive statistics of different anthropometric and body composition measures of Bengali adolescents. An overall significant sexual dimorphism was found in height, weight, sitting height (SHt), MUAC, Head Circumference (HdC), TSF, SSSF, PBF, FFM and FMI at the level <0.01 and <0.05. Higher mean of height, weight, SHt, MUAC, HdC, FFM were observed among boys whereas, in case of TSF, SSSF, PBF and FMI higher mean values were found among girls. Both sex and age-specific significant differences were observed in height, weight, SHt, MUAC, HdC, TSF, SSSF, PBF, FFM and FMI at the level <0.01 and <0.05 for both sexes. Significant age variations were observed for all the anthropometric and derived variables in both sexes (p<0.01 and <0.05) as represented in table 1.

Table 1. Age and Sex-specific descriptive statistics of(mean ± standard deviation) different anthropometric and body composition measures.

Variable (s)	Gender (Boys 190Girls 202)	Age (years)							Total	F-value
		11 (Boys22 Girls29)	12 (Boys34 Girls31)	13 (Boys25 Girls29)	14 (Boys33 Girls36)	15 (Boys29 Girls28)	16 (Boys23 Girls24)	17 (Boys24 Girls25)		
Height (cm)	Boys	141.24 (8.30)	149.67 (8.44)	155.94 (10.27)	157.91 (9.74)	161.65 (7.19)	163.48 (5.76)	164.47 (6.55)	156.2 (10.9)	24.810**
	Girls	141.93 (6.13)	144.53 (6.77)	149.82 (4.94)	149.30 (5.57)	152.13 (4.81)	151.95 (6.12)	150.24 (5.18)	148.41 (6.64)	13.063**
	t-value	0.342	-2.691 **	-2.847 **	-4.554 **	-5.858 **	-6.643 **	-8.455 **	-8.696 **	
Weight (kg)	Boys	38.10 (13.31)	40.62 (10.06)	47.16 (13.47)	45.41 (12.33)	55.58 (15.14)	55.89 (13.94)	54.44 (10.39)	47.89 (14.14)	8.632 **
	Girls	35.59 (9.03)	36.40 (7.29)	49.47 (14.31)	46.16 (11.09)	46.51 (8.48)	53.79 (12.93)	45.95 (7.39)	44.55 (11.89)	11.415**
	t-value	-.802	-1.916	.605	.264	-2.778 **	-.537	-3.308 ***	-2.545*	
SHt (cm)	Boys	73.78 (4.45)	77.33 (4.63)	80.69 (5.58)	81.15 (5.17)	84.55 (3.41)	86.14 (3.12)	84.56 (7.49)	81.11 (6.27)	19.283**
	Girls	74.12 (3.27)	75.36 (3.7)	78.63 (3.24)	78.59 (4.21)	80.87 (2.62)	81.15 (3.56)	77.79 (14.69)	77.98 (6.49)	5.089 **
	t-value	.313	-1.847	-1.691	-2.261*	-4.564 **	-5.097 **	-2.018*	-4.843 **	
MUAC (cm)	Boys	22.53 (4.67)	22.62 (2.94)	24.07 (3.09)	23.66 (3.64)	26.85 (3.41)	27.62 (4.19)	26.09 (3.05)	24.67 (3.98)	8.823 **
	Girls	21.21 (3.18)	21.27 (2.70)	24.96 (4.49)	24.50 (3.34)	23.97 (2.39)	26.75 (3.79)	24.37 (2.85)	23.78 (3.74)	10.157**
	t-value	-1.201	-1.921	.824	.995	-3.678 **	-.744	-2.043*	-2.299*	
HdC (cm)	Boys	52.42 (1.95)	52.67 (1.88)	53.21 (2.48)	53.28 (2.37)	54.22 (1.74)	54.38 (2.09)	54.40 (1.52)	53.48 (2.14)	4.233 **

	Girls	51.19 (1.67)	51.76 (2.24)	53.00 (2.11)	52.55 (1.76)	52.54 (1.46)	53.98 (1.95)	52.71 (1.51)	52.49 (1.98)	6.278**
	t-value	-2.432*	-1.778	-.333	-1.465	-3.939**	-.676	-3.911**	-4.779**	
TSF (mm)	Boys	12.07 (5.29)	11.02 (4.53)	10.96 (4.12)	9.51 (3.94)	12.70 (5.44)	13.18 (5.24)	10.37 (3.82)	11.31 (4.73)	2.197*
	Girls	10.89 (3.50)	10.13 (2.65)	14.93 (4.79)	14.86 (4.15)	14.59 (4.19)	18.22 (5.29)	13.79 (4.01)	13.81 (4.75)	12.058**
	t-value	-1.126	-.950	3.236**	5.484**	1.466	3.286**	3.070**	5.153**	
SSSF (mm)	Boys	11.26 (6.49)	10.66 (5.07)	10.82 (4.70)	10.15 (4.79)	13.70 (6.13)	14.27 (5.75)	11.91 (4.27)	11.72 (5.45)	2.392*
	Girls	12.16 (5.99)	12.42 (4.08)	18.71 (7.76)	17.73 (5.59)	15.56 (4.23)	20.49 (6.58)	16.78 (6.58)	16.16 (6.48)	7.850**
	t-value	0.449	1.531	4.474**	6.013**	1.328	3.447**	3.165**	7.337**	
BMI (kg/m^2)	Boys	18.72 (4.64)	17.94 (3.38)	19.18 (4.06)	17.95 (3.28)	21.09 (4.79)	20.87 (4.79)	20.02 (3.01)	19.29 (4.13)	3.058**
	Girls	17.52 (3.65)	17.37 (3.04)	21.97 (6.02)	20.57 (4.18)	20.11 (3.55)	23.18 (4.86)	20.39 (3.37)	20.07 (4.57)	7.208**
	t-value	-1.030	-.712	1.961	2.870**	-.877	1.637	.412	1.750	
PBF (%)	Boys	21.14 (8.98)	20.09 (7.64)	20.31 (6.71)	18.44 (6.89)	23.66 (8.47)	24.57 (8.11)	20.79 (6.33)	21.13 (7.75)	2.165*
	Girls	20.19 (5.25)	20.40 (4.48)	25.70 (4.91)	25.98 (4.50)	25.02 (3.75)	27.95 (2.80)	24.99 (4.31)	24.23 (5.10)	12.637**
	t-value	-0.493	.194	3.409**	5.420**	.779	1.939	2.700*	4.696**	
FM (kg)	Boys	9.04 (7.02)	8.77 (5.27)	10.27 (6.69)	8.93 (5.76)	14.21 (8.51)	14.56 (8.04)	11.75 (5.62)	10.93 (7.00)	3.727**
	Girls	7.56 (3.99)	7.69 (3.02)	13.29 (5.86)	12.35 (4.54)	11.86 (3.81)	15.28 (4.91)	11.69 (3.65)	11.28 (5.00)	11.991**
	t-value	-0.970	-.994	1.774	2.753**	-1.338	.385	-.058	.568	
FFM (kg)	Boys	29.06 (6.71)	31.85 (5.64)	36.89 (7.53)	36.48 (7.59)	41.37 (7.61)	41.34 (6.97)	42.69 (6.29)	36.97 (8.25)	14.091**
	Girls	28.02 (5.34)	28.71 (4.48)	36.18 (8.57)	33.80 (6.84)	34.65 (4.97)	38.50 (8.18)	34.25 (4.19)	33.26 (7.10)	10.234**
	t-value	-0.595	-2.467*	-.332	-1.542	-3.934**	-1.283	-5.523**	-4.765**	
FMI (kg/m^2)	Boys	4.33 (2.92)	3.84 (2.16)	4.12 (2.35)	3.46 (1.94)	5.35 (3.02)	8.44 (2.92)	4.31 (1.96)	4.35 (2.53)	2.526*
	Girls	3.70 (1.81)	3.66 (1.39)	5.89 (2.51)	5.48 (1.82)	5.13 (1.64)	6.58 (1.93)	5.19 (1.64)	5.05 (2.07)	9.596**
	t-value	-0.959	-.386	2.658*	4.447**	-.334	1.596	1.709	3.005**	
FFMI (kg/m^2)	Boys	14.39 (1.86)	14.10 (1.42)	15.06 (1.95)	14.49 (1.80)	15.74 (2.11)	15.43 (2.22)	15.72 (1.54)	14.95 (1.92)	3.739**

	Girls	13.82 (1.93)	13.71 (1.74)	16.08 (3.57)	15.09 (2.52)	14.98 (2.02)	16.60 (2.99)	15.20 (1.93)	15.02 (2.61)	5.194 **
	t-value	-1.031	-1.005	1.268	1.126	-1.403	1.504	-.998	.308	

*significant at p<0.05; **significant at p<0.01; ***significant at p<0.001 (abbreviations: SHt- Sitting Height, MUAC- Mid-Upper Arm Circumference, HdC- Head Circumference, TSF- Triceps Skinfold, SSSF- Sub-scapular Skinfold, BMI- Body Mass Index, PBF- Percent Body Fat, FM- Fat Mass, FFM- Fat Free Mass, FMI-Fat Mass Index, FFMI- Fat Free Mass Index)

Table 2 presents the sex-specific correlations of BMI with the body composition variables. It is found that, in both sexes, all the measures showed significant positive correlations (p<0.01) with BMI. It was observed that all the fat measures (PBF, FM, FFM, FMI and FFMI) have stronger associations with BMI in both sexes. However, noticeable sexual dimorphism was found in FFM (boys r=0.757; girls r=0.924).

Table 2. Sex-specific correlation between BMI with different body composition measures

Gender	Body Composition Measurements (Pearson correlation)				
	PBF	FM	FFM	FMI	FFMI
Boys	0.856**	0.941**	0.757**	0.945**	0.903**
Girls	0.814**	0.949**	0.924**	0.971**	0.982**

**significant at p<0.01(abbreviations: PBF- Percent Body Fat, FM- Fat Mass, FFM- Fat Free Mass, FMI- Fat Mass Index, FFMI- Fat Free Mass Index)

Linear regression analysis showed the dependency of BMI and PBF on the selected anthropometric and body composition variables among adolescents depicted in Table 3 and Table 4. The results showed that BMI positively influences the anthropometric and body composition variables for both male and female (Table 3). R^2 analysis showed that MUAC SSSF, FMI and FFMI (for both) and PBF (for male), FM, FFM (for female) have greater association (R^2 >0.7) with BMI (p<0.01). Also PBF (Table 4) showed the positive influences on the anthropometric and body composition variables for both sexes. From R^2 analysis, PBF was found to have greater association (R^2 >0.7) with TSF, SSSF, FM and FMI (p<0.01) for both sexes.

Table 3. Regression analysis (simple linear) of BMI with different anthropometric and body composition variables

Variables	Gender	B	R	R^2	t-value
MUAC	Boys	0.913	0.881	0.776	25.484**

	Girls	1.108	0.905	0.819	30.123**
TSF	Boys	0.718	0.822	0.676	19.786**
	Girls	0.773	0.783	0.614	17.827**
SSSF	Boys	0.661	0.873	0.762	24.512**
	Girls	0.610	0.842	0.709	22.095**
PBF	Boys	0.456	0.856	0.732	22.680**
	Girls	0.730	0.814	0.662	19.782**
FM	Boys	0.555	0.941	0.885	38.101**
	Girls	0.868	0.949	0.901	42.648**
FFM	Boys	0.379	0.757	0.574	15.906**
	Girls	0.595	0.924	0.855	34.278**
FMI	Boys	1.541	0.945	0.893	39.625**
	Girls	2.145	0.971	0.943	57.504**
FFMI	Boys	1.937	0.903	0.815	28.756**
	Girls	1.720	0.982	0.964	73.324**

**significant at p<0.01 (abbreviations: MUAC- Mid-Upper Arm Circumference, TSF- Triceps Skinfold, SSSF- Sub-scapular Skinfold, PBF- Percent Body Fat, FM- Fat Mass, FFM- Fat Free Mass, FMI-Fat Mass Index, FFMI- Fat Free Mass Index)

Table 4. Regression analysis of PBF with different anthropometric and body composition variables

Variables	Gender	B	R	R^2	t-value
MUAC	Boys	1.576	0.810	0.656	18.925**
	Girls	1.127	0.827	0.684	20.792**
TSF	Boys	1.600	0.976	0.952	61.349**
	Girls	0.970	0.882	0.778	26.500**
SSSF	Boys	1.389	0.976	0.954	62.098**
	Girls	0.725	0.898	0.806	28.810**
FM	Boys	1.028	0.929	0.863	34.419**
	Girls	0.924	0.908	0.824	30.563**
FFM	Boys	0.458	0.487	0.237	7.647**
	Girls	0.516	0.720	0.518	14.660**
FMI	Boys	2.958	0.966	0.933	51.272**

	Girls	2.262	0.919	0.844	32.956**
FFMI	Boys	2.279	0.565	0.320	9.399**
	Girls	1.359	0.696	0.485	13.726**

**Significant at p<0.01(abbreviations: MUAC- Mid-Upper Arm Circumference, TSF- Triceps Skinfold, SSSF- Sub-scapular Skinfold, FM- Fat Mass, FFM- Fat Free Mass, FMI-Fat Mass Index, FFMI- Fat Free Mass Index)

The boys were found to be taller for all ages than the girls (except 11years). The boys were also heavier than the girls except for 13 and 14 years and the BMI was found to be high in the girls than the boys except for 11,12 and 15 years. Total mean of sitting height (SHt), MUAC and HdC were found to be more in case of boys in comparison to the girls. Figure 1 represents a gradual increase in PBF among girls and the values were higher from 13 to 17 years of age, whereas, a reversetrend is seen in FFM (figure 2). According to the PBF classification (Singh et al. 2020) for fit and obese category (PBF 21-24% as fit and ≥32% as fat) it was found that 16.83% females were fit and no one found to be obese but in case of male adolescents 7.89% were fit but 15.79% were found to be obese.

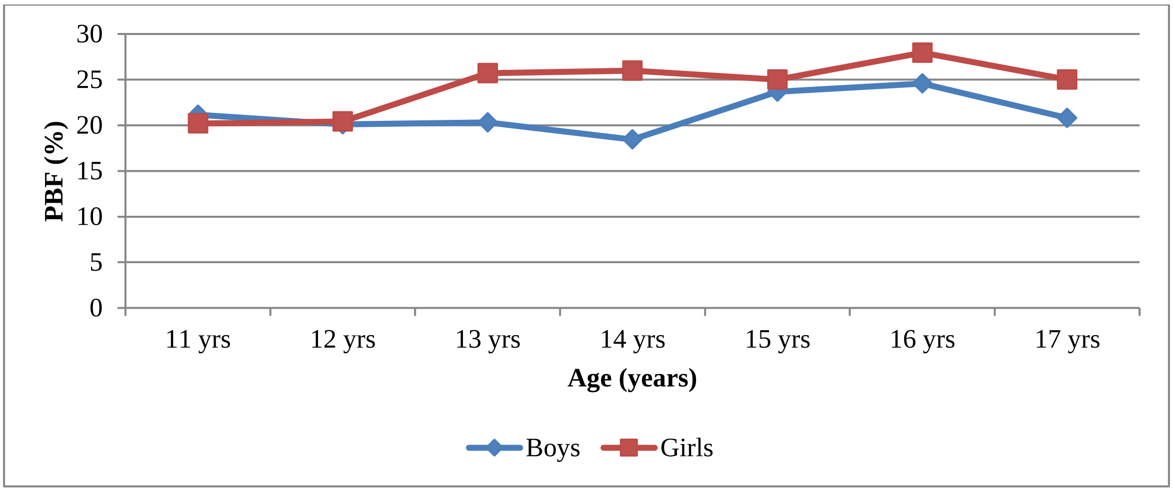

Figure 1. Age-specific PBF (%) among the studied adolescents.

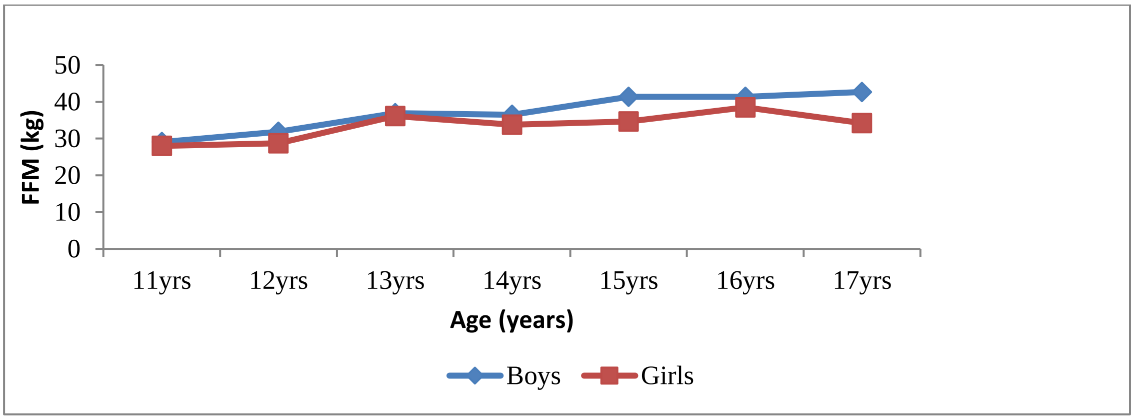

Figure 2. Age-specific FFM (kg) among the adolescents.

DISCUSSION

Body composition depicts the composition of muscle mass and the body fat percentage in an individual, reflecting the nutritional intake over time (Thibault et al. 2012; Singh et al. 2020). Anthropometry is a widely used and practical technique to assess the growth, body composition, and nutritional status among individuals (Rolland-Cachera, 1993; Derman et al., 2002; Banerjee et al., 2009; Basu et al., 2010; Sen and Mondal, 2013; Mondal et al., 2017; Sharma and Mondal, 2018). Poor physical growth and body composition attainments are associated with several physical manifestations, such as delays in menarche, poor reproductive outcomes, or low birth weight (Sharma and Mondal, 2018; WHO, 1995). The age-specific, more incredible spurts in height for boys were seen in 12 years, and for weight, they were seen in 15 years, whereas greater height and weight spurts were seen in the case of 13 years for girls (Table 1).

While compared to various Indian studies (Khopkar et al., 2014; Khatun et al., 2017; Mondal, 2017; Pal et al., 2017; Sahu et al., 2020; Mandal et al. 2021; Das and Gautam, 2022) it was observed that the mean height of the present studied adolescent boys were higher (except 16 years) (Figure 3) but the girls were taller only in case of 12 and 13 years (Figure 4) in comparison to the previous studies (Khopkar et al. 2014; Roy et al. 2016; Khatun et al. 2017; Pal et al. 2017; Sahu et al. 2020; Mandal et al. 2021; Das and Gautam, 2022). The studied population (boys for all age groups and girls except 15 and 17 years) was also heavier than any other Indian adolescents (Figures 5 and 6). After scrutiny, it was found that this study's percentile values of height and weight (sometimes higher) were very close to the 25th percentile values of the IAP (2015) growth reference. The percentile values were also compared to the International growth reference values (NHANES, 1999-2002 and CDC, 2000), and the values of the present study were lower than the International cut-offs (Figures 7 to 10).

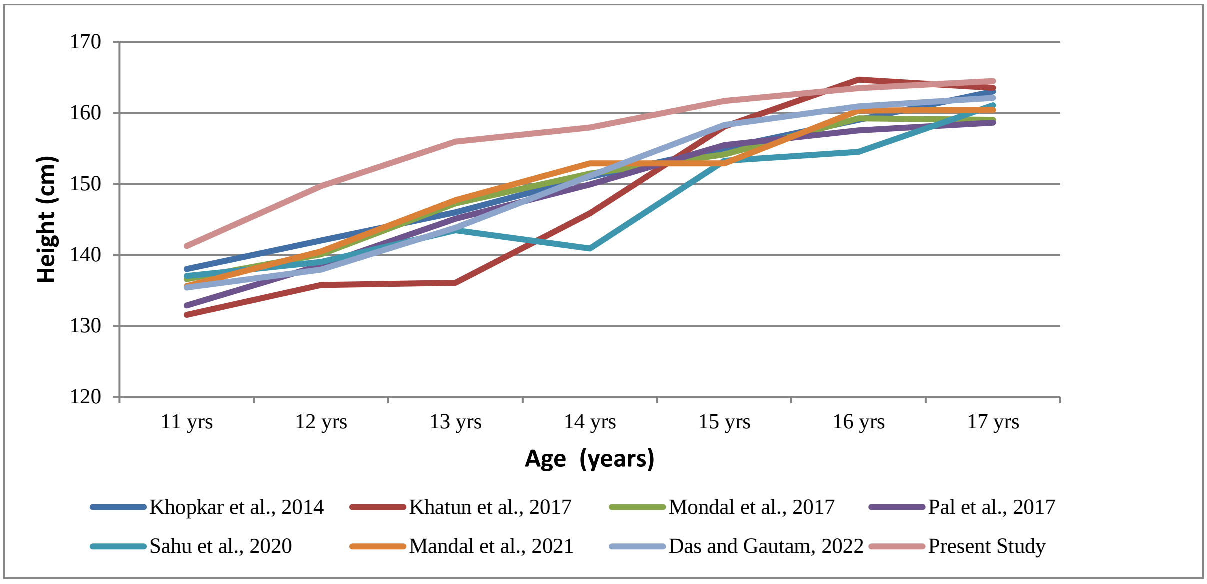

Figure 3. Comparison of mean height (cm) among the adolescent boys of present population with other Indian studies.

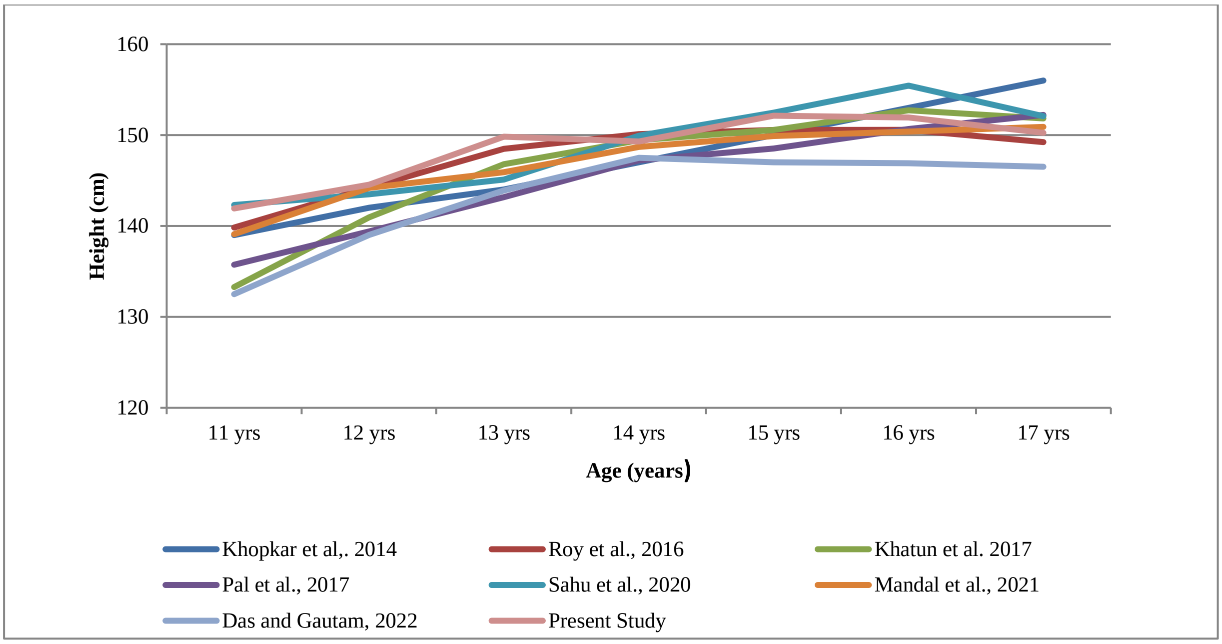

Figure 4. Comparison of mean height (cm) among the adolescent girls of present population with other Indian studies.

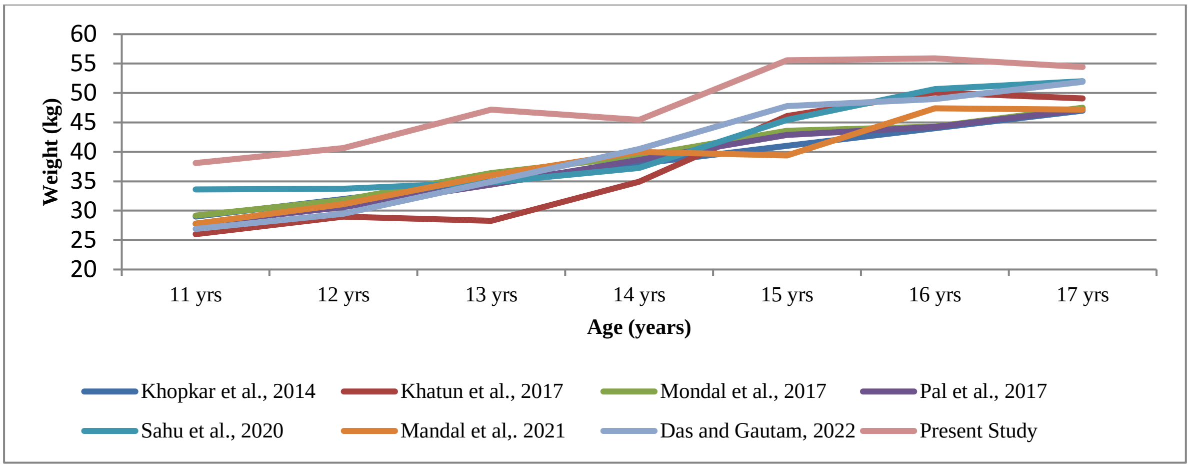

Figure 5. Comparison of mean weight (kg) among the adolescent boys of present population with other Indian studies.

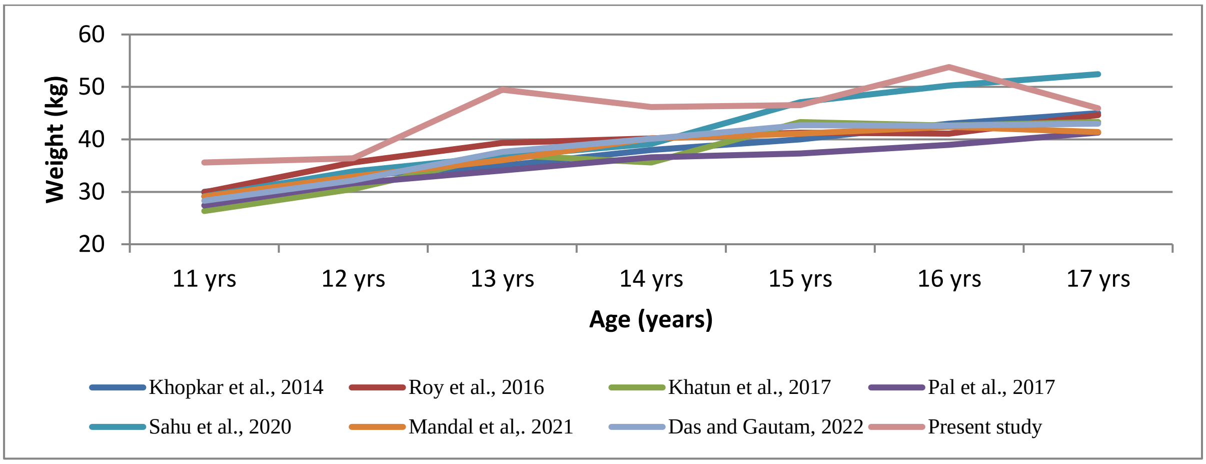

Figure 6. Comparison of mean weight (kg) among the adolescent girls of present population with other Indian studies.

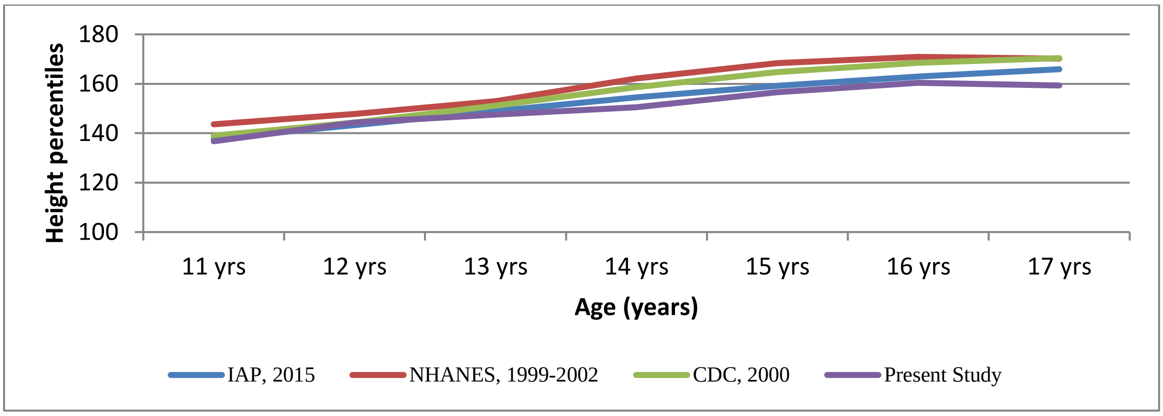

Figure 7. Comparison of 25th percentile values of height with National and International cut offs for boys.

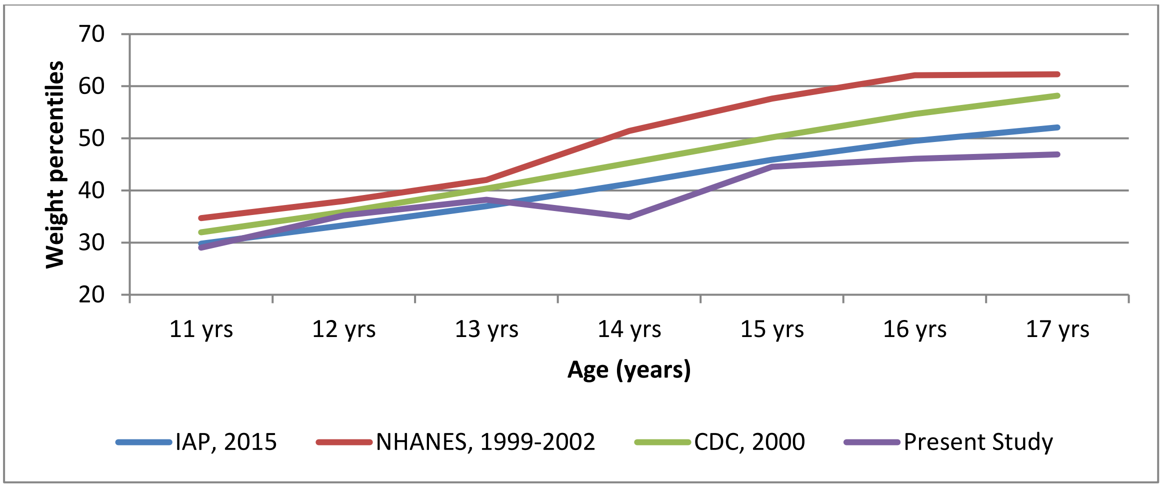

Figure 8. Comparison of 25th percentile values of weight with National and International cut offs for boys.

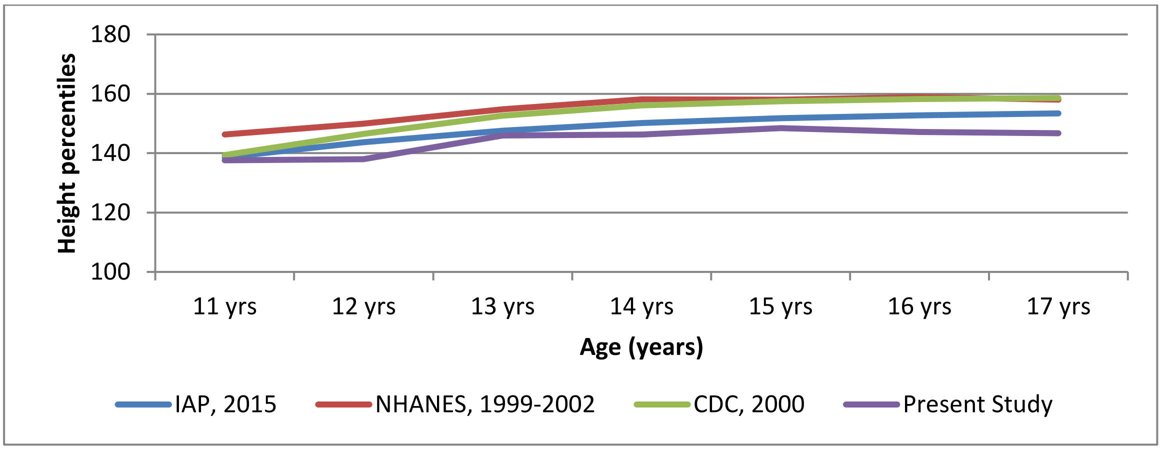

Figure 9. Comparison of 25th percentile values of height with National and International cut offs for girls.

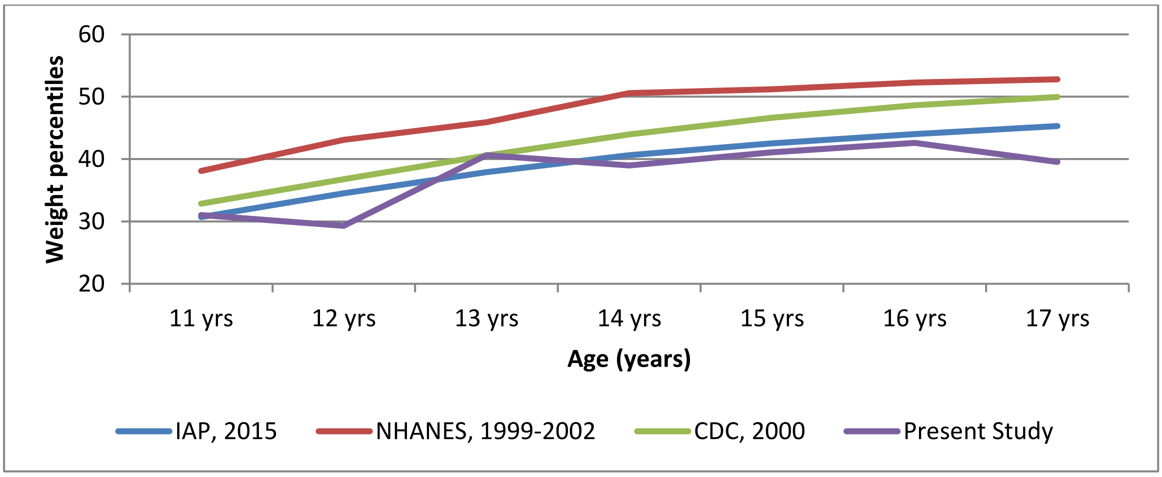

Figure 10. Comparison of 25th percentile values of weight with National and International cut offs for girls.

TSF showed a decreasing trend from 11 to 14 years among the boys, but the trend was reversed among the girls from 12 to 16 years. However, SSSF did not show any gradual increase or decreasing trends among adolescents with the advancement of age. PBF shows a decreasing trend for 11 to 14 years in boys, while a gradual increase was found among females (except for 17 years). Comparing the total mean of PBF, FM, and FFM, it was observed that females have high levels of adiposity and more fat mass, and males have more lean body mass. Similar observations were reported by various Indian and non-Indian studies (Chowdhury et al., 2007; Mehdad et al., 2012; Feedman et al., 2013; Rakic and Pavlica, 2014; Sharma and Mondal, 2018; Mandal et al., 2021). The linear regression results show that BMI and PBF are positively and significantly associated with anthropometric and body composition variables. Tremendous variability was seen in the case of FFMI with BMI (Table 3) in the case of females ($p<0.01$), which is similar to the findings of Sharma and Mondal (2018) and Dutta and Sengupta (2020) with FMI for males ($p<0.01$). From linear regression (Table 4), it is also found that the most significant variability was found for FMI with PBF among girls ($p<0.01$) and with SSSF followed by TSF among boys ($p<0.01$).

De (2017) reported an increment of PBF with an increase in age among adolescent girls. Cintra et al. (2013) also observed that body fat percentage increased in girls with sexual maturity, but the trend was reversed in boys. However, such a trend was not found in our study. BMI significantly correlated with all the body composition parameters for males and females. A study conducted by Maynard et al. (2001) also reported a high correlation between BMI and body composition parameters. This study used Triceps and Sub-scapular skinfolds for the assessment of body composition, and according to an earlier study, girls possess higher adiposity in their triceps and sub-scapular regions (Zimmermann et al. 2004), which may be the reason the females of this study indicated more fat accumulation than boys. However, through longitudinal study, this phenomenon can be explained better.

CONCLUSION

Present study provides information about the physical growth and body composition of the studied Bengali adolescents residing one of the community development block of Darjeeling district. The boys were taller than other Indian adolescent boys but not the girls. Both male and female adolescents were heavier than their other Indian peers. The growth percentile shows similar pattern with the 25th percentiles of National (IAP, 2015) cut offs but comparison with International cut offs (CDC, 2000; NHANES, 1999-2002) proved that the adolescents were shorter and thinner than their international counterparts indicating poor growth among them. The boys had more lean mass whereas; the girls had more adiposity levels with more fat mass (in total). However, there was no sex-specific significant difference in fat mass (FM). In-depth studies are required to understand such phenomenon. Moreover, this study also reflects the needs of development of regional growth standard necessary for better understanding of growth among adolescents of different ethnic groups.

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