

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

Jaydip Sen, Sima Dey, Nitish Mondal

Department of Anthropology, University of North Bengal, India

Correspondence to: Jaydip Sen, Department of Anthropology, University of North Bengal, P.O.: NBU, Raja Rammohunpur, Dist.: Darjeeling-734013, West Bengal, India. E-mail: jaydipen@rediffmail.com

Abstract

Background: Stunting, wasting and under-weight have been conventionally utilized to assess the prevalence of under-nutrition among children. As these indices grossly underestimate this prevalence mainly due to overlapping of the children into multiple categories of anthropometric failure, there is a need for an appropriate single measure to assess this prevalence and identify the more susceptible individuals. The present study tries to ascertain whether the use of the Composite Index of Anthropometric Failure (CIAF) is more appropriate than the conventional indices for the estimation of under-nutrition among children.

Methods: The present cross-sectional study was undertaken to compare the prevalence of under-nutrition using both the conventional indices and the CIAF among 1143 children aged between 5 years to 11 years (565 boys; 578 girls) belonging to the Bengalee Muslim Population (BMP), and residing in the district of Darjeeling, West Bengal, India. The children were selected using a multi-stage stratified random sampling procedure. The data was collected during the period from February 2009 to May 2010. Height and weight of the children were recorded using standard procedures. The conventional anthropometric indices and the CIAF were compared with the National Center for Health Statistics reference data to determine the prevalence of under-nutrition. A child having a value $\geq 2SD$'s below that of the reference median in any of these indices was classified as suffering from under-nutrition. All the necessary approvals and consents were obtained from the Gram Panchayets and school authorities, and the study was conducted in accordance with the ethical guidelines for human experiments as laid down in the Helsinki Declaration of 2000.

Results: Using the conventional indices, the prevalence of under-nutrition was observed to be 17.4% (wasting), 38.5% (stunting) and 47.0% (under-weight). However, with the use of the CIAF, this prevalence increased to 57.6% and included both single and multiple anthropometric failures. The prevalence of CIAF was observed to be higher among boys (60.4%) than girls (54.8%), although the differences were not statistically significant (chi-value = 0.96; d.f. 1, $p > 0.05$). Using the conventional indices too, boys were more affected than girls (stunting: chi-value = 0.20; d.f. 1, $p > 0.05$; wasting: chi-value = 1.94; d.f. 1, $p > 0.05$; under-weight: chi-value = 2.81; d.f. 1, $p > 0.05$).

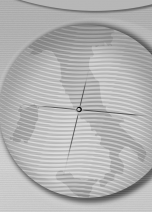
Conclusions: It is concluded that under-nutrition among BMP children is a serious health issue. According to our results, the majority of these children aged between 5 and 11 years were under-weight, followed by stunting and wasting. The use of the CIAF increased this prevalence. The potential advantage and appropriateness of using CIAF over conventional indices for evaluating child under-nutrition is discussed. Further studies are recommended for the comprehensive understanding of the scenario of under-nourishment in different Indian populations using CIAF. Nutritional intervention programmes are necessary to improve the nutritional status of the children covered in course of this study.

Key words: under-nutrition, CIAF, children, Muslim, India

Introduction

Child under-nutrition is the major public health issue in many developing countries such as India. It also continues to be one of the principal causes of ill-health and premature mortality and morbidity among children of these countries [1-3]. The World Health Organization (WHO) has estimated

that 60.0 % of the 10.9 million deaths that occur annually among children aged less than five years in the developing countries are associated with under-nutrition [4]. Studies on nutritional assessment among children in India remain a very challenging task. The country's large population size, its poverty-stricken population groups,



socio-economic disparities, high percentage of illiteracy and inadequate health facilities, all pose serious challenges to such studies. The situation remains the same in the northern part of the state of West Bengal, an area popularly known as North Bengal. Given the region's general backwardness in educational, health and medical facilities, individuals residing in this area remain very vulnerable to under-nutrition [5-7]. Studies have also reported that the magnitude of under-nutrition was appreciably high among children of this region [8-10].

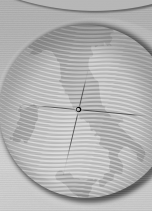
The anthropometric measurements of height and weight along with age have been conventionally used to evaluate child under-nutrition [11]. The three conventional anthropometric indices of stunting (low height-for-age), wasting (low weight-for-height) and under-weight (low weight-for-age) have generally been used for evaluating the nutritional status [3, 11]. According to the WHO, these indices reflect distinct biological processes and their uses are necessary for determining appropriate nutritional interventions [11]. It needs to be mentioned here that the first and foremost aim of nutritional assessment studies among children is to determine the design and timing of different nutritional programs to be launched to combat child under-nutrition [12]. Children experiencing stunting and wasting are considered to be under-nourished, with the former indicating chronic under-nutrition and the latter associated with acute under-nutrition. The index of under-weight is used as a composite measure of stunting and wasting, but does not distinguish between the two [3, 11, 13]. The Body Mass Index (BMI) is another surrogate anthropometric indicator that can be utilized for the assessment of the nutritional status among children and this assessment is done in terms of thinness (low-BMI-for-age) [11, 14]. Although the interpretation of BMI is complicated by the changes that occur in weight, height and body composition during child and adolescent growth [15, 16], the WHO has recommended the use of BMI for assessing the nutritional status of children (0 year to 5 years) and adolescents in terms of thinness by a comparison with a representative reference norm [17, 18].

It is now agreed that the conventional indices discussed above only allow for the categorization of children into the general categories of under-nutrition and do not provide an opportunity to determine the overall prevalence of under-nutrition that is associated with multiple failures [3, 19, 20]. As a result, it has been opined that these conventional anthropometric indices alone

were not sufficient and that the number of under-nourished children was being under-estimated primarily due to overlapping of the children into multiple categories of anthropometric failure. It has been further suggested that the conventional anthropometric indices are unable to depict the overall prevalence of under-nutrition because a researcher has to 'choose' a certain category of anthropometric failure for assessing nutritional status [20]. Hence, while some stunted children may not be affected with wasting and/or under-weight, and other similar combinations, others might suffer from all three nutritional failures of stunting, under-weight and wasting [3, 13, 19, 21].

Subsequently, the use of the Composite Index of Anthropometric Failure (CIAF), which is an aggregated single anthropometric measure providing an overall estimate of under-nourishment in children, has been proposed [3, 19]. The original model, proposed by Svedberg [19], comprised of 6 sub-groups of anthropometric failure (Groups A-F) to which Nandy et al. [3] supplemented one more sub-group (Group Y). The CIAF includes those children who experience stunting, classification under-weight, wasting and multiple failures (Groups B-Y) and excludes those children who do not exhibit any anthropometric failure (Group A). These composite groups include children who have a height and weight appropriate for their age of reference and show data that are not considered as anthropometric failure. On the other hand, children whose height and weight for their age are below the reference are, thus, experiencing one or multiple forms of anthropometric failure [3]. The combination of 'wasted and stunted' is not included in the CIAF classification as it is physically impossible for a child to simultaneously experience stunting and wasting and not be under-weight [3].

Using the conventional indices of stunting, wasting and under-weight, there have been a number of studies on the assessment of nutritional status of children both from India and abroad [22-29]. But very few studies have used the CIAF to assess nutritional status of children primarily because the development of this index is quite recent. Most of the studies on nutritional status and the CIAF have been conducted among children aged less than 5 years and belonging to different non-Indian and Indian ethnic populations [3, 8, 20, 21, 30-33]. In the present study, the prevalence of under-nutrition has been documented in a group of children aged 5 years to 11 years and residing in North Bengal, assessed using both the conventional indices and the CIAF. The hypothesis is that the



use of the CIAF appears to be more appropriate than the conventional nutritional indices for the estimation of under-nutrition among children aged 5 years to 11 years.

Materials and methods

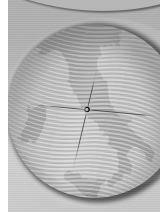
Study region, subjects and method of sampling

The area known as North Bengal lies in the state of West Bengal, India and comprises the districts of Darjeeling, Jalpaiguri, Cooch Bihar, North Dinajpur, South Dinajpur and Malda. The area chosen for the present study is located in the Darjeeling district of this region. A number of tribal (Lepcha, Rabha, Meche, Toto, Oraon, Santal and Munda), and non-tribal (Rajbanshi, Bengalee Caste and Bengalee Muslim) populations inhabit this region. The present cross-sectional study was carried out among school going children aged between 5 years to 11 years and belonging to the Bengalee Muslim Population (BMP). According to the 2001 census of India, the Muslim population accounted for approximately 12.0% of the total population of the country. Ethnically, the BMP is a Bengali-speaking ethnic community and by religion faithful to Islam and constitutes of 20.2 million individuals or 25.3% of the total population of the state of West Bengal [34]. The Muslim population is the largest minority population in India, whose representatives are generally poorer, less educated and belong to the most vulnerable segments of society [35, 36]. More often, they are economically backward, with more than 70.0% living below the poverty line [37]. Between 1961 and 2001, the Muslim population has grown from 47 million to 138 million, a growth of 193.0%, which has been the highest recorded increase compared to that any other population group in the country. A number of states have witnessed very large population growth among Muslims, and West Bengal happens to be one of those states. It has also been reported that Muslims have been at the lowest step of the ladder in terms of the basic categories of socio-economic indicators of development [38]. Several authorities have opined that a certain caste system exists among Muslims, which forms a basis for social relations, but its form has been greatly weakened and modified [39, 40]. Moreover, Muslims generally practice consanguineous marriages, which have significant effects on their fertility, mortality, and net-fertility rates [41, 42]. Limited numbers of nutritional assessment studies have been carried out among BMP children and adults in the state of West Bengal, but none of them have used the CIAF [9, 31, 43, 44].

The children in the context of this study were the residents of Phansidewa block, under Siliguri sub-division, Darjeeling district, West Bengal. The study area is a predominantly a rural and remote area located approximately 40 km to 45 km from the sub-divisional town of Siliguri. The children were students in 12 different primary schools under three Gram Panchayets (local level governing authorities) of Phansidewa block. These schools have a large percentage of Muslim students. The data was collected during the period from February 2009 to May 2010. All necessary approvals and consents were obtained from the Gram Panchayets and school authorities. The study was conducted in accordance with the ethical guidelines for human experiments as laid down in the Helsinki Declaration of 2000 [45].

The children were selected using a two-stage stratified random sampling method. Initially, children belonging to the BMP were identified from the schools based on their surnames which were subsequently verified from the school and Gram Panchayet records. In the first stage, a total of 1326 BMP children were identified and approached for the study. Of these, 18 children disagreed to participate in the study. The age of the remaining 1308 children was determined from the school records which were subsequently verified from their birth certificates issued by the Gram Panchayet authorities. However, the date of birth of 97 children was not available in the school records and/or Gram Panchayet records and, as such, these were excluded from the study. An additional 68 children were excluded as they were either below or higher than the age range under study. Hence, the final study sample comprised of 1143 children (565 boys; 578 girls). Special attention was given so that each category (sex/age) had a minimum of 60 individuals. All the children were physically normal and devoid of any deformities.

A modified version of the Kuppuswamy scale, proposed by Mishra and Singh [46], was utilized to determine the socio-economic status (SES) of the children. Relevant data on monthly family income, education and nature of occupation was obtained utilizing pre-structured and pre-tested schedules for the purpose. It may be noted here that, in a number of nutritional assessment studies among different Indian ethnic populations, this modified Kuppuswamy scale has been used to determine the SES [9, 47, 48]. The schedules were completed by interviewing parents and carrying out home visits. It was subsequently observed that all the children belonged to a lower SES.



Anthropometric measurements recorded

The anthropometric measurements recorded were height and weight following a standard procedure [49]. Height of the children was recorded with the help of an anthropometer to the nearest 0.1 cm. The weight of the children was recorded with children wearing minimum clothing using a portable weighing scale to the nearest 0.5 kg. The anthropometric measurements were taken by two of the authors (SD and NM). The intra-observer and inter-observer differences were calculated in order to test the reliability of the collected measurements using the technical error measurement (TEM) following the method used by Ulijaszek and Kerr [50]. The TEM values were within the cut-off limits. Hence the measurements taken by both the authors were deemed reliable.

Assessment of nutritional status

The prevalence of under-nutrition was evaluated both using the three commonly utilized conventional anthropometric indices of stunting, under-weight and wasting [11] and the CIAF [3, 19]. The interpretation of the three conventional indices involves a comparison with an international reference population to determine under-nutrition [11]. As recommended by the WHO, the data from the National Centre of Health Statistics (NCHS) [51] has been utilized as the reference population for the evaluation of under-nutrition [11]. The justification for the use of such a reference population is based on the empirical finding that well-nourished children in all populations follow similar growth patterns [52].

However, several authorities have expressed some concerns about the suitability of the NCHS reference data as the basis of comparisons for assessing the nutritional status of children

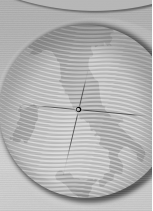
from developing countries [53-55]. Recently, the WHO published child growth standards for attained weight and height to replace those previously recommended NCHS/WHO [51] reference data. These new standards are based on breastfed infants and appropriately fed children of different ethnic origins, raised in optimal conditions and measured in a standardized manner [18, 56]. These reference data were proposed so as to identify individuals at risk, assess response to intervention and facilitate international comparison [57]. However, the NCHS reference data [51] has been found to be consistent with these currently advocated international growth references for children [11, 58]. It has been reported, however, that when using the old and new reference data, the prevalence of under-weight decreased in children aged 5 months and more, and that the prevalence of stunting and wasting increased among the same group [59]. Given these issues, the NCHS data [51] has been used to assess the magnitude of under-nutrition in children of the present study. The prevalence of under-nutrition has been subsequently assessed utilizing Z-scores according to the classification proposed by the WHO [11]. A child having values $-2SD$'s below that of the reference median in the indices for stunted, under-weight and wasted, were classified as under-nourished [11, 60].

The combination of Svedberg's [19] model of six groups (stunted only, under-weight only, wasted only, wasting and under-weight, stunted and under-weight and lastly stunted, wasted and under-weight) and that of Nandy et al. [3] (under-weight only) was utilized for assessing under-nutrition using the CIAF. A descriptive disaggregation of the CIAF is depicted in Table 1.

Table 1. Classification of the Composite Index of Anthropometric Failure (CIAF)*.

Groups	Description	Wasting	Stunting	Under-weight
A	No failure	No	No	No
B	Wasting only	Yes	No	No
C	Wasting and under-weight	Yes	No	Yes
D	Wasting, stunting & under-weight	Yes	Yes	Yes
E	Stunting & under-weight	No	Yes	Yes
F	Stunting only	No	Yes	No
Y	Under-weight only	No	No	Yes

* Based on Nandy et al., 2005 [3]



Statistical analysis

The statistical analysis was carried out using SPSS for Windows (Version 15.0). The descriptive statistics (mean and standard deviation) of height and weight were calculated. One way analysis of variance (ANOVA) was used to assess the differences in mean height and weight. Chi-square analysis was performed to determine the sex difference in the overall prevalence of under-nutrition using both the conventional indices and the CIAF. Chi-square analysis was also performed to assess sex differences in the sub-groups of the CIAF. A p-value of less than 0.05 was considered to be statistically significant.

Results

The analysis of under-nutrition using the conventional indices showed that the overall prevalence was 17.4% (wasting), 38.5% (stunting) and 47.0% (under-weight). Compared to conventional anthropometric indices, the CIAF, which aggregated children from both single and multiple failures, showed the highest overall prevalence of under-nutrition to be 57.6% (Table 2). The prevalence of the CIAF was observed to be higher among boys (60.4%) than girls (54.8%). The differences were, however, not statistically significant when tested by chi-square analysis (chi-value = 0.96; d.f. 1, $p > 0.05$). Observing the conventional indices of stunting, wasting and under-weight, also suggested that boys were more affected than girls (stunting: chi-value = 0.20; d.f. 1, $p > 0.05$; wasting: chi-value = 1.94; d.f. 1, $p > 0.05$; under-weight: chi-value = 2.81; d.f. 1, $p > 0.05$).

The age and sex distribution, mean and standard deviation of height and weight, the prevalence of under-nutrition among children using the conventional indices, and the CIAF are shown in Table 3. The age and sex specific means of height and weight increased with age among both sexes. Using ANOVA, the differences were found to be statistically significant among both boys (height:

$F = 71.49$; d.f. 6, $p < 0.05$; weight: $F = 56.62$; d.f. 6, $p < 0.05$) and girls (height: $F = 64.07$; d.f. 6, $p < 0.05$; weight: $F = 50.04$; d.f. 6, $p < 0.05$). The children belonging to the higher age groups were found to be more affected by stunting and under-weight. The highest prevalence was observed in both boys (65.8% and 71.2% respectively) and girls (60.3% and 66.7% respectively) aged 11 years. The overall sex specific prevalence of under-nutrition using both the conventional anthropometric indices and the CIAF among the BMP children is depicted in Figure 1. For a better understanding of the results, the prevalence of under-nutrition has been broken up and graphically represented in the different age groups under study (Figures 1a-1g).

The age and sex specific prevalence of children suffering from single and multiple failures in different sub-groups of the CIAF (Groups B-Y) are depicted in Table 4. Overall, 42.4% of the children (boys: 39.7%; girls: 45.2%) showed no anthropometric failure (Group A). The results indicate that the overall prevalence of under-nutrition was found to be the highest in Group E (overall: 27.2%; boys: 28.7%; girls: 25.8%). The incidences were found to be approximately similar in Group B (overall: 5.2%; boys: 5.1%; girls: 5.2%) , in Group D (overall: 5.9%; boys: 6.7%; girls: 5.0%) and in Group F (overall: 5.4%; boys: 4.1%; girls: 6.8%). The incidences of wasting and under-weight (Group C) and under-weight only (Group Y) were 6.4% (boys: 7.4%; girls: 5.4%) and 7.5% (boys: 8.3%; girls: 6.8%) respectively. It was further observed, in case of age and sex specific prevalence in the sub-groups of the CIAF, that boys were found to be more affected than their girl counterparts, with the exception being in Group F (stunting only). Regarding overall prevalence, sex differences were not statistically significant (Groups B-Y) when investigated through χ^2 analysis ($\chi^2 = 8.38$, d.f. 6, $p > 0.05$). Using χ^2 analysis, sex differences were also not statistically significant ($p > 0.05$) when the data

Table 2. Overall prevalence of under-nutrition using the conventional indices and the CIAF among the BMP children.

Indices	Boys (N= 565)	Girls (N=578)	Total (N=1143)
Wasting	109 (19.3)	90 (15.6)	199 (17.4)
Stunting	223 (39.5)	217 (37.5)	440 (38.5)
Underweight	289 (51.2)	248 (42.9)	537 (47.0)
CIAF	341 (60.4)	317 (54.8)	658 (57.6)
<i>Values in parenthesis indicate percentages</i>			

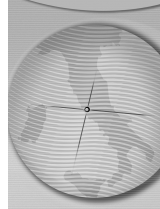


Table 3. Age and sex specific descriptive statistics of height and weight (mean \pm SD), prevalence of under-nutrition using the conventional indices and the CIAF among the BMP children.

	5 years		6 years		7 years		8 years		9 years		10 years		11 years	
	Boys (N=61)	Girls (N=72)	Boys (N=62)	Girls (N=88)	Boys (N=112)	Girls (N=106)	Boys (N=105)	Girls (N=94)	Boys (N=77)	Girls (N=76)	Boys (N=75)	Girls (N=79)	Boys (N=73)	Girls (N=63)
Height (cm)	109.8 ± 7.2	108.6 ± 6.9	112.6 ± 6.9	115.2 ± 8.7	118.9 ± 7.7	117.3 ± 7.51	121.6 ± 7.8	120.5 ± 7.1	124.3 ± 7.3	123.7 ± 6.5	128.9 ± 7.1	126.6 ± 6.4	129.6 ± 6.4	127.7 ± 6.9
Weight (kg)	16.6 ± 2.4	15.9 ± 2.0	17.4 ± 2.9	18.2 ± 3.2	19.4 ± 2.9	18.9 ± 3.03	20.3 ± 3.3	19.9 ± 3.1	21.4 ± 3.1	21.1 ± 3.6	23.1 ± 3.2	22.3 ± 3.2	23.9 ± 2.8	23.8 ± 3.7
Wasting	12 (19.7)	12 (16.7)	14 (22.6)	9 (10.2)	23 (20.5)	16 (15.1)	25 (23.8)	14 (14.9)	16 (20.8)	16 (21.1)	12 (16.0)	15 (18.9)	7 (9.6)	8 (12.7)
Stunting	20 (32.8)	20 (27.8)	19 (30.6)	27 (30.7)	29 (25.9)	28 (26.4)	36 (34.3)	31 (32.9)	36 (46.8)	29 (38.2)	35 (46.7)	44 (55.7)	48 (65.8)	38 (60.3)
Under-weight	24 (39.3)	21 (29.2)	38 (61.3)	25 (28.4)	46 (41.1)	33 (31.1)	50 (47.6)	35 (37.2)	42 (54.6)	41 (53.9)	37 (49.3)	51 (64.6)	52 (71.2)	42 (66.7)
CIAF (B-Y)	36 (59.0)	37 (51.4)	40 (64.5)	39 (44.3)	54 (48.2)	47 (44.3)	62 (59.1)	44 (46.8)	51 (66.2)	43 (56.6)	42 (56.0)	57 (72.2)	56 (76.7)	50 (79.4)
<i>Values in parenthesis indicate percentages</i>														

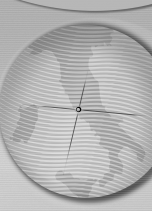


Figure 1. Overall prevalence of under-nutrition using the conventional anthropometric indices and the CIAF among the BMP children.

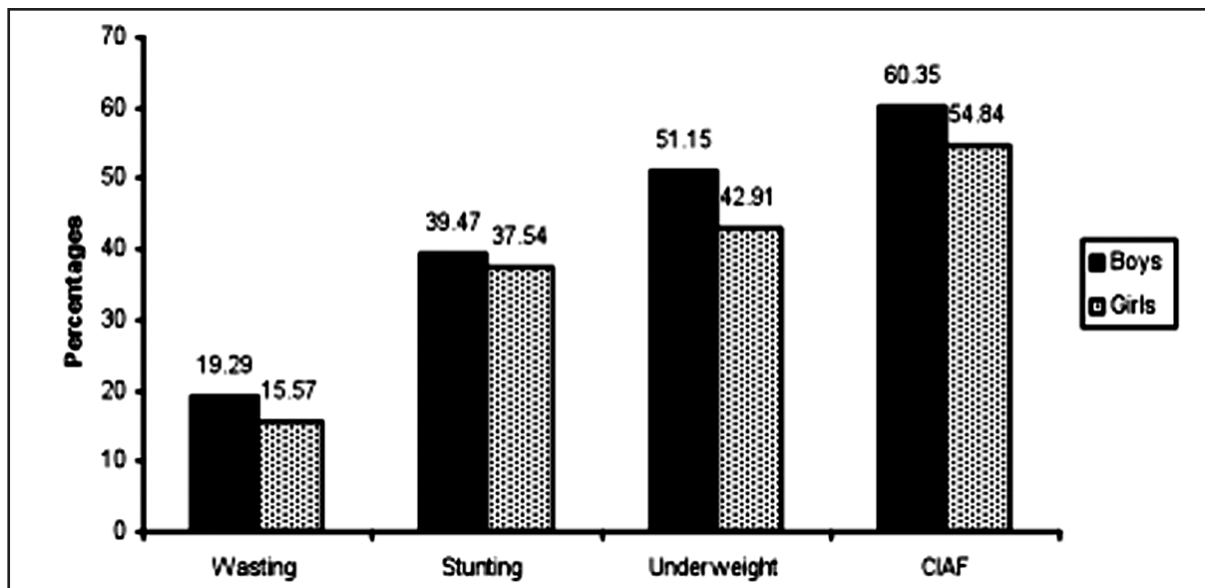


Figure 1a. Prevalence of under-nutrition using the conventional anthropometric indices and the CIAF among the BMP children aged 5 years.

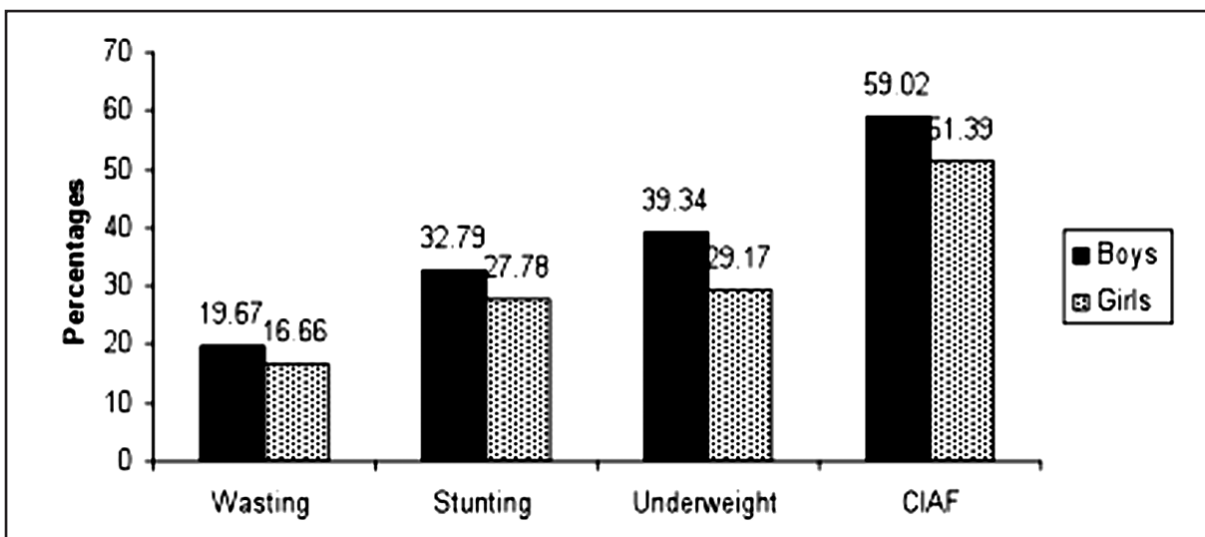
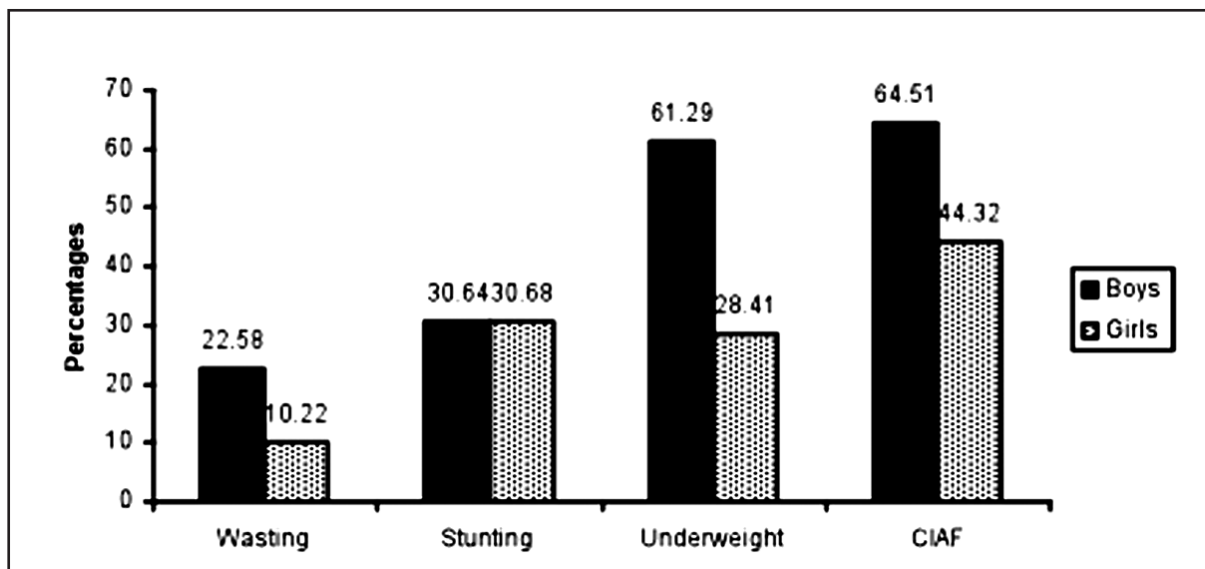
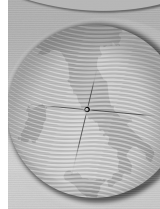


Figure 1b. Prevalence of under-nutrition using the conventional anthropometric indices and the CIAF among the BMP children aged 6 years.





ITALIAN JOURNAL OF PUBLIC HEALTH

Figure 1c. Prevalence of under-nutrition using conventional anthropometric indices and the CIAF among BMP children aged 7 years.

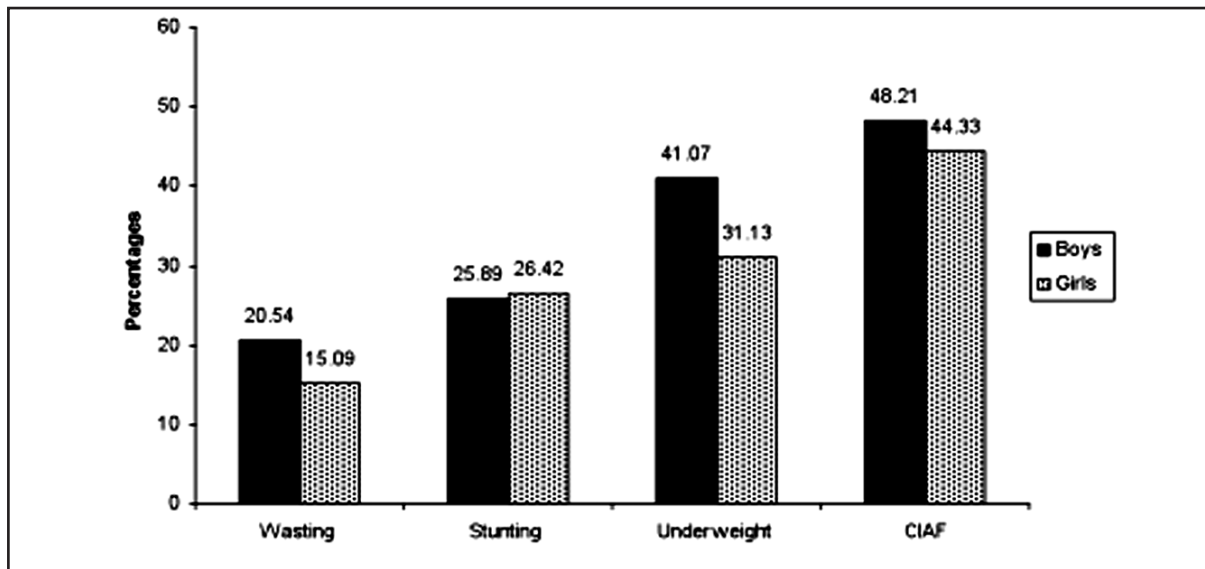


Figure 1d. Prevalence of under-nutrition using the conventional anthropometric indices and the CIAF among the BMP children aged 8 years.

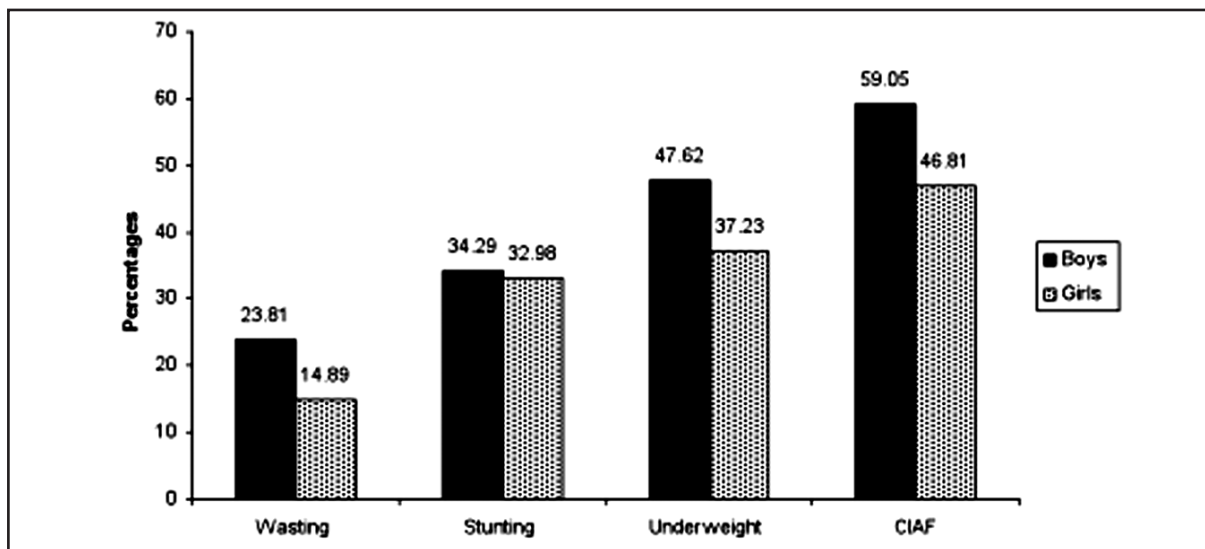
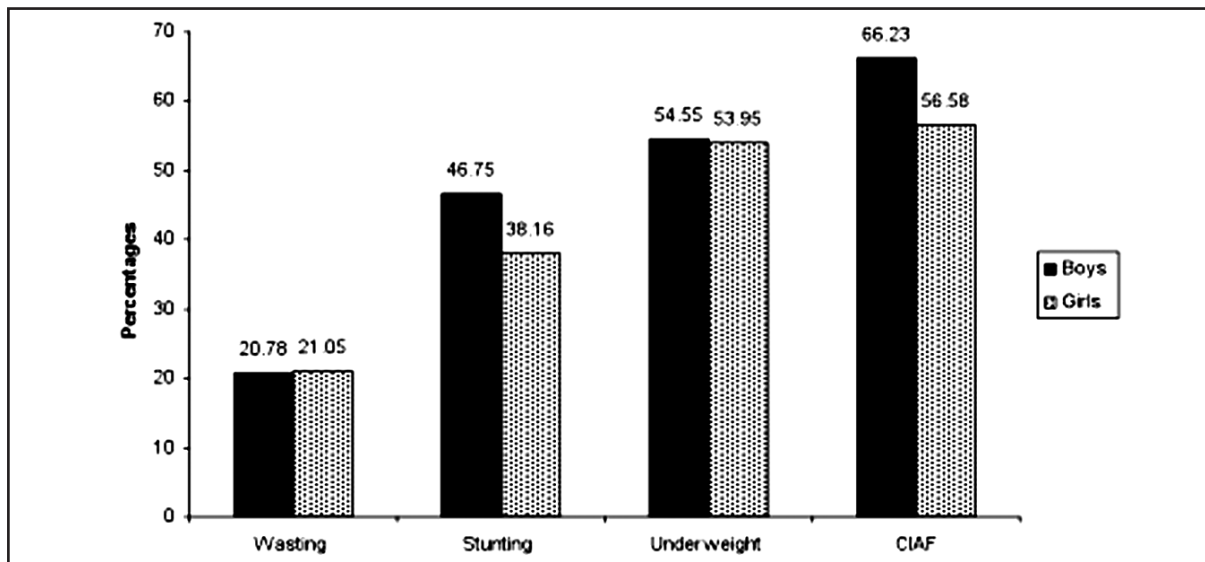


Figure 1e. Prevalence of under-nutrition using the conventional anthropometric indices and the CIAF among the BMP children aged 9 years.



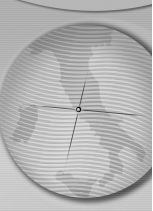


Figure 1f. Prevalence of under-nutrition using the conventional anthropometric indices and the CIAF among the BMP children aged 10 years.

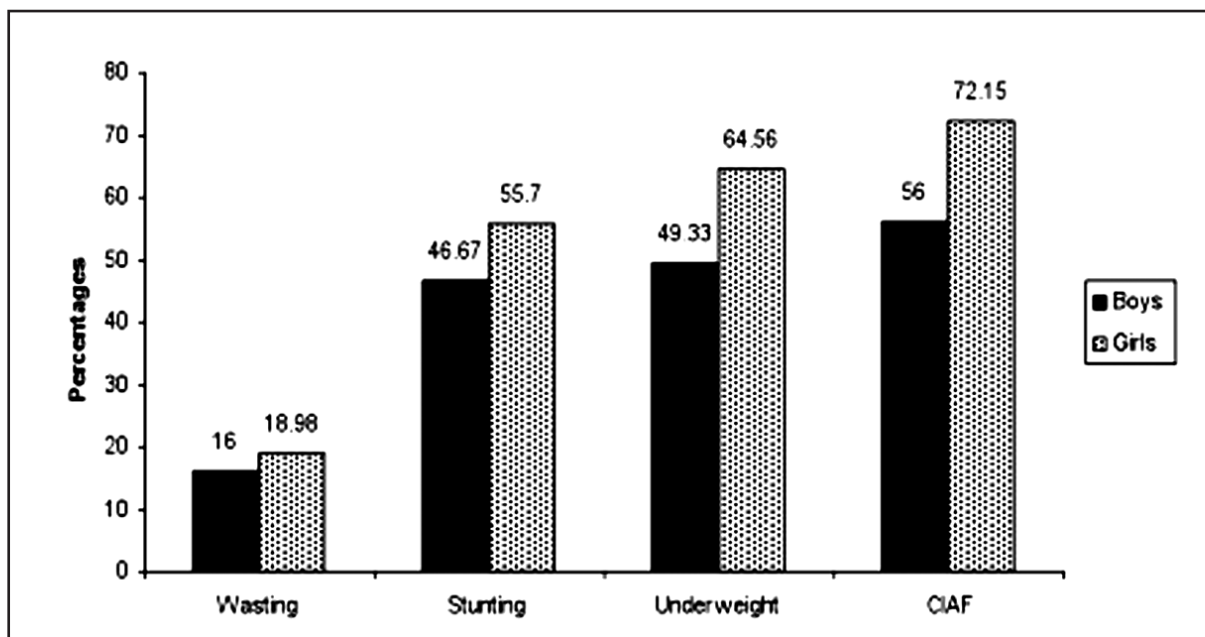
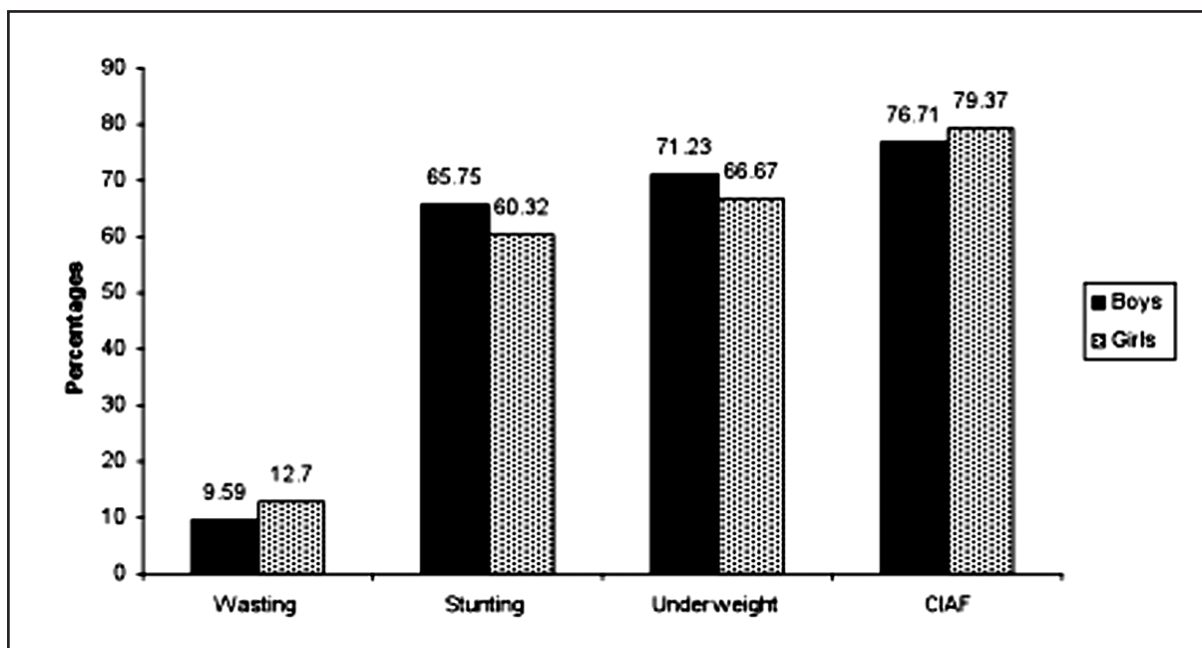


Figure 1g. Prevalence of under-nutrition using the conventional anthropometric indices and the CIAF among the BMP children aged 11 years.



was split into the sub-groups of the CIAF (B-Y). The age and sex specific disaggregation of the children into different CIAF indices is also shown in Figure 2.

Discussion

There appears to be a need for an appropriate single measure to assess the magnitude of under-nutrition and identify susceptible groups in the population, as studies have indicated that under-nutrition is closely associated with a larger proportion of child mortality with adverse health

outcomes [61-64] and with children suffering from different forms of ill-health as compared to normal children [65, 66]. An under-nourished child has a far lower chance of survival than a child who is well-nourished. This is where the use of the CIAF bears prime significance as an assessment tool of the accurate prevalence of under-nourishment in the target population. As the use of the CIAF is a recent development, there are a handful of studies that have reported the extent of the prevalence of under-nutrition among Indian children using this instrument [3,

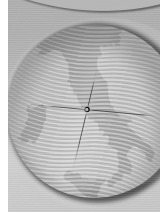


Table 4. Age and sex specific prevalence in the different groups of the CIAF among the BMP children.

Group	5 years		6 years		7 years		8 years		9 years		10 years		11 years		Total	
	Boys (N=61)	Girls (N=72)	Boys (N=62)	Girls (N=88)	Boys (N=112)	Girls (N=106)	Boys (N=105)	Girls (N=94)	Boys (N=77)	Girls (N=76)	Boys (N=75)	Girls (N=79)	Boys (N=73)	Girls (N=63)	Boys (N=565)	Girls (N=578)
A (No failure)	25 (40.9)	35 (48.6)	22 (35.5)	49 (55.7)	58 (51.8)	59 (55.7)	43 (40.9)	50 (53.2)	26 (33.8)	33 (43.4)	33 (44.0)	22 (27.9)	17 (23.3)	13 (20.6)	224 (39.7)	261 (45.2)
B (Wasting only)	7 (11.5)	6 (8.3)	2 (3.2)	5 (5.7)	7 (6.3)	9 (8.5)	7 (6.7)	6 (6.4)	5 (6.5)	2 (2.6)	1 (1.3)	0	0	2 (3.2)	29 (5.1)	30 (5.2)
C (Wasting and under-weight)	5 (8.2)	4 (5.6)	8 (12.9)	4 (4.6)	10 (8.9)	4 (3.8)	7 (6.7)	3 (3.2)	7 (9.1)	6 (7.9)	2 (2.7)	8 (10.1)	3 (4.1)	2 (3.2)	42 (7.4)	31 (5.4)
D (Wasting, stunting & under-weight)	0	2 (2.8)	4 (6.5)	0	6 (5.4)	3 (2.8)	11 (10.5)	5 (5.3)	4 (5.2)	8 (10.5)	9 (12.0)	7 (8.9)	4 (5.5)	4 (6.4)	38 (6.7)	29 (5.0)
E (Stunting & under-weight)	15 (24.6)	8 (11.1)	15 (24.2)	18 (20.5)	22 (19.6)	20 (18.9)	20 (19.1)	23 (24.5)	28 (36.4)	21 (27.6)	22 (29.3)	31 (39.2)	40 (54.8)	28 (44.4)	162 (28.7)	149 (25.8)
F (Stunting only)	5 (8.2)	10 (13.9)	0	9 (10.2)	1 (0.9)	5 (4.7)	5 (4.8)	3 (3.2)	4 (5.2)	0	4 (5.3)	6 (7.6)	4 (5.5)	6 (9.5)	23 (4.1)	39 (6.8)
Y (Under-weight only)	4 (6.6)	7 (9.7)	11 (17.7)	3 (3.4)	8 (7.1)	6 (5.7)	12 (11.4)	4 (4.3)	3 (3.9)	6 (7.9)	4 (5.3)	5 (6.3)	5 (6.9)	8 (12.7)	47 (8.3)	39 (6.8)
<i>Values in parenthesis indicate percentages</i>																

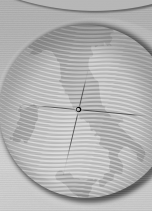
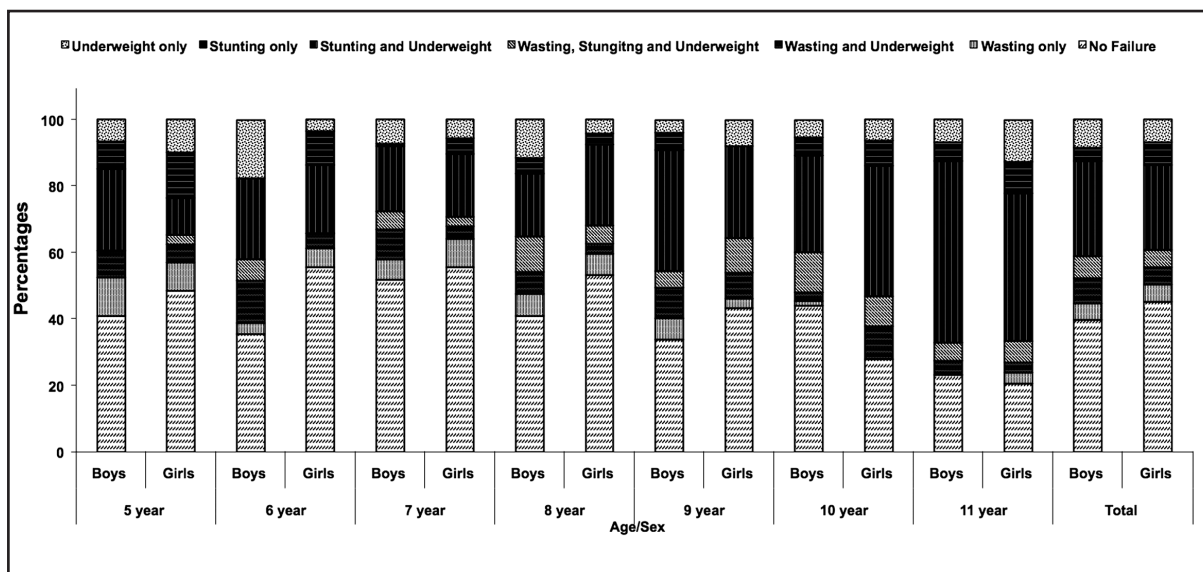


Figure 2. Age and sex specific prevalence in different sub-groups of the CIAF among the BMP children.years.



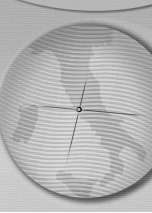
8, 21, 31-33, 67]. Nandy et al. [3] utilizing data from the National Family Health Survey (NFHS-2) of 1998-99, reported that the prevalence of under-nutrition was 59.8% while Seetharaman et al. [21] reported that 68.6% of children of Tamil Nadu were under-nourished. Using the CIAF, a very high prevalence of under-nutrition has been reported among children from different districts of West Bengal. This prevalence was 73.1% in Hooghly [33], 66.3% in Purulia [32], 65.6% in Darjeeling [8] and 60.4% in Nadia [31]. However, all these studies have been conducted among children aged 1 year to 6 years.

The present study is the first of its kind to extend the use of CIAF to child groups aged 5 years to 11 years. A high incidence of under-nutrition (57.6%) was observed among these children using the CIAF. This is considerably higher than the prevalence obtained using the three conventional nutritional indices. Using the CIAF, an overall 57.6% of these children showed single and multiple anthropometric failures whereas the conventional indices had depicted 17.4% (wasting), 38.5% (stunting) and 47.0% (under-weight). As a result, the CIAF provided an additional prevalence of 40.2% (wasting), 19.1% (stunting) and 10.6% (under-weight) to the quantity of child under-nourishment as compared to that by the conventional indices.

Very recently, Mondal and Sen [9] reported that a very high proportion of children residing in the district of Darjeeling, West Bengal, was suffering from stunting, under-weight and wasting (Rajbanshi: 35.9%, 37.4% and 13.6%; tribal ethnic communities: 41.7%, 50.6% and 23.5%). The incidences of stunting and under-weight observed

in the present study were higher than the Santal children of Purulia district of West Bengal, as reported by Chowdhury et al. [68] (stunting: 17.6%; under-weight: 33.7%). However, the prevalence of stunting was lower than that reported for the Kamar children of Chhattisgarh (50.0%) [69] and the Oraon children of North Bengal (54.0%) [5]. Very recently, a cohort study reported that there was a significant decline in the prevalence of under-weight from 38.4% (2003-04) to 29.9% (2005-06) among children aged 5 years to 16 years in Ernakulam district of Kerala [70].

The CIAF can be disaggregated based on its sub-groups (Groups B-Y) to investigate the possible risk factors and to correlate them with the specific causes of mortality and morbidity patterns where conventional anthropometric indices have failed to identify groups of children with multiple failures [21, 71]. The use of the CIAF helps to visualize the a truer picture and identify the high risk groups better. This disaggregation provides for a far more comprehensible depiction of under-nutrition which conventional indices do not predict [3, 21]. In the present study, 39.5% of the children showed double and/or multiple failures (e.g., C, D and E groups) as compared to single anthropometric failure (18.1%) (e.g., B, F and Y groups). These interesting applications of the CIAF as a tool for assessing under-nutrition among the vulnerable segments of a population would be considerably helpful for health and policy planners, a fact that has been opinioned earlier by Nandy et al. [3]. Children have a greater risk of illnesses and they are more likely to belong to a lower socio-economic background, a fact that is supported by the Kuppaswamy's index. The



BMP children under study belonged to a lower SES group that was determined using a number of variables such as parents' education, nature of occupation and family income. The major underlying factors for the prevalence of under-nutrition are poor socio-economic conditions in different Asian countries and the environmental and ethnic differences [22]. It is a well established fact that under-nourished children are more likely to come from poorer backgrounds [3, 72], and one of the key causes of under-nutrition in among Indian populations is related to the lack of access to sufficient food and resource inequality [73]. However, further studies should be initiated to understand whether children who are identified as under-nourished by the CIAF are more likely to be ill and susceptible to diseases, as compared with those experiencing singular failures such as stunting, wasting and under-weight. In this context, the studies of Nandy et al. [3] and Deshmukh et al. [67] on diarrhea and acute respiratory infection, and acute childhood disease related morbidities with the CIAF respectively, are an encouraging step forward.

The present study has successfully documented the prevalence of under-nutrition among Bengalee Muslim children aged 5 years to 11 years of the Darjeeling district, West Bengal, India, using both conventional anthropometric indices of stunting, under-weight and wasting, and the CIAF. The potential advantage and appropriateness

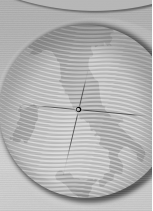
of using the CIAF over the conventional indices for evaluating child under-nutrition has also been discussed. The advantageous use of the CIAF will serve to bring more precision to the identification of the more nutritionally vulnerable segment of the population. This composite measure has the sufficient potential to enhance the efficacy of nutritional intervention programs by identifying double or multiple failure groups. Further studies are recommended for a comprehensive understanding of the scenario of under-nourishment in different Indian ethnic communities using the CIAF. Studies should also be initiated to document the increase in mortality morbidities among children who are affected with multiple failures. Such studies are necessary for the introduction of any supplementary nutritional intervention program aimed at target populations. Moreover, as the ultimate goal of nutritional assessment studies is to improve human health, nutritional intervention programmes are necessary to ameliorate the nutritional status of the children covered in course of this study.

Acknowledgements

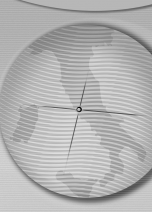
The authors acknowledge the help and co-operation of the schools and local Gram Panchayets authorities from where the data was collected. The study was funded by the University Grants Commission, Government of India (UGC Ref. No. F. No. 34-118\2008 SR dated 31.12.2008).

References

- 1) Pelletier DL. The relationship between child anthropometry and mortality in developing countries: Implications for policy, progress and future research. *J Nutr* 1994; 124:2047S-81.
- 2) Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? *Lancet* 2003; 361:2226-34.
- 3) Nandy S, Irving M, Gordon D, et al. Poverty, child under-nutrition and morbidity: New evidence from India. *Bull World Health Organ* 2005; 83:210-6.
- 4) World Health Organization. Childhood nutrition and progress in implementing the international code of marketing of Breast-milk substitute. Geneva: WHO, 2002. (Document A55/14).
- 5) Mittal PC, Srivastava S. Diet, nutritional status and food related traditions of Oraon tribes of New Mal (West Bengal), India. *Rural and Remote Health* 2006; 6: 385. Available from: <http://www.rrh.org.au/articles/subviewnew.asp?ArticleID=385> [Accessed 12th may 2009].
- 6) Banik SD, Bhattacharjee P, Das S, et al. Sexual dimorphisms in health and nutritional status of three communities of Darjeeling district in West Bengal and comparison with some other population of Eastern India: An anthropometric appraisal. *J Life Sci* 2009; 1: 27-34.
- 7) Banik SD, Bose K, Bisai S, et al. Under-nutrition among adult Dhimals of Naxalbari, West Bengal: comparison with other tribes of eastern India. *Food Nutr Bull* 2007; 28:348-52.
- 8) Mukhopadhyay DK, Biswas R, Chakraborty M, et al. Anthropometric failure, a new approach to measure under-nutrition: an experience from a rural community of West Bengal, India. *J Indian Med Assoc* 2009; 107:211-4.
- 9) Mondal N, Sen J. Prevalence of under-nutrition among children (5-12 years) belonging to three communities residing in a similar habitat in North Bengal, India. *Ann Hum Biol* 2010; 37:199-217.
- 10) Mondal N, Sen J. Prevalence of stunting and thinness among rural adolescents of Darjeeling district, West Bengal, India. *Italian J Pub Health* 2010; 7: 54-63.
- 11) World Health Organization. The use and interpretation of Anthropometry - Report of WHO Expert committee. WHO Tech Rep Series 854. Geneva: WHO, 1995.
- 12) de Onis M, Blossner M. WHO global database on child growth and malnutrition, Geneva: WHO, 1997.



- 13) Nandy S, Miranda JJ. Overlooking under-nutrition? Using a composite index of anthropometric failure to assess how under-weight misses and misleads the assessment of under-nutrition in young children. *Soc Sci Med* 2008; 66: 1963-6.
- 14) Cole TJ, Flegal KM, Nicholls D, et al. Body mass index cut-offs to define thinness in children and adolescents: international survey. *Br Med J* 2007; 335:194. Available from: <http://www.bmj.com/content/335/7612/194.long> [Accessed 5th september, 2009].
- 15) Horlick M. Body mass index in childhood -measuring a moving target. *J Clin Endocrinol Metab* 2001; 86:4059-60.
- 16) Franklin MF. Comparison of weight and height relation in boys from 4 countries. *Am J Clin Nutr* 1999; 70:1578-62S.
- 17) Must A, Dallal GE, Dietz WH. Reference data for obesity: 85th and 95th percentiles of body mass index (wt/ht²) and triceps skinfold thickness. *Am J Clin Nutr* 1991; 53:839-46.
- 18) World Health Organization Multicentre Growth Reference Study Group: WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development. Geneva, WHO, 2006.
- 19) Svedberg P. Poverty and under-nutrition: Theory, measurement, and policy. Oxford India Paperback: New Delhi, 2000.
- 20) Berger MR, Fields-Gardner C, Wagle A, et al. 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* 2008; 108:1014-7.
- 21) Seetharaman N, Chacko TV, Shankar SLR, et al. Measuring Malnutrition -The Role of Z Scores and the Composite Index of Anthropometric Failure (CIAF). *Indian J Community Med* 2007; 32:35-9.
- 22) Frongillo EA Jr, de Onis M, Hanson KMP. Socioeconomic and demographic factors are associated with worldwide patterns of stunting and wasting of children. *J Nutr* 1997; 127:2302-9.
- 23) Bhandari D, Choudhary SK. An epidemiological study of health and nutritional status of under five children in semi-urban community of Gujarat. *Indian J Public Health* 2006; 50:213-9.
- 24) Som S, Pal M, Bhattacharya B, et al. Socioeconomic differentials in nutritional status of children in the states of West Bengal and Assam, India. *J Biosoc Sci* 2006; 38:625-42.
- 25) Bose K, Biswas S, Bisai S, et al. Stunting, under-weight and wasting among Integrated Child Development Services (ICDS) scheme children aged 3-5 years of Chapra, Nadia District, West Bengal, India. *Matern Child Nutr* 2007; 3:216-21.
- 26) Semproli S, Gualdi-Russo E. Childhood malnutrition and growth in a rural area of Western Kenya. *Am J Phys Anthropol* 2007; 132:463-9.
- 27) Chowdhury SD, Chakraborty T, Ghosh T. Prevalence of under-nutrition in Santal children of Puruliya district, West Bengal. *Indian Pediatr* 2008; 45:43-6.
- 28) Hein NN, Kam S. Nutritional status and the characteristics related to malnutrition in children under five years of age in Nghean, Vietnam. *J Prev Med Public Health* 2008; 41:232-40.
- 29) Ghosh A, Adhikari P, Chowdhury SD, et al. Prevalence of under-nutrition in Nepalese children. *Ann Hum Biol* 2009; 36:38-45.
- 30) Dang SN, Yan H. [Optimistic factors affecting nutritional status among children during early childhood in rural areas of western China]. *Zhonghua Yu Fang Yi Xue Za Zhi* 2007; 41:S108-14.
- 31) Biswas S, Bose K, Mukhopadhyay A, et al. Prevalence of under-nutrition among pre-school children of Chapra, Nadia District, West Bengal, India, measured by composite index of anthropometric failure (CIAF). *Anthropol Anz* 2009; 67:269-79.
- 32) Das S, Bose K. Report on "anthropometric failure" among rural 2-6 years old Indian Bauri caste children of West Bengal. *Anthrop Rev* 2009; 72: 81-8.
- 33) Mandal GC, Bose K. Assessment of overall prevalence of under-nutrition using composite index of anthropometric failure (CIAF) among preschool children of West Bengal, India. *Iranian J Pediatrics* 2009; 19:237-43.
- 34) Das Chaudhuri AB, Basu S, Chakraborty S. Twinning rate in the Muslim population of West Bengal. *Acta Genet Med Gemellol (Roma)* 1993; 42:35-9.
- 35) Mondal R. Muslim population in India: some demographic and socio-economic features. *Int J Anthropol* 2000;15:91- 107.
- 36) Syed A. Collective and Elective Ethnicity: Caste among Urban Muslims in India. *Sociological Forum* 2002;17:593-620.
- 37) Engineer AA. Indian Muslims: A Study of the Minority Problems India. New Delhi: Ajanta Publications, 1985.
- 38) Khan R. Minority Segments in Indian Polity: Muslim Situation and Plight of Urdu. *Eco Pol Weekly* 1978;13:1509-15.
- 39) Ahmad I. Endogamy and status mobility among the Siddiqui Sheikhs of Allahabad, Uttar Pradesh. In Imtiaz Ahmad (ed.), *Caste and Social Stratification among the Muslims*. Delhi: Manohar publication, 1978.
- 40) Dumont L. *Homo Hierarchicus: The Caste System and Its Implications*. Chicago: University of Chicago Press, 1980
- 41) Basu SK. Effect of consanguinity among North India Muslims. *J Popul Res* 1975;2:57-68.
- 42) Bittles AH, Hussain R. An analysis of consanguineous marriage in the Muslim population of India at regional and state levels. *Ann Hum Biol* 2000;27:163-71.
- 43) Ghosh JR, Khatoon Z, Bhattacharjee P, et al. A Comparative Study on Anthropometric Variables in Two Communities of West Bengal, India. *Anthropologist* 2005; 7: 217-9.
- 44) Khatoon Z, Tapadar JR, Chatterjee D, et al. Relationship between anthropometric measures and body composition among Muslim females of West Bengal, India. *Anthropol Anz* 2008; 66:349-53.
- 45) Touitou Y, Portaluppi F, Smolensky MH, et al. Ethical principles and standards for the conduct of human and animal biological rhythm research. *Chronobiol Int* 2004; 21:161-70.
- 46) Mishra D, Singh HP. Kuppaswami's socio-economic status scale - A revision. *Indian J Pediatr* 2003; 70:273-4.
- 47) Chowdhury SD, Chakraborty T, Ghosh T. Fat patterning of Santal children: a tribal population of West Bengal, India. *J Trop Pediatr* 2007; 53:98-102.
- 48) Ghosh A, Choudhary S, Chowdhury SD, et al. Fat and fat-free mass in Nepalese children: an assessment of nutritional status. *Eur J Pediatr* 2009; 168:1513-7.
- 49) Weiner JS, Lourie JA. *Practical human biology*. London: Academic Press, 1981.
- 50) Ulijaszek SJ, Kerr DA. Anthropometric measurement error and the assessment of nutritional status. *Br J Nutr* 1999; 82:165-77.
- 51) World Health Organization. *Measuring change in nutritional status*. Geneva: WHO, 1983.
- 52) Habicht JP, Martorell PR, Yarbrough C, et al. Height and weight standard for preschool children: How relevant are



- ethnic differences in growth potential? *Lancet* 1974; 1:611-4.
- 53) Martorell R, Habicht J. Growth in early childhood in developing countries. In: Falkner F, Tanner J, eds. *Human growth: a comprehensive treatise*. New York: Plenum Press, 1986.
- 54) Eveleth P, Tanner J. *Worldwide variations in human growth*. Cambridge: Cambridge University Press, 1990.
- 55) de Onis M, Garza C, Habicht JP. Time for a new growth reference. *Pediatrics* 1997;100:5. Available from: <http://www.who.int/childgrowth/publications/timeforanew/en/index.html> [Accessed: 25th october 2010].
- 56) de Onis M, Onyango AW, Borghi E, et al. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007; 85:660-7.
- 57) de Onis M, Dasgupta P, Saha S, et al. The National Center for Health Statistics reference and the growth of Indian adolescent boys. *Am J Clin Nutr* 2001; 74:248-53.
- 58) de Onis M, Habicht JP. Anthropometric reference data for international use: recommendations from a World Health Organization Expert Committee. *Am J Clin Nutr* 1996; 64:650-8.
- 59) de Onis M, Onyango AW, Borghi E, Garza C, Yang H, for the WHO Multicentre Growth Reference Study Group. Comparison of the World Health Organization (WHO) child growth standards and the national center for health statistics/WHO international growth reference: implications for child health programmes. *Public Health Nutrition* 2006; 9:942-7.
- 60) WHO Working Group. Use and interpretation of anthropometric indicators of nutritional status. *Bull World Health Organ* 1986; 64:929-41.
- 61) Rice AL, Sacco L, Hyder A, et al. Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. *Bull World Health Organ* 2000; 78:1207-21.
- 62) Bhan MK, Bhandari N, Bahl R. Management of the severely malnourished child: perspective from developing countries. *BMJ* 2003; 326:146-51.
- 63) Müller O, Krawinkel M. Malnutrition and health in developing countries. *CMAJ* 2005; 173:279-86.
- 64) Collins S. Treating severe acute malnutrition seriously. *Arch Dis Child* 2007; 92:453-61.
- 65) Pelletier DL, Frongillo EA Jr, Schroeder DG, et al. The effects of malnutrition on child mortality in developing countries. *Bull World Health Organ* 1995; 73:443-8.
- 66) Cunha A. Relationship between acute respiratory infection and malnutrition in children under 5 years of age. *Acta Paediatrica* 2000; 89:608-9.
- 67) Deshmukh PR, Dongre AR, Sinha N, et al. Acute childhood morbidities in rural Wardha: Some epidemiological correlates and health care seeking. *Indian J Med Sci* 2009; 63: 345-54.
- 68) Chowdhury SD, Chakraborty T, Ghosh T. Prevalence of under-nutrition in Santal children of Puruliya district, West Bengal. *Indian Pediatr* 2008; 45:43-6.
- 69) Mitra M, Kumar PV, Chakrabarti S, et al. Nutritional status of Kamar tribal children in Chhattisgarh. *Indian J Pediatr* 2007; 74:381-4.
- 70) Raj M, Sundaram KR, Paul M, et al. Dynamics of growth and weight transitions in a pediatric cohort from India. *Nutr J* 2009; 23:8:55. Available from: <http://www.nutritionj.com/content/8/1/55> [Accessed 24th october 2010].
- 71) Mahgoub S, Silo L, Fields-Gardner C. Effect of Dietary protein Enrichment Pilot Program on the growth of under-five children in day care centres in Gaborone, Botswana, 2009. Available from: http://www.wishh.org/nutrition/botswana_daycare_vasps.pdf [Accessed 7th April, 2009].
- 72) Wagstaff A, Watanabe N. Socio-economic inequalities in child malnutrition in the developing world. Policy Research Working Paper No. 2434. Washington, DC: World Bank, 2000.
- 73) Measham AR, Chatterjee M. *Wasting away: The crisis of malnutrition in India*. Washington DC: The World Bank, 1999.