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THE USE OF THE SITTING HEIGHT INDEX OF BUILD TO DETERMINE UNDERNUTRITION AMONG RURAL BENGALEE PRESCHOOL CHILDREN OF WEST BENGAL, INDIA

ABSTRACT: At earlier ages, the body mass index (BMI) has some limitations in assessing nutritional status owing to the differential increase of the body segments. The present study assessed the nutritional status by using a new measure, the sitting height index of build (SHIB). A total of 1012 children (498 boys; 514 girls) aged between 2 to 6 years from 20 Integrated Child Development Service (ICDS) centers of Bali Gram Panchayat, Arambagh, West Bengal, India were studied. Height, weight, and sitting height (SH) were measured following standard protocol. The SHIB was calculated as [weight (kg) / Sitting Height (m)^3]. The prevalence of undernutrition was assessed by converting the thinness cut-offs to SHIB cut-offs. All the anthropometric variables showed the gradual increase with age except the subjects' BMI. The SHIB showed significant sex differences in the lower age groups. The prevalence of undernutrition as evaluated using SHIB was slightly lower (82.7%) than that utilizing thinness (low BMI for age) (85.2%). The sex-specific rates of undernutrition were 81.7 % and 83.7 % among boys and girls, respectively. The SHIB can be considered an alternative, dependable, and useful index to evaluate undernutrition among pre-school children. This index may have a distinct advantage in determining nutritional status across ethnic groups who vary in body size and shape, regardless of BMI.

KEY WORDS: Sitting-height index of build – BMI – undernutrition – Preschool children – India

INTRODUCTION

Body Mass Index (BMI) is a universally acceptable and widely used parameter for assessing body mass as well as the evaluation of under and over-nutrition of the population. However, the main complication arises due to the progressive change of proportions of a body during the growth period of the children and

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adolescents as it is dependent on age and height (Cole 1991). There is a tendency of increasing BMI with the ratio of sitting height (SH) to height, at least in adults (Bogin, Beydoun 2007). Furthermore, body composition not only influences the BMI but also it is influenced by relative leg length, which increases markedly in early ages (Bogin, Varela-Silva 2010, Burton 2015). Moreover, there are ethnic differences in the leg length. For example, the Inuit population of Greenland has a higher sitting height in comparison to the Danish population (Becker-Christensen 2005). Inuits have shorter leg length (Szathmary 1984), and sitting height/height ratios were higher than the Canadian population (Demirjian 1980). According to Charbonneau-Roberts and others (2005), BMI has its limitations, needs to be adjusted for sitting height and as Asians have shorter leg lengths, standing height in calculating BMI may mislead the estimation of undernutrition, overweight and obese.

Whereas, a relatively new, Sitting Height Index of Build (SHIB) is to be considered as a better and improve index for assessment. It is calculated by weight (body mass) / sitting height^3 (kg / m^3) and is much less age and leg length-dependent (Burton 2015). The leg length seems to have a negative impact on its mean cross-sectional area leads to little influence on leg mass. A special feature of the human pattern is that between birth and puberty the legs grow relatively faster than other post-cranial body segments (Bogin, Varela-Silva 2010). This justifies the exclusion of leg length from that index (Burton 2015). The other disadvantage of BMI is that different sized individuals having the similar geometrical structure (isometric), the larger ones have higher BMIs (Burton 2015). Sitting height in relation to in the context of body mass is being used for several years and Walker (1916) used sitting height because it is comparable to the quadrupeds' body length and opined that the means of sitting height increases approximately in proportion to (body mass) 1/3. In another study, Bardeen (1923) concluded that the equation 100 X (body mass) / (sitting height^3) remained constant and uncontrolled with age. For the determination of health risks through the cross-sectional and longitudinal evaluation the sitting height should be routinely incorporated (Charbonneau-Roberts *et al.* 2005). So, SHIB is considered to be a valid and better predictive index of build with advantages over BMI (Burton 2018).

BMI is not only used to measure a the body mass, adiposity, and so on but also to evaluate the prevalence of undernutrition as well as over-nutrition among the children, adolescents, and adults. For assessing the nutritional status of the children and adolescents, Cole and colleagues proposed (2007) cut off for undernutrition evaluated as thinness. On the other hand, the prevalence of overweight and obesity is also identified by the cut-offs as proposed by Cole and others (2000). Considering the disadvantages of BMI and the advantages of SHIB as a measure of assessing undernutrition among the 2–6 years studied preschool children, here we used the converted cut off of SHIB from the cut-offs as proposed by Cole and others (2007) for thinness (low BMI for age and sex) (*Table 2).*

TABLE 1: Distribution of the children under study by age and sex.

Age (Years)	Boys	Girls	Total
2	91	92	183
3	125	106	231
4	110	131	241
5	115	124	239
6	57	61	118
Total	498	514	1012

Objectives: The objective of the present study was to assess the nutritional status by using a new measure, SHIB among the rural preschool children from the Integrated Child Development Service (ICDS) centers. We also compared the findings thus obtained with the results evaluated using conventional thinness cut-off points.

MATERIALS AND METHODS

Area of study

The present study was conducted at ICDS centers of Bali Gram Panchayat, Arambagh, Hooghly District, West Bengal, India. There are 20 such centers and all were covered. This was a rural area approximately 100 km away from Kolkata, the provincial capital of West Bengal.

Children under study

A total of 1012 children (498 boys; 514 girls) aged between 2 to 6 years were included in this cross-sectional study (*Table 1*). All children present on days of study were included. They were of Bengalee speaking and all were Hindus by religion.

Anthropometric variables

Anthropometric measurements height (cm), weight (kg), and sitting height (cm) were taken by the first author following standard methods (Lohman *et al.* 1988). The Body Mass Index (BMI, kg/m^2) was calculated using internationally accepted standard formula: Weight (kg) / Height $(m)^2$.

The new parameter, SHIB was calculated by the following formula (Burton 2015):

$$SHIB = \frac{\text{Weight (kg)}}{\text{Sitting Height (m)}^3}$$

The technical error of measurements (TEM) was calculated for height and sitting height vertex and they were found to be within reference values as given by Ulijaszek & Kerr (1999). Thus, TEM was not incorporated in any analyses.

Assessment of nutritional status

Thinness was determined using age and sex-specific BMI cut off as proposed by Cole *et al.* (2007). The SHIB was computed following the standard formula of Burton (2018):

$$\frac{SHIB}{BMI} = \frac{\text{Weight (kg)}}{\text{Sitting Height (m)}^3} \times \frac{\text{Height (m)}^2}{\text{Weight (kg)}} = \frac{\text{Height}^2}{\text{Sitting Height}^3}$$

For example, if the cut-off BMI value for thinness Grade III for boys aged 2 years is 13.37 (kg/m^2). The equation value as proposed by Burton (2018) is 4.6 (kg/m^3). Then the new cut off for SHIB will be $13.37 \times 4.6 = 61.50$ (kg/m^3). Following the equation, we have converted the equivalent 'cut-off' values for all three categories (Grade I, II and III) based on age and sex of the children as initially proposed by Cole and others (2007) for assessing thinness which is presented in *Table 2*.

Statistical analyses

Statistical analyses were performed using SPSS (version 16.0). Between sexes differences in means of the variables were tested by students' t-test. The χ^2 test was applied to test for sex differences in the prevalence of undernutrition.

RESULTS

Table 3 represents the age-specific mean (SD), significance of sex differences, and overall sex combined values of the anthropometric variables among the studied children. Mean of the all anthropometric variables showed the gradual increase with age except in case of BMI where it decreased from lower to higher age groups. Regarding sexual dimorphism, children aged 4 years showed significant differences ($p < 0.01$ and $p < 0.001$) except in BMI. In case of the age group of 2 years, significant sexual dimorphisms ($p < 0.01$) were noticed in height, weight, and SHIB, whereas, among the children of the age group of 3 years weight, BMI and SHIB showed significant sex differences ($p < 0.01$). The new index of build, SHIB displayed significant sex differences ($p < 0.01$) among the children of lower age groups i. e. 2, 3, and 4 years but not among the children of 5 and 6 years.

Table 4 shows the prevalence of undernutrition based on SHIB. It is noticed from the table that, the overall prevalence (age and sex combined) of

TABLE 2: The converted SHIB (kg/m^3) cut-off values for undernutrition for 2–6 years old children.

Age	Boys			Girls		
(years)	Grade III	Grade II	Grade I	Grade III	Grade II	Grade I
2	61.50	64.95	69.64	58.26	61.16	65.25
3	64.14	67.57	72.23	63.60	66.64	70.90
4	69.44	73.00	77.92	67.47	70.70	75.21
5	72.16	75.87	81.00	70.0	73.30	78.10
6	75.00	78.90	84.42	73.92	77.58	82.92

TABLE 3: Sexual dimorphism and mean (SD) of the anthropometric variables among the studied children. ** (level of significance) = $p < 0.01$; *** = $p < 0.001$. This signifies the higher significant level than the previous one. That means the differences which are noticed reflect statistical significance.

Age (Years)	Sex	Height (cm)	Weight (kg)	Sitting ht. (cm)	BMI (kg/m^2)	SHIB (kg/m^3)
2	Boys	83.7 (5.0)	9.8 (1.6)	46.1 (2.9)	13.9 (2.0)	63.4 (8.9)
	Girls	81.6 (6.7)	9.2 (1.4)	45.2 (3.6)	13.9 (2.22)	61.0 (7.1)
	't' test	2.43**	2.48**	1.90	0.1	2.02**
	Overall	82.7(6.0)	9.5(1.5)	45.7(3.3)	13.9(2.1)	62.2(8.1)
3	Boys	90.9 (6.3)	11.3 (1.7)	50.4 (3.2)	13.7 (1.9)	67.4 (8.7)
	Girls	90.6 (5.5)	10.7 (1.5)	49.8 (2.9)	13.1 (1.6)	64.4 97.5)
	't' test	0.489	2.91**	1.30	2.8**	2.83**
	Overall	90.7 (5.9)	11.0 (1.6)	50.1 (3.1)	13.4 (1.2)	66.0(8.3)
4	Boys	98.8 (5.1)	12.8 (1.5)	53.8 (2.8)	13.1 (1.3)	71.3 (7.0)
	Girls	96.7 (4.8)	12.0 (1.4)	52.7 (2.7)	12.9 (1.2)	68.5 (6.5)
	't' test	3.22**	4.1***	3.20**	1.5	3.2**
	Overall	97.7(5.0)	12.4(1.5)	53.2(2.8)	13.0(1.8)	69.8(6.9)
5	Boys	103.1 (5.3)	13.4 (1.6)	56.1 (2.9)	12.5 (1.2)	71.3 (6.8)
	Girls	102.8 (4.3)	13.3 (1.6)	56.1 (2.2)	12.6 (1.0)	71.0 (7.2)
	't' test	0.566	0.358	0.03	-0.1	0.34
	Overall	102.9(4.8)	13.3(1.6)	56.1(2.6)	12.6(1.2)	71.2(7.0)
6	Boys	107.9 (4.9)	14.8 (1.8)	58.4 (3.1)	12.7 (1.1)	75.9 (6.9)
	Girls	107.9 (5.5)	14.8 (1.6)	58.5 (3.1)	12.7 (1.1)	75.8 (6.2)
	't' test	0.035	0.023	-0.22	-0.04	0.10
	Overall	107.9(5.2)	14.8(1.7)	58.5(3.1)	12.7(1.1)	75.9(6.7)
Age and sex combined		95.8 (9.8)	12.1 (2.3)	52.4 (5.1)	13.1 (1.6)	68.6 (8.5)

undernutrition as measured by SHIB cut-offs was 82.7 % (boys = 40.2 %; girls = 42.5 %). The sex-specific rates of undernutrition were 81.7 % and 83.7 %, among boys and girls, respectively. The χ^2 test proved that there was no statistically significant sex difference. The prevalence of severely undernourished (Grade – III) children was were much higher among both sexes (boys 45.0 %; girls 42.2 %), whereas, in the case of Grade II and Grade I, these rates were less (18.0 to 22.0 %).

DISCUSSION

The mean height of the children of our study (95.8 cm) compares favourably with other regional investigations on preschool children. Among previous studies, preschool children of Madhyamgram (Bose *et al.* 2008) showed the lowest mean height (91.3 cm.) while ICDS children of Chapra, Nadia, (Bose *et al.* 2007) reported the highest (96.9 cm.) mean height. Slum children of Medinipur (Bisai *et al.* 2009) as well as the Lodha children of Paschim Medinipur (Bisai *et al.* 2008) had reported mean heights of 96.3 cm. and 96.5 cm., respectively. Considering the weight, the highest overall mean weight (13.5 kg.) was noticed among Punjabi children (Singh and Grover, 2003), whereas, the lowest (11.8 kg.) was found among the Sugalis of Andhra Pradesh (Reddy and Rao, 2000). The overall mean weight of 12.1 kg. of our study was less than those reported in most of these studies,

TABLE 4: Prevalence of undernutrition among the 2–6 years preschool children based on SHIB cut off values. % are given in the parentheses.

Age (years)	Boys Undernutrition – Grade III	II	I	Over all	Normal	Girls Undernutrition - Grade III	II	I	Over all	Normal
2	40 (43.9)	19 (20.9)	12 (13.2)	71 (78.0)	20 (22.0)	34 (36.9)	20 (21.7)	18 (19.6)	72 (78.3)	20 (21.7)
3	52 (41.6)	17 (13.5)	18 (14.4)	87 (69.6)	38 (30.4)	54 (50.9)	14 (13.2)	18 (17.0)	86 (81.1)	19 (18.1)
4	45 (40.9)	21 (19.1)	24 (21.8)	90 (81.8)	20 (18.2)	52 (39.7)	27 (20.6)	34 (26.0)	113 (86.3)	18 (13.7)
5	64 (55.6)	20 (17.4)	22 (19.1)	106 (92.2)	9 (7.8)	54 (43.5)	27 (21.8)	24 (19.4)	105 (84.7)	20 (16.0)
6	23 (40.3)	16 (28.1)	14 (24.6)	53 (93.0)	4 (7.0)	23 (37.7)	12 (19.7)	19 (31.1)	54 (88.5)	7 (11.5)
Total	224 (22.1)	93 (9.2)	90 (8.9)	407 (40.2)	91 (9.0)	217 (21.4)	100 (9.9)	113 (11.2)	430 (42.5)	84 (8.3)
Sex specific	(45.0)	(18.7)	(18.0)	(81.7)		(42.2)	(19.5)	(22.0)	(83.7)	
Overall					837 (82.7)					

including Lodha's (Bisai *et al.* 2008). The boys were taller as well as heavier than girls similar to the findings in the Sagar area, West Bengal, India (Biswas *et al.* 2018). The overall mean sitting height of the present study was 52.4 cm, which was more than Sugalis (Reddy and Rao, 2000) of Andhra Pradesh (49.5 cm.). The mean BMI of the children of the present study (13.1) was similar to the rural preschool children of Sagar Block, (13.39), West Bengal, India (Giri *et al.* 2017). Giri et al's study (2017) also reported an inverse age trend of mean BMI. In our study, in general, there existed sexual dimorphism in anthropometric characteristics among the studied children of all ages. Boys had higher mean values. Similar results had been obtained by Bose *et al.* (2008) in Madhyamgram and Bisai *et al.* (2008) among Lodhas of Paschim Medinipur. The study of Singh and Grover (2003) among Punjabi preschool children also revealed a similar trend in height and weight.

The present study mainly focused on the assessment of the prevalence of undernutrition based on the new measure i.e. SHIB. Our study was undertaken in a limited geographical area on a relatively small sample. These are the two main limitations of this study. However, to the best of our knowledge, hitherto, no previous study has used this index to evaluate nutritional status. When we compared (*Table 5*) the prevalence of undernutrition among the studied children based on thinness cut-offs as proposed by Cole *et al.* (2007) with the new parameter SHIB, it was noticed that the overall age and sex combined prevalence was slightly lower (82.7%) than the previous one (85.2%). This difference was statistically not significant (χ^2 = 2.3; d.f. 1). The similarity of prevalence using these two methods existed across sex. The utility of this index is that it is internally derived and does not depend on fixed BMI cut-off to determine nutritional status. Lastly, this index may have a distinct advantage in determining nutritional status across ethnic groups who vary in body size and shape.

CONCLUSION

The SHIB can be considered an alternative, dependable, and useful index to evaluate nutritional status among pre-school children. India is a nation having innumerable ethnic groups with varying body shapes and sizes. This index may have a distinct

TABLE 5: Prevalence of undernutrition based on the thinness and SHIB. % are given in the parentheses.

Age (years)	Thinness Boys (N=498)	Girls (N=514)	Overall (N=1012)	SHIB Boys (N=498)	Girls (N=514)	Overall (N=1012)
2	72 (14.4)	70 (13.6)	142 (14.0)	71 (14.2)	72 (14.0)	143 (14.1)
3	94 (18.9)	92 (17.9)	186 (18.4)	87 (17.5)	86 (16.7)	173 (17.1)
4	93 (18.7)	116 (22.6)	209 (20.7)	90 (18.1)	113 (22.0)	203 (20.1)
5	109 (21.9)	107 (20.8)	216 (21.3)	106 (21.3)	105 (20.4)	211 (20.8)
6	54 (10.8)	55 (10.7)	109 (10.8)	53 (10.6)	54 (10.5)	107 (10.6)
Total	422 (84.7)	440 (85.6)	862 (85.2)	407 (81.7)	430 (83.7)	837 (82.7)

advantage in determining thinness across ethnic groups who vary in body structure. Thus, further studies are required from India to better understand whether this new index can be utilized to determine nutritional status, as measured by thinness, across ethnicity.

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