Stunting may not be Stunting When Body Shape is Factored into its Assessment

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Abstract: The study investigated the relationship between height-for-age and body shape of children under 5 in some parts of Peru, India, Bangladesh and Guinea. The objective of the study was to determine whether the consideration of body shape measured by SSHr in the assessment of stunting could change our understanding of stunting in children in different areas of the world.

Anthropometric samples of children aged between 2 to 5 years were collected from Terre des homes Foundation (A Swiss NGO) nutrition project sites in Peru (districts of Andahuaylas, Ventanilla, Huancaray, Turpo, Talavera, San Jeronimo, Lliupapuquio), Guinea (Municipalities of Dixinn, Ratoma), Bangladesh (districts of Mogholbasa, Belgacha, Holokhana, Panchgachi) and India (districts of the Sunderban). The SSHr of the children under study were:

	Peru	Bangladesh	India	Guinea
24-35 months	0.605	0.580	0.572	0.556
36-47 months	0.584	0.571	0.557	0.542
48-59 months	0.573	0.562	0.552	0.531
All children	0.586	0.568	0.561	0.543

Global delay of growth using the HAZ indices among these children were Peru: 32.4% (MDG-23.1%; SDG- 9.4%), Guinea: 18.5% (MDG- 11.0%; SDG- 7.5%), India 43.6% (MDG- 27%; SDG- 16.6%) Bangladesh: 30.5% (MDG- 26.0%; 4.6%). These figures changed dramatically particularly for Peru when the SSHr was factored into the calculations of stunting: Peru: 0.4% (MDG-0.4%; SDG- 0%), Guinea: 18.4% (MDG- 10.0%; SDG- 8.4%), India 16.4% (MDG- 13.7%; SDG- 2.7%) Bangladesh: 2.9% (MDG- 2.7%; SDG- 0.3%).

Keywords: Nutrition, Stunting, Body shape, Anthropometry, Epigenetics.

1. INTRODUCTION

Terre des hommes (Tdh) Foundation nutrition projects in some parts of Southeast Asia, South America and West Africa provided the opportunity to measure and compare anthropometric indices of wasting, underweight and stunting in children from these three regions of the world .The study specifically investigated the relationship between height-for-age and body shape of children under 5 in different settings. The standing / sitting height ratio (SSHr) was used as an index of body shape. Four cross-sectional nutritional anthropometry surveys were undertaken, in Bangladesh and India in the South Asian region, in Guinea in the West African region and in Peru in the Andean region.

When used with adults, SSHr is known as the Cormic Index and is used to correct body mass index (BMI), a weight-for-height index used in adults, whenever between-population comparisons of pre-valence or mean BMI are to be made [1]. Mean SSHr for populations of adults varies from minimum values, *i.e.*, relatively longest legs, for Australian Aborigines (SSHr = 47.3 for men and 48.1 for women) to the maximum SSHr values, *i.e.*, relatively shortest legs, for Guatemala Maya men and Peruvian women (SSHr = 54.6 and 55.8).

At present, height-for-age indices (HAZ calculated using the WHO Child Growth Standard) are not corrected for body shape when used with children. HAZ has been endorsed by the World Health Organization (WHO) as a suitable tool for diagnosing stunting. Myatt and colleagues analysing data, collected in Ethiopia in May 2006 by the Emergency Nutrition Co-ordinating Unit (ENCU) of the Government of Ethiopia, showed that the standing / sitting height ratio (SSHr) in children belonging to pastoral population was quite low compared with the one measured in children belonging to agrarian sedentary population [2]. It is a long-standing observation that body shape varies with climate with SSHr tending to be lower in populations

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from areas with higher mean temperatures [3]. The reason for this is believed to be thermoregulatory since SSHr is strongly associated with the ratio of body surface area to mass [4]. This raised the question of whether the consideration of body shape measured by SSHr in the assessment of stunting could change our understanding of stunting in children in different areas of the world.

2. METHOD

Anthropometric samples of children aged between 2 to 5 years were collected from Terre des hommes nutrition project sites in Peru (districts of Andahuaylas, Ventanilla, Huancaray, Turpo, Talavera, San Jeronimo, Lliupapuquio), Guinea (Municipalities of Dixinn, Ratoma), Bangladesh (districts of Mogholbasa, Belgacha, Holokhana, Panchgachi) and India (districts of the Sunderban). The surveys used the following eligibility criteria - age between 24 and 59 months. These eligibility criteria were used because measurements of supine length, rather than standing height are normally used in children younger than 2 years. Nevertheless a small minority of children measured were younger than 2 years and others older than 5 (Table **1**).

The anthropometric measurement procedures followed best practices as far as was feasible. Age was determined by reference to official documents (e.g. vaccination records, birth certificates, 'road to health' cards) or – but rarely – by maternal report when official documents were unavailable. Weight was measured to the nearest 0.1kg using mechanical hanging scales using standard methods. All children were weighed with light clothing and without shoes. Standing height was measured to the nearest 1mm using portable height boards of standard construction using standard methods. Sitting height was measured to the nearest 1mm using portable height boards of standard construction placed on chairs. Children were measured with the backs of the knees resting on the edge of the chair, thighs horizontal, back straight, buttocks and scapula against the height board, hands on their knees, looking straight ahead and breathing normally. This deviates from best practice in that the feet were not supported and the measurement was not routinely taken when the child had exhaled fully.

A sitting-to-standing height ratio value (SSHr) – a height-based index of body shape – was calculated for each child in the study sample. This provides a measure of the relative length of trunk (trunk + head) and legs [1]. The SSHr is calculated as (sitting height / standing height) * 100. It defines the percentage of total stature that is comprised by head and trunk. The remaining portion of the body will be the length of the legs. Smaller values of SSHr indicate longer limbs and/or shorter trunks. Larger values of SSR indicate longer trunks and/or shorter limbs. In previous studies, body shape measured by SSR has been found to change with age, with the SSHr declining shortly after birth until the onset of puberty [5].

We used two indirect ways to assess stunting on a sitting height base (1) in calculating a standing height with a standard by age fixed sitting / standing height ratio (recalculated standing height = measured sitting height / SSHr) and (2) using multiple regression analysis. These recalculated standing height were then compared to height for age standard indices (2005 WHO standard).

3. RESULTS

With cleaned collected anthropometric data (age, weight, standing height as well as sex), we assessed rates of wasting, underweight and stunting in the four representative sample of the children population

Table 1: Samples of the Research (before Database Cleaning)

		Country				Total
		Peru	Guinea	India	Bangladesh	
Age	6-23 months	3 (00.6%)	4 (00.6%)	5 (00.6%)	0 (00.0%)	12 (0.40%)
	24-35 months	160 (31.3%)	289 (41.8%)	280 (35.3%)	103 (13.0%)	832 (29.8%)
	36-47 months	124 (24.2%)	197 (28.5%)	288 (36.3%)	334 (42.0%)	943 (33.8%)
	48-59 months	199 (38.9%)	135 (19.5%)	213 (26.9%)	352 (44.3%)	899 (32.2%)
	> 60 months	26 (05.1%)	66 (09.6%)	7 (00.9%)	7 (00.8%)	107 (03.8%)
		n=512	n=691	n=793	n=795	N=2'791

supported by Tdh Foundation (Bangladesh, India, Guinea) and Kusi Warma (Peru). Analysis of data (Table **2**) showed mean high rates of global wasting (moderate + severe) for India and Guinea, medium for Bangladesh and very low for Peru; very high rates of stunting in India, Bangladesh and Peru and not so high in Guinea.

The rates of stunting as a nutritional disease (or at least a problem) in India, Bangladesh [6] and as well in Guinea [7] could be explained, however the situation in Peru demanded further investigation. The table below shows stunting in different age groups of the children studied (Table **3**).

Stunting rates are quite high in all the project countries except in Bangladesh (Figure **1**), where, however high stunting rates are recorded for age group 24-35 months (Table **3**) This implies that mean height

Table 2: Types of Malnutrition by Countries (2005 WHO Standard)

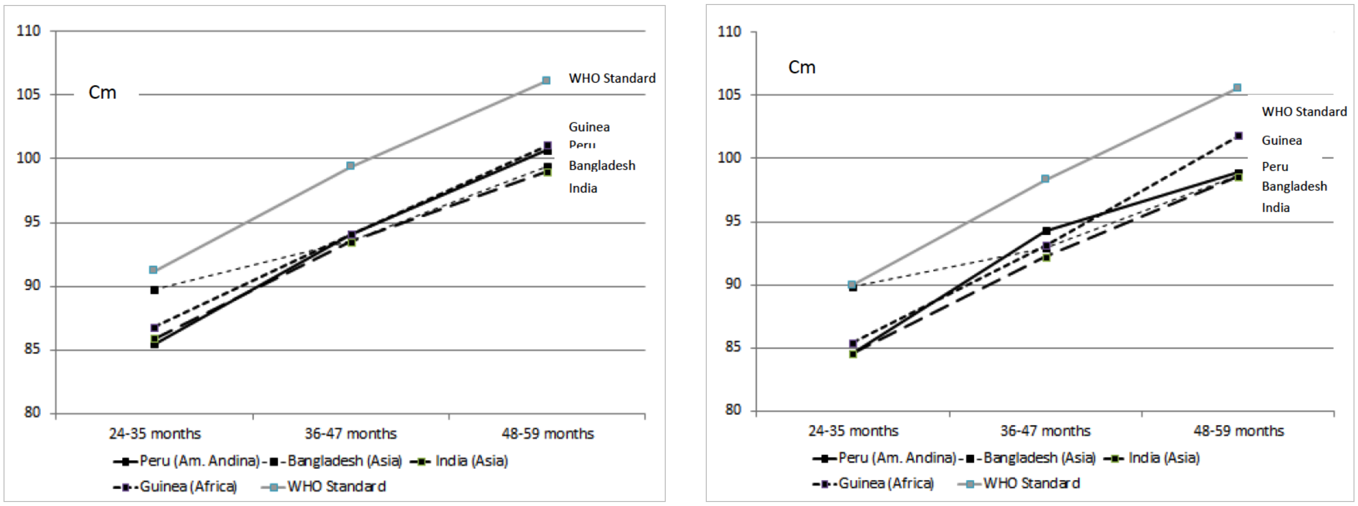
		Country			
		Peru	**Guinea**	**India**	**Bangladesh**
Wasting (WHO)	Normal	486 (99.8%)	504 (73.8%)	532 (68.6%)	702 (88.3%)
	MAM	1 (0.2%)	134 (19.6%)	179 (23.1%)	87 (10.9%)
	SAM	0 (0.0%)	45 (6.6%)	65 (8.4%)	6 (0.8%)
	Total	487 (100.0%)	683 (100.0%)	776 (100.0%)	795 (100.0%)
Stunting (WHO)	Normal	333 (68.0%)	574 (83.7%)	461 (59.2%)	549 (69.5%)
	MDG	112 (22.9%)	74 (10.8%)	225 (28.9%)	205 (25.9%)
	SDG	45 (9.2%)	38 (5.5%)	93 (11.9%)	36 (4.6%)
	Total	490 (100.0%)	686 (100.0%)	779 (100.0%)	790 (100.0%)

MAM: Moderate acute malnutrition (HW: between -2.99 sd and -2.00 sd).
SAM: Severe acute Malnutrition (HW: ≤ -3.00 sd).
MDG: Moderate delay of growing (HA: between -2.99 sd and -2.00 sd).
SDG: Severe delay of growing (HA: ≤ -3.00 sd).

Table 3: Stunting by Age Groups (2005 WHO Standard)

		Country			
		Peru	**Guinea**	**India**	**Bangladesh**
Stunting (WHO) 24-35 months	Normal	97 (60.6%)	227 (79.6%)	141 (51.3%)	97 (94.5%)
	MDG	49 (30.6%)	41 (14.4%)	93 (33.8%)	6 (5.8%)
	SDG	14 (8.8%)	17 (6.0%)	41 (14.9%)	0 (0.0%)
	Total	160 (100.0%)	285 (100.0%)	275 (100.0%)	103 (100.0%)
Stunting (WHO) 36-47 months	Normal	85 (69.7%)	168 (85.7.6%)	174 (61.3%)	230 (68.9%)
	MDG	20 (16.4%)	15 (7.4%)	76 (26.8%)	94 (28.1%)
	SDG	17 (13.9%)	13 (6.6%)	34 (12.0%)	10 (3.0%)
	Total	122 (100.0%)	196 (100.0%)	284 (100.0%)	334 (100.0%)
Stunting (WHO) 48-59 months	Normal	143 (71.9%)	118 (87.4%)	141 (66.5%)	221 (62.8%)
	MDG	42 (21.1%)	12 (8.9%)	53 (25.0%)	105 (29.8.8%)
	SDG	14 (7.0%)	5 (3.7%)	18 (8.5%)	26 (7.4%)
	Total	199 (100.0%)	135 (100.0%)	212 (100.0%)	352 (100.0%)
TOTAL		481 (100.0%)	616 (100.0%)	771 (100.0%)	789 (100.0%)

MDG: Moderate delay of growing (HA: between -2.99 sd and -2.00 sd).
SDG: Severe delay of growing (HA: ≤ -3.00 sd).



(a) (b)

Figure 1(a): Mean height by age groups (all males irrespective stunting status). **(b):** Mean height by age groups (all females irrespective of stunting status).

by age groups (both sexes) is significantly lower in Bangladesh than the WHO standard projections (Figures **1a** and **1b**).

As we have data not only for standing height as usually available in any nutrition survey, but also for sitting height, we calculated the sitting / standing height ratio (SSHr) and compared it for the four samples (Figure **2**) and for three age groups (Figure **3**).

As SSHr decreases when age increases, being lower in older children than in younger, we compared it by country for separated age groups (Figure **2**). In the three selected age groups (24-35, 36-47 and 48-59 months) the difference in SSHr was very significant (p<0.0001) between each pair of countries. As we detected a bias in sampling (i.e., mean age for any age group was significantly different comparing country), we used a linear multiple regression analysis to assess the accurateness and comparable role of age between site projects (e.g. in age group 24-35 months, mean age was 30.1 months in Peru, 26.1 in Guinea, 30.6 in India and 32.4 in Bangladesh, a very significant difference with p<0.001).

We employ three models of regression (Table **4**). Sex is not included as a determinant as it does not make any statistically significant difference. The first

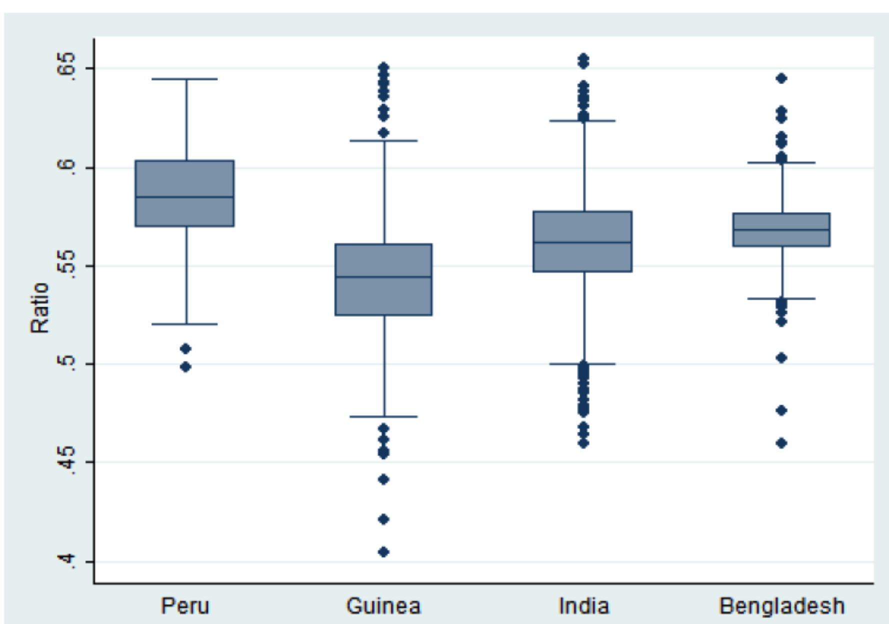


Figure 2: SSHr by countries.

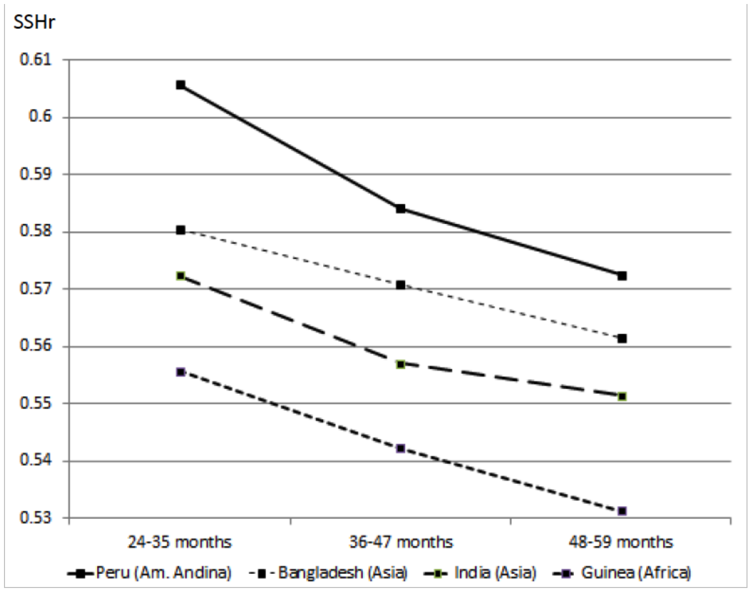


Figure 3: SSHr by age groups and by countries.

Table 4: Multiple linear regression models of prediction of SSHr

Model		Unstandardized Coefficients B	Standardised Coefficients β	T	Sig.
n°1	(Constant)	0.588		283.806	0.000
	Age (in months)	-0.001	-0.227	-12.246	0.000
n°2	(Constant)	0.579		338.595	0.000
	Age (in months)	-0.001	-0.375	-23.873	0.000
	Andean region (Peru)	0.049	0.682	36.994	0.000
	Asia region (Bangladesh + India)	0.028	0.499	26.701	0.000
n°3	(Constant)	0.582		208.262	0.000
	Age (in months)	-0.001	-0.415	-14.673	0.000
	Andean region (Peru)	0.064	0.883	13.249	0.000
	Asia region (Bangladesh + India)	0.014	0.239	3.549	0.000
	Andean region * Age	0.000	-0.198	-2.775	0.006
	Asia region * Age	0.000	0.287	3.788	0.000

one (n°1) includes only the age as key determinant of the SSHr. This first model explains 5.1% of the variance of SSHr (r^2=0.051). The second model (n°2) includes age and two region dummies (i.e., America and Asia regions, to capture the presence of three regions in the study. This second model explains 37.2% of the variance of SSHr (r^2=0.372). In the third model (n°3) we added the interaction terms of the region dummies with age, in addition to the determinants used in model n°2. This last and more sophisticated model explains 38.2% of the variance of SSHr (r^2=0.382). In general, the results of these selected models of regression show that age has a negative impact on the SSHr value. Furthermore, as shown by the results of Model n°3, region moderates the effect of age on SSHr such that (1) the negative effect of age on SSHr becomes even stronger in the Andean region (i.e., stronger negative effect of age), and (2) such negative effect becomes weaker in the Asia region (as comparisons with the West Africa region). Specifically, Model n°3 shows that the negative slope (predicting of SSHr by age) is strongest for the Andean region, followed by the West African region and finally the Asian region.

If we analyse and compare the mean length of trunk (= trunk + head) and legs separately by age and sex, whatever the nutritional status (underweight or not), we

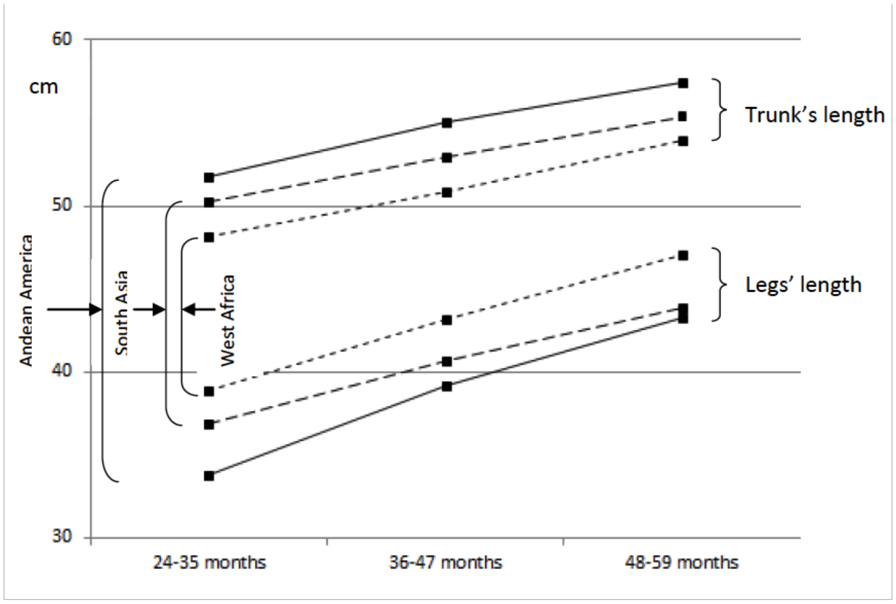


Figure 4: Length of trunk and legs by region and by age groups (males).

see that Andean American children (Peru) have the longer mean trunk and the shorter mean legs. West African children (Guinea) have the shorter mean trunk and the longer mean legs. South Asian children (Bangladesh and India) are intermediary. It's true for males (Figure **4**) and females.

4. DISCUSSION

If we accept the hypothesis that height of trunk should be more meaningful than legs' length for assessing health and nutrition, we can recalculate the rate of stunting of Andean (Peruvian), Asiatic (Bangladeshi and Indian) and African children (Guinea). For this purpose, we calculated what would be the height (standing height) of the child by dividing the measured sitting height of the child divided by the calculated SSHr using the model n°3 of the multiple regression equation (Table **5**). We considered this approach to calculate the alternative stunting index to be appropriate as mean age is significantly different between country samples in the 3 age groups.

From the table above, we can observe new stunting rates (much lower than official figures). As we adopted

Table 5: "New" Stunting by Age Groups (2005 WHO Standard)

		Country			
		Peru	**Guinea**	**India**	**Bangladesh**
"New" Stunting (WHO) 24-35 months	Normal	159 (99.4%)	227 (79.1%)	225 (80.9%)	103 (100.0%)
	MDG	1 (0.6%)	33 (11.5%)	42 (15.1%)	0 (0.0%)
	SDG	0 (0.0%)	27 (9.4%)	11 (4.0%)	0 (0.0%)
	Total	160 (100.0%)	287 (100.0%)	278 (100.0%)	103 (100.0%)
"New" Stunting (WHO) 36-47 months	Normal	122 (100.0%)	161 (81.7%)	232 (81.4%)	328 (98.2%)
	MDG	0 (0.0%)	17 (8.6%)	46 (16.1%)	6 (1.8%)
	SDG	0 (0.0%)	19 (9.6%)	7 (2.5%)	0 (0.0%)
	Total	122 (100.0%)	197 (100.0%)	285 (100.0%)	334 (100.0%)
"New" Stunting (WHO) 48-59 months	Normal	198 (99.5%)	117 (86.7%)	192 (90.1%)	334 (95.2%)
	MDG	1 (0.5%)	12 (8.9%)	18 (8.5%)	15 (4.3%)
	SDG	0 (0.0%)	6 (4.4%)	3 (1.4%)	2 (0.6%)
	Total	199 (100.0%)	135 (100.0%)	213 (100.0%)	351 (100.0%)
TOTAL		481 (100.0%)	619 (100.0%)	776 (100.0%)	788 (100.0%)

the SSHr of Guinea as a gold standard, stunting rates are not very different, and where there are diferences, they are due to very limited variations of individual SSHr from the standardised ratio by age groups within each sample). Recalculated rates in India and Bangladesh are more in line with the reality of the strong decrease in mortality in the last decade, as well as with the reality of the difference in under five mortality rates between some Sahelian African countries and south Asia (India and Bangladesh).

CONCLUSION

This study showed that when body shape as measured by SSHr is factored into the assessment of stunting for different regions, the rates of stunting as measured only by HAZ significantly decreases. There is a need for further investigations in order to avoid misdiagnosis of stunting and a waste of resources on otherwise normally (for their environment) growing children.

REFERENCES

[1] Norgan NG. Relative sitting height and the interpretation of body mass index. Ann Hum Biol 1994; 21: 79-82. https://doi.org/10.1080/03014469400003092

[2] Myatt M, Duffield A, Seal A and Pasteur F. The effect of body shape on weight-for-height and mid-upper arm circumference based case definitions of acute malnutrition in Ethiopian children. Annals of Human Biology 2009; 5-20. https://doi.org/10.1080/03014460802471205

[3] Taylor-Weale R and Vinicius L. Independent roles of climate and life history in hunter-gatherer anthropometric variation. Internet J Biol Anthropol 2008; 1(2).

[4] Schreider E. Morphological variations and climatic differences. J Hum Evol 1975; 4: 529-539. https://doi.org/10.1016/0047-2484(75)90153-0

[5] Eveleth PB and Tanner JM. Worldwide variation in human growth (2nd edition). Cambridge: Cambridge University Press 1990.

[6] Schneider K, Pranab R and Hasan M. Food insecurity and child malnutrition in North Bangladesh. Field Exchange 2009; 36.

[7] Papart JP and Lagunju A. Multi-pronged approach to the management of moderate acute malnutrition in Guinea. Field Exchange 2012; 42.

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