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Body Composition of Rural Children Aged 2-6 Years of Bengalee Ethnicity from Arambagh, West Bengal, India

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ABSTRACT Knowledge of the body composition in terms of fat and fat-free mass is used in pediatrics to estimate a child's nutritional status and the prevalence of obesity in children and youth. The present cross-sectional study focused to evaluate the relationship of age, sex and Body Mass Index (BMI) with body fat composition measures among preschool children of Bali Gram Panchayat, Arambagh, Hooghly District in West Bengal, India.A total of 1,012 children (boys = 498. girls = 514) aged 2-6 years were measured. Significant age and sex variations were found in BMI and the body composition measures. Sex specific correlation of age with six body composition variables (except BMI) showed highly significant ($p < 0.01$) positive correlations except only in one, that is, PBF among boys, which showed a negative correlation. Sex specific correlation of BMI with other five body composition variables showed significant positive correlations ($p< 0.01$) between both the sexes. Authors have a weaker correlation among boys ($r = 0.12$) compared to much stronger correlation among girls ($r=0.72$) in case of PBF.

INTRODUCTION

A very rapid postnatal growth occurs in infancy and is accompanied by major changes 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). Nutrition, physical activity and behavior modifying techniques are widely applied components of interventions treating obese children and adolescents (Martínez-Gomez et al. 2009). In a very recent study, it was found that the relation between body composition and physical activity has not confirmed in expected parameters among the preschool children of Poland and the effect of inadequate physical activity is not visible in this period of life but may have serious health consequences in adulthood (Palanska et al. 2017). Intervention efforts 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 behavior (Draper et al. 2016). Several methods are available to assess childhood and adolescent obesity but the most widely used both in clinical and epidemiological settings, are weight, height and body mass index (Moreno et al. 1999). Tracking of obesity in children is generally performed using body mass index (BMI). However, the limitation of BMI is that it does not distinguish obesity due to excess fat mass from the obesity due to excess lean body mass (Must and Anderson 2006). Nowadays, BMI has progressively replaced the concept of 'ideal body weight' since the latter had the drawback of being dependent upon reference standards of body weight and height from populations, which slowly changed from decade to decade and also varied according to which reference standard was used (Garn et al. 1986). Methods to examine changes in children's body fat composition include simple field methods such as bioelectrical impedance (BIA) and skin fold thickness measurements (Vicente-Rodriguez et al. 2012).Repeated and accurate assessment of body composition during infancy enables one to determine the composition of the weight gained over time and provides key information for evaluating nutritional requirements, the efficacy of diet

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and medical interventions, and the influence of chronic diseases (Olhager et al. 2003). The global prevalence of overweight and obesity among children increased from 4.2 percent in 1990 to 6.7 percent in 2010 and is expected to reach 9.1 percent by 2020 (de Onis et al. 2010). Childhood obesity is a serious risk factor for the development of obesity in adulthood, which impacts the overall state of health of the individual by increasing the risk of developing diabetes mellitus, hypertension, coronary artery diseases and metabolic syndrome (Aronne and Segal 2002, Lee et al. 2012). The assessment of body composition in children has taken on greater significance because of the need to study the prevalence of obesity in children and youth, the need to better document the tracking and genetics of body fatness, the need to relate fat patterning in childhood and fat patterning in adults, and the need to assess changes in the prevalence in obesity over time in a given population (Lohman 1989).

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 exist. These techniques are often difficult to apply in daily practice. An anthropometric approach is therefore relevant because of its simplicity (Gerver and Bruin 1996). Fat distribution or patterning in children is also associated with a higher incidence of coronary heart disease risk factors. Subscapular, suprailiac and abdominal skin folds have been used as indices of central body fat and have been found to be associated with high blood pressure (Shear et al. 1987) and higher serum lipid levels (Freedman et al. 1985). The major patterns of fat distribution develop in childhood and adolescence in both males and females (Bary and Bouchard 1988). Males develop more trunk fat than females, and this development is more clearly established after puberty. The alteration of fat patterns is being investigated using nutritional, exercise and medication intervention programs (Bary and Bouchard 1988).

The concept of fat-free mass index (FFMI) and fat mass index (FMI), in analogy to the BMI but using a two compartment model, merits a reappraisal and appears to be of interest in the classification of overweight/over fat patients and underweight/under lean, respectively (Schutz et al. 2002). Measuring fat-free mass (FFM) in infants and young children is of scientific and public health interest (Sen et al. 2009). Growth involves the deposition of both fat mass (FM) and fat-free mass (FFM) components. Quantitative information on FM and FFM has been extensively reported in different populations (Guo et al. 1997; Prins et al. 2008; Wickramasinghe et al. 2008; Kubo et al. 2010).

The relation between fat intake and body fat may develop over time and may not be evident in preschool children. Energy expenditure, in particular physical activity level, may have a greater influence on body composition in early childhood (Atkin and Davies 2000). Infants and young children grow rapidly and require nutrients not only for maintenance but also for growth. They require relatively more nutrients (2-3 times) per kg body weight than adults (ICMR 2009).

Objective

The objective of the present study was to evaluate the relationship of age, sex and BMI with body composition measures among preschool children of Bali Gram Panchayat, Arambagh, Hooghly District, West Bengal, India.

METHODOLOGY

The Area

The area of the present cross sectional study comprised remotely located villages under Bali Gram Panchayat, Arambagh, Hooghly District in West Bengal, India. The majority of inhabitants were Hindus. The data was collected from20 Integrated Child Development Service (ICDS) centers, commonly known as "Anganwadis", which provide food supplementation to these children, in the form of porridge.

Sample

A total of 1,012 children (boys = 498. girls = 514) aged 2-6 years were measured. Age and ethnicity of the subjects were verified from official records.

Anthropometric Variables

The anthropometric data collections were carried out by the first author (GCM) following a standard method (Lohman et al. 1988). Height was measured using anthropometric rod to the nearest 0.1cm.Weight was measured using weighing machine to the nearest 100g. Skinfold measurements were used to measure BF (%) from which fat mass (FM, kg) and fat-free mass (FFM, kg) were calculated. Triceps (TRSF) and subscapular (SSSF) skin fold thickness were measured to the nearest 0.1mm using Holtain skin fold caliper. Three derived variables were calculated, such as, BMI, FMI and FFMI.

Body mass index (BMI, kg/m^2)= Weight (kg)/ Height $(m)^2$ (WHO, 1995)

Percent body fat (PBF, %) (Slaughter et al. 1988)=

1.21 (TRSF+SSSF) -0.008 $(TRSF+SSSF)^2$ -3.2 (For Boys)

1.33 (TRSF+ SSSF) -0.013 $(TRSF+SSSF)^2$ -2.5 (For Girls)

Fat mass (FM, kg) = Body Weight (Kg) x [PBF/ 100] (Van Itallie et al. 1990)

Fat mass index (FMI, Kg / m^2) = [FM (Kg) / $Height^2$ (m^2)] (Van Itallie et al. 1990)

Calculation of FFM and FM indices:

The FFM and FM indices are equivalent concepts to the BMI, as shown in the following definition:

FFMI = Fat Free Mass (kg)/ $Height^2$ (m^2)

FMI = Fat mass (kg)/ $Height^2$ (m^2)

Note that, mathematically, BMI (kg/m^2) = FFMI(kg/m^2) + FMI (kg/m^2).

Reference intervals of FMI versus FFMI can be used as indicative values for the evaluation of nutritional status (over-nutrition and under-nutrition) of apparently healthy subjects and can provide complementary information to the classical expression of body composition reference values (Pichard et al. 2000). FMI is able to identify individuals with elevated BMI but without excess FM. Conversely, FMI can identify subjects with 'normal' BMI but who are at potential risk because of elevated FM (Schutz et al. 2002).

Statistical Analyses

Besides mean and SD, t-test and ANOVA were also done to test the significance level of sex differences and trends of growth, respectively. Pearson's correlation coefficient (r) was done to assess the level of correlation. The statistical analyses were done using computer package for social sciences (SPSS, version 11.0).

RESULTS

Table 1 represented the mean, SD, F and t (with significance) of age and sex specific six body composition and anthropometric variables. Except some cases, all the variables were highly correlated with age ($p < 0.001$). In case of PBF, among boys the mean values were decreasing with the increase in age (Fig.1) whereas, it was

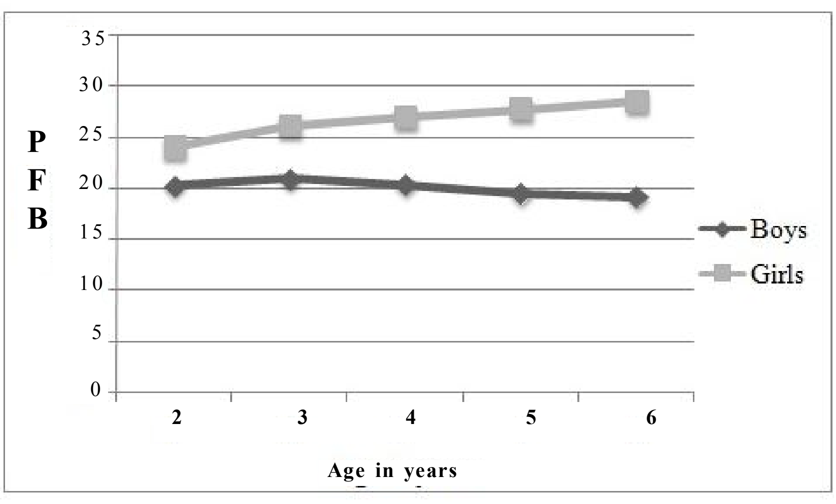

Fig. 1. Comparison of PBF between sexes with age

Table 1: Means, SDS, F and t (with significance) of age and sex-specific values of BMI and body composition measures

Variables	*Sex*	*Age in years* 2	3	4	5	6	*F*
	Boys	20.3 (1.8)	21.0 (1.4)	20.4 (1.5)	19.5 (1.5)	19.2 (1.6)	21.0***
PBF	Girls	24.1 (1.6)	26.2 (1.5)	27.0 (1.3)	27.8 (1.3)	28.6 (1.4)	124.1***
	t	-15.4***	-26.9***	-33.9***	-37.0***	-33.8***	
	Boys	2.0 (0.4)	2.4 (0.4)	2.6 (0.4)	2.6 (0.4)	2.9 (0.5)	42.8***
FM	Girls	2.2 (0.4)	2.8 (0.5)	3.3 (0.5)	3.7 (0.6)	4.2 (0.5)	203.1***
	t	-3.6***	-6.9***	-11.0***	-16.8***	-14.2***	
	Boys	7.8 (1.2)	8.9 (1.3)	10.2 (1.1)	10.7 (1.2)	11.9 (1.3)	138.7***
FFM	Girls	8 (1.0)	7.9 (1.0)	8.8 (1.0)	9.6 (1.0)	10.6 (1.1)	156.4***
	t	4.9***	6.8***	10.5***	7.8***	6.1***	
	Boys	0.2 (0.01)	0.3 (0.01)	0.3 (0.01)	0.3 (0.01)	0.4	62.0***
FMI	Girls	0.21 (0.01)	0.3 (0.01)	0.4 (0.01)	0.5 (0.01)	0.6	179.4***
	t	-0.8 ns	-2.4*	-4.5***	-9.7***	-8.1***	
	Boys	0.8 (0.3)	1 (0.3)	1.3 (0.3)	1.5(0.3)	1.8 (0.4)	117.3***
FFMI	Girls	0.7 (0.2)	0.9 (0.2)	1.1 (0.2)	1.3 (0.2)	1.6 (0.3)	159.7***
	t	3.6***	4.9***	7.1***	4.2***	3.0***	
	Boys	13.9 (2.0)	13.7 (1.9)	13.1 (1.3)	12.6 (1.8)	12.7 1.1)	14.9***
BMI	Girls	13.9 (2.2)	13.1 (1.6)	12.9 (1.2)	12.5 (1.2)	12.7 (1.1)	12.2***
	t	0.7 ns	2.8*	1.6 ns	-0.1ns	-0.03 ns	

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$, ns= not significant

the reverse in case of girls. Although the sex differences were significant in case of FM, FFM, FMI and FFMI, both boys and girls showed increasing trend with age. Except BMI, all other variables showed higher means among girls than boys. All the variables showed significant sex differences in each of the age groups but it was different in BMI, where it was significant ($t = 2.8$, $p < 0.05$) in case of only 3 years of age. Considering FMI, there was no significant sex difference among the children of age group 2 years and in case of the children of the age group of 3 years there was a slightly weaker association ($t = 2.4$, $p < 0.05$).

Sex specific correlation of age with six body composition and anthropometric variables is presented in Table 2. All the variables (except BMI) showed highly significant ($p < 0.01$) positive correlations except only in one, that is, PBF among boys, which was negatively correlated. A very important finding was that there was a significant negative correlation ($r = -0.29$. $p < 0.01$) of age with PBF among boys whereas age was strongly positively significantly ($r = 0.68$. $p<0.01$) associated with PBF among girls. In case of both FM and FMI, there were stronger correlations among the boys than the girls. R= 0.47 among the boys in comparison to the girls (R=0.78) in FM whereas, in case of FMI, these were R= 0.56 and R= 0.74, respectively. Other two variables showed more or less similar associations. As expected, significant negative correlations were found in case of BMI.

Table 2: Sex specific correlation of age with 6 BC variables

Variables	*R* *Boys*	*Girls*
PBF	-0.29**	0.68**
FM	0.47**	0.78**
FFM	0.72**	0.74**
FMI	0.56**	0.76**
FFMI	0.69**	0.74**
BMI	-0.31**	-0.26**

** $p < 0.01$

In Table 3 sex specific correlations of BMI with other five body composition variables are shown. All the variables showed significant positive correlations ($p< 0.01$) between both the sexes except in PBF among boys ($p<0.05$). In this table, the heterogeneity in the relationship of BMI with PBF between the sexes was also noticed. Although BMI was significantly correlated with PBF in both boys ($r = 0.12$. $p < 0.05$) as well as girls ($r = 0.72$. $p < 0.01$), the strength of this association was much stronger amongst the latter. Among other body composition measures like FFM, FMI, FFMI the level of correlation was more or less the same except in FM where a

Table 3: Sex specific correlation of BMI with 5 BC variables

Variables	*R*	
	Boys	*Girls*
PBF	0.12*	0.72**
FM	0.92**	0.98**
FFM	0.99**	0.99**
FMI	0.96**	0.98**
FFMI	0.99**	0.99**

* $P < 0.05$. ** $p < 0.01$

slightly stronger association was found among boys (r = 0.92) than girls (r= 0.98).

DISCUSSION

Based on skin fold measurement, Yajnik et al. (2002-2003) have shown that Indian babies are not only small at birth but they also have less muscle mass and relatively more fat mass, the so-called 'thin-fat baby' syndrome. Unhealthy body composition has an immediate and long-term negative impact on children. Adult diseases, such as non-insulin-dependent diabetes mellitus (NIDDM) and cardiovascular diseases (CVD) are now increasingly showing up in youth. Socialization and early learning patterns are affected negatively and can last a lifetime (Dietz 1998).

A study on Caucasian children has shown that the difference in fat distribution between boys and girls increases with sexual maturity (Taylor et al. 2010). The Slaughter et al. (1988) equation that was developed in Caucasian and African American children living in the USA tended to underestimate BF (%) for most of the Indian children. The Slaughter et al. (1988) equation was published over twenty years ago, since when children in most populations have become more adipose. Indians have been shown to have relatively increased abdominal fat, including subcutaneous as well as intra-abdominal fat, compared with Caucasians (Raji et al. 2001). The PBF, FM and FMI among the preschool children of the present study were much higher than the children of same age groups from Purulia (Das and Bose 2012). The important finding of significant negative correlation of age with PBF among boys and age was strongly positively significantly associated with PBF among girls. This implied that there was heterogeneity in these relationships between the sexes. A very important finding was that there was a significant negative correlation of age with PBF among boys whereas age was strongly positively significantly associated with PBF among girls whereas, among the Thai preschool children, there was no gender difference in body fat distribution indices and change in central body fat distribution of children could be strongly influenced by their changes in age, BMI and total body fat (Yamborisut 2012). Most of the recent studies emphasized on the physical activities and body fat composition and its effect on overweight, obesity and serious health consequences in adulthood (Volgyi et al. 2015; Draper et al. 2016; Palanska et al. 2017).

CONCLUSION

Significant age and sex variations were found in BMI and the body composition measures. A very important finding was that there was a significant negative correlation of age with PBF among boys whereas age was strongly significantly positively associated with PBF among girls. This implied that there was heterogeneity in these relationships between the sexes. Similarly, although BMI was significantly correlated with PBF in both boys as well as girls, the strength of this association was much stronger amongst the latter. With increasing age, there was significant gain in body fat in girls, which was absent in boys. Moreover, the increase in BMI with age was due to enhanced fat in girls while in case of boys that was not the case. In boys, increase in BMI with age may be due to increased musculature and other non-fat components like bones.

RECOMMENDATIONS

Further longitudinal studies are required to fully understand the dynamics of age and sex variations in BMI and body composition among pre-school children. Hitherto, such studies are lacking from India. Moreover, since India is a land of immense population diversities, this type of a study should be undertaken with other ethnic populations as well.

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