

Assessment of Body Composition, Fat Mass, Fat-Free Mass and Percent of Body Fat among Rural School Children of Northeastern India

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ABSTRACT

Recently recognized important indicators of body composition are fat mass (FM), fat-free mass (FFM) and percent body fat (PBF). The aim of this cross-sectional study is to determine body composition of the pre-adolescent children by using FM, FFM, and PBF. This study was performed using data from 584 children (281 boys and 303 girls) aged 6–10 years of Ahom descent from upper Assam state, Northeast India. Four anthropometric measurements i.e. height, weight, skinfold at triceps (TSF) and sub-scapular (SSF) were taken to calculate FM, FFM, FMI, FFMI, PBF, PBF for age (PBFZ), body mass index (BMI). Age-specific mean values of FM ranged from 2.12–4.00 kg (boys) and 2.16–4.40 kg (girls) and the age-specific mean values of FFM ranged from 14.45–23.93 kg (boys) and 14.01–23.03 kg (girls). The highest PBF value was observed at the age of 6 years for both groups of the children while the lowest value was observed at the age of 10 years and 9 years for boys and girls respectively. Sex-specific mean differences between sexes were statistically significant in SSF, PBF, FM, and FMI. For future investigations in clinical and epidemiological studies, these results are very important as they can be used to identify the risk of lower or higher adiposity and body composition using PBF, FM, and FFM.

Key words: body composition, fat mass, fat-free mass, percent body fat

Introduction

For human body, the body fat is a normal component that accumulates in adipose tissue. It serves as a useful marker for assessing adiposity of individuals.^{1,2,3} Anthropometric measures such as height, weight, percent body fat (PBF), body mass index (BMI), waist-hip ratio and skinfold thickness are the predictors of body fatness and body composition.^{4,5} Body composition is of interest to nutritionists because of the impact of nutritional status, specific diet, exercise, disease, and genetic factors. Nowadays, several new techniques such as bioelectrical impedance analysis, dual-X-ray absorptiometry, computerized tomography, underwater weighing have also been developed to determine body composition^{6,7,8} but anthropometric measurements are still widely used for this purpose. Anthropometry is quick, easy, reliable and inexpensive technique⁹. The body adiposity proportions vary with age, sex, and environmental conditions, and it serves as a good indicator of health and nutritional status of children.^{10,11,12}

BMI is commonly used to assess body composition as it measures excess adiposity in relation to greater body

weight relative to height rather than excess adiposity.^{13,14} BMI also includes fat mass (FM) and fat free mass (FFM) [$BMI = FFM (kg)/height^2 (m^2) + FM (kg)/height^2 (m^2)$] FM index (FMI) and FFM index (FFMI).¹⁵ But its limitation is that it cannot differentiate between excess body-weight associated with fat mass.^{16,17,18} For children health outcomes it is important to include in the assessment of body composition the amount and distribution of body fat and composition of FM and FFM.¹⁹ These both the indices (FMI, FFMI) are discrete and adjusted for body size.²⁰

A comparatively better measure of excess adiposity or obesity is percent body fat (PBF). The overall adiposity level is estimated by PBF mainly in epidemiological settings and studies have reported a significant relationship between PBF and BMI when sex and age are taken into account.^{21,22} Using the standard equations the triceps and sub-scapula skinfold measurements are used to determine body adiposity.^{23,24}

Several studies have highlighted the important relationship between under-nutrition and body composition

among various vulnerable segments of the population in India.^{25,26} Hence, assessment of body composition is becoming imperative among the Indian populations. Given the above reasons, the present study aims to assess age-sex specific adiposity levels and body composition of rural school children using PBF, FM, FFM, FMI, and FFMI so as to assess their nutritional status.

Subjects and Methods

This study was performed using data from 584 school children (281 boys and 303 girls) aged 6–10 years of Ahom descent of upper Assam state, in Northeast India. Ages were collected on the basis of school records and cross-checked by their parents. Special care was taken so that each category (age/sex) had a minimum of 50 children. Data was collected from July 2010 to December 2011. All the children were free from deformity and were not suffering from any diseases at the time of data collection. The parents of the children and the school authorities were informed about the objectives of the study prior to data collection.

The Ahoms are one of the major Mongoloid populations of Assam. They belong to the Tai or Shan family and came to Assam from Myanmar through Patkai range in 1228 A.D. Linguistically the Ahoms belong to the Siamese Chinese branch of the Sino-Tibetan language family. At present, they are mainly concentrated in Dibrugarh, Tinsukia, Lakhimpur, Dhemaji, Sibsagar and Jorhat districts of upper Assam. Pre structured and pre-tested schedule was used to collect the socio-economic and demographic data. All necessary approvals were obtained from the village level local authorities and school authorities prior to conduct the data collection.

Anthropometric measurements of height, weight, triceps and sub-scapula skin folds were recorded using standard procedures.^{25,27} One-way analysis of variance (ANOVA) using the Scheffe procedure was done to assess age-specific mean differences in the anthropometric and body composition variables.

Two-way ANOVA was used to control the influence of age and sex on the body composition variables (e.g., BMI, PBF, FM, FFM, FMI, and FFMI). BMI reflects both the fat mass (FM) and the fat-free mass (FFM) in the body.

The following equations of Slaughter et al.¹⁹ were used to estimate PBF:

$$\text{Boys} = 1.21 (\text{TSF} + \text{SSF}) - 0.008 (\text{TSF} + \text{SSF})^2 - 1.7$$

$$\text{Girls} = 1.33 (\text{TSF} + \text{SSF}) - 0.013 (\text{TSF} + \text{SSF})^2 - 2.5$$

The following equations of Vanitallie et al.¹⁸ were utilized to assess the proportion of fat mass (FM), fat-free mass (FFM), fat mass index (FMI) and fat-free mass index (FFMI):

$$\text{FM (kg)} = (\text{PBF}/100) \times \text{weight (kg)}$$

$$\text{FFM (kg)} = \text{Weight (kg)} - \text{FM (kg)}$$

$$\text{FMI (kg/m}^2\text{)} = \text{FM/Height}^2 \text{ (m}^2\text{)}$$

$$\text{FFMI (kg/m}^2\text{)} = \text{FFM/Height}^2 \text{ (m}^2\text{)}$$

BMI was calculated to assess the body composition characteristics of the children using the following standard equation:

$$\text{BMI (kg/m}^2\text{)} = \text{Weight (kg)/Height}^2 \text{ (m}^2\text{)}$$

$$\text{Z-score} = \{(\text{X/M}) * \text{L} - 1\} / (\text{L} * \text{S})$$

where X=PBF, L, M, and S are the age-sex specific values of the appropriate table corresponding reference populations.

The recently proposed L, M, and S age-sex specific reference values using the National Health and Nutrition Examination Survey (NHANES) conducted by the National Centre for Health Statistics data were used to calculate age and sex-specific z-scores among the children.

Results

The age-specific mean skinfold thickness (e.g., TSF and SSF) values were observed to be significantly higher among girls compared to boys ($p < 0.01$). The age-specific mean value of TSF was higher at the age of 6 years (5.34 mm and 5.29 mm) and lowest in 7 years (4.25 mm and 4.76 mm) among boys and girls, respectively. The age-specific mean value of SSF was ranged 6.00 mm (in 6 years) to 6.04 mm (in 10 years) and 5.63 mm (in 6 years) to 6.50 (in 10 years) among boys and girls, respectively. Age-specific mean BMI values were observed to be slightly higher among boys than girls. The highest BMI value is observed in the 10 years of age i.e. 14.83 and 14.88 for boys and girls respectively. The lowest value for boys is 14.05, which is seen in the 8 years of age. In case of girls, lowest value is observed in the age group 6 and 8 years of age i.e. 13.79. The mean value of FFM gradually increases with advancement of age among the children. However, the mean values of FM show irregular result. Age-specific mean values of FM ranged from 1.82 to 2.25 kg (in boys) and 1.56 to 1.99 kg (in girls). The age-specific means PBF and PBF_{AZ} values did not show any uniform increase among the children. The highest PBF value is observed in 6 years of age for both groups of the children while the lowest value is observed in 10 years and 9 years of age for boys and girls respectively. The age-sex specific mean FMI values ranged between 1.82–2.26 kg/m² (in boys) and 1.57–1.98 kg/m² (in girls). Similarly, the age-sex specific mean FFMI values ranged from 12.49 kg/m² (in 6 years) to 23.85 kg/m² (in 10 years) and 14.26 kg/m² (in 6 years) to 24.19 kg/m² (in 10 years) among boys and girls, respectively. (Tables 1a, 1b, 1c, 2)

Using independent sample t-test, there were statistically significant sex differences ($p < 0.05$) in anthropometric and body composition indicators of SSF (t-value = 2.46), PBF (t-value = 4.84), FM (t-value = 5.33) and FMI (t-value = 4.70) except in weight (t-value = 0.207), height (t-value = 0.060), TSF (t-value = 0.481), FFM (t-value = 0.429), FFMI (t-value = 1.94) and BMI (t-value = 0.60) (not significant). The existence of significant sex differences indicates that these body composition indicators reflect sexual dimorphism in PBF, FM and FMI ($p < 0.05$). Using ANOVA, (Table 2) differences in anthropometric

TABLE 1A
 AGE-SPECIFIC DESCRIPTIVE STATISTICS: MEANS AND STANDARD DEVIATION OF THE AN-
 THROPOMETRIC VARIABLES IN CHILDREN

Age	Sample Size		Height(cm)		Weight(kg)		TSF(mm)		SSF(mm)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6	67	57	109.68	107.28	17.05	15.91	5.34	5.29	6.00	5.63
			5.01	5.50	2.18	2.16	1.41	1.19	1.29	1.16
7	52	60	119.66	117.96	20.33	19.98	4.25	4.76	5.12	5.62
			6.20	5.60	3.32	3.06	1.13	1.31	1.02	1.13
8	54	53	123.26	121.84	21.42	20.53	4.27	4.85	5.70	5.84
			5.64	5.37	2.99	2.44	0.98	1.40	1.10	1.25
9	55	64	129.30	128.70	24.73	24.20	4.87	4.94	6.40	5.95
			5.96	5.92	4.31	3.39	1.33	1.47	1.49	1.31
10	53	69	131.49	131.72	25.74	25.93	4.40	5.18	6.04	6.50
			5.96	5.71	3.82	3.87	0.95	1.37	1.46	1.82
Total	281	303	122.08	122.03	21.63	21.55	4.19	4.24	5.09	4.81
			9.87	10.31	4.64	4.69	1.25	1.33	1.39	1.37
F value			138.86	178.87	64.67	98.57	37.16	44.15	18.97	26.11

Abbreviations: TSF – triceps skinfold; SSF – sub-scapular skinfold
 P=<0.05

TABLE 1B
 AGE-SPECIFIC DESCRIPTIVE STATISTICS: MEANS AND STANDARD DEVIATION OF THE AN-
 THROPOMETRIC VARIABLES IN CHILDREN

Age	Sample Size		BMI(Kg/m²)		PBF (%)		PBFZ		FM(Kg)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6	67	57	14.17	13.79	11.74	10.38	-0.78	-1.75	2.00	1.65
			1.58	1.25	2.86	1.90	0.90	0.83	0.55	0.04
7	52	60	14.13	14.29	8.98	9.37	-1.83	-2.41	1.82	1.87
			1.44	1.29	2.77	2.64	1.23	1.27	0.09	0.08
8	54	53	14.05	13.79	9.53	9.69	-1.54	-2.39	2.04	1.99
			1.28	0.97	2.09	2.72	0.72	1.24	0.06	0.07
9	55	64	14.71	14.55	9.09	6.46	-1.77	-4.14	2.25	1.56
			1.66	1.20	1.70	1.68	0.57	1.13	0.07	0.06
10	53	69	14.83	14.88	7.35	6.71	-2.46	-3.95	1.89	1.74
			1.33	1.50	1.17	1.20	0.49	0.78	0.36	0.43
Total	281	303	14.37	14.30	9.46	8.40	-1.63	-3.28	2.00	1.76
			1.50	1.33	2.67	2.63	0.99	1.42	0.56	0.53
F value			3.31	8.75	29.88	47.26	32.34	60.99	5.26	6.06

BMI – body mass index; PBF – percent of body fat; PBFZ– percent of body fat for-age z-score;

and body composition variables were also observed to be statistically significant ($p<0.05$) with respect to age and weight, height, TSF, SSF, BMI, PBF, PBFZ, FM, FFM, FMI and FFMI among boys and girls (Tables 1a, 1b, 1c). Two way ANOVA showed statistically insignificant association for the anthropometric and body composition variables of height, weight, PBF, TSF, SSF, FM, FFM, FMI except in FFMI, BMI and PBFZ ($p<0.001$) with respect to age and sex (Not in table).

Discussion

In clinical nutrition, skinfold thickness is often measured to estimate body composition in children, although very limited information is available on its validity. FM (amount and distribution of body adiposity) and FFM (composition of muscularity) are now understood to be important health outcomes in body composition assessment in infants and children. Slaughter et al.¹⁹ equation is used for the evaluation of body fat among pre-pubertal children because it provides more accurate estimates of PBF than

TABLE 1C
AGE-SPECIFIC DESCRIPTIVE STATISTICS: MEANS AND STANDARD DEVIATION OF THE ANTHROPOMETRIC VARIABLES IN CHILDREN

Age	Sample Size		FFM (Kg)		FMI(Kg/m ²)		FFMI (Kg/m ²)	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6	67	57	15.05	14.26	2.00	1.65	12.49	14.26
			2.01	2.12	0.55	0.40	1.29	1.95
7	52	60	18.50	18.10	1.82	1.87	18.51	18.10
			3.23	2.98	0.63	0.66	3.17	2.81
8	54	53	19.37	18.54	2.03	1.98	19.40	18.55
			2.93	2.38	0.45	0.57	2.86	2.38
9	55	64	22.48	22.64	2.26	1.57	22.46	22.64
			4.24	3.33	0.66	0.48	3.82	3.16
10	53	69	23.85	24.19	1.89	1.74	23.85	24.19
			3.45	3.61	0.36	0.43	3.60	3.61
Total	281	303	19.63	19.79	1.36	1.20	19.02	19.80
			4.44	4.58	0.44	0.38	5.09	4.58
F-values			73.63	115.46	18.30	29.40	130.27	115.10

FFM – fat-free mass; FMI – fat mass index; FFMI – fat-free mass index

TABLE 2
ANOVA ANALYSIS OF THE CHILDREN

		Sum of Squares	df	Mean Square	F	Sig.
Height	Between Groups	40648.233	4	10162.058	311.991	.000
	Within Groups	18924.132	581	32.572		
	Total	59572.365	585			
Weight	Between Groups	6633.627	4	1658.407	158.692	.000
	Within Groups	6071.738	581	10.450		
	Total	12705.366	585			
S F TRI	Between Groups	339.364	4	84.841	77.006	.000
	Within Groups	640.117	581	1.102		
	Total	979.480	585			
S F S S	Between Groups	182.320	4	45.580	28.019	.000
	Within Groups	945.141	581	1.627		
	Total	1127.462	585			
BMI	Between Groups	77.910	4	19.477	10.382	.000
	Within Groups	1089.958	581	1.876		
	Total	1167.868	585			
PBF	Between Groups	1299.443	4	324.861	63.734	.000
	Within Groups	2961.421	581	5.097		
	Total	4260.864	585			
PBF AZ	Between Groups	345.829	4	86.457	61.397	.000
	Within Groups	818.142	581	1.408		
	Total	1163.971	585			
FM	Between Groups	2.594	4	.649	2.091	.081
	Within Groups	180.187	581	.310		
	Total	182.782	585			
FFM	Between Groups	6667.113	4	1666.778	185.296	.000
	Within Groups	5226.236	581	8.995		
	Total	11893.349	585			
FMI	Between Groups	2.594	4	.649	2.091	.081
	Within Groups	180.187	581	.310		
	Total	182.782	585			
FFMI	Between Groups	8578.069	4	2144.517	242.137	.000
	Within Groups	5145.693	581	8.857		
	Total	13723.761	585			

the other methods. The differences in adiposity measures FFM are observed more prominently with the advancement of age and the total sex-specific mean values are higher in girls than the boys. Sen and Mondal²⁸ have reported similar trends of body composition among the Bengali Muslim children. The present study shows that girls have higher body fat levels than their male peers in connection with adiposity indicators like TSF, FFM. The age-specific mean values of FM, FFM, FMI and FFMI among the Ahom children are lower than the values reported by Eckhardt et al.²⁹. The reason behind this variation may be due to different environmental conditions, ecological stress, etc.

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This study, although preliminary, strongly suggests that to improve screening for undernutrition in clinical settings and to reduce chronic under nutrition-related mortality and morbidity, the evaluation of body composition is urgently required. Based on the review of literature, there are still several areas that could benefit from further research. Some intervention programs are required so that we can accurately identify risk of a lower or higher adiposity status.

Declaration of interest

The authors declare that they have no conflict of interest.

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PROCJENA TJELESNOG SASTAVA, MASNE I NEMASNE TJELESNE MASE I POSTOTKA MASNOG TKIVA U ŠKOLSKE DJECE U SJEVEROISTOČNOJ INDIJI

SAŽETAK

Važni pokazatelji sastava tijela su masna tjelesna masa (FM), nemasna tjelesna masa (FFM) i postotak masnog tkiva (PBF). Cilj ove transverzalne studije je određivanje sastava tijela pomoću ovih indikatora u djece na prepubertetskom stupnju razvoja. Istraživanje je provedeno na uzorku od 584 djece (281 dječaka i 303 djevojčice) u dobi između 6 i 10 godina, iz populacije Ahom koja živi u gornjoj državi Assam, u sjeveroistočnoj Indiji. Antropometrijskim mjerenjem prikupljeni su podaci o visini i težini te kožnim naborima na nadlaktici i leđima kako bi se izračunali indeksi FM, FFM, FMI, FFMI, PBF, PBF prema dobi (PBFZ) i indeks tjelesne mase (BMI). Rezultati pokazuju vrijednosti masne tjelesne mase FM prema dobi u rasponu od 2,12–4,00 kg za dječake i 2,16–4,40 kg za djevojčice, a vrijednosti nemasne tjelesne mase FFM prema dobi u rasponu od 14,45–23,93 kg za dječake i 14,01–23,03 kg za djevojčice. Najviša vrijednost postotka masnog tkiva PBF zabilježena je u dobi od 6 godina u oba spola, dok je najniža vrijednost bila u dobi od 10 godina za dječake i 9 godina za djevojčice. Srednje razlike prema spolu su statistički značajne za kožni nabor na leđima, PBF, FM i FFM. Prikazani rezultati su važni za buduća klinička i epidemiološka istraživanja jer pokazuju da se PBF, FM i FFM mogu koristiti za identifikaciju rizika pretilosti ili neuhranjenosti i sastava tijela.