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Assessment of Undernutrition using Head Circumference-for-Age among Karbi Preschool Children of Karbi Anglong, Assam, India

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ABSTRACT Undernutrition is a major public health problem in most of the developing countries of the world. India is a country with the large population size, socio-economic disparities and existence of high undernutrition among children. The aim of the present investigation is to assess the prevalence of undernutrition using head circumference (HC)-for-age among preschool children. This cross-sectional investigation was carried out among 490 (211 boys; 279 girls) Karbi preschool children (<5 years) of Diphu, Karbi Anglong, Assam, using stratified random sampling method. The HC was measured using standard anthropometric procedures and HC-for-age Z-score (HCAZ) values were calculated using Lambda-Mu-Sigma (LMS) method. The age-sex specific HCAZ values of <-2SD to -3SD and <-3SD are considered as moderately and severely undernourished, respectively. The overall age-specific mean differences were observed to be significant in HC and HCAZ among boys and girls (p<0.05). The overall prevalence of undernutrition (low HC-for-age) was observed to be higher among girls (49.10%) than boys (42.18%) (p>0.05). The moderate and severe undernutrition was found to be 34.49 percent (boys 35.54%; girls 33.69%; p>0.05) and 11.36 percent (boys 6.63%; girls 15.41%; p<0.05). There is a high prevalence of undernutrition among preschool children and girls were more vulnerable shows the gender-related trend in undernutrition. This call for the formulation of necessary healthcare intervention strategies and/or to evaluate the efficacy of ongoing intervention programme to improve the nutritional status in preschool children.

INTRODUCTION

Physical growth assessment provides important indication of overall health and nutritional status and considered being an estimation of the quality of life in community/populations (Maiti et al. 2012). Anthropometry is a simple, reliable, easy-to-use, non-invasive technique to assess the physical growth and nutritional status in children (WHO 1995; Hall et al. 2007). Several anthropometric measurements of height, weight, mid upper arm circumferences (MUAC), head circumference (HC) and skinfold thickness (for example, triceps or sub-scapular) are widely used to assess the physical growth and nutritional status (WHO 1995; Hall et al. 2007). A set of anthropometric measures of height-for-age, weight-for-height, weight-for-height, MUAC-for-age, HC-for-age, and Body mass index (BMI)-for-age used to assess the magnitude of undernutrition among preschool children (WHO 1995, 2007; Nandy et al. 2005; Bose et al. 2007; Mondal and Sen 2010; Sen and Mondal 2012; Maiti et al. 2012; Tigga et al. 2015; Bharali and Mondal 2018; Debnath et al. 2018). The HC-for-age is now being considered as an accurate, rapid, non-invasive and recommended anthropometric measure to determine the physical growth and nutritional status in preschool children (that is, <5 years) (Anzo et al. 2002; Bartholomeusz et al. 2002; Singh and Grover 2003; Singh and Bisnoi 2005; Zaki et al. 2008; Geraedts et al. 2011; Maiti et al. 2012; Tigga et al. 2016; Tiwari et al. 2017; Giri et al. 2018; Yeasmin and Yeasmin 2018). It is used to determine the cranial growth attainments and considered being a proxy measure of undernutrition or protein energy malnutrition (PEM) and brain size/intra-cranial volume development and genetic disorders among preschool children (Leiva Plaza et al. 2001; Bartholomeusz et al. 2002; Ivanovic et al. 2004; Joffe et al. 2005; Singh and Bisnoi 2005; Lee et al. 2010; Laron et al. 2012; Tigga et al. 2016; Tiwari et al. 2017; Giri et al. 2018; Martini et al. 2018). The

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HC-for-age is used most significantly during the physical examinations, especially in physical growth, development evaluation and neurological disorders diagnosis and/or abnormal brain volume among preschool children (Karabiber et al. 2001; Elmali et al. 2012; Talebian et al. 2013; Tigga et al. 2016; Tiwari et al. 2017; Yeasmin and Yeasmin 2018). However, a rapid increase in the histological change is related to the HC-for-age among preschool children (Talebian et al. 2013). Moreover, the attainment of brain size growth is rapid during early stages (that is, <3 years) owing to the brain development in preschool children (Huelke 1998; Savage et al. 1999).

Undernutrition produces notable morphological changes in the brain size development which may damage the intellectual potential and can limit the productivity in preschool children (Cornelio-Nieto 2007; Sukanya et al. 2014; Tiwari et al. 2017). Poor attainment of physical growth of the brain affects the cognitive abilities (Gale et al. 2004; Lee et al. 2010; Talebian et al. 2013; Leviton et al. 2010; Guellec et al. 2015) and the HC-for-age is being considered as the most important non-invasive and practical anthropometric measurement of long-term or chronic nutritional deficiencies associated with intellectual impairment during infancy and/or childhood (Ivanovic et al. 2000; Gale et al. 2004; Lee et al. 2010; Tigga et al. 2016; Giri et al. 2018). The prevalence of undernutrition (for example, PEM) triggers microcephaly and/or neurological disorders and directly related to the development quotient and cognitive impairments of such children (Karabiber et al. 2001; Lee et al. 2010; Elmali et al. 2012; Talebian et al. 2013; Tiwari et al. 2017). Several research investigations have reported the physical growth pattern and magnitude of undernutrition (low HC-for-age; <-2SD) among preschool children in India (Singh and Grover 2003; Singh and Bisnoi 2005; Mandal and Bose 2010; Maiti et al. 2012; Sukanya et al. 2014; Tigga et al. 2016; Giri et al. 2018). Moreover, the early detection of nutritional status using HC-for-age will definitely help to reduce the relative risks of nutritional inadequacy, morphological changes, neurological disorders and brain damage especially among nutritionally vulnerable segments (for example, preschool children) of population. However, there is insufficient information on the ethnic/population specific physical growth retardation and undernutrition assessment cause due to low HC-for-age among preschool children of India. The objective of the present investigation is to assess the physical growth pattern and prevalence of undernutrition using HC-for-age among the Karbi preschool (<5 years) children of Assam, Northeast India.

MATERIAL AND METHODS

The present community based cross-sectional investigation was carried out among 490 (boys 211; girls 279) Karbi tribal preschool children (< 5 years) in Diphu of Karbi Anglong district (25°33’ N to 26°35’ N latitude and 92°10’ E to 93°50’ E longitude) of Assam, Northeast India. The major tribal ethnic groups of this district are Karbis, Dimasas, Kukis, Garos, Rengma Nagas, Bodos, Tiwas, Khasi, Pnar and Hmars residing in the district of Karbi Anglong, Assam. According to the National Census 2011, the Karbi Anglong district had a total population of 9,65,280 individuals (4,93,482 male; 4,71,798 female) with an average literary rate of 59.52 percent (56.82% male; 43.18% female). The age of preschool children was determined through the birth certificates or relevant documents issued by Government. The data were collected using the stratified random sampling method. The children were homogeneous in nature mainly collected among Karbi tribal population residing in rural regions of the district. Ethnically, the Karbi population belongs to the Tibeto-Mongoloid population and Tibeto Burman sub-linguistic group (Kumar et al. 2004). They are found to be significantly differ from the ‘Bodo group’ which includes Kachari and Sonowal tribal populations. The 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.

The minimum number (N) of subjects/children are required to estimating the magnitude of undernutrition was determined using the standard method of sample size estimation (Lwanga and Lemeshow 1991). In this method, the expected/anticipated population proportion (that is, low HC-for-age) of 50 percent, absolute precision of marginal error of 5 percent and confidence interval (that is, the maximum amount of tolerance) of 95 percent were taken into consideration. The standard equation was used to determine the sample size as follows: $N = (z/\Delta)^2 p(1 - p)$ [where, p = 0.50, Δ=0.05 and z = 1.96]. The minimum sample size, thus estimated was N=385 individuals. In the first stage, the households of those individuals belonging to the Karbi population were identified based on the surnames, language spoken and cultural traits. The ethnicity of the subjects was also verified using the official documents issued by government authorities. The data of the present investigation were collected by using pre-structured schedules. In the second stage, 520 Karbi preschool children were identified and approached for the present investigation. Finally, a total of 490 Karbi preschool children in the age group of 1-5 years from those identified households were selected and included in this investigation. Hence, the final sample size of the present investigation was found to be appreciably higher than the estimated sample size and the overall participation rate was 94.23 percent. However, 5.76 percent (N=30) 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. A special care was taken that each sex/age categories had a minimum sample of 30 subjects. The participation of the subjects in the present investigation was voluntary in nature and the verbal consent was taken from either of their parent prior to collect data. Each informant and subject was interviewed and measured in the respective household and the data of the present investigation obtained by using household survey method, respectively. The present research investigation was carried out in accordance with the ethical guidelines of human experiment as laid down in the Helsinki Declaration (Touitou et al. 2004; Portaluppi et al. 2010). The data was collected during the period of December, 2016 to July, 2017.

Collection of Head Circumference

The HC of children was measured by the standard anthropometric procedures (Hall et al. 2007) using a non-stretchable plastic coated flexible measuring tape. Exerting light pressure, the measuring tape was passed over the glabella to the area near the top of the occipital bone (opisthocranion) as to get the maximum circumference nearest 0.1 cm. Especial care was taken into consideration to keep the tape flat against the head and parallel on both the sides (Tigga et al. 2016). The standard method of technical errors of the measurement (TEM) for both intra and inter-observer were determined to test the reliability of the anthropometric measurement (for example, HC) (Ulijaszek and Kerr 1999). For this, HC was measured from 30 preschool children other than those selected for the present investigation by the authors (JS and NM). 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) of TEM was calculated using the following equation: $R=\{1-(TEM)^2/SD^2\}$, SD= standard deviation of the measurements. Very high values of R (>0.985) were obtained for both intra- and inter-observer TEM and these values were found to be higher than the recommended cut-off value (R>0.95) (Ulijaszek and Kerr 1999). Therefore, the anthropometric measurements (that is, HC) collected in this investigation were considered being reliable and reproducible. Hence, anthropometric measurement (that is, HC) among preschool children in the present research investigation was recorded by the author (JS).

Assessment of Nutritional Status

The HC-for-age Z- scores (HCAZ) value was calculated for the assessment of undernutrition among Karbi preschool children using the Lambda-Mu-Sigma (LMS) method. This method is based on three important curves referred to as L (lambda), M (mu), and S (sigma) curves (Cole and Green 1992; Cole et al. 1998; WHO 2007). The 'M' curve is the median or 50th percentile curve, the 'S' curve is a measure of the coefficient of variation and the 'L' curve is the power of the Box-Cox transformation, which measures the changing skewness of the distribution with age (WHO, 2007). The age-sex specific HCAZ was calculated using the standard equation: $HCAZ=\{(X/M)^{L-1}\}/(L*S)$. [Where, X=HC, L, M and S are the age-sex specific values of appropriate table corresponding reference populations]. The HCAZ-score value was calculated by utilizing the age and sex-specific L, M and S values of the WHO child growth reference of preschool children (0-5 years) (WHO 2007). Where, children of HCAZ values between -3 to <-2 Z-score and '<-3'Z-score were considered being moderately and severely undernourished, respectively (WHO 1995, 2007).

Statistical Analysis

The data was statistically analyzed using the Statistical Package for Social Sciences (SPSS version 16.0). A p-value of less than 0.05 and 0.01 was considered to be statistically significant. Anthropometric measures were depicted in terms of descriptive statistics (mean ± standard deviation). The age-sex specific mean differences in anthropometric variables were done utilizing one way analysis of variance (ANOVA). The age-sex differences in the overall, moderate and severe grades of undernutrition (that is, low HC-for-age) between sexes were done by utilizing the Chi-square analysis (χ^2).

The LMS method software computer program fits smooth percentile curves to the reference data using the 'L' (lambda), 'M' (mu), and 'S' (sigma) method as described by Cole and Green (1992). This method is being considered as a concept of an age varying adjustment for skewness of the Box-Cox transformation. This method converts the anthropometric measurements (for example, HC) of known age-sex to evaluate percentile and standard deviation score or Z-score in children (Cole and Green 1992; Cole et al. 1998). The LMS Chartmaker Light software (version 2.54) was used to derive smooth percentile growth curves (Pan and Cole 2011). The age and sex-specific percentile curves with 3rd, 10th, 15th, 25th, 50th, 75th, 90th and 97th smoothed percentile lines of HC-for-age were plotted separately.

RESULTS

Age and sex-specific subject distribution, descriptive statistics of HC and HCAZ among Karbi preschool children is presented in Table 1. The age-sex specific mean HC values were observed to be significantly higher among boys than girls (p<0.05). The overall mean of HC values was observed to be higher in boys (48.46±2.0 cm) than the girls (45.71±2.08 cm) (p<0.01). The age-specific mean HCAZ was observed to be significantly lower among girls. The mean HCAZ values ranged from -1.07 to -1.65 (in boys) and -1.66 to -2.11 (in girls) aged 1 to 5 years. The overall mean HCAZ was significantly higher in boys (-1.52±0.98) than girls (-1.92±1.12) (p<0.05). The age-sex specific mean HC values were significantly increasing with age among Karbi preschool children. The higher increase of HC was observed in 2 years in both boys (4.01%) and girls (5.50%) and lower increase was observed in 4 years in boys (0.44%) and girls (0.83%). The overall age-specific mean differences were observed to be statistically significant in HC and HCAZ among boys (F-value=61.32, p<0.01; F-value=2.54, p<0.05) and girls (F-value=64.03, p<0.01; F-value=2.98, p<0.05). The sex-specific mean differences anthropometric measures of HC (F=37.41, d.f., 1, 489; p<0.01) and HCAZ (F=17.29, d.f., 1, 489; p<0.01) was observed to be statistically significant among boys and girls using ANOVA (p<0.05).

The age and sex-specific mean HC values of Karbi preschool children were compared with different percentiles of WHO (2007) growth reference to assess the physical growth attainments is presented in Figure 1. The overall comparison showed that children were observed to be <15th percentile of growth references, but the exceptions were observed in 5 years (in boys) and 3-5 years (in girls), whereas mean values were <5th percentile of the growth reference (WHO 2007) (Fig. 1). The age-sex specific smooth percentile curves were also derived for further evaluation of physical growth pattern and nutritional status using the LMS procedure for HC

Table 1: Age and sex specific descriptive statistics of the head circumference and head circumference for age Z-score (HCAZ) among Karbi pre-school children

Age (years)	*Sample*		*HC (cm)*		*HCAZ*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
1	43	46	44.41±1.43	42.95±1.62	-1.65±0.96	-2.06±1.12
2	47	70	46.19±1.12	45.31±1.63	-1.62±0.78	-1.68±1.23
3	37	54	47.22±1.67	46.02±1.43	-1.67±1.19	-2.11±1.12
4	38	54	48.21±1.24	46.40±1.38	-1.07±0.98	-2.19±1.02
5	46	55	48.42±1.39	47.56±1.41	-1.54±0.93	-1.66±1.00
Total	211	279	48.86±2.01	45.71±2.08	-1.52±0.98	-1.92±1.12
F-value			61.32**	64.03**	2.54*	2.98*

*p<0.05; **p<0.01

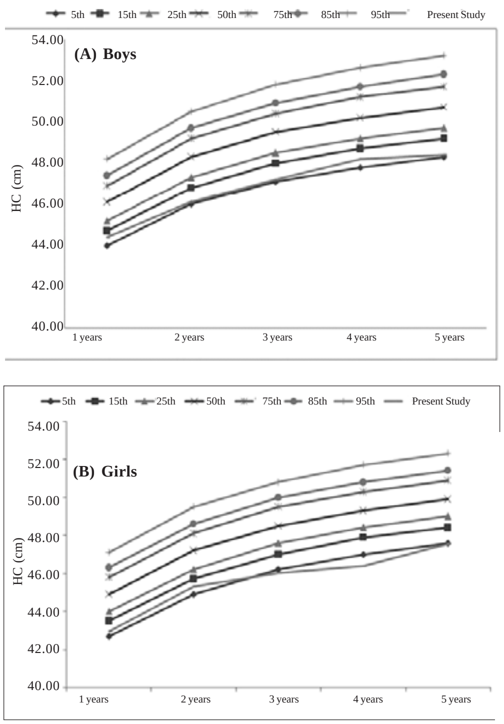

Fig. 1. Comparison of age-sex –specific mean HC values with WHO (2007) reference among Karbi pre-school children of Assam

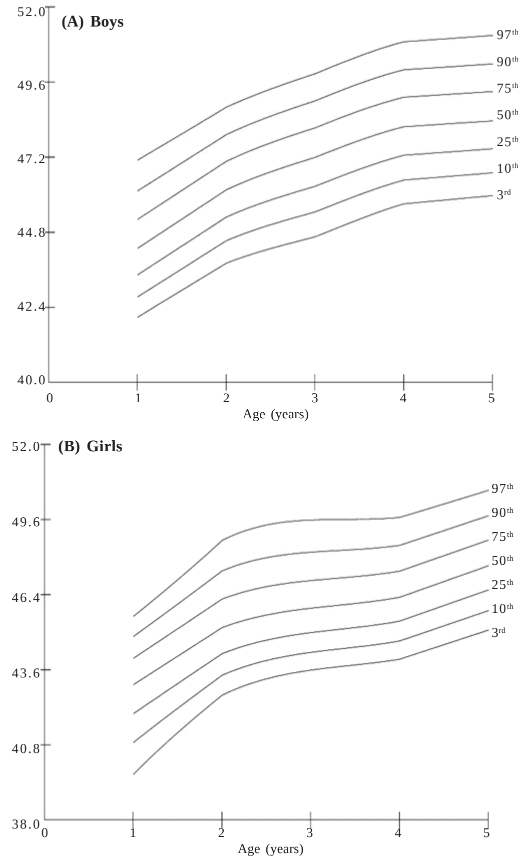

Fig. 2. Age-sex specific L, M, S reference curve of HC (cm) among Karbi pre-school children of Assam

among the Karbi preschool children and are shown in Figure 2.

Prevalence of Undernutrition (Low HC-for-Age) among Children

The overall (age-sex combined) prevalence of undernutrition (<-2 Z-score) using HC was observed to be 46.12 percent. The sex-specific prevalence was observed to be higher among girls (49.10%) than the boys (42.18%) (Table 2). The age and sex-specific prevalence of severe grades (11.63%) of undernutrition was observed to be lower than moderate grades (34.49%)

Table 2: Age and sex- specific prevalence of undernutrition using head circumference among Karbi pre-school children

Age (years)	*Sample*		*Severe (<-3 Z-score)*		*Moderate (-3 to <-2 Z-score)*		*Undernutrition (<-2 Z-score)*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
1	43	46	3 (6.98)	8 (17.39)	17 (39.53)	16 (34.78)	20 (46.51)	24 (52.17)
2	47	70	1 (2.13)	7 (10.00)	23 (48.94)	24 (34.29)	24 (51.06)	31 (44.28)
3	37	54	6(16.22)	12 (22.22)	11 (29.73)	18 (33.33)	17 (45.94)	30 (55.56)
4	38	54	1 (2.63)	12 (22.22)	8 (21.05)	15 (27.78)	9 (23.68)	27 (50.00)
5	46	55	3 (6.52)	4 (7.27)	16 (34.78)	21 (38.18)	19 (41.30)	25 (45.45)
Total	211	279	14 (6.64)	43 (15.41)	75 (35.54)	94 (33.69)	89 (42.18)	137 (49.10)

Values in parenthesis indicate percentages among preschool children. Age-specific trend in the prevalence of undernutrition in both moderate and severe categories were absent in both sexes, but the magnitude was greater among children aged 1-3 years and 5 years (girls). The overall prevalence of moderate undernutrition was found to be 35.54 percent (in boys) and girls (33.69%). Similarly, the girls (15.41%) were observed to be more undernourished than boys (6.63%) in severe grades of undernutrition (<0.05). The sex-specific overall undernutrition (<-2SD Z-score) was invariably higher among girls than boys (p>0.05). The sex-specific differences in the prevalence of undernutrition were found to be statistically not significant in moderate (χ^2=0.05, d.f., 1; p>0.05) and overall (χ^2 =0.86, d.f., 1; p>0.05), except severe grades (χ^2 =7.22, d.f., 1; p<0.01) of undernutrition using χ^2 analysis. The sex-specific differences in the prevalence of different grades (that is, moderate and severe) of undernutrition was observed to be statistically not significant among boys and girls using χ^2-analysis (p>0.05).

DISCUSSION

The HC-for-age is being considered as an important anthropometric measure of physical growth, development and powerful predictor of brain volume and used to assess the magnitude of undernutrition, physical growth pattern and brain development/size among preschool children (Anzo et al. 2002; Singh and Grover 2003; Joffe et al. 2005; Singh and Bisnoi 2005; Zaki et al. 2008; Sukanya et al. 2014; Tigga et al. 2016; Tiwari et al. 2017; Giri et al. 2018; Yeasmin and Yeasmin 2018). Several researchers have used HC to relate the physical examination, brain development, cognitive impairments, early diagnosis of neurological and genetic disorders in preschool children (Lindley et al. 1999; Singh and Grover 2003; Lee et al. 2010; Leviton et al. 2010; Talebian et al. 2013; Guellec et al. 2015; Senbanjo et al. 2016; Tiwari et al. 2017) and also the association of HC with the reduced intellectual capacity, future performance and achievements among preschool children (Oyedeji et al. 1997; Leiva Plaza et al. 2001; Gale et al. 2004; Ivanovic et al. 2004). Moreover, the HC/brain development is very rapid during early stages and reaches approximately 90 percent of the adult size at the age of 3 years (Huelke 1998; Savage et al. 1999), thus, for apparently normal growing children, routine follow-up (for example HC-for-age) is considered to be important in identifying the early risks of poor physical growth attainment, development or any neurological disorders in preschool children. The adequate growth attainments with respect to the growth references during early childhood (<5 years) is the most important factor for both physical and mental/cognitive development, therefore, poor development of the brain size/volume may lead to poor intellectual capacity and thus making the child less productive (Donma and Donma 1997; Ivanovic et al. 2000; Gale et al. 2004; Guellec et al. 2015; Tiwari et al. 2017). Several studies have recommended the age-sex specific population/ethnic references to assess the physical growth and nutritional status among preschool children using HC (Zaki et al. 2008; Rollins et al. 2010; Elmali et al. 2012; Júlíusson et al. 2013; Xie et al. 2014; Amare et al. 2015; Neyzi et al. 2015). The results of the present investigation showed sexual dimorphism in HC among Karbi preschool children. The age and sex-specific mean values of HC were observed to be significantly higher in boys than girls (p<0.01) (Table 1). It is believed that sexual dimorphism in HC emerges largely during postnatal period and increases throughout maturation processes, particularly in humans who reach to the adult dimorphism (Joffe et al. 2005). Several studies have reported sexual dimorphism in HC among preschool children and sex-specific mean HC values were significantly (p<0.05) higher among boys than girls (Oyedeji et al. 1997; Singh and Grover 2003; Joffe et al. 2005; Zaki et al. 2008; Mandal et al. 2010; Tigga et al. 2015). Further, the age-specific mean HC values were significantly increased with age among boys and girls (p<0.05) (Table 1). Several research studies have reported similar age-related effect on HC among preschool children (Bartholomeusz et al. 2002; Senbanjo et al. 2016). The age and sex-specific mean HC values of Karbi preschool children were compared with different age and sex-specific HC reference percentiles of WHO (2007) and showed that children were observed to be <15th percentile of growth references in both boys and girls, but exceptions were observed in 5 years (in boys) and 3-5 years (in girls), where mean values were <5th percentile of the growth reference (Fig. 1). Several researchers have reported the poor growth attainment of physical growth (that is, HC) compared to the growth references/normal counterparts including Indian preschool children (Oyedeji et al. 1997; Singh and Grover 2003; Singh and Bisnoi 2005; Tigga et al. 2016).

The magnitude of undernutrition was observed to be greater among girls than boys using different conventional anthropometric measures in India (Bose et al. 2007; Mondal and Sen. 2010; Sen and Mondal 2012; Tigga et al. 2015; Bharali and Mondal 2018; Debnath et al. 2018). The sex-specific overall prevalence of moderate undernutrition (Z-score <-2 to -3) was observed to be higher among boys than girls (35.54% vs. 33.69%; $p>0.05$), but the reverse trend was noticed in severe undernutrition (Z-score <-3) where girls were more affected than the boys (15.41% vs. 6.64%) among preschool children ($p<0.05$) (Table 2). The sex-specific prevalence of low HC-for-age (<-2SD) was observed to be higher among girls (49.10%) than boys (42.18%) ($p>0.05$). The sex-specific comparison with different research investigation have showed that girls were nutritionally vulnerable in undernutrition (low HC-for-age) than boys in India (Mandal and Bose 2010; Maiti et al. 2012; Tigga et al. 2016; Giri et al. 2018) (Table 3). Mandal and Bose (2010) reported high prevalence of low HC-for-age (boys: 64.90%; girls: 62.80%) among rural preschool children of Hooghly district of West Bengal. A significantly lower prevalence of low HC-for-age ($p<0.05$) was reported among Bengalee preschool boys of Midnapore, West Bengal (boys: 19.20%; girls: 22.60%) (Maiti et al. 2012) ($p<0.05$). Recently, a similar study has reported that the sex-specific prevalence of undernutrition (that is, low HC-for-age) was significantly higher among girls (42.12%) than boys (28.33%) in Sagar Island, West Bengal ($p<0.05$) (Giri et al. 2018) (Table 3). However, Sukanya et al. (2014) in their study reported that boys were more affected in low HC-for-age (<-2SD) than girls (boys: 37.03%; girls: 28.23%) among urban slums preschool children of Karnataka. Similarly, the high prevalence of moderate (boys: 33.3%; girls: 30.0%) and severe (boys: 6.3%; girls: 13.5%) undernourishment reported among Bangladeshi children (Yeasmin and Yeasmin 2018). The results of the present research investigation showed that the magnitude of undernutrition (that is, low HC-for-age) was greater in the age-group of 1-3 years and 5 years than their older counterparts among Karbi preschool children (Table 2). The prevalence of undernutrition was observed to be higher among 5 years and lower among 4 years aged pre-school children. Similarly, age-specific trend in the prevalence of low HC-for-age were reported among urban slum preschool children of Karnataka (Sukanya et al. 2014), Bengalee preschool children of Midnapore, West Bengal (Maiti et al. 2012) and rural preschool children of Darjeeling, West Bengal (Tigga et al. 2016). Moreover, the unsatisfactory attainment of physical growth pattern as compared to the growth references and high prevalence of undernutrition (that is, low HC-for-age) among Karbi preschool children may be attributed to the fact that the children are residing in rural regions, especially the tribal populations have poor or inadequate access of healthcare facilities, lack of healthcare during early stage of physical growth (that is, infancy and childhood), high illiteracy and socio-economic disparities, inadequate nutrition, poverty, lack of adequate dietary knowledge, maternal education, disease and environment (Ball and Pust 1993; Singh and Grover 2003; Singh and Bisnoi 2005; Mondal and Sen 2010; Bocca-Tjeertes et al. 2011; Sen and Mondal 2012; Tigga et al. 2015; Bharali and Mondal 2018; Debnath et al. 2018).

CONCLUSION

The prevalence of undernutrition (low HC-for-age) is found to a persistent health problem among the Karbi preschool children. The girls were severely undernourished than boys in the studied population which might be the cause of

Table 3: Comparison of overall undernutrition (low HC-for-age) among pre-school children (<5 years) in India

Population	*Area*	*Sample*	*Boys (%)*	*Girls (%)*	*Total (%)*	*References*
ICDS Children	24 Parganas, West Bengal	656	28.84	42.12	35.52	Giri et al. 2018
Rural Children	Darjeeling, West Bengal	477	53.16	58.16	52.62	Tigga et al. 2016
Pre-school	Karnataka, Bangalkot	166	37.03	28.23	32.53	Sukanya et al. 2014
Bengalee Children	Midnapore, West Bengal	1060	19.20	22.60	20.75	Maiti et al. 2012
ICDS Children	Hooghly, West Bengal	894	62.80	64.90	63.80	Mandal and Bose 2010
Karbi Children	Karbi Anglong, Assam	490	42.18	49.10	46.12	Present Study

sex/gender related effect or cultural preferences in population, suggesting a need for better health intervention strategy to ameliorate the nutritional status. Moreover, the greater prevalence of undernourishment may adversely affect the brain development by reducing head size causing irreversible and permanent effects on brain and hampering their cognitive and intellectual potentials in future life. Therefore, the regular monitoring of physical growth pattern provides the early detection of any poor growth attainment or retardation, reduce the risk of growth disorders, neurological problems and undernutrition among preschool children by providing the appropriate intervention and management. The finding calls for the formulation of appropriate health management and intervention strategies, and/or to evaluate the efficacy of ongoing intervention progamme to improve the overall nutritional status of the pre-school children.

RECOMMENDATIONS

1. The present investigation recommends the HC-for-age as a measure to assess the prevalence of physical growth pattern and undernutrition status due to its non-invasive, inexpensive and easy-to-use nature in epidemiological and clinical investigations over more commonly used conventional anthropometric measures (that is, height-for-age, weight-for-age and weight-for-height) of undernutrition among preschool children. Nutritional assessment studies are necessary to evaluate and document the overall magnitude and compare the undernourishment using HC-for-age among different vulnerable ethnic populations in India. Moreover, the early detection of undernutrition will reduce the relative nutritional risks, poor physical growth attainments and disease burden among preschool children. Hence, the ethnic/population specific HC-for-age growth references are necessary to assess the unsatisfactory physical growth attainment and undernutrition/nutritional risks.

2. The results of the present investigation showed that a high prevalence of undernourishment (low HC-for-age) among preschool children. Therefore, a comprehensive intervention programme related to the supplementary balanced diet and micronutrient-rich or protective foods are necessary to improve the existing nutritional status in the population. A multi-disciplinary health camp offering comprehensive health-care facilities include varied medical service should be organized at regular intervals in the population/community levels. These camps should include paediatricians, dieticians and nutritionists and counsellor to provide free medical diagnosis, medicines, counselling and management to prevent timely physical growth risks and nutritional deficiencies due to infections, diseases and faulty feeding practices.

3. Efforts should be made to organise health-awareness camps by the Government and non-government agencies to disseminate the knowledge related to nutritional requirements, appropriate feeding and dietary consumptions, health and hygiene practices, physical growth and nutritional risks, during the infancy, early childhood and pregnancy periods among the parents/women to prevent the relative risk of undernutrition and poor intra-uterine growth retardations. Moreover, creating appropriate nutritional and health-related awareness will help to improve the better quality of life among the preschool children.

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