

## ROLE OF NEW ANTHROPOMETRIC INDICES, VALIDITY OF MUAC AND WEECH'S FORMULA IN DETECTING UNDER-NUTRITION AMONG UNDER-FIVE CHILDREN IN KARNATAKA

Krutarth R Brahmhatt\*, Shahul Hameed, Prashant M Naik, Prasanna KS, Jayram S

\*Department of Community Medicine, A. J. Institute of Medical Sciences, Mangalore- 575004, Karnataka, India.

E-mail of Corresponding Author: [krutarth\\_brahmbhatt@rediffmail.com](mailto:krutarth_brahmbhatt@rediffmail.com)

### Abstract

**Background and Objective:** There should be one comprehensive measure or index which can represent the overall prevalence of under-nutrition of all three forms (underweight, wasting and stunting). Composite index of anthropometric failure is one such indicator, proposed by Svedberg. Three new indices namely UI, WI and SI has also been proposed and used. The advantage of use of MUAC is its simplicity. Weech's formula is an age old formula used by clinicians to identify undernourished children.

**Material and methods:** The study included 171 children under the age of five years, who were referred from the anganwadis of Dakshina Kannada region during the period of January-March 2012. The proportion of underweight, wasting and stunting were calculated according to the new child growth standard of the WHO. CIAF, UI, WI and SI were calculated. Sensitivity, specificity, predictive value and likelihood ratios were calculated for MUAC and Weech's formula.

**Results:** 58.4% children belonged to category "D" of CIAF. Weech's formula's sensitivity in detecting underweight and stunted children was 100% and 96% respectively.

**Conclusion:** Use of CIAF, UI, WI and SI is recommended to present the overall picture of under-nutrition among under-five children. Weech's formula is a sensitive and specific tool to identify to undernourished children.

**Keywords:** CIAF, Underweight index, Wasting index, Stunting index, Weech's formula

### 1. Introduction

ICDS (Integrated child development services) scheme represents one of the largest and most unique programs for early childhood development in India today. The scheme was launched in the year 1975. India adopted the new WHO child growth standards on 15<sup>th</sup> of August 2008 for growth monitoring of children in Anganwadi centers<sup>1</sup>.

As per the new WHO growth standards the prevalence of three important indicators of under-nutrition namely underweight (low weight for age), wasting (low weight for height) and stunting (low height for age) among under-five children in India is 43%, 20% and 48% respectively. The corresponding figures for the world, with the use of same assessment parameters are 16%, 10 % and 27% respectively<sup>2</sup>. These three indicators overlap – i.e. a child who is underweight, may also be wasted and stunted and other similar combinations of these indicators of under-nutrition are possible. There should be one comprehensive measure or index which can represent the overall prevalence of under-nutrition of all three forms (underweight, wasting and stunting). Composite index of anthropometric failure is one such indicator, proposed by

Svedberg<sup>3</sup>. In the original model, he suggested six sub-groups of anthropometric failure and one more was added by Nandy et al<sup>4</sup>.

Although CIAF is an useful composite measure, it fails to highlight the individual contribution and importance of underweight, wasting and stunting relative to the overall prevalence of under-nutrition<sup>5</sup>. Therefore three new indices namely UI, WI and SI has been proposed and used, which give information on relative significance and severity of the conventional indicators of under-nutrition with respect to the total prevalence of under-nutrition<sup>6</sup>.

Age independent measurement, which has practical application in screening children between 1-5 years of age, for under-nutrition is MUAC. The advantage of use of MUAC is its simplicity, neither it requires special equipment nor it is difficult to measure and interpret<sup>7</sup>.

Most of the anthropometric indicators require use of reference tables, which may not be practically feasible in field studies. Weech's formula is an age old formula used by clinicians to identify under-nourished children<sup>8</sup>.

An ideal anthropometric indicator should have a high sensitivity to detect under-nutrition correctly, and high specificity so that government

resources and facilities meant for malnourished children may reach only those in need of them.

This study was carried out to justify use of new anthropometric indicator- CIAF and three new indices namely UI, WI and SI and to compare the commonly used anthropometric indicators in terms of their sensitivity, specificity and predictive value.

## 2. Methodology

The study included 171 children under the age of five years, who were referred from the anganwadis of Dakshina Kannada region during the period of January-March 2012. Mothers of the selected children were interviewed to obtain information on their socio-economic, demographic and health and nutrition-related issues through pretested semi-structured questionnaires. Anthropometric data were obtained in the same manner to minimize the potential sampling errors. Weight of the child was measured in gram with the precision of 100g and height was measured in centimeter with the

precision of 0.5cm. For children aged less than two years, weight was calculated by subtracting the weight of the mother from the combined weight of the mother-child pair, and recumbent length was measured with a locally-made wooden stadiometer. MUAC was measured to the nearest millimetre at the exact midpoint of the left arm using a narrow, flexible, and non-stretchable tape made of plastic<sup>3, 4</sup>. Age and the birth weights of children were recorded from the mother. Birth weight  $\geq 2.5$ kg was considered as normal birth weight,  $< 2.5$ kg as low birth weight and  $< 1.5$ kg as very low birth weight. Immunization status was assessed with the help of immunization card; children, who received all the vaccines, due as per the age, were considered as fully immunized. The proportion of underweight, wasting and stunting were calculated according to the child growth standard of the World Health Organization (WHO) [TABLE 1]<sup>9</sup>. The Anthro 2005 software of the WHO was used for calculating the z-score.

**Table 1 WHO Growth standards (z- score)**

Anthropometric Indicator	Z score		
	-2 SD to +2 SD	< -2 SD to -3 SD	< -3 SD
Weight for age	Normal	Moderately underweight	Severely underweight
Weight for height	Normal	Moderately wasted	Severely wasted
Height for age	Normal	Moderately stunted	Severely stunted

Mid-upper arm circumference (MUAC) cut-off values for normal, moderately underweight and severe acute malnutrition were  $>12.5$  cm, 11.5-12.5 cm and  $<11.5$  cm respectively<sup>10</sup>.

Weech's formula was used to calculate expected weight and height in the following way.

Weight for age:  $2x + 8$  = reference weight.

Height for age:  $6x + 77$  = reference height<sup>8</sup> (Generally "x" is age in completed years, but as suggested by

Joseph et al.<sup>11</sup>, we considered "x" as age rounded off to nearest quarter of a year).

Children with weight for age  $\leq 80\%$  and  $\leq 60\%$  were labeled as underweight and severely underweight respectively<sup>12</sup>. Similarly stunting and severe stunting were defined as height for age  $\leq 95\%$  and  $\leq 85\%$  respectively<sup>13</sup>.

Composite Index of Anthropometric Failure (CIAF) was used to assess the overall percentage of undernourished children [TABLE 2].

**Table 2 Composite Index of Anthropometric Failure (CIAF)**

A	No failure
B	Wasting only
C	Wasting and Underweight
D	Wasting, Stunting and Underweight
E	Stunting and Underweight
F	Stunting only
Y	Underweight only

Formulas for three new anthropometric indices are:

UI = Underweight / CIAF, WI = Wasting / CIAF, SI = Stunting / CIAF<sup>6</sup>. CIAF after excluding children belonging to category "A" (no failure).

Sensitivity, specificity, predictive value and likelihood ratios were calculated for MUAC and Weech's formula.

## 3. Results

Total 171 children, aged 1-5 years were included in the study [Table 3]. 17 (10%) children had history of acute respiratory tract infections. 126 (73.7%) children received prophylaxis for worm infestation in past six months.

**Table 3 Profile of study participants (n=171)**

Variable	Girls	Boys	Total
	<b>90 (100)</b>	<b>81 (100)</b>	<b>171 (100)</b>
Mean age of children	3.2 (3.0-3.4)	3.1 (2.9-3.4)	3.2 (3.0-3.4)
<b>Age groups</b>			
<3 years	31 (34.4)	29 (35.8)	60 (35.1)
3-4 years	25 (27.8)	26 (32.1)	51 (29.8)
4-5 years	34 (37.8)	26 (32.1)	60 (35.1)
<b>Birth weight</b>			
Normal birth weight	30 (33.3)	42 (51.9)	72 (42.1)
Low birth weight	53 (58.9)	35 (43.2)	88 (51.5)
Very low birth weight	07 (7.8)	04 (4.9)	11 (6.4)
<b>Breastfeeding</b>			
Exclusive breastfeeding (yes)	81 (90)	67 (82.7)	148 (86.5)
<b>Immunization</b>			
Fully immunized	90 (100)	79 (97.5)	169 (98.8)
Partially immunized	00 (00)	02 (1.2)	02 (1.2)

Composite index for anthropometric failure was calculated for both sexes separately and then combined for both sexes [Table 4].

**Table 4 Sex wise classification of children with anthropometric failure**

Sex	A	B	C	D	E	F
<b>Girls</b>	3	2	23	46	16	0
<b>90 (100)</b>	(3.3)	(2.2)	(25.6)	(51.1)	(17.8)	(0.0)
<b>Boys</b>	0	1	14	54	11	1
<b>81 (100)</b>	(0.0)	(1.2)	(17.3)	(66.7)	(13.6)	(1.2)
<b>Total</b>	3	3	37	100	27	1
<b>171 (100)</b>	(1.8)	(1.8)	(21.6)	(58.4)	(15.8)	(0.6)

Anthropometric indices like Stunting index, Wasting index and Underweight index were also calculated [Table 5].

**Table 5. Sex wise classification of SI, WI and UI among children**

Index	Girls	Boys	Combined
<b>Stunting index</b>	0.712	0.814	0.761
<b>Wasting index</b>	0.816	0.851	0.833
<b>Underweight index</b>	0.977	0.975	0.976

Sensitivity, specificity and predictive values were calculated for MUAC (with two different cut-off values for severe acute malnutrition) and Weech's formula [Table 6].

**Table 6 Validity of MUAC and Weech's formula in detecting under-nutrition**

Component	MUAC (WHO cut-off value,12.5cm)*	MUAC (13.5cm cut-off value)	Weech's formula (Weight for age)	Weech's formula (Height for age)
<b>Sensitivity (%)</b> <b>(95% CI)</b>	19.3 (13.1-27.0)	74.2 (55.4-88.1)	100.0 (97.8-100.0)	96.0 (91.1-98.7)
<b>Specificity (%)</b> <b>(95% CI)</b>	90.3 (74.2-98.0)	45.7 (37.3-54.3)	85.7 (42.1-99.6)	46.5 (31.1-62.3)
<b>Positive predictive value (%) (95% CI)</b>	90.0 (73.4-97.9)	23.2 (15.3-32.8)	99.3 (96.7-100.0)	84.2 (77.3-89.7)
<b>Negative predictive value (%) (95% CI)</b>	19.9 (13.7-27.0)	88.9 (79.2-95.0)	100.0 (54.0-100.0)	80.0 (59.3-93.1)
<b>Positive likelihood ratio</b>	1.993	1.367	7.00	1.78
<b>ROC curve Area under the curve</b>	0.548 (0.441-0.655)	0.600 (0.493-0.706)	0.929 (0.775-1.082)	0.713 (0.612-0.814)

\* □ Compared to WHO age and sex specific weight-for-height standards [9].

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#### 4. Discussion

In this study, as per CIAF, 98.2% children were suffering from one or other form of anthropometric failure. This proportion was very high in comparison to other studies<sup>14, 15</sup>. A study done by Das and Bose, including 251 children in the age group 2-6 years, from 12 different villages of Purulia district, West Bengal (India) in the year 2009-10, reported that 43.4% children suffered from one or other form of anthropometric failure<sup>14</sup>. In another study done by Seetharaman et al., in the six slums of Coimbatore (India) including 405 children under the age of five years in the year 2006-07 reported prevalence of under-nutrition as 68.6% (as per CIAF)<sup>15</sup>. The reported prevalence of under-nutrition from these two studies and the current study is quite different, as the study participants in this study were referred children, while Das and Bose conducted study among tribal pre-school children and Seetharaman et al., among children from urban slums. The criteria used to grade the children as stunted, wasted and underweight was also different. As in the present study, we used new WHO growth standards (2006), while those two studies used NCHS standards.

As per CIAF, 58.4% children belonged to category "D" (stunted, wasted and underweight simultaneously). This is the extra information, we can elicit by the use of CIAF, as we get the information that if the child is underweight whether that child is wasted and stunted also or not. More number of boys than girls belonged to category "D". As the study participants were referred children, this number was higher than studies done in other settings. In a study done by Seetharaman et al., 5.7% children belonged to category "D" of CIAF<sup>15</sup>.

In this study, we calculated the new anthropometric indices namely SI, UI and WI. We compared the values of these indices with other studies. As the denominator includes undernourished children only, we can compare these indices with those from other studies. [Table 7]. UI and WI found in this study were highest among all. Four out of six studies reported higher proportion of chronic malnutrition than acute malnutrition among all malnourished children. At national level also we have highest prevalence of stunting followed by underweight and wasting<sup>2</sup>.

**Table 7 Comparison of SI, UI and WI from different studies**

Study	SI	UI	WI
Nandy et al., 2005 [4]	0.756	0.788	0.266
Seetharaman et al., 2007 [15]	0.723	0.681	0.294
Biswas et al., 2009 [16]	0.799	0.799	0.175
Mandal and Bose., 2009 [6]	0.364	0.866	0.684
Das and Bose., 2010 [14]	0.606	0.881	0.294
Present study	0.761	0.976	0.833

In comparison to new WHO growth standards for weight-for-height, sensitivity and specificity of MUAC (<11.5 : severe acute malnutrition) were 19.3% and 90.3% respectively in this study. In a study done by Kumar et al., in Ambala, Haryana including 3747 children upto the age of six years, reported that in comparison to NCHS standards, sensitivity and specificity values for the same cut-off value of MAUC (<11.5cm) as 11.9% and 90.7% respectively<sup>17</sup>. As the present study was done among referred children, the positive predictive value was 90.0%, while in Kumar's study it was 65.2%. When the cut-off value for SAM was increased to 12.5 cm, the sensitivity increased to 74.2%, but specificity decreased to 45.7% in this study. While in the study by Kumar et al., the corresponding values were 36.5% and 93.8% respectively. As MUAC is a simple measure to assess the nutritional status of

children, it plays important role in screening the children for undernutrition. Although sensitivity was low, its specificity was very high in this study, thus providing an opportunity for earlier detection of under-nutrition.

In comparison to WHO standards for weight for age, the sensitivity and specificity of Weech's formula were 100% and 85.7% respectively in this study. In a study done by Haq et al., including 294 children of 1-6 years of age in Aligarh (North India) in the year 2009, reported sensitivity and specificity values for Weech's formula as 100% and 84.9% respectively<sup>18</sup>. Sensitivity and specificity of Weech's formula height for age, in comparison to WHO height for age z score were 96% and 46.5% respectively. While in the study by Haq et al.<sup>18</sup>, the corresponding figures were 100% and 53.8% respectively. We rounded off the age to the

nearest quarter of the year in calculating expected weight and height, while in the Haq's study<sup>18</sup> age was taken in completed years. Weech's formula was found as a sensitive tool to identify underweight and stunting among under-five age group children in this study.

### Conclusion

In this study we recommend use of Composite index of anthropometric failure (CIAF) to present overall proportion of under-nutrition among under-five children. Use of UI, WI and SI helps in planning and prioritizing the interventions for undernourished children. MUAC can be used as a specific tool to screen children for under-nutrition. Weech's formula is a sensitive and specific tool to identify undernourished children in the settings where use of WHO reference tables is not practically feasible.

### Limitations

This study was done on 171 referred children. The catchment area cannot be defined and findings cannot be generalized.

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