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Body Adiposity Index in Relation to Body Mass Index and Central Adiposity Measures in Preschool Children from Purulia, West Bengal, India

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ABSTRACT

Introduction: Many indices are available to evaluate adiposity. A new index, body adiposity index (BAIp) (expressed in % fat) for children [Hip circumference (cm)/ Height (m)0.8) – 38] has been developed (El Aarbaoui *et al.*, 2013). The objective of the present study was to use the index in a sample of preschool children to understand the association between BAIp and other anthropometric characteristics estimating adiposity. **Methods: T**he study was cross-sectional and the participants were 2- to 5-year-old preschoolers (505 boys and 463 girls) from Purulia district in West Bengal, India. Anthropometric measurements recorded were height, weight, waist circumference (WC), hip circumference (HC); derived indices were body mass index (BMI) and adiposity measures including waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), conicity index (CI) and BAIp. **Results:** Mean age of the participants was 4.03 years. Significant sex differences ($p< 0.05$) of anthropometric characteristics were found with respect to the mean values of body weight, BMI, HC, WHR, CI, and BAIp. Mean value of BAIp was higher in girls (13.0%fat) than in boys (12.28%fat). The BAIp was highly correlated ($p< 0.05$) to WHtR (r= 0.87 in boys, 0.86 in girls) than to BMI (r= 0.36 in boys, 0.41 in girls) and CI (r= 0.52 in boys, 0.46 in girls). In linear regression models, adiposity measures were observed to be significantly related to BAIp in preschoolers; age and sex were other predictors; coefficient was highest for WHtR (78.89) and least for WC (0.34). **Conclusion:** The results confirmed the existing hypothesis that BAIp, as an index for the assessment of children's body fatness, works with acceptable accuracy.

Key words: Adiposity, BMI, conicity index, waist-height ratio waist-hip ratio

INTRODUCTION

Body mass index (BMI) is a commonly used and reliable index of weight adjusted for height that correlates reasonably well with measures of adiposity for pediatric samples (Bouchard, 2007; Heymsfield *et al.*, 1995; Pietrobelli *et al.*, 1998). However, BMI is not always considered to be a reliable indicator of adiposity because body mass includes both fat mass and lean body mass (Cole *et al.*, 2007). The use of BMI is limited by differences in body fatness for a given age, sex, and ethnic background (Camhi *et*

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al., 2011; Datta Banik *et al*., 2014 a,b; Jackson *et al*., 2002).

It is reported that the body adiposity index (BAI) developed for using among adults (Bergman *et al*., 2011) overestimates body fat (%) in children (El Aarbaoui *et al*., 2013). To deal with this restriction, a study developed the new body adiposity index (BAIp) for children (El Aarbaoui *et al*., 2013). The study mentioned that BAIp [(Hip circumference (cm)/ Height $(m)^{0.8}$) – 38] is meant to be valid for large-scale surveys (El Aarbaoui *et al*., 2013). However, data representing communities from different countries are still unreported. Thus the present study deals with how well BAIp is associated with BMI and other anthropometric measures to depict adiposity in a sample of 2- to 5-year-old preschool children from Purulia in West Bengal, India.

METHODS

The study was cross-sectional in nature and included 2- to 5-year-old preschool children (505 boys, 463 girls) from thirty villages of Purulia district in West Bengal during 2011-12. The villages were located around 250 km towards West from Kolkata, the provincial capital of West Bengal, India. Selection of villages was done considering Census of India (2011) data following random sampling technique (Cochran, 1977). In those selected villages, households having 2- to 5-year-old children were identified. A probabilistic sample of 968 children of this age group representing heterogeneous social groups including Hindu castes and tribal communities was finally obtained. Boys and girls in the sample were in equivalent proportions as recorded in the survey. The children representing four age groups were: 2 years (27.2 %), 3 years (19.4 %), 4 years (21.1 %), and 5 years (32.3 %). Verbal as well as written informed consent were obtained from legal guardians of the participants before commencement of data collection. Ethical approval was obtained from the appropriate authority before commencement of the study. All measurements were taken by a single investigator (SD) to avoid any inter-observer disparity in values of the measurements. Anthropometric measurements were recorded following standard international protocol (Lohman *et al*., 1988). Height was measured to the nearest 0.1 cm using a standard Martin's anthropometer and body weight was recorded to the nearest 0.1 kg using a standard weighing scale (Libra, New Delhi). Waist and hip circumferences were measured using a plastic fibre tape (non-stretchable) directly on the skin at the level of the iliac crest (for waist) and at the maximum extension of the buttocks (for hip) (Wang *et al*., 2009). The body adiposity index (BAIp) for children was calculated (expressed in % fat) as follows: [(Hip circumference (cm)/ Height $(m)^{0.8}$) – 38] (El Aarbaoui *et al*., 2013). Other anthropometric measurements and derived indices included waist circumference (WC), hip circumference (HC), body mass index [BMI= weight (kg)/height^2 (m)], waist-to-hip ratio [WHR= waist circumference (cm)/hip circumference (cm)] and waist-to-height ratio [WHtR = waist circumference (cm)/height (cm)]. Conicity index [CI= waist circumference / (0.109 x square root of weight/ height)] was also calculated (Taylor *et al*., 2000). Independent sample *t*-test was used to determine the significant difference between sexes for all anthropometric measurements and derived indices. Multiple correlations showed the association between BAIp and other anthropometric parameters by sex. We also estimated the inter-relationships between BAIp and other anthropometric parameters (BMI, WC, HC, WHR, WHtR, and CI) through linear regression models considering age and sex as other predictors. A p-value < 0.05 was considered to be statistically significant. Data analysis was performed using Statistical Package for Social Sciences (SPSS 16) for windows.

Table 1. Descriptive statistics of age and anthropometric characteristics in boys (n= 505) and girls (n= 463).

Variables	*Sex*	*Mean (SD)*	*t*	*p-value*
Age (years)	Boy	4.06 (1.24)		
	Girls	4.01 (1.24)	0.62	0.54
Height (cm)	Boy	97.09 (11.05)		
	Girls	97.00 (11.59)	0.14	0.89
Weight (kg)	Boy	13.57 (2.90)		
	Girls	13.15 (2.93)	2.22	0.03
Body mass index (kg/m2)	Boy	14.32 (1.34)		
	Girls	13.91 (1.42)	4.66	<0.001
Waist circumference (cm)	Boy	47.51 (3.19)		
	Girls	47.82 (2.97)	-1.56	0.12
Hip circumference (cm)	Boy	48.83 (3.68)		
	Girls	49.46 (3.53)	-2.72	<0.01
Waist-to-hip ratio	Boy	0.97 (0.04)		
	Girls	0.97 (0.04)	2.35	0.02
Waist-to-height ratio	Boy	0.49 (0.05)		
	Girls	0.50 (0.05)	-1.39	0.17
Conicity index	Boy	1.18 (0.08)		
	Girls	1.20 (0.08)	-5.33	<0.001
Body adiposity index (BAIp) (%fat)	Boy	12.28 (4.14)		
	Girls	13.00 (3.90)	-2.77	<0.01

SD: Standard deviations (in parentheses).

RESULTS

Mean (± standard deviation) values of age in boys (4.06 ± 1.24 years) and girls (4.01± 1.24 years) were not significantly different (p> 0.05). However, a significant sex difference (p< 0.05) was found in body weight and BMI with higher mean values for boys. On the other hand, significant sex difference (p< 0.05) with respect to HC, CI, and body adiposity index (BAIp) (%fat) were also observed where girls had higher mean values than boys (Table 1).

Correlation between BAIp and WHtR was higher than for BMI and other anthropometric parameters (p< 0.05) in both sexes. In addition, BAIp was also significantly correlated (p< 0.05) to CI in boys and girls (Table 2).

The linear regression models for BAIp in relation to the adiposity measures (separately for WHtR, CI, WHR, BMI, HC, and WC) in boys and girls showed consistently significant (p< 0.05) interrelationships between the dependent variable (BAIp) and predictors (Table 3). Age and sex were other predictors. The regression models were significant and residuals were normally distributed. The regression coefficient of WHtR (78.89) was quite high and adjusted R-square (0.78) value showed highest variation in BAIp explained by the predictors (Model 1). Another index for central obesity, CI (regression coefficient 25.85) also showed significant interrelationship with BAIp (Model 2). However, regression coefficient for WHR was found to be negative (Model 3).

DISCUSSION

Childhood obesity is growing very fast worldwide and might have serious health consequences in adulthood (WHO, 2010). It is of paramount interest for all nutritionist, health specialists, and anthropologists to develop such measures that best reflect overall adiposity among infants and chil-

Table 2. Multiple correlation between age, BMI, the measures of adiposity and BAIp in boys (n= 505) and girls (n= 463).

Variables	*Age*	*BMI*	*WC*	*HC*	*WHR*	*WHtR*	*CI*	*BAIp*
Age	x	-0.24*	0.55*	0.58*	-0.16*	-0.50*	0.07	-0.31*
BMI	-0.15	x	-0.03	-0.06	0.07	0.40*	-0.42*	0.36*
WC	0.52*	0.01	x	0.85*	0.08	-0.09*	0.59*	0.21*
HC	0.62*	-0.08	0.81*	x	-0.46*	-0.05	0.43*	0.31*
WHR	-0.29*	0.14*	-0.09*	-0.51*	x	0.25*	0.18*	-0.23*
WHtR	-0.46*	0.45*	-0.01	-0.25*	0.44*	x	0.52*	0.87*
CI	-0.02	-0.42*	0.49*	0.24*	0.30*	0.49*	x	0.52*
BAIp	-0.27*	0.41*	0.12*	0.13*	-0.05	0.86*	0.46*	x

BMI: Body mass index; WC: Waist circumference; HC: Hip circumference; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio; CI: Conicity index; BAIp: Body adiposity index (for children). Boys: Above the diagonal; Girls: Below the diagonal. *p <0.05.

dren. These should include inexpensive, simple, non-invasive methods, use of portable instruments and be applicable in large-scale surveys. The previous study (El Aarbaoui *et al.*, 2013) developed one such indicator (BAIp) to estimate adiposity in children using anthropometric measurements, keeping in mind the limitations of expensive and sophisticated techniques for large-scale survey among children. An earlier study reported that BMI and body adiposity index or BAI (Bergman *et al.*, 2011) were significantly correlated to percent body fat (PBF) and the association between BMI and PBF was higher than that between BAI and PBF (Zhao & Zhang, 2015).

In our present study in a sample of preschool children in Purulia, West Bengal, the results showed significant correlation between BAIp and BMI along with other anthropometric characteristics estimating central obesity including WHtR and CI; correlation between BAIp and WHtR was higher than other adiposity measures in both sexes. Our study has further indicated that BMI may not be considered always as a reliable measure of adiposity. In the studied sample, boys showed a higher mean value of BMI than girls with significant sex difference (p<0.05). However, girls had higher mean values of adiposity measures including BAIp (expressed as %fat) and CI than boys with significant sex difference (p<0.05). Therefore, the present study further confirmed the results of previous reports representing different age groups and ethnic backgrounds (Datta Banik *et al.*, 2014a,b). The regression models showed that WHtR predicted BAIp with highest coefficient while other anthropometric parameters also had significant interactions (p< 0.05) with the index in boys and girls. In conclusion, the results of the present study confirmed the existing hypothesis that BAIp, as a new index for children's body fatness, works with acceptable accuracy (El Aarbaoui *et al.*, 2013). Further studies are needed in other age groups of children with higher sample size, representing different populations from this or other parts of the world in order to determine further the validity and concordance between BAIp and adiposity measures.

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Table 3. Regression of body adiposity index (BAIp) in response to the anthropometric characters among boys (n= 505) and girls (n= 463).

	Predictors	*B*	*SeB*	*Beta*	*t*	*p-value*	*Adj. R^2*	*R^2 Change*	*F Change*
Model 1	Constant	-26.73	0.85						
	Age	0.51	0.06	0.16	8.89	<0.001			
	Sex	0.41	0.13	0.05	3.24	<0.001			
	Waist-to-height ratio	78.89	2.02	0.95	7.74	<0.001	0.78	0.77	1067.70*
Model 2	Constant	-14.01	1.63						
	Age	-1.00	0.09	-0.31	-11.72	<0.001			
	Sex	-0.02	0.22	-0.01	-0.11	0.92			
	Conicity index	25.85	1.36	0.50	18.97	<0.001	0.34	0.34	165.08*
Model 3	Constant	37.95	3.19						
	Age	-1.11	0.10	-0.34	-11.11	<0.001			
	Sex	0.53	0.24	0.06	2.17	<0.05			
	Waist-to-hip ratio	-22.25	3.11	-0.22	-7.17	<0.001	0.14	0.14	51.75*
Model 4	Constant	0.22	1.45						
	Age	-0.74	0.09	-0.23	-7.72	<0.001			
	Sex	1.08	0.24	0.13	4.58	<0.001			
	Body mass index (kg/m2)	0.89	0.14	0.35	6.37	<0.001	0.20	0.20	79.94*
Model 5	Constant	-13.52	1.57						
	Age	-2.18	0.11	-0.70	-20.59	<0.001			
	Sex	0.16	0.21	0.02	0.76	0.45			
	Hip circumference (cm)	0.49	0.06	0.47	7.92	<0.001	0.35	0.35	171.43*
Model 6	Constant	-9.61	1.89						
	Age	-1.75	0.11	-0.54	-16.17	<0.001			
	Sex	0.44	0.23	0.06	1.95	<0.001			
	Waist circumference (cm)	0.34	0.08	0.28	4.47	<0.001	0.24	0.24	102.81*

Dependent variable: body adiposity index. B: regression coefficient; SeB : Standard error of B; Beta : Standardsed regression coefficient;
Adj. R^2: Adjusted R^2. * $p< 0.001$.

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