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Composite Index of Anthropometric Failure (CIAF) among pre-school (2-5 years) tribal children of Assam (India)

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ABSTRACT

Background*: Undernutrition is the major public health problem in developing countries including India. The conventional anthropometric measurements of stunting, underweight and wasting are used to assess the undernutrition. The composite index of anthropometric failure (CIAF) is recently proposed as an alternate anthropometric measure of undernutrition assessment in children.* ***Aims and objectives****: The objectives of the present study are to assess and compare the prevalence of undernutrition using conventional anthropometric measures and CIAF among pre-school Karbi children of Karbi Anglong District, Assam, India.* ***Material and Methods****: Present community based cross-sectional study was carried out among 400 Karbi (197 boys; 203 girls) pre-school children aged 2-5 years in Karbi Anglong, Assam, Northeast India. Anthropometric measurements of height and weight were collected using standard anthropometric procedures. The WHO Anthro software (version 3.2.2) was used to calculate the Z-scores values of weight-for-height, weight-for-age and height-for-age. Z-score value of any indices found to be <−2SD is classified as undernutrition. Standard classification of CIAF was used to assess undernutrition. Statistical analysis of descriptive statistics, ANOVA and chi-square analysis was done using SPSS (version 17.0).* ***Results****: The overall prevalence of underweight, stunting, wasting and CIAF were 26.75%, 35.50%, 18.50% and 51.00%, respectively. It was further revealed that the girls were observed to be more affected due to wasting (18.72% vs. 18.27%), underweight (28.57% vs.24.87%) and CIAF (51.72% vs.50.25%), except stunting (35.47% vs. 35.53%) (p>0.05). It was further observed that the girls were observed to be more affected in sex-specific undernutrition in different CIAF categories (i.e., Groups B, D, E and Y) than boys, with the exception being in Group C and Group F (p>0.05).* ***Conclusion****: These finding will help to identify population-specific nutritional deprivation and aid in planning nutritional supplementation policies and programmes especially for the tribal children to reduce the actual burden of undernutrition and for the overall improvement of health status of the community.*

KEYWORDS: Undernutrition; CIAF; Anthropometry; Karbi; Children; Public Health; Tribe; India

INTRODUCTION

Prevalence of undernutrition is being a major public health problem among children in many developing countries. India has reported being the highest occurrence of childhood malnutrition in the world. Undernutrition in childhood is one reason for the high child mortality and morbidity and also detrimental to the future of those who survive (Black et al., 2003; Nandy et al., 2005). Prevalence of undernutrition in children impaired their growth and cognitive development. Children in the pre-school stage require the most attention, as this is the period of rapid growth and development, which makes them vulnerable to undernutrition (WHO, 1995, 2007). The anthropometry is a single most used non-invasive, inexpensive and easy-to-use technique to assess the physical growth and nutrition among children in epidemiological, clinical and field investigations (WHO, 1995, 2007; Hall et al., 2007). Several anthropometric measurements of height-for-age (stunting), weight-for-age (underweight) and weight-for-height (wasting) were recommended to assess the magnitude of undernutrition among children in population (WHO, 1995; Nandy et al., 2005; Bose et al., 2007; Mukhopadhyay et al., 2009; Mondal and Sen, 2010; Sen and Mondal, 2012; Savanur and Ghugre, 2015). These anthropometric measures reflect distinct biological processes of human life, and their usages are very important for determining appropriate nutritional interventions (WHO, 1995). Children experiencing stunting and wasting have been undernourished, with the former showing chronic undernutrition and the latter showing acute undernutrition. Underweight a composite measure of stunting and wasting but did not distinguish between the two (Nandy et al., 2005; Nandy and Miranda, 2008).

It has also been argued that these conventional anthropometric measures are overlapping in nature and unable to assess the actual magnitude of undernutrition (Svedberg, 2000; Nandy et al., 2005; Nandy and Miranda, 2008; Nandy and Svedberg, 2012). The Composite Index of Anthropometric failures (CIAF) is more useful over the conventional anthropometric indices (i.e., stunting, underweight and wasting) in assessing the overall magnitude of undernutrition and identifying children with multiple anthropometric failures (Nandy et al., 2005; Nandy and Miranda, 2008; Nandy and Svedberg, 2012; Sen and Mondal, 2012; Savanur and Ghugre, 2015). The CIAF comprises typical anthropometric indicators and their combination into seven categories and proposes an additional measure to study malnutrition as an alternative to the evaluation of stunting, wasting and underweight as the separate measure. Some researchers further suggested that conventional anthropometric indices could not provide the overall prevalence of undernutrition as the researcher had to ‘choose’ a certain category of anthropometric failure when assessing nutritional status (Nandy et al., 2005; Berger et al., 2008). Several studies have also reported the magnitude of overall undernutrition status using the proposed classification of CIAF among Indian children (Nandy et al., 2005; Seetharaman et al., 2007; Biswas et al., 2009; Das and Bose, 2009; Deshmukh et al., 2009; Mandal and Bose, 2009; Mukhopadhyay et al., 2009; Sen et al., 2011; Sen and Mondal, 2012; Agarwal et al., 2015; Savanur and Ghugre, 2015; Dhok and Thakre, 2016; Goswami, 2016; Gupta et al., 2017; Vollmer et al., 2017). Malnutrition in children under five years of age is one of the most serious health problems in developing countries including India. Several studies have reported the socio-economic and demographic variables have the significant effect on undernutrition in children (Bose et al., 2007; Mondal and Sen, 2010; Sen and Mondal, 2012; Mondal et al., 2015; Tigga et al., 2015; Rengma et al., 2016; Vollmer et al., 2017). Therefore, it is imperative to assess the magnitude of undernutrition to implement intervention programme for reducing the actual burden on the population. Therefore, there is an urgent requirement for an appropriate single anthropometric measure to assess the actual population burden of undernutrition and identify the more vulnerable individuals in the population. An undernourished child has a lower chance of survival than a child who is well-nourished. This is where the use of CIAF bears prime importance to assess the prevalence of child undernourishment in multiple categories among the target population.

Therefore, the objectives of the present study are to assess and compare the prevalence of undernutrition using both conventional anthropometric measures and CIAF among Karbi preschool children of Karbi Anglong District, Assam, India. The data of the present study will be more beneficial to the Government agencies and policy-making bodies to find out the current efficacy of ongoing nutritional intervention programmes and also implement appropriate nutritional intervention programme for the tribal children and for the overall development of health status in the population.

MATERIAL AND METHODS

The present community based cross-sectional study was undertaken among 400 (Boys: 197 and Girls: 203) Karbi pre-school children aged 2-5 years of Karbi Anglong district of Assam, India., the Karbi population belongs to the Tibeto-Mongoloid population and Tibeto Burman linguistic group. Karbis are mainly concentrated in the Karbi Anglong, Dima Hasao, Kamrup, Morigaon, Nagaon, Golaghat, Karimganj, Lakhimpur and Sonitpur districts of the state of Assam, Northeast India. They are also inhabited in the states of Nagaland, Arunachal Pradesh and Meghalaya. All the study participants were the residents of Karbi-Anglong district (25°33′ N to 26°35′ N latitude and 92°10′ E to 93°50′ E longitude) of the state of

Assam, Northeast India (Figure 1). A total of 12 villages under Lumbajong block inhabited by the homogeneous Karbi tribal population situated 5-8 km from the district town Diphu, Karbi Anglong were covered in course of the present study. The Karbi Anglong is the largest district amongst the 33 districts of Assam and covers an area of 10,434 km2. According to the National Census, the district had a population of 9,65,280 individuals (males: 4,93,482; females: 4,71,798) with an average literacy rate of 59.52% (males: 56.82%; females: 43.18%).

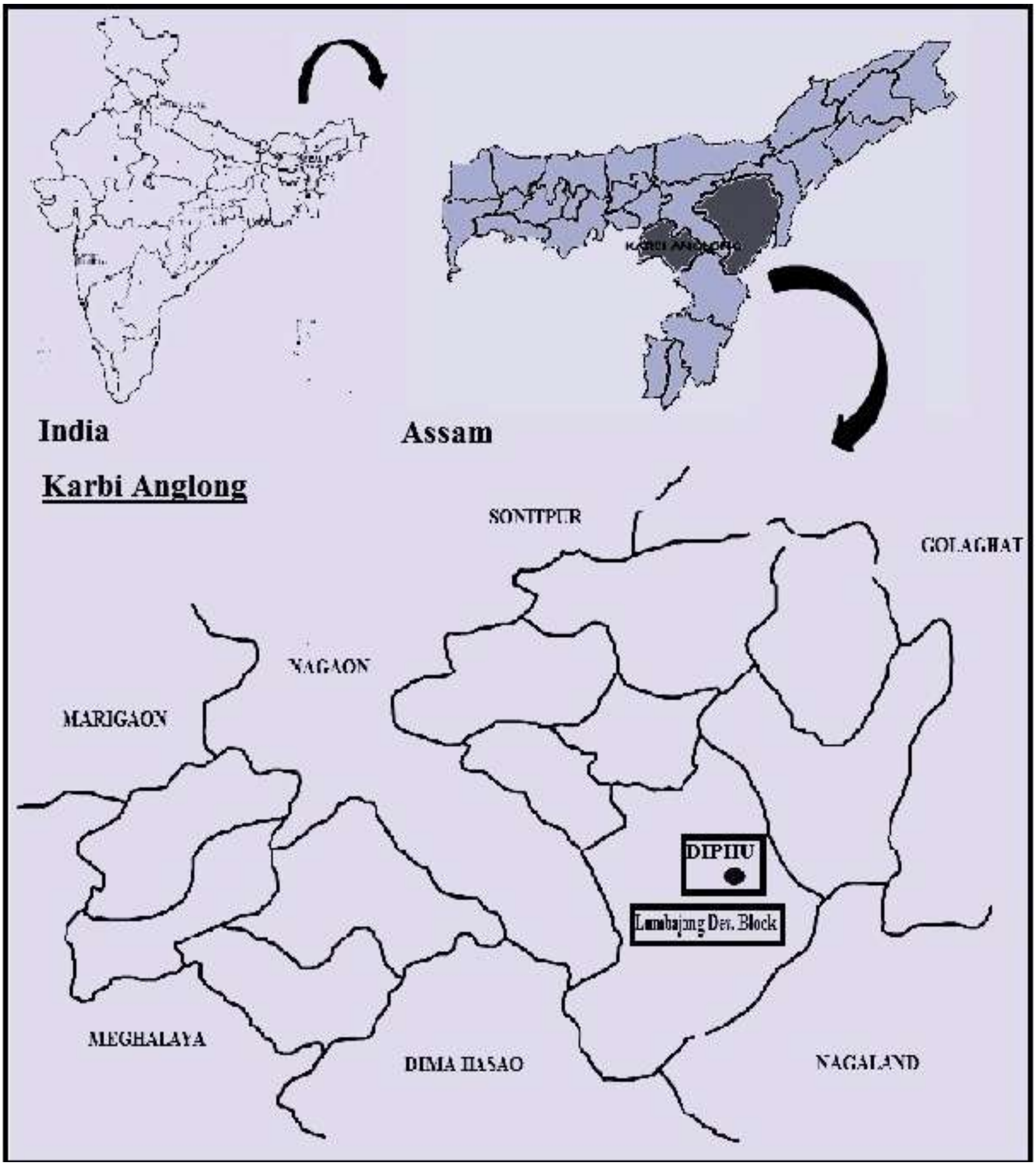

Figure 1: Map showing the location of study area of Lumbajong block, Diphu, Karbi Anglong Assam (India)

The minimum number of individuals required for estimating the prevalence of undernutrition and CIAF in the present study was calculated following the standard method of estimating sample size (Lwanga and Lemeshow, 1991). In this method, the expected population proportion of 50%, absolute precision of 5% and confidence interval of 95% were taken into consideration. The reported prevalence of undernutrition and CIAF on the Indian children (Das and Bose, 2011; Sinha and Maiti, 2012; Sen and Mondal, 2012; Acharya et al., 2013; Savanur and Ghugre, 2015; Dhok and Thakre, 2016) was taken into consideration to calculate the minimum sample size in the present study. This prevalence was observed to be up to 50% in these afore mentioned studies. The minimum sample size, thus estimated was 384 individuals. In the first stage, the households of those individuals belonging to the Karbi population were identified based on the surnames and language spoken and cultural traits. In the second stage, 425 Karbi children were identified and, 400 Karbi children in the age group of 2-5 years from those identified households were selected and included in this study. The overall participation rate was 94.12%. However, 5.88% (N=25) of the total identified subjects were not included due to an inappropriate age record or physical deformities and/or suffering from diseases at the time of data collection. The participation of the subjects in the present study was voluntary. A verbal consent was taken from either of their parent prior to collect data on socio-economic, demographic and anthropometric data. Each informant and subject was interviewed and measured in the respective household. Permission to conduct the research was taken from the village level local authorities and the village headmen prior to conducting the study. The study was conducted in accordance with the ethical guidelines for human experimental research as laid down in the Helsinki Declaration of 2000 (Touitou et al., 2004).

Collection of socio-economic and demographic data

The information on socio-economic, demographic and lifestyle-related variables was collected through pre-structured questionnaire by adopting household survey method. The information was collected by interviewing parents and prior information was provided about the aims of the present study. The data on sex, age, birth order, study area, father's education, mother's education, ethnic group, toilet facility, electricity, father's occupation, mother's occupation and household income were recorded. A modified version of the scale of Kuppuswamy was used to ascertain the socioeconomic status (SES) of the children (Kumar et al., 2012). The data on education, occupation and family income were used to determine the SES and based on the above scale, all the children in the present study belonged to a lower to the middle socio-economic group. To elicit valid responses, ample care was taken while briefing the questions to the respondents at the time of interview.

Collection of Anthropometric data

The anthropometric measurements of height and weight were taken using standard procedures (Hall et al., 2007). Height was recorded with the help of an anthropometer rod, with the participant standing erect, looking straight and the head oriented in the Frankfort horizontal plane. It was measured to the nearest 0.10 cm. Weight was taken using a portable digital weighing scale with the participant wearing minimum clothing to the nearest 100 gm. The subjects covered during of this study were measured with ample precision to avoid any systematic errors (e.g., instrumental or definition of landmarks) in the process of anthropometric data collection.

Intra-observer technical errors of the measurements (TEM) were calculated to determine the accuracy of the measurements using the standard procedure (Ulijaszek and Kerr, 1999). The TEM was calculated using the following equation: $TEM=\sqrt{(\Sigma D^2/2N)}$, [D= Difference between the measurements, N= Number of individuals]. The coefficient of reliability (R) was calculated from TEM using the following equation: $R=\{1-(TEM)^2/SD^2\}$, SD= Standard deviation of the measurements. For calculating TEM, height and weight were recorded from 50 Karbi women other than those selected for the study. High values were observed of R (>0.975) for both height and weight and these values were within the acceptable limits of 0.95 as recommended (Ulijaszek and Kerr, 1999). Hence, the measurements recorded in the present study were being reliable and reproducible.

Assessment of Nutritional Status

The undernutrition was assessed using the three used conventional anthropometric measures of stunting, underweight and wasting (WHO 1995, 2007) and the CIAF (Svedberg 2000; Nandy et al., 2005). The prevalence of undernutrition has been assessed using Z-scores according to the classification of the WHO (1995). The age/sex-specific Z-score value was calculated by using the WHO Anthro software (version 3.2.2). Interpreting the three conventional indices involves a comparison with an international reference population to determine undernutrition, the data from the World Health Organization (WHO, 2007) were also been used as the reference population for the evaluation of undernutrition. These new standards were based on breastfed infants and fed children of different ethnic origins, raised in optimal conditions and measured in a standardized manner (de Onis et al., 2007). A child having the z-score value below −2 SD in the indices of stunted, underweight and wasted was categorised as undernourished (WHO, 1995). The situation of public health condition was assessed on the severity of undernutrition in terms of conventional anthropometric measures using the WHO proposed classification among children (WHO, 1995) (Table 1). The combination of Svedberg's (2000) model of six groups (stunted only, underweight only, wasted only, wasting and underweight, stunted and underweight and stunted, wasted and underweight) and Nandy et al. (2005) (underweight only) have been utilized for assessing undernutrition using the CIAF. The proposed classification of CIAF for the assessment of undernutrition is presented in Table 2.

Table 1: Public health situation classification according to the severity of undernutrition

Classification	Low (%)	Medium (%)	High (%)	Very high (%)
Underweight	<10	10-19	20-29	≥30
Stunting	<20	20-29	30-39	≥40
Wasting	<5	5-9	10-14	≥15

Table 2: Classification of children with the composite index of anthropometric failure*

Groups	Description	Wasting	Stunting	Underweight
A	**No Failure**	**No**	**No**	**No**
B	**Wasting only**	**Yes**	**No**	**No**
C	**Wasting and Underweight**	**Yes**	**No**	**Yes**
D	**Wasting, Stunting and Underweight**	**Yes**	**Yes**	**Yes**
E	**Stunting and Underweight**	**No**	**Yes**	**Yes**
F	**Stunting only**	**No**	**Yes**	**No**
Y	**Underweight only**	**No**	**No**	**Yes**

*** Classification based on Nandy et al., (2005).**

Statistical Analysis

The statistical analysis was done using the Statistical Package for Social Sciences (SPSS) for Windows (Version 17.0). Homogeneity of variance was tested using the Levene's test of equality of variance. For all anthropometric variables, the p-value was observed to be statistically significant ($p<0.01$). Chi-square (χ^2) and phi-coefficient analysis were done to assess sex differences in the overall prevalence of undernutrition and CIAF. The p-values of <0.05 and <0.01 were being statistically significant.

RESULTS

Sex-specific descriptive statistics of anthropometric variables among Karbi children are presented in Table 3. The overall mean values of height (93.28 cm vs.93.12 cm), and HFAZ (−1.15 vs. −1.30) were observed to be higher among girls but weight (12.93 kg vs.

12.56 kg), WFHZ (−0.81 vs. −0.91) and WFAZ (−1.28 vs. −1.32) were observed to be higher in boys. Using ANOVA, the mean differences in mean anthropometric variables were found to be statistically not significant between boys and girls (p>0.05). The sex-specific and overall prevalence of wasting, underweight, stunting and CIAF are presented in Table 4. The overall prevalence of wasting, underweight, stunting and CIAF was observed to be 18.50%, 26.75%, 35.50% and 51.00%, respectively. It was further revealed that the girls were observed to be more affected due to wasting (18.72% vs. 18.27%), underweight (28.57% vs. 24.87%) and CIAF (51.72% vs. 50.25%), except stunting (35.47% vs. 35.53%) (p>0.05) (Figure 2). The sex difference in the prevalence of undernutrition was observed to be statistically not significant using chi-square analysis (p>0.05). The sex-specific association of undernutrition was observed to be statistically not significant using Phi-coefficient analysis (p>0.05).

Table 3: Descriptive statistics of anthropometric variables among Karbi children

Variables	Boys (N=197)	Girls (N=203)	F-value	P
Height (cm)	93.12±9.12	93.28±9.85	0.031	0.861
Weight (kg)	12.93±2.26	12.56±2.25	2.679	0.102
WFHZ	-0.81±1.41	-0.91±1.40	0.557	0.456
WFAZ	-1.28±1.24	-1.32±1.19	0.112	0.738
HFAZ	-1.30±1.94	-1.15±1.84	0.632	0.427

Table 4: Prevalence of wasting, underweight, stunting and CIAF among Karbi children

Undernutrition	Boys (N=197)	Girls (N=203)	Total (N=400)	Sex difference (χ^2)	Phi (φ) coefficient
Wasting	36 (18.27)	38 (18.72)	74 (18.50)	0.013*	−0.006*
Underweight	49 (24.87)	58 (28.57)	107 (26.75)	0.698*	−0.042*
Stunting	70 (35.53)	72 (35.47)	142 (35.50)	0.000*	0.001*
CIAF	99 (50.25)	105 (51.72)	204 (51.00)	0.086*	−0.015*

p>0.05

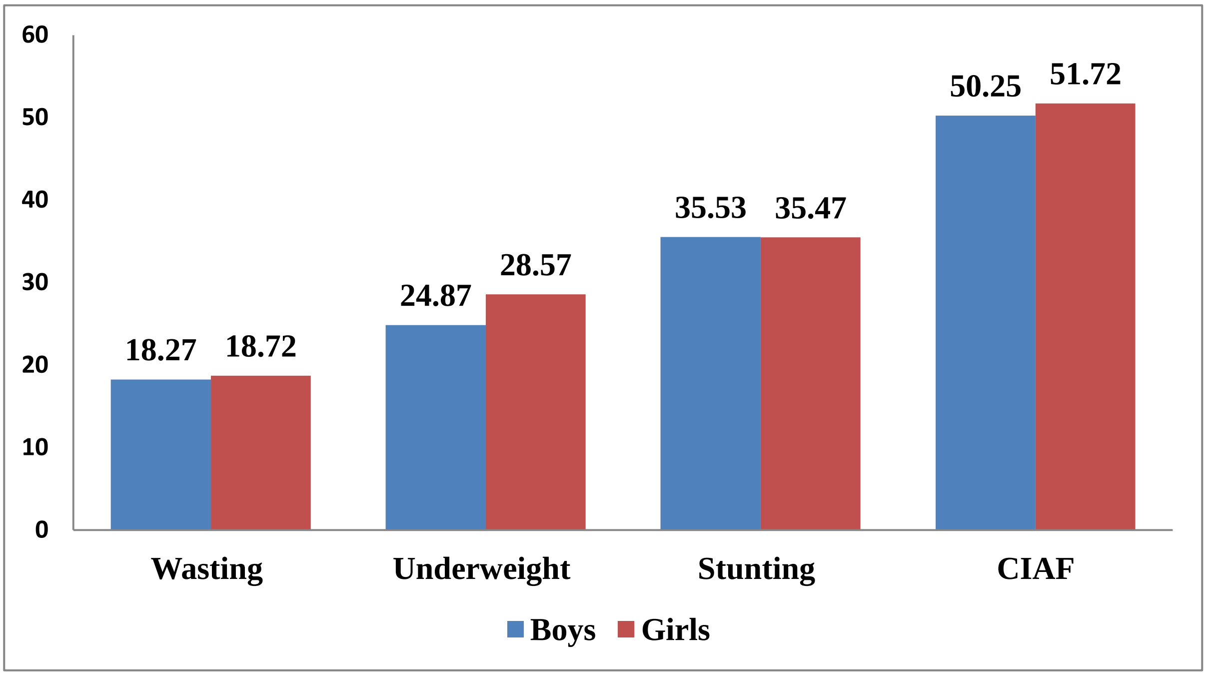

Figure 2: Sex-specific prevalence of undernutrition and CIAF among Karbi children

Table 5: Prevalence of composite index of anthropometric failure among Karbi children

Groups	Description	Boys (N=197)	Girls (N=203)	Total (N=400)	Sex difference
A	No Failure	98 (49.75)	98 (48.28)	196 (49.00)	9.738* (d.f.,6)
B	Wasting only	16 (8.12)	21 (10.34)	37 (9.25)	
C	Wasting and Underweight	13 (6.60)	7 (3.45)	20 (5.00)	
D	Wasting, Stunting and Underweight	7 (3.55)	10 (4.93)	17 (4.25)	
E	Stunting and Underweight	29 (14.72)	36 (17.73)	65 (16.25)	
F	Stunting only	34 (17.26)	26 (12.81)	60 (15.00)	
Y	Underweight only	0 (0.00)	5 (2.46)	5 (1.25)	

***Chi-square analysis; p>0.05**

The sex-specific prevalence of the children suffering from single and multiple failures of the CIAF (Groups B–Y) are depicted in Table 5. Overall, 49.00% of the children (boys: 49.75%; girls: 48.28%) showed no anthropometric failure (Group A). The CIAF aggregating the children suffering from single, double and multiple failures (Groups B–Y) showed a high prevalence of undernutrition (boys: 50.25%; girls: 51.72%). The results also showed that the overall prevalence of undernutrition was found to be highest in Group E (Overall: 16.25%, Boys: 14.72% and Girls: 17.73%) followed by single failures in Group F (Overall: 15.00%, Boys: 17.26% and Girls: 12.81%). The prevalence was found to be similar in Group C (Overall: 5.00%, Boys: 6.60%, Girls: 3.45%) and Group D (Overall: 4.25%, Boys: 3.55%, Girls: 4.93%. The prevalence of acute undernutrition (i.e., Group B) (Overall: 9.25%, Boys: 8.12%, Girls: 10.34%) was observed to be higher than the combined multiple failures groups (e.g., C and D). It was further observed that the girls were observed to be more affected in sex-specific undernutrition in different CIAF categories (i.e., Groups B, D, E and Y) than boys, with the exception being in the Group C and Group F. The overall sex difference in CIAF categories were observed to be statistically not significant using chi-square analysis (Chi-value: 9.738, d.f., 6, p>0.05).

DISCUSSION

Assessments of undernutrition play a significant role in developing countries such as India where the majority of the populations are undernourished and underprivileged. Such assessments are important for the improvement of their health and overall development of the population concerned. The major underlying factors for the prevalence of undernutrition are poor socioeconomic conditions/inequalities, environmental and ethnic/population differences in developing countries (Black et al., 2003; Nandy et al., 2005; Mahgoub et al., 2009; Sen and Mondal, 2012; Mondal et al., 2015; Tigga et al., 2015; Rengma et al., 2016; Vollmer et al., 2017). It is a well-established fact that vulnerable children are more likely found in poor socio-economic backgrounds and underprivileged segments of the population (Nandy et al., 2005; Bose et al., 2007; Mukhopadhyay and Biswas, 2011; Mondal and Sen, 2010; Sen and Mondal, 2012; Rengma et al., 2016). Several research investigations have reported that one of the key causes of undernutrition in Indian populations is related to the inadequate access to enough food, protective nutrients, healthcare facilities, socio-economic and poor living conditions that leads to disease and subsequent undernutrition (Nandy et al., 2005; Mukhopadhyay and Biswas, 2011; Mondal and Sen, 2010; Sen et al., 2011; Sen and Mondal, 2012; Rengma et al., 2016).

The conventional anthropometric measures (e.g., stunting, underweight and wasting) are used to assess the magnitude of undernutrition among children, but these indices are unable to estimates the actual burden of undernourishment in population due to overlapping in nature (Svedberg, 2000; Nandy et al., 2005; Nandy and Miranda, 2008; Nandy and Svedberg, 2012). The conventional anthropometric measures discussed above only allow for the categorization of children into the general categories of undernourishment and do not provide an opportunity to determine the overall burden of undernutrition that is associated with multiple anthropometric failures (Svedberg 2000; Nandy et al., 2005; Berger et al., 2008; Nandy and Svedberg, 2012). The CIAF is to visualize the amount of the underestimation and it provides an overall estimate of total number of undernourished children in population (Nandy et al., 2005; Seetharaman et al., 2007), which is not provided and/or underestimated by any of the conventional anthropometric measures of undernutrition (i.e., stunting, underweight and wasting). The estimation of the overall prevalence of undernutrition in a population involves the integration of such an aggregate index of undernutrition (i.e., CIAF) (Seetharaman et al., 2007; Sen and Mondal, 2012; Vollmer et al., 2017). Therefore, this could be a potential tool to health planners and policymakers - considering the CIAF to assess the actual burden of malnutrition in the most vulnerable segment of the population. The present study was assessed to evaluate the prevalence of undernutrition using both conventional anthropometric measures and CIAF. Overall, only 51.00% (boys: 50.25%, girls: 51.75%) children were suffering from different grades of anthropometric failure (Table 3). A comparison of undernutrition using conventional anthropometric measures and CIAF among Indian children with present study is depicted in Table 6. The comparison with the present study was found to be lower than the children of Hooghly (73.1%) (Mandal and Bose, 2009), Purulia (66.3%) (Das and Bose, 2009), Darjeeling (65.6%) (Mukhopadhyay et al., 2009), Nadia (60.4%) (Biswas et al., 2009), Tamil Nadu (68.6%) (Seetharaman et al., 2007), Uttar Pradesh (62.8%) (Kumar et al., 2010), Delhi (62.0%) (Gupta et al., 2017) and Indian children (59.8%) (Nandy et al., 2005).

The present study showed that the prevalence of stunting, underweight and wasting was found to be lower than the reported studies among children of Bauri caste (Das and Bose, 2009), urban slum children (Dewan et al., 2015), children of Agra (Agarwal et al., 2014), urban children of Midnapore (Sinha and Maiti, 2012), urban children of Delhi (Gupta et al., 2017). The comparison suggested that the high prevalence of undernutrition is a major public health problem among Indian children, but CIAF has provides the increased magnitude of undernutrition among targeted children (Das and Bose, 2009; Sinha and Maiti, 2012; Agarwal et al., 2015; Dewan et al., 2015; Gupta et al., 2017) (Table 6). Therefore, the uses of CIAF will prove to be an important undernutrition measure over conventional anthropometric measures to report the actual prevalence of undernutrition in the population. Present study showed that the prevalence of undernutrition was higher in girls than boys using both conventional anthropometric measure (i.e., wasting and underweight) and the CIAF ($p<0.05$). Therefore, these variables were observed to have greater explanatory power to identify the reason for the vulnerable segments of the population with different disaggregated indices of the CIAF (Seetharaman et al., 2007; Sen et al., 2011; Sen and Mondal, 2012). Studies have confirmed that the sex/gender-specific prevalence of undernutrition was observed to be higher in girls than boys (Bose et al., 2007; Mondal and Sen, 2010; Sen and Mondal, 2012). It is attributed to the intra-household food allocation, cultural practices, socio-economic and poor access to healthcare services could be the main causes of such nutritional manifestation in the population.

The CIAF helps to decide the actual proportions and find out the relative risk of undernourishment in various disaggregated sub-groups (Groups B–Y). It is helpful to find out the risk factors and cause-specific mortality and co-morbidity where the conventional anthropometric indices didn't identify the groups of children with multiple failures (Seetharaman et al., 2007; Mahgoub et al., 2009; Sen et al., 2011; Sen and Mondal, 2012; Savanur and Ghugre, 2015). This disaggregation provides the comprehensible description of undernutrition, which the conventional indices are unable to predict due to overlapping nature (Nandy et al., 2005; Seetharaman et al., 2007; Sen and Mondal, 2012; Savanur and Ghugre, 2015). The proportion of combined single failure (i.e., Groups B, F and Y) and double/multiple failures (Groups C, D and E) are observed being high prevalence (i.e., 25.50% each) in children (Table 5). Quantifying the relationship between the different undernutrition (i.e., B-Y) and adverse health outcomes and the choice of more appropriate anthropometric indicators to assess the actual magnitude and how the different risk factors are associated with various forms of undernourishment remains to be accomplished (Sen and Mondal, 2012). Therefore, these interesting applications of the CIAF as an alternative measure of undernutrition and will be helpful for the health and policy planners (Nandy et al., 2005; Seetharaman et al., 2007; Sen and Mondal, 2012). Mukhopadhyay and Biswas (2011) reported that multiple anthropometric failures were more likely to be prevalent in Indian children belonging to a low food secure households and a low food secure household. Nandy et al., (2005) reported that children who were suffering from multiple anthropometric failure (i.e., Group D: stunted, underweight and wasted) have greater risk factors for illness/disease and morbidity. The adverse ramifications of undernutrition have impaired cognitive and motor development, poor educational achievement, reduced intellectual capacity, human capital development, decreases offspring birth weight or low birth weight and a higher risk of metabolic disease into adulthood (Blössner et al., 2005; Black et al., 2008; Victora et al., 2008; Prendergast and Humphrey 2014; Rengma et al., 2016). The segregation of the CIAF categories serves an important aspect related to the identification of multiple categories of undernourishment (e.g., C, D and E) (Nandy et al., 2005; Sen and Mondal, 2012).

Table 6: Comparison of undernutrition using conventional anthropometric indices and CIAF among pre-school children in India

Population/Ethnic group	Area/Region	Sample size	Age group	Stunting (%)	Underweight (%)	Wasting (%)	CIAF (%)	References
Indian children	State wise data, India	24,395	0-5 years	45.1	47.1	15.9	59.8	Nandy et al., 2005
Slum children of Coimbatore	Coimbatore, Tamil Nadu	405	0-5 years	48.4	49.6	20.2	68.6	Seetharaman et al.; 2007
Children of Chapra Nadia District	West Bengal	2016	3-5.9 years	48.2	48.3	10.6	60.4	Biswas et al., 2009
Bauri caste	Purulia District, West Bengal.	347	2-6 years	39.2	51.2	26.6	66.3	Das and Bose, 2009
Children of Hooghly	West Bengal	1012	2-6 years	26.6	63.3	50.0	73.1	Mandal and Bose, 2009
Preschool children of Darjeeling	Darjeeling, West Bengal	256	1-3 years	46.9	52.3	15.2	65.6	Mukhopadhyay et al.; 2009
Rural-urban children	Allahabad, Uttar Pradesh	371	0-5 years	40.7	49.1	14.6	62.8	Kumar et al., 2010
Santal ethnic group	West Bengal	251	2-6 years	26.3	38.2	12.7	43.4	Das and Bose., 2011
Children of Midnapore Town	West Bengal	658	2-6 years	40.6	43.8	23.4	58.2	Sinha and Maiti, 2012
Bangalee ethnic group	Purba Medinipur, West Bengal.	225	3-6 years	30.7	42.7	12.0	50.2	Acharya et al., 2013
Urban slum children of Mumbai city	Maharashtra	634	2-4 years	33.8	35.7	18.5	47.8	Savanur and Ghugre, 2015
Children of Agra city	Uttar Pradesh	458	0-5 years	41.9	42.8	22.7	60.0	Agarwal et al., 2015
Children of Singur Block	West Bengal	113	0-5 years	17.0	17.0	15.0	32.7	Dasgupta et al., 2015
Urban slum children	Jammu	250	0-5 years	42.8	38.8	20.4	73.2	Dewan et al., 2015
Bhumij children	Odisha	136	1-6 years	32.4	42.6	25.0	54.4	Goswami, 2016
Urban Slum children	Nagpur city	256	0-5 years	34.8	45.3	15.2	58.6	Dhok and Thakre, 2016
Children of Delhi	Delhi	100	0-5 years	43.0	35.0	25.0	62.0	Gupta et al., 2017
Karbi tribe	Karbi Anglong, Assam	400	2-5 years	35.50	26.75	18.50	51.00	Present study

Conclusion

The present study has addressed the potential advantage and appropriateness of using the CIAF over the conventional indices used to the assessment of child undernutrition. The conventional anthropometric indicators are important as they show distinct biological processes, but the new indices can supplement the information by providing the overall aggregated magnitude of the number of undernourished children. Despite the conceptual limitation, the CIAF provides an overall picture of undernutrition and it helps in prioritizing undernourished children, in terms of both single and multiple anthropometric failures may explain greater childhood morbidity. The valuable use of the CIAF will bring more precision in identification of greater vulnerable segments in the population both epidemiological or clinical assessment and policy implementation. The cross-sectional design and the sample size of the present study represented a difficulty in drawing major conclusions to find the trends and causes of undernutrition and CIAF among children. The findings of the present study, however, are important for the effective implementation of any public health programme, for the maternal and child health programme. The CIAF has potential to enhance the efficacy of the various ongoing nutritional intervention programmes by identifying the single or double or multiple failure groups. Therefore, the CIAF become necessary for introducing the nutritional intervention programme in the population.

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REFERENCES

Acharya A, Mandal GC, Bose K. 2013. Overall burden of under-nutrition measured by a Composite Index in rural pre-school children in Purba Medinipur,West Bengal, India. *Anthropological Review* **76**:109–116.

Agarwal D, Misra SK, Chaudhary SS and Prakash G. 2015. Are we underestimating the Real Burden of Malnutrition? An Experience from Community-Based Study. *Indian J Community Med* **40**: 268–272.

Anwar F, Gupta MG, Prabha C, Srivastava RK. 2013. Malnutrition among rural Indian children: An assessment using web of indices. *Int J Public Health Epidemiol* **2**: 78–84.

Berger MR, Fields-Gardner C, Wagle A, Hollenbeck CB. 2008. Prevalence of malnutrition in human immunodeficiency virus/acquired immunodeficiency syndrome orphans in the Nyanza province of Kenya: a comparison of conventional indexes with a composite index of anthropometric failure. *J Am Diet Assoc* **108**: 1014–17.

Biswas S, Bose K, Mukhopadhyay A, Bhadra M. 2009. Prevalence of undernutrition among pre-school children of Chapra, Nadia District, West Bengal, India, measured by composite index of anthropometric failure (CIAF). *Anthropol Anz* **67**: 269–79.

Black RE, Allen LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, Mathers C, Rivera J. 2008. Maternal and child undernutrition: Global and regional exposures and health consequences. *Lancet* **371**: 243–60.

Black RE, Morris SS, Bryce J. 2003. Where and why are 10 million children dying every year? Lancet **361**: 2226–34.

Blössner, M, de Onis M, Prüss-Üstün A. 2005. Malnutrition : Quantifying the health impact at national and local levels. Geneva: World Health Organization.

Boregowda GS, Soni GP, Jain K, Agrawal S. 2015. Assessment of Under Nutrition Using Composite Index of Anthropometric Failure (CIAF) amongst Toddlers Residing in Urban Slums of Raipur City, Chhattisgarh, India. *J Clin Diagn Res* **9**: LC04–6.

Bose K, Biswas S, Bisai S, Ganguli S, Khatun A, Mukhopadhyay A, Bhadra M. 2007. Stunting, Underweight and Wasting among Integrated Child Development Services (ICDS) scheme children aged 3–5 years of Chapra, Nadia District, West Bengal, India. *Matern Child Nutr* **3**: 216–221.

Bose K, Mandal GC. 2010. Proposed New Anthropometric Indices of Childhood Undernutrition. *Mal J Nutr* **16**: 131–36

Das S, Bose K. 2011. Assessment of Nutritional Status by Anthropometric Indices in Santal Tribal Children. *J Life Sci* **3**: 81–85

Das S, Bose K. 2009. Report on “anthropometric failure” among rural 2-6 years old Indian Bauri caste children of West Bengal. *Anthropological Review* **72**: 81–88

Dasgupta A, Sahoo SK, Taraphdar P, Preeti PS, Biswas D, Kumar A, Sarkar I. 2015. Composite index of anthropometric failure and its important correlates: A study among under-5 children in a slum of Kolkata, West Bengal, India. *Int J Med Sci Public Health* **4**: 414–419.

de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. 2007. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* **85**: 660–67

Deshmukh PR, Dongre AR, Sinha N, Garg BS. 2009. Acute childhood morbidities in rural Wardha: Some epidemiological correlates and health care seeking. *Indian J Med Sci* **63**: 345–354.

Dewan D, Gupta R, Kumar D. 2015. Can we rely solely on conventional measures to estimate undernutrition among under fives? *Indian J Community Health* **27**:361–65.

Dhok RS, Thakre SB. 2016. Measuring undernutrition by composite index of anthropometric failure (CIAF): a community-based study in a slum of Nagpur city. *Int J Med Sci Public Health* **5**: 2013–18

Goswami M. 2016. Prevalence of Undernutrition Measured by Composite Index of Anthropometric Failure (CIAF) Among the Bhumij Children of Northern Odisha, India. *J Nepal Paediatr Soc* **36**: 61–67.

Gupta G, Sharma AK, Choudhary TS. 2017. Assessment of undernutrition among children below 5, using Composite Index of Anthropometric Failure (CIAF). *Indian J Comm Health* **29**: 108–113.

Hall JG, Allanson JE, Gripp KW, Slavotinek AM. 2007. Handbook of Physical Measurements. Oxford, UK: Oxford University Press.

Kumar D, Mittal PC, Sharma MK. 2010. Socio-demographic Risk Factors of Child Undernutrition. *J Pediatr Sci* **2**:e7

Kumar N, Gupta N, Kishore J. 2012. Kuppuswamy's socioeconomic scale: Updating income ranges for the year 2012. *Indian J Public Health* **56**: 103–4.

Lwanga SK, Lemeshow S. 1991. Sample Size Determination in Health Studies: A Practical manual. Geneva, Switzerland: World Health Organization.

Mahgoub S, Silo L, Fields-Gardner C. 2009. Effect of dietary protein enrichment pilot program on the growth of under-five children in day care centres in Gaborone, Botswana. Available online at: http:// www.wishh.org/nutrition/botswana_daycare_ vasps.pdf.

Mandal G, Bose K. 2009. Assessment of Overall Prevalence of Undernutrition Using Composite Index of Anthropometric Failure (CIAF) among Preschool Children of West Bengal, India. *Iran J Pediatr* **19**: 237-43.

Mondal N, Basumatary B, Kropi J, Bose K. 2015. Prevalence of double burden of malnutrition among urban school going Bodo children aged 5-11 years of Assam, Northeast India. *Epidemiol Biostat Public Health* **12**: e11497(1–10).

Mondal N, Sen J. 2010. Prevalence of undernutrition among children (5–12 years) belonging to three communities residing in a similar habitat in North Bengal, India. *Ann Hum Biol* **37**: 198–216.

Mukhopadhyay DK, Biswas AR, Chakraborty M, Sadhukhan SK, Banik KK. 2009. Anthropometric failure, a new approach to measure undernutrition: An experience from the rural community of West Bengal, India. *J Indian M Assoc* **107**: 211–4.

Mukhopadhyay DK, Biswas AB. 2011. Food security and anthropometric failure among tribal children in Bankura, West Bengal. *Indian Pediatr* **48**: 311–14.

Nandy S, Miranda JJ. 2008. Overlooking undernutrition. Using a composite index of anthropometric failure to assess how underweight misses and misleads the assessment of undernutrition in young children. *Soc Sci Med* **66**: 1963–6.

Nandy SM, Irving M, Gordon D, Subramanian SV, Davey Smith G. 2005. Poverty, child undernutrition and morbidity: New evidence from India. *Bull World Health Organ* **83**: 210–6.

Nandy S, Svedberg P. 2012. The Composite Index of Anthropometric Failure (CIAF): An alternative indicator for malnutrition in young children. Preedy VR, ed. Handbook of anthropometry: physical measures of human form in health and disease. New York: Springer Verlag, pp-127–36.

Prendergast AJ, Humphrey JH. 2014. The stunting syndrome in developing countries. *Paediatr Int Child Health* **34**: 250–65.

Rengma MS, Bose K, Mondal N. 2016. Socio-economic and demographic correlates of stunting among adolescents of Assam, North-east India. *Anthropological Review* **79**: 409–425

Savanur MS, Ghugre PS. 2015. Magnitude of undernutrition in children aged 2 to 4 years using CIAF and conventional indices in the slums of Mumbai city. *J Health Popul Nutr* **33**: 3; doi: 10.1186/s41043-015-0017-x.

Seetharaman N, Chacko TV, Shankar S, Mathew A C. 2007. Measuring malnutrition - The role of Z scores and the composite index of anthropometric failure (CIAF). *Indian J Community Med* **32**: 35–9

Sen J, Dey S, Mondal N. 2011. Conventional nutritional indices and Composite Index of Anthropometric failure: which seems more appropriate for assessing under-nutrition among children? A cross sectional study among school children of the Bengalee Muslim Population of North Bengal, India. *Italian J Pub Health* **8**: 66–79.

Sen J, Mondal N. 2012. Socio-economic and demographic factors affecting the Composite Index of Anthropometric Failure (CIAF). *Ann Hum Biol* **39**: 129–36.

Sinha NK, Maiti S. 2012. Prevalence of undernutrition among under-privileged preschool children (2-6yrs) of Midnapore town, India. *Malaysian J Paediat Child Health* **06**: 18.

Svedberg P. 2000. Poverty and under-nutrition: theory, measurement, and policy. New Delhi: Oxford India Paperback.

Tigga PL, Sen J, Mondal N. 2015. Association of some socio-economic and socio-demographic variables with wasting among pre-school children of North Bengal, India. *Ethiop J Health Sci* **25**: 63–72.

Touitou Y, Portaluppi F, Smolensky MH, Rensing L. 2004. Ethical principles and standards for the conduct of human and animal biological rhythm research. *Chronobiol Int* **21**: 161–170.

Ulijaszek SJ, Kerr DA. 1999. Anthropometric measurement error and the assessment of nutritional status. *Br J Nutr* **82**: 165–177.

Victora CG, Adair L, Fall C, Hallal PC, Martorell R, Richter L, Sachdev HS. 2008. Maternal and Child Undernutrition Study Group. Maternal and child undernutrition: *Lancet* **371**: 340–357.

Vollmer S, Harttgen K, Kupka R, Subramanian SV. 2017. Levels and trends of childhood undernutrition by wealth and education according to a Composite Index of Anthropometric Failure: evidence from 146 Demographic and Health Surveys from 39 countries. *BMJ Glob Health* **2**:e000206.

World Health Organization. 1995. Physical Status: The use and Interpretation of Anthropometry. Technical report Series no. 854. WHO: Geneva.

World Health Organization. 2007. WHO Child Growth Standards: length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age [http://www.who.int/childgrowth/standards/en].