An anthropometric study on the children of Tripura: Nutritional and health coverage and redefining WHO percentile cut-off points

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Abstract: **Objectives:** To provide baseline anthropometric data on the problems of malnutrition among different sub-groups of Tripura's children aged up to 18+ years, consulting internationally recognized SD (standard deviation) system and to examine if there is any disagreement between the SD-and percentile-based cut-off points of malnutrition. **Methods:** A cross-sectional study of children's lengths/heights and weights, and calculating individual body mass index (BMI) were undertaken. The study included 9,498 children aged 0+ to 18+ years from randomly selected 16 areas of Tripura. Medians of lengths/heights and BMI by age and sex, SD prevalence of stunting, wasting/thinness, overweight-cum-obesity by age group (under-five, above-five and above-ten children), sex, locality and caste, and SD and percentile prevalence of stunting, wasting/thinness, overweight-cum-obesity by age group (under-six and above-six children) were evaluated. **Results:** The problems of stunting and overweight-cum-obesity were more prevalent ($p<0.001$) among under-five children, and the problem of wasting/thinness more prevalent among above-five ($p<0.001$) and above-ten children ($p<0.001$) than the remaining groups. On the other hand, <-2SD and <3rd percentile based prevalence of stunting and thinness differed significantly ($p<0.001$) among above-six children. **Conclusions:** Existence of under-nutrition among a group of children suggests undertaking intervention programs of health and nutrition for all children aged 0+-18+ years. However, for the assessment of under-nutrition, WHO (World Health Organization) percentile cut-off points of stunting and thinness for above-six children should be redefined for the agreement of their results with that of -2 SD cut-off points.

Index Terms: Stunting, overweight-cum-obesity, wasting/thinness, WHO growth standards/references

1. INTRODUCTION

Malnutrition is the greatest single threat to the world's public health and accounts for 11% of global diseases [1]. It includes both under-nutrition and over-nutrition. Malnutrition can be assessed anthropometrically, because malnutrition impairs growth and/or changes body composition that lead to abnormal changes in body dimensions [2]. The most preferred anthropometric indices are length/height-for-age and BMI-for-age. The former identifies stunting and reflects chronic under-nutrition. The later quantifies overweight-cum-obesity and wasting/thinness, and indicates acute malnutrition. Stunting results in the problems of childbirth in women and remains associated with poor intelligence and increased susceptibility to fatness [1, 3-4], whereas wasting makes the children susceptible to infections, and increases the incidences of stunting and low birth weight [1, 3]. Overweight-cum-obesity causes breathing difficulties, increases the risks of early markers of cardiovascular disease, hypertension, insulin resistance, fractures and psychological abnormalities in the children. In addition, all forms of malnutrition are associated with poor productivity, disability, premature death and problems of pregnancy [1, 5]. Malnutrition affects both preadolescent and adolescent children [2, 3, 6-7]. To reduce the risks of malnutrition, early diagnosis of it and prompt undertaking of appropriate intervention programs are necessary.

In respect of malnutrition, there was a scarcity of baseline data on the children of Tripura. But because of socio-economic backwardness [8], children of Tripura were suspected to be victims of malnutrition. Consequently, a number of nutritional and health intervention programs have been undertaken for preschool and primary school children in the State since 1970 [8-11]. National Family Health survey-1 (NFHS-1) of 1992-93 reported a high stunting prevalence for under-five children of Tripura [12]. The study did not consider overweight-cum-obesity and did not include children aged 5+-18+ years. Besides, there was no internationally agreed on method for assessing nutritional status of adolescent children [13]. On the other hand, though the problems of stunting, wasting/thinness and overweight-cum- obesity are generally assessed consulting SD or percentile system [2,14-15], there was a scarcity of study exploring if there is any disagreement between these two systems. In this background, we aimed at 1) providing baseline anthropometric data on the different forms of malnutrition among different sub-groups of Tripura's children consulting SD system and 2) examining if there is any disagreement between SD and percentile-based cut-off points of malnutrition, undertaking a

cross-sectional study on the lengths/heights and weights of children aged up to 18^+ years under a multi-purpose study during 1996-98.

2. MATERIALS AND METHODS

2.1. Study design and selection of population

Tripura is a sub-Himalayan hilly State of North-east India. Total population of Tripura was 31,99,203 (Census Report,2001) and most of them belonged to low socioeconomic status [8]. For this study, 13 rural areas (from 17 pre-selected villages of 17 rural blocks) and 3 urban areas (1 from Agartala Municipality, 2 from 4 preselected areas of 10 Notified Areas) were selected following multi-stage random sampling method. The selected rural areas were Taranagar, R.K.Nagar, Madhupur, Kunjaban, Purba Ramchandraghat, N.C.Nagar, Bhuratali, Jolaibari, Kalabaria, Dakshin Chandrapur, Rajkang-Rangkang, Manughat and Sonaimuri, whereas the selected urban areas included Agartala Municipality, Teliamura N.A. and Khowai N.A. Secondly, in each of the study area, schools ensuring children of both sexes and all available classes were chosen. For the pre-school children, nearby houses of the chosen schools were considered. Before conducting the study, permission of the Headmasters of the selected schools and guardians of the chosen families was taken. Then the lengths/heights and weights of the willing school and preschool children of the selected schools and houses were taken. The study was conducted during the period of 1996-98. However, data analysis got started after about one decade of their collection, when internationally agreed on methods for all children aged up to 18+ years were available [16-25]

2.2. Data collection

The heights of above-two children were measured using a metal anthropometer of 2 meters length. For under-two children, lengths from crown to heel were measured with an auto-recoiling hard steel tape which was identical to anthropometer in calibration. For length measurement, two flat hard board papers were kept perpendicular to the lying plane and parallel to one another touching respectively the tip of the head and the sole of the feet of the under-two children, and the distance between the two hard papers was taken as a measure of length. The measured lengths /heights were recorded nearest to 0.1 cm.

Weights of the bare-foot children were measured using a portable personal weighing scale (capacity: 125 kg. Calibration: 0.5 kg). Weights were measured nearest to 0.25 kg (interpreting positions of scale needle in the middle of two calibrations as 0.25 kg) and recorded making reasonable reduction for clothing that children used depending on age and sex. For an under-two child, difference between the weight of a child with mother and the weight of mother alone was recorded as the child's weight.

2.3. Data analysis

Data of the children were grouped according to their ages (for example, age 18+ years included data of 18- <19 years, and were considered equivalent to 18 years 6 months). BMI of every child was calculated from his/her weight and length/height. Medians of lengths/heights and BMIs for ages were assessed and expressed as percentages of WHO standard/reference medians of respective age and sex [16-24]. A child having length/height-for-age and BMI-for-age <-2 SD values or $<3^{rd}$ percentile values of WHO standards/references of respective age and sex [16-24] was classified as stunted or wasted/thin respectively as per WHO criteria [14, 25]. A child of age group 0-<5 years having BMI-for-age >+3SD/>99th percentile value (for a child of age group 5-<19 years: >+2SD/>97th percentile) or BMI-for-age >+2SD/>97th percentile (for a child of age group 5-<19 years: >+1SD/>85th percentile) of WHO standards/references of respective age and sex [21-24] were considered as obese or overweight respectively as per WHO criteria [14, 25]. The incidences of stunting, wasting/thinness, obesity and overweight-cum-obesity were expressed in percentages by age group, sex, locality and caste. Chi-square (χ^2) test was performed to assess the significance levels of prevalence differences. For data sorting and graphical representation, Microsoft Office Excel 2007 and Microsoft Graph Chart software were used.

3. RESULTS

The study included 9,498 children (boys: 4930, girls: 4568) aged 0+-18+ years. The Table 1 shows age-wise medians of lengths/heights and BMIs by sex. Medians of our study were lower than the WHO standard/reference medians for most of the ages. Table 2 presents SD prevalence of stunting, wasting/thinness, and overweight-cum-obesity by age group, sex, locality and caste. Stunting was higher in children of under-five ($p<0.001$), rural areas ($p<0.01$) and in girls ($p<0.001$). Thinness was higher in children of above-five ($p<0.001$), rural areas ($p<0.01$), General caste ($p<0.001$) and in boys ($p<0.001$) and overweight-cum-obesity was higher in children of rural areas ($p<0.01$), STs (Scheduled Tribes) ($p<0.001$) and in boys ($p<0.02$).

Figures 1 and 2 show respectively comparison of median weights and lengths/heights among the boys and girls of Tripura and America. SD- and percentile-based prevalence of stunting, wasting/thinness, overweight-cum-obesity for under-six and above-six age groups is shown in Table 3. Figure 3 represents age-wise SD and percentile prevalence of stunting, wasting/thinness, and overweight-cum-obesity. Percentile results were significantly higher than that of SD results for stunting ($P<0.001$) and thinness ($P<0.001$) among above-six age group.

4. DISCUSSION

4.1. SD-based prevalence of malnutrition among the children of Tripura

An objective of our study was to gather information about the prevalence of stunting, wasting/thinness and overweight-cum-obesity following WHO SD system.

4.1.1. Stunting

Stunting i.e., low length/height-for-age is an indicator of past growth failure that have resulted from previous long-term or repeated short-term nutrient deficiencies and/or illness, and/or might be related to low birth weight, and poor economic conditions [1, 15]. The study showed a stunting prevalence of higher severity (Table 2) than that of NFHS studies (1992-93: 46.0%, 1998-99: 44.6%, 2005-06: 35.7%) for under-five (i.e., 0+-4+ years old) children of Tripura [12, 26-27]. Under-five stunting prevalence of our study was also more severe than that of the nation (1992-93: 52%, 1998-99: 45.5%, 2005-06: 48.0% [12, 27-28], and developing countries (1995: 33.5%, 2000:

Table 1. Medians of length(l)/ height (h), weight (w) and BMI by age and sex among the children of Tripura

Age (year)	Boys Total	Median l/h (cm)	Median w (kg)	Median BMI	Girls Total	Median l/h (cm)	Median w (kg)	Median BMI
0+	20	61.9 (91.6)	6.4	17.0 (98.3)	24	61,0 (92.8)	6.1	16.4 (97.0)
1+	21	73.0 (88.7)	8.5	15.8 (98.1)	20	70.9 (87.9)	7.6	14.9 (94.9)
2+	32	82.0 (89.2)	10.3	16.1 (101.9)	17	79.1 (87.2)	9.5	15.1 (97.4)
3+	34	90.0 (90.1)	12.0	14.8 (96.1)	25	85.1 (86.0)	11.0	14.8 (96.7)
4+	30	94.5 (88.6)	12.9	14.6 (95.4)	28	94.1 (88.6)	12.8	14.3 (93.5)
5+	39	99.5 (88.1)	14.5	14.1 (92.2)	39	99.0 (882)	14.0	13.8 (90.8)
6+	487	111.5 (93.8)	16.8	13.5 (87.7)	431	110.0 (93.2)	16.3	13.4 (87.6)
7+	431	117.0 (94.0)	18.5	13.5 (86.5)	433	116.8 (94.4)	18.0	13.3 (85.8)
8+	473	122.0 (93.9)	20.3	13.7 (86.2)	418	121.3 (93.7)	20.0	13.6 (85.5)
9+	425	127.0 (93.9)	22.5	14.0 (86.4)	421	126.8 (93.6)	22.0	13.9 (85.3)
10+	385	131.0 (93.3)	24.3	14.1 (84.4)	374	133.0 (93.8)	25.3	14.4 (85.2)
11+	503	136.0 (93.2)	27.0	14.7 (85.5)	439	139.2 (93.9)	29.0	15.1 (85.8)
12+	495	143.6 (94.2)	31.5	15.4 (86.0)	518	145.0 (94.2)	34.8	16.5 (89.7)
13+	432	152.1 (95.2)	37.3	16.0 (86.0)	385	146.5 (92.5)	38.0	17.4 (90.6)
14+	380	157.1 (94.5)	42.5	16.9 (87.1)	364	148.3 (92.2)	40.0	18.0 (90.5)
15+	315	160.2 (93.6)	44.8	17.2 (85.6)	300	149.4 (92.1)	41.3	18.6 (90.7)
16+	224	161.5 (92.7)	46.0	17.8 (85.6)	208	150.0 (92.2)	42.0	18.7 (89.5)
17+	136	161.6 (91.9)	47.9	18.4 (86.0)	73	149.0 (91.4)	41.3	18.5 (87.3)
18+	68	163.0 (92.4)	47.8	18.1 (81.8)	51	149.2 (91.5)	41.5	18.4 (86.4)
Grand Total	4930		4568					

***NB**. Medians of length/height and BMI as percentages of standard/reference median data of WHO [16-18,21-22] are given in parentheses. Here '+' indicates 6 (six) months.*

Table 2. SD-Based prevalence of stunting, wasting/thinness, overweight-cum-obesity by age-group and sex among the children of Tripura

Group	Total No.	Stunting (<-2SD l/h, cm) (%)	Wasting /thinness (<-2SD BMI) (%)	Overweight-cum-Obesity (>+1SD/ >+2SD* BMI) (%)
Age-group				
0+ -4+ y	251	69.7	4.8	2.4
5+-9+ y	3597	28.7 (S)	30.6 (S)	0.4 (S)
10+-18+ y	5650	31.3 (P<0.05, S)	24.8 (S, S)	1.4 (S, NS)
Sex				
Boys	4930	29.5 [27.9**]	31.9 [31.1**]	0.7 [0.8**]
Girls	4568	33.5 [34.9**] (S) [S**]	20.6 [18.0**] (S) [S**]	1.4 [2.0**] (P<0.02) [P<0.01**]
Locality				
Urban	1944	28.6	22.7	1.7
Rural	7554	32.2 (P<0.01)	27.4 (S)	0.8 (P<0.01)
Caste				
General	5922	32.9	29.6	0.8
SC	2555	32.3 (NS)	25.0 (S)	0.7 (NS)
ST	1021	20.4 (S, S)	12.1 (S, S)	3.3 (S, S)
Grand Total	9498	31.4	26.5	1.0

***NB** *= For under-five children only; **= For above-ten children only. SC=Scheduled Castes, ST=Scheduled Tribes, S=Significant (p<0.001), NS=Not significant (p>0.05). 1ST mentioned significance levels are in respect of the previous counterpart of the group and 2nd ones (where applicable) are in respect of the furthest counterpart of the group.*

29.6%, 2005: 26.5%) [6]. According to WHO epidemiological criteria [29], under-five stunting prevalence of our study was very high (≥40.0%).

Stunting prevalence of Tripura had declined in above-five (i.e., 5+-9+ years old) children by 41% (p<0.001) which subsequently had increased in above-ten (i.e., 10+-18+ years old/adolescent) children by 2.6% (p<0.05) (Table 2). The decline of stunting prevalence among above-five children with its subsequent increase in above-ten children indicates a spurt of linear growth in above-five children, which however deteriorated in above-ten children. Stunting prevalence of above-five and above-ten children of Tripura was lower than that of the rural school children (range: 48-56%) of five low income countries (including India) in 1998 [7]. A high prevalence of stunting is of serious concern, whether it is associated with wasting or not. In case of high stunting prevalence, prevention strategy needs to aim at increasing food availability, dietary quality, hygiene, and antenatal care, adequate supply of potable water, and prevention and treatment of infectious diseases [1, 15].

4.1.2. Wasting/Thinness

Wasting (for under-five children)/Thinness (for above-five children) i.e., low BMI-for-age indicates recent weight loss or failure to gain weight because of inadequate food intake and/or illness, and is linked to child mortality and requires immediate intervention [1-2]. For Tripura, under-five wasting prevalence of our study was lower than that of NFHS studies (1992-93: 17.5%, 1998-99: 18.0%, 2005-06: 24.6%) [12, 26-27]. Under-five wasting prevalence of our study was also lower than that of the nation (1992-93: 17.5%, 1998-99: 15.5%, 2005-06: 19.8%) [12, 27-28] and all developing countries (1995: 8.3%, 2000: 8.2%, 2005: 8.3%) [6]. According to WHO epidemiological criteria [29], under-five wasting prevalence of our study was very low (<5.0%).

Our above-five thinness prevalence was higher by 25.8% (p<0.001) than our under-five wasting prevalence, which subsequently had decreased in above-ten children by 5.8% (p<0.001) (Table 2). The increase in thinness among above-five children with its subsequent decrease in above-ten children indicates that the spurt of linear growth of above-five children met acute nutrient deficiencies non-compensation of which perhaps led the spurt to be adapted to the prevailing nutrient deficiency causing an increase in stunting among above-ten children. Overall adolescent thinness prevalence of our study was lower than that of slum-dwelling adolescent school children of Mumbai (53%, <5th percentile) and Bangladesh (67%, <5th percentile of NCHS reference) [7]. It is important to note that a condition of low or no wasting does not indicate the absence of current nutritional problems that cause stunting [29]. In case of high wasting prevalence, efforts need to be directed towards providing adequate foods, prevention and treatment of infectious diseases [1, 15].

4.1.3. Overweight-cum-obesity

Overweight-cum-obesity is a condition of excessive fat accumulation. It results from high energy intakes and/or from decreases in physical activity, and is characterized by high BMI-

for-age [5]. For Tripura, under-five overweight-cum-obesity prevalence of our study (Table 2) was nearly close to that of NFHS study (2.2%) of 2005-06 [27]. Under-five overweight-cum-obesity prevalence of our study was lower than that of all developing countries (1995: 2.9%, 2000: 3.0%, 2005: 3.4%) [6]. Our study showed a decrease in overweight-cum-obesity prevalence among above-five children by 2% ($p<0.001$) which subsequently had increased in above-ten children 1% ($p<0.001$) (Table 2). Overweight-cum-obesity prevalence of our study was lower in the children of above-five and above-ten (Table 2) than that of Indian affluent adolescent school children (7.4%) [3] and that of global school and adolescent children (1.2-37.1%) [6]. Overweight-cum-obesity prevalence of our study showed a decrease among above-five and above-ten children (Table 2). The decline in overweight-cum-obesity prevalence among older children indicates that their calorie consumption was lower than their calorie requirements (Table 2).

A decrease in overweight-cum-obesity among above-five children with its subsequent increase among above-ten children indicates that the spurt of linear growth of above-five children was at the expense of surplus energy that in turn possibly increased the incidences of stunting among the affected children impeding their growth spurt. As a result of stunting, the same available energy perhaps started becoming sufficient again for the same children increasing the trend of overweight-cum-obesity among them subsequently.

4.1.4. Malnutrition by sex

This study showed lower stunting prevalence among adolescent boys and girls (Table 2) of Tripura than among Indian adolescent boys (39.5%) and girls (39.1%) [7]. It showed higher prevalence of stunting ($p<0.001$) and overweight-cum-obesity ($p<0.02$), and lower wasting/thinness prevalence ($p<0.001$) in girls than in boys. The national prevalence of thinness (38.8%) and overweight-cum-obesity (1.7%) of adolescent girls of 1998-99 were higher and lower respectively [30] than that of our adolescent girls (Table 2). Our study indicates that girls were of lower growth spurt and more victims to chronic under-nutrition than boys. It might be the result of their long-standing lower access to food and health facilities because of intra-family gender biasness.

4.1.5. Malnutrition by locality

The rates of stunting and wasting/thinness of our study were lower ($p<0.001$) among urban children indicating their better nutritional status than rural ones. These differences were possibly the reflection of cumulative effects of more favorable living conditions and opportunities of urban areas. Urban children were more affected by overweight-cum-obesity ($p<0.01$) indicating their excessive energy intake and/or lower physical activity than rural ones.

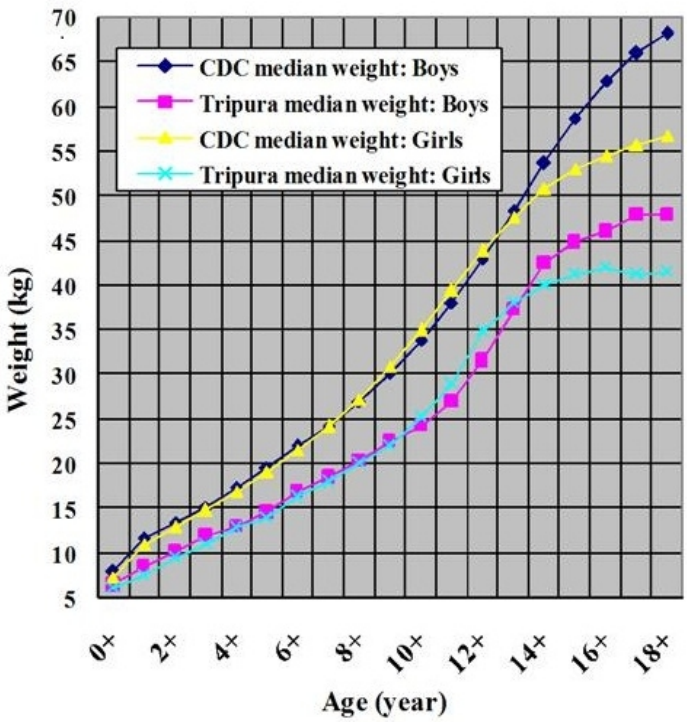
4.1.6. Malnutrition by caste

The children of General castes showed the highest prevalence of stunting and wasting/thinness showing their lowest growth status and nutrient availability. On the other hand, ST children of our study showed the lowest prevalence of stunting ($p<0.001$) and wasting/thinness ($p<0.001$) indicating their better growth status and higher nutrient availability than the other castes. There is report that STs of Tripura traditionally use a large variety of forest products as food [31]. The better nutritional status of STs might be partly due to their free access to these wild forest products. The study shows the highest rates of overweight-cum-obesity among ST children ($p<0.001$) reflecting dominance of surplus energy intake and/or lower physical activity among them.

4.1.7. Relative trends of boys and girls being taller and heavier

Our study shows that boys were both taller and heavier than girls in most of the ages, while the girls were both taller

Figure 1. Comparison between median weights of Tripura and America (CDC)



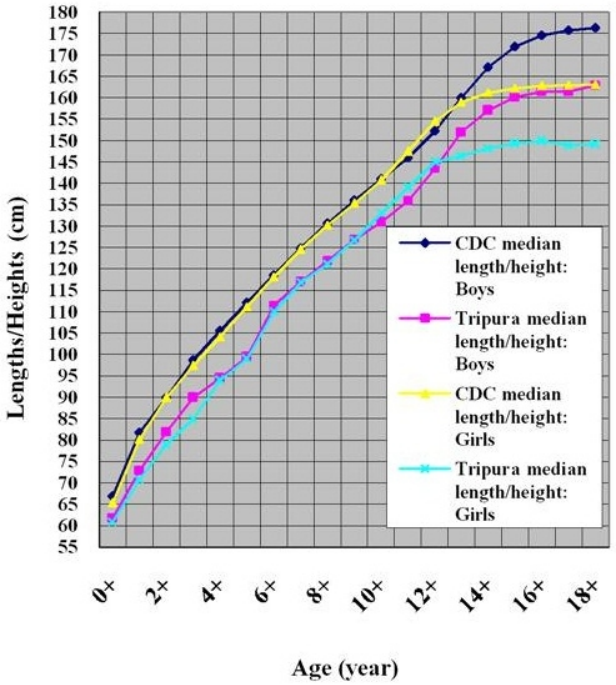
and heavier in the age groups 10+ to 12+ years and only heavier in the age group of 13+ years than boys (Fig. 2 & 3). Children of Tripura differed from the American CDC growth reference [32], girls being both heavier and taller instead of being only heavier in the age group 10+ years and being both shorter and lighter instead of being only heavier in the age groups 8+ and 9+ years than the boys. These findings indicate that Tripura's relative trends of boys and girls being taller and heavier were nearly identical to the American trends.

Our study also reveals the fact that in comparison to the CDC reference, age-wise median heights and weights of Tripura's children were lower in both the sexes. These indicate that CDC growth references also support the existence of under-nutrition among the studied children of Tripura.

4.1.8. Malnutrition on overall

This study reveals that the problems of stunting and wasting/thinness were quite high among almost all groups of children. Under-five children showed very low prevalence of wasting against very high prevalence of stunting. The stunting prevalence was highest among those who were under-five by

Figure 2. Comparison between median lengths/heights of CDC and Tripura



age-group, girls by sex, rural by locality and General by caste. The prevalence of wasting/thinness was found highest among above-five by age-group, boys by sex, rural by locality and General by caste. The decline of stunting prevalence by 41% among above-five children (in comparison to under-five children) indicates a spurt of linear growth in above-five children. The normal current nutritional status (i.e., wasting prevalence <5%) of the stunting dominated under-five children might have acted as a prerequisite for the initiation of this growth spurt among them at their above-five stage. However, the prevalence of overweight-cum-obesity among the children of Tripura was negligible. The overweight-cum-obesity problem was highest among those who were under-five by age-group, girls by sex, urban by locality and ST by caste. Overall, the ST children fared better than the General and SC children in health and nutrition. However, stunting, wasting/thinness and overweight-cum-obesity problems of Tripura showed a trend that was lower than or nearly similar to that of the nation and other developing countries, except for Tripura's under-five stunting that was higher. In this regard, it should be kept in mind that prevalence of these problems is not strictly comparable across time periods even for a given region as each round of study uses different sampling methodologies and includes different age groups [33].

The high prevalence of stunting and wasting/thinness in the children of Tripura after sustainable running of different health and nutritional programs for about two decades, questioned the effectiveness of the undertaken intervention programs. A recent study on 608 rural tribal children aged 6-15 years that showed higher prevalence of stunting (<3rd percentile: 23.7%) and thinness (BMI <5th percentile: 33.39%), and lower prevalence of overweight (BMI >85th percentile: 0.8%) than that of our overall ST children [34], indicates that the situation has not improved even after about three and half decades of intervention. All these underline the necessity of a composite program involving supplementation of food, sustainable correction of micronutrient deficiencies, improvement of mothers' feeding and child caring behavior, provision of purified water and proper sanitation, strengthening of health care system and programs of regular physical activity, and regular monitoring and surveillance of undertaken programs [1, 5, 33]. On the other hand, high prevalence of under-nutrition among all groups of Tripura's children suggests undertaking intervention programs of health and nutrition for all of them. As the study was conducted about one and half decades ago, the under-nutritional problems of Tripura's children (as evidenced by the high prevalence of stunting and/or wasting/thinness) might have undergone a substantial change during this interval. Undertaking intervention programs based on our study, therefore, may not be appropriate to Tripura's children in present scenario.

The exemplary anthropometric data of our study on the distribution of under-nutritional problems (i.e., the distribution of stunting and wasting/thinness) across different groups by age, sex, caste and locality among the children aged 0+-18+ years (Table 2) document that till there prevail the conditions of under-nutrition (i.e., the conditions of stunting and/or wasting/thinness) among the children of a group, the children of remaining groups sharing the same conditions cannot remain healthy. This observation of our study underlines that the study on a group of children revealing under-nutrition is entitled to suggest undertaking intervention programs of nutrition and health for all children. Our study provides background for the subsequent studies involving even a single group of children to suggest something for all children. Thus arises one relevancy of our old study in present scenario.

In addition, this study provides baseline data on the problem of overweight/obesity for under-five and above-five children and on the problems of stunting and thinness for above-five and above-ten children of Tripura, that may help evaluate the effectiveness of the subsequent intervention programs.

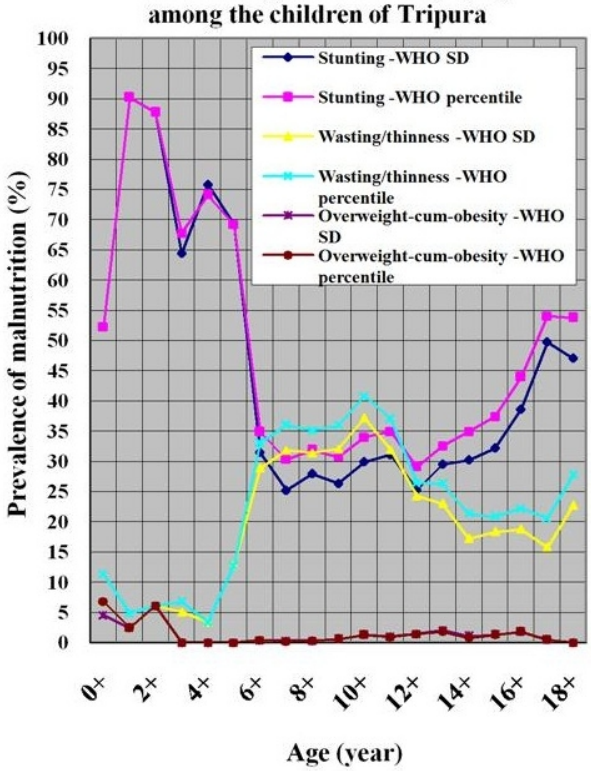
4.2. Comparison between SD-and percentile systems

Another objective of this study was to examine if there is any disagreement between SD and percentile systems of WHO growth standards/references [16-24]. WHO recommends the use of both SD and percentile systems giving preference to the former, because (1) the SD system can provide useful summary statistics, (2) SD cut-off point intervals of similar magnitude always imply a fixed difference for height, weight or any other anthropometric measurement, and (3) all anthropometric indices show similarity in respect of percentage of children who remain below or above a particular SD cut-off point of an age among the reference/standard population [2, 29]. Percentile system is commonly used in clinical or community settings, because it indicates simply and clearly an individual's rank position within the context of standard/reference population [2]. For the normal distribution of a measurement, each SD value has a fixed corresponding percentile (or cumulative probability).i.e., 34.13% of the data would lie between 0 SD to -1 SD or 0 SD to +1 SD, 13.59% between -1 SD to -2 SD or +1 SD to +2 SD, 2.14% between -2 SD to -3SD or +2 SD to +3 SD and 0.14% below

Table 3. Comparison between SD- and percentile-based prevalence of stunting, wasting/thinness, overweight-cum-obesity by age-group and sex among under-six and above-six children of Tripura

Growth status & group	Total No.	Prevalence (%) SD	Prevalence (%) Percentile	Significance level of difference (χ^2-test)
Stunting		<-2SD	<3rd percentile	
0+-5+ y	329	72.64	73.25	P>0.05
6+-18+ y	9169	29.95	34.14	p<0.001
[6+-18+y: Boys	4754	27.83	31.72	P<0.001]
[6+-18+y: Girls	4415	32.23	36.76	P<0.001]
Wasting		<-2SD	<3rd percentile/Thinness	
0+-5+ y	329	6..69	7.90	P>0.05
6+-18+ y	9169	27.17	30.90	P<0.001
[6+-18+ y: Boys	4754	32.69	36.92	P<0.001]
[6+-18+ y: Girls	4415	21.22	24.42	P<0.01]
Obesity		>+2SD	>97th percentile	
0+-5+ y	329	1.82	2.13	P>0.05
6+-18+ y	9169	0.08	0.10	P>0.05
Overweight-cum-obesity		>+1SD	>85th percentile	
0+-5+ y	329	6.69	6.08	P>0.05
6+-18+ y	6169	1.00	0.94	P>0.05

Figure 3. WHO SD and percentile-based prevalence of stunting, wasting/thinness and overweight-cum-obesity by age among the children of Tripura



-3SD or above +3 SD [25, 35]. Thus, -2SD cut-off value for stunting and wasting/thinness, and +1SD and +2SD values (for under-five children, +2SD and +3SD) for overweight and obesity correspond exactly to 2.28th, 84.13th and 97.72th (for under-five children, 97.72th and 99.86th) percentile values respectively.

But WHO has rounded those percentiles as 3rd, 85th and 97th (for under-five children, 97th and 99th) percentiles respectively [14, 25]. Therefore, there is a probability of percentile-based prevalence being higher for stunting, wasting/thinness and obesity, lower for overweight than the SD-based prevalence for them. Our study showed the trend of overestimation for the 3rd percentile cut-off points of stunting and thinness and the 97th percentile cut-off point of obesity and the trend of underestimation for the 85th percentile cut-off point of overweight (including obesity) in comparison to corresponding SD cut-off points. The study also showed that the 3rd percentile cut-off point causes significant overestimation of stunting (P<0.001) and thinness (P<0.001) among the children aged 6+-18+ years (Table 3 and Figure3).

5. CONCLUSIONS

Existence of under-nutrition among a group of children suggests undertaking intervention programs of health and nutrition for all children aged 0+-18+ years. However, for the assessment of under-nutrition, WHO percentile cut-off points of stunting and thinness for above-six children should be redefined for the agreement of their results with that of -2 SD cut-off points.

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Authors' Contributions

The plan of work and anthropometric study of 1/4th study areas were accomplished by IR and AKC jointly. Anthropometric study of remaining study areas, preparation of manuscript and statistical analyses were done by IR. Interpretations and conclusions expressed in this article are made by IR in association with AKC. IR and AKC are equally responsible for the parts of article critical to its main conclusions.

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