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Body Composition among Rural Bengalee Preschool Children of Integrated Child Development Service (ICDS) Scheme of Sagar Island, South 24 Parganas, West Bengal, India

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ABSTRACT The present study was carried out to studyage and sex variations in body composition characteristics among preschool children of Integrated Child Development Service (ICDS) Scheme from Sagar Island, South 24 Parganas, West Bengal. This cross-sectional study was undertaken at 28 Integrated Child Development Services scheme centres of this area. Subjects were randomly selected from these centers. A total of 656 (Boys: 326; Girls: 330) preschool children of 3-5 years were measured. It was found that boys were taller and heavier than girls at all ages except 3 years. With increasing age, there was a gradual decline in mean skinfolds thickness. ANOVA revealed that there existed significant age variations ($p< 0.001$) in all anthropometric measurements, body mass index (BMI) and body composition variables except for fat mass (FM) among boys. Mean Percentage Body Fat (PBF) values among boys decreased with increasing age, but among girls mean PBF values increased with increasing age. A similar sexual dimorphism trend was observed with fat mass (FM) and fat mass index (FMI). Results of the sex specific correlation coefficient between anthropometric measurements and body composition variables showed that majority of the body composition variables were highly correlated with the anthropometric variables. In conclusion, the researchers observed that there was sexual heterogeneity in the relationship between age and body adiposity as measured by PBF, FM and FMI.

INTRODUCTION

Body composition has been commonly investigated in epidemiological, clinical and population studies for health purpose. During the last few decades, investigators have emphasized the accuracy of newer techniques, such as Dual-Energy X-ray Absorptiometry (DXA), Magnetic Resonance Imaging (MRI) and Computerized Tomography (CT), for measuring body composition. Nevertheless, anthropometry is still the most widely used method and it is used to estimate fat distribution (Moreno et al. 2001). The distinct advantages of anthropometry are that it isportable, non-invasive, inexpensive and useful in field studies,and there is also a substantial literature available (Wang et al. 2000). However, recently, a great deal of attention has been given to include body composition. These studies arise from the necessity for more sensitive index of nutritional status and its relation with socio-economic status of populations (Zavaleta and Malina 1982).

Due to very rapid postnatal growth during infancy period major changes occur in body composition. Knowledge of these changes in body composition in infants is useful in understanding the nutritional needs and functional outcome of nutritional management for healthy and sick infants (Koo 2000). Therefore, assessment of fat (FM) and fat-free mass (FFM) is of considerable interest in the evaluation of body composition and nutritional status in children. Knowledge of the body composition in terms of fat and fat-free mass is used in pediatrics to estimate a child's nutritional status. To obtain the fat content or protein content sophisticated techniques are also available (Mandal and Bose 2017).

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Several studies have been conducted in children to estimate the body composition by measuring percentage of body fat (PBF), FM, and FFM (Mesa et al. 1996; Musaiger and Gregory 2000). It is documented that the amount of body fat is a good indicator of health and nutritional status (Eveleth and Tanner 1990). If the energy balance is negative, the stored fat depletes, which is reflected in lower PBF and FM. It has been suggested by many authors that fat distribution also indicates fat tissue development as well as nutritional status (Lopez-Contreras Blanc 1988;Walus et al. 2004). The FFM is an indicator of muscularity and has been recommended in several studies as a simple anthropometric method to assess the nutritional status in children (Boye et al. 2002). It has been reported that the fat mass index (FMI) and fat free mass index (FFMI) are also useful indicators in assessing the nutritional status in tall and dwarf subjects with protein-energy malnutrition (VanItallie et al. 1990).

Sexual dimorphism in human body composition was evident from fetal life but emerges primarily during puberty (Wells 2007). Interventions may be better directed at maintaining a healthy weight for the majority of preschool children, which can still be achieved through the promotion of physical activity and gross motor skill development through activities that could also improve cognitive development and the reduction of sedentary behaviour (Draper et al. 2016). Determination of fat and fat-free mass is of considerable interest in the evaluation of body composition and nutritional status in children. Measuring FFM in infants and young children is of scientific and public health interest (Sen et al. 2009). Different scholars suggest the use of the skinfold method, the measurement of subcutaneous fat, in field setting as an alternative to laboratory methods. This method is the most widely adopted field method for measurement of body fat in children (Heyward and Stolarczyk 1996; Heyward 2006).

The FFM is an indicator of strong build of the body composition, especially among preschool children. At present the most commonly used methods are BMI and skinfolds. These anthropometric based methods are easier, inexpensive and relatively quick to perform but are not direct measures of adiposity from skinfold data requiring equations to calculate PBF from thickness measurements. In this present study the researchers use a new skinfold equation developed among South Asian children by Sen et al. (2010) for converting anthropometric measurements to PBF.

Objective

The objective of the present study was to evaluate the relationship of age, sex and anthropometric parameters with body composition characteristics among studied preschool children.

METHODOLOGY

The Setting

The present study was undertaken at Sagar Block of South 24 Parganas district, West Bengal, India. The study area is situated at Gangasagar, Sundarban area of Kakdwip subdivision. This is located at approximately 130 km away from Kolkata, the provincial capital of West Bengal. Total area of Sagar Islandsis 194.60 miles (504 km^2) and it has a population of 206890 (Census 2011). This block has a population density of 1063.155 (410.49 per km^2) per square mile. Growth rate was 20.38 percent during 2001-2011 but decadal growth rate of South 24 Parganas is 20.89 percent whereas this block decadal growth rate is 17.84 percent. The area is remote and mostly inhabited by Hindus.

The Sample

All preschool children (3-5 years old) living in Sagar Block are enrolled at the above mentioned centres. The subjects were randomly selected from 28 ICDS centres of Sagar Block, South Parganas District. The total sample size was 656 children (326 males and 330 females), aged 3 to 5 years.

Estimation of Age

Ages of the children were ascertained from the "*Anganwadi*" registers and immunization card and also subsequently confirmed by parents of the children. For statistical analyses, age was grouped into 12 months intervals.

Institutional Approval

Formal ethical approval was obtained from Vidyasagar University and ICDS authorities prior to the commencement of the study.

Administrative Nutritional Supplementation

The ICDS authorities have allocated Indian Rupees 4/- per head (children) per day for children 6-72 months, 6/- Rupees per head (children) per day for the severely malnourished children, aged 6-72 months and also 5/- Rupees for pregnant women and nursing mothers by the Government of India to provide supplementary nutrition to the children. This financial assistance ensures that each child is given a porridge consisting of 500kcal., 12-15 gram protein and for severely malnourished children 800 kcal. and 20-25 gram protein per day. For pregnant women and nursing mothers it is 600 kcal. and 18-20 gram protein per head per day.

Anthropometric Measurements

All anthropometric measurements were measured by one investigator (SPG) on each subject following the standard method (Lohman et al. 1988; Musaiger and Gregory 2000). Height was measured using Martins anthropometric rod to the nearest 0.1 cm. Weight was measured using spring balance weighing machine and recorded nearest 100 gm. Mid-upper arm circumference (MUAC) was measured using non-stretchable plastic measuring tape to the nearest 1 mm accuracy. Skinfold measurements such as Triceps (TRISKF), Biceps (BISKF) and Suprailiac skinfold (SUPRAISKF) thickness were measured to the nearest 0.1 mm using Holtain skinfold calliper. Measurements of MUAC and skinfold thickness were taken on the left side of the subject body.

Assessment of Body Composition

Percentage of Body Fat (PBF) of the subjects was derived using three skinfold thickness that is, Triceps (TRISKF), Biceps (BISKF) and Suprailiac (SUPRAISKF) skinfold. After deriving PBF, Fat Mass (FM, kg) and Fat- Free Mass (FFM, kg) were also calculated.All measurements were taken on the left side of the subject body. PBF was calculated using standard formulae (Sen et al. 2010).

These equations were:

Boys: Percentage of body fat (PBF) $=-8.75+3.73\times B+2.57\times S$.

Girls: Percentage of body fat (PBF) $=-69.26+5.76\times B-0.33\times T^2+5.40\times M+0.01\times A^2$.

Where, B= biceps skinfold thickness in mm, T=triceps skinfold thickness in mm, S=suprailiac skinfold thickness in mm, M=mid-upper-arm circumference in cm and A=age in months.

The FM, FFM, FMI and FFMI were calculated following the standard formula:

FM = [PBF/100] × Body Weight (kg) (Van Itallie et al. 1990).

FFM (Lean Body Mass, LBM) =Body weight (kg) - FM (kg) (Van Itallie et al. 1990).

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

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

Data Management and Statistical Analyses

Statistical analyses were performed using SPSS (Version 16.00) and MS Excel software. Sex differences (age-specific) were determined using student's t-test. One-way ANOVA (Scheffe's procedure) analyses was undertaken to test for age variations of these variables. Pearson's correlation coefficients were used to evaluate the relationship between anthropometric variables and composition variables.

RESULTS

The results of the present study revealed that boys were taller and heavier than their counterparts at all ages, except of 3 year (Table 1). Significant age variations in all anthropometric variable were observed (Table 1), maximum age variation was found in height (Boys: F= 336.58; $p<0.001$; Girls: F= 293.44; $p<0.001$), followed by weight (Boys: F= 115.04; $p<0.001$; Girls: F= 145.44; $p<0.001$). There were significant sex differences in mean height ($t = 2.48$, $p< 0.01$), weight ($t = 2.53$, $p< 0.01$) and triceps skinfold thickness ($t = -2.28$, $p< 0.05$) at age of 5 years. The younger girls showed greater mean values in triceps skinfold thickness. The boys at age of 3($t =2.30$, $p<0.01$) and 5 ($t = 2.53$, $p< 0.01$) years were heavier than girls. Middle aged boys showed more mean values of MUAC ($t = 3.86$, $p<0.01$) and biceps skinfold thickness ($t =2.40$, $p<0.01$).

The characteristics of adiposity measurersare presented in Table 2. Generally all adiposity measurers showed significant age variations except for FM among boys. Maximum age variations were observed in FFM and FM among boys and girls, respectively. Overall boys showed significantly higher mean values of FFM and FFMI at all ages. Girls showed significantly higher mean values of PBF, FM and FMI.

Table 1: Age and sex-specific anthropometric characteristics of the subjects

Variables	*3 years*			*4 years*			*5 years*			*ANOVA*	
	Mean (SD)			*Mean (SD)*			*Mean (SD)*			*F-value*	
	Boys (n =119)	*Girls (n =120)*	*t-value*	*Boys (n =103)*	*Girls (n =110)*	*t-value*	*Boys (n =104)*	*Girls (n =100)*	*t-value*	*Boys*	*Girls*
Height (cm)	91.55(4.31)	91.91(4.03)	-0.66	99.12(3.70)	98.62(4.16)	0.93	105.97(4.36)	104.61(3.39)	2.48**	336.58***	293.44***
Weight (kg)	11.94(1.32)	11.57(1.19)	2.30**	12.90(1.47)	12.76(1.39)	0.74	14.78(1.46)	14.35(0.98)	2.53**	115.04***	145.44***
MUAC (cm)	14.22(0.91)	14.35(0.88)	-1.09	14.73(0.67)	14.35(0.77)	3.86***	14.85(0.95)	14.78(0.82)	0.60	17.35***	9.53***
BISKF (mm)	5.37(1.22)	5.12(0.80)	1.92	4.93(0.76)	4.64(0.97)	2.40**	4.58(0.77)	4.65(0.82)	-0.57	19.16***	11.29***
TRISKF(mm)	7.95(1.63)	7.97(1.20)	-0.08	7.52(1.10)	7.19(1.40)	1.89	6.75(0.92)	7.10(1.29)	-2.28*	25.20***	15.46***
SUPRAISKF(mm)	6.40(1.59)	6.50(1.66)	-0.46	6.13(1.47)	5.99(1.76)	0.65	5.51(1.01)	5.83(1.22)	-0.18	11.67***	5.55**

Significance level: $p < 0.05 = ^{*}$, $p < 0.01 = ^{**}$, $p < 0.001 = ^{***}$

Table 2: Age and sex-specific adiposity characteristics of the subjects

Variables	*3 years*			*4 years*			*5 years*			*ANOVA*	
	Mean (SD)			*Mean (SD)*			*Mean (SD)*			*F-value*	
	Boys (n =119)	*Girls (n =120)*	*t-value*	*Boys (n =103)*	*Girls (n =110)*	*t-value*	*Boys (n =104)*	*Girls (n =100)*	*t-value*	*Boys*	*Girls*
BMI (kg/m^2)	14.23(1.03)	13.69(1.08)	3.95*	13.10(0.94)	13.14(1.37)	-0.20	13.15(0.79)	13.10(0.60)	0.48	53.21***	10.75***
PBF	27.74(7.15)	33.38(6.50)	-6.39***	25.39(5.47)	45.91(6.51)	-24.95*	22.51(4.71)	62.39(8.28)	-42.06***	21.51***	456.84***
FM (kg)	3.34(1.08)	3.88(0.94)	-4.18***	3.28(0.88)	5.88(1.18)	-18.28***	3.34(0.81)	8.97(1.49)	-33.46***	0.13	489.46***
FFM (kg)	8.60(1.11)	7.68(0.92)	6.99***	9.62(1.28)	6.88(1.00)	17.32**	11.45(1.27)	5.37(1.15)	35.9***	153.94***	142.76***
FMI	3.95(1.10)	4.58(1.00)	-4.62***	3.34(0.88)	6.05(1.21)	-18.80***	2.96(0.65)	8.17(1.07)	-41.60***	33.88***	292.66***
FFMI	10.28(1.24)	9.11(1.06)	7.83***	9.76(0.84)	7.08(1.01)	20.98***	10.19(0.85)	4.94(1.15)	37.10**	8.12***	415.27***

Significance level: $p < 0.05 = ^{*}$, $p < 0.01 = ^{**}$, $p < 0.001 = ^{***}$

It should be mentioned that among boys mean PBF values decreased with increasing age, but in case of girls mean PBF values increased with age. A distinct increase in mean FM with age was observed among girls.While there was an increase in mean FFM (or lean body mass, LBM) with age in boys, there was a sharp decrease in girls. Among girls, there was a distinct increase in mean FMI with age and a corresponding decrease in FFMI with age. A reverse trend was observed among boys.

The results of the sex specific Pearson correlation coefficients between anthropometric variables and body composition variables are shown in Table 3. Most of the adiposity measurers were highly correlated with anthropometric variables. However, PBF, FM, FFM, FFMI and FFMI did not show significant correlation with weight, height, BMI and MUAC for boys; BMI and BISKF for girls. Most of the adiposity measurers showed positive correlation with anthropometric variables.

DISCUSSION

It has been reported that skinfold thickness is accepted as body fatness predictors and it represents about forty to sixty percent of total body fat in the subcutaneous region of the body and can be directly measured using a well-calibrated caliper. Equations that predict body composition values provide away of obtaining such data from variables that can be measured easily and accurately in large-scale epidemiological and population studies where sophisticated laboratory settings are impractical. The predicted values of body composition are less precise than those from measured laboratory procedures, but they are less expensive, and they are practical and easy to apply (Moreno et al. 2002). Slaughter et al. (1988) developed equations for estimating PBF based on data among Caucasian and African American children living in the USA. These equations tended to underestimate fatness for most of the Indian children. Indians have been shown to possess relatively increased abdominal fat, including subcutaneous as well as intra- abdominal fat, compared with Caucasians (Raji et al. 2001).Therefore, the equation to estimate PBF developed by Sen et al. (2010) on data among Indian children was more applicable on this study's data.

The results of the present study clearly show that boys showed significantly higher mean values of FFM (or lean body mass, LBM) and FFMI at all ages and girls showed significantly higher mean values of PBF, FM and FMI. It could be interpreted as boys being more muscular. Similarly, it was also found that among boys mean PBF values decreased with increasing age, but in case of girls mean PBF values increased with age, therefore it might be stated that boys were losing their body fat by with a concomitant increase in musculature. Gender dimorphism of fat patterning in children is present even at the preschool and early school age (Horvat et al. 2009; Sakai et al. 2012). It was also found that most of the adiposity measurers were highly correlated with anthropometric variables. It has been reported that Indian infants are not only small at

Table 3: Sex specific Pearson correlation coefficients between anthropometric measurements and body composition variables

Sex	*Variables*	*PBF*	*FM*	*FFM*	*FMI*	*FFMI*
Boys	Height	-0.24**	0.20**	0.82**	-0.31**	-0.10
	Weight	-0.10	0.41**	0.86**	-0.04	0.19**
	BMI	0.26**	0.33**	-0.02	0.51**	0.55**
	MUAC	0.20**	0.46**	0.37**	0.23**	-0.04
	BISKF	0.85**	0.75**	-0.48**	0.82**	-0.57**
	TRISKF	0.79**	0.64**	-0.51**	0.79**	-0.45**
	SUPRAISKF	0.84**	0.70**	-0.52**	0.81**	-0.54**
Girls	Height	0.75**	0.81**	-0.45**	0.66**	-0.79**
	Weight	0.69**	0.83**	-0.24**	0.76**	-0.54**
	BMI	-0.13*	-0.01	0.35**	0.13*	0.43**
	MUAC	0.41**	0.42**	-0.28**	0.50**	-0.27**
	BISKF	-0.05	-0.04	0.07	0.04	0.17**
	TRISKF	-0.34**	-0.27**	0.41**	-0.25**	0.41**
	SUPRAISKF	-0.20**	-0.18**	0.17**	-0.15**	0.24**

Significance level: $p < 0.05 = ^{*}$, $p < 0.01 = ^{**}$, $p < 0.001 = ^{***}$

birth but they also have less muscle mass and relatively more fat mass, the so-called 'thin-fat body' syndrome (Yajnik et al. 2002; Yajnik et al. 2003). Enhanced total body fatness with age was confirmed by many studies over the last two decades (Horvat et al. 2009). Energy expenditure, in particular physical activity level, may have a greater influence on body composition in early childhood (Atkin and Davies 2000) and also the amount of body fat is a good indicator of health and nutritional status (Eveleth and Tanner 1990).

There is an immediate and long-term negative impact of unhealthy body composition on children. It leads to non-insulin-dependent diabetes mellitus (NIDDM) and cardiovascular disease (CVD) among youths. Also, socialization and early learning patterns are affected negatively and can last a lifetime (Dietz 1998). Recently different studies have emphasized on the physical activities and fatness and its effect on overweight, obesity and serious health consequences in adulthood (Volgyi et al. 2015; Draper et al. 2016; Palanska et al. 2017). The fatness among the preschool children of the present study was much higher than the children of same age group from the previous studies of the same state of West Bengal (Biswas and Bose 2011; Das and Bose 2012; Mandal and Bose 2017).

An important finding of the present study was that there existed a significant negative correlation of age with PBF among boys and a strongly significantly positive association of PBF with age among girls. This implied that there was heterogeneity in these relationships between the sexes. However a previous study on Thai preschool children had shown no gender difference in body fat distribution (Yamborisut et al. 2012).

CONCLUSION

Significant age and sex variations were found in the fatness. A very important finding was that there was a significant positive and negative correlation of age with PBF among boys and girls, respectively. With increasing age, there was significant gain in body fat in girls, which was absent in boys.

RECOMMENDATIONS

To fully understand the progressive of age and sex variations in BMI and fatness among preschool children more studies are required. Hitherto, such studies are lacking from India. Moreover, since India is a land of immense population diversities, such investigations should be undertaken among other ethnic populations as well.

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