Validity of Weech's formulae in detecting undernutrition in children

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ABSTRACT

Primary care physicians in developing countries frequently use Weech's formulae to estimate the expected weight and height of children using age as a variable. The present study was undertaken to assess the validity of Weech's formulae in diagnosing undernutrition. We collected anthropometric information from 294 consecutive children, aged 12-59 months, who visited a health centre. Age was calculated from birth records and was recorded in completed months as well as completed years. Weight and height/length were measured using standard methods. Weight-for-age and height-for-age Z scores were calculated using WHO Anthro. Weech's formulae were used to calculate weight-for-age (%) and height-for-age (%). A cut off of ≤80.0% weight-for-age and ≤95.0% height-for-age were used to evaluate the validity of underweight and stunting respectively; a cut off of ≤60.0% weight-for-age and <85.0% height-for-age were used for severe underweight and severe stunting respectively. Weech's formulae were found to be 100% sensitive in detecting underweight (weight-for-age Z score<-2) and stunting (height-for-age Z score<-2). When evaluating severe underweight (weight-for-age Z score<-3) and severe stunting (height-for-age Z score<-3), Weech's formulae were found to be 100% specific but the sensitivity was very low, 25.0% and 15.4% respectively. Based on the findings of our study Weech's formulae appear to be a sensitive tool to detect underweight and stunting in children between 12-59 months of age. Such formulae should however be used with caution when evaluating severe forms of undernutrition.

Keywords: Undernutrition, anthropometry, prevalence, validity.

INTRODUCTION

Persistent undernutrition is a major obstacle to human development and economic growth, especially among the poor and the vulnerable, where the prevalence of malnutrition is highest. Undernutrition is usually assessed by anthropometric indices such as weight-for-age, height-for-age, weight-for-height, mid upper arm circumference (MUAC), body mass index (BMI), and skin fold thickness. Such assessments need comparison with a reference standard. Weight-for-age and height-for-age are commonly used age dependent criteria. Weight-for-height, though age independent, needs the use of growth curves or appropriate nomograms. Different cut off limits of MUAC for diagnosing undernutrition can be found in literature.[1-4]

The World Health Organization (WHO) Multicentre Growth Reference Study (MGRS) generated new growth curves for assessing growth and development of infants and young children around the world.[5] These growth curves provide a single international standard representing physiological growth of children from birth to five years of age. However, such growth curves may not be available for reference to a primary care physician or, given the case load in health care facilities in developing countries, he may not have sufficient time to refer to them. Because of the limitations of using MUAC and difficulties in calculating weight-for-height, weight-for-age and height-for-age are commonly used by primary care physicians in developing countries to diagnose undernutrition in children of known age. Therefore to estimate the expected weight or height of a child rapidly many primary care physicians and health workers use Weech's formulae[6] using age as a variable. We conducted this study to assess the validity of Weech's formulae in diagnosing undernutrition.

MATERIAL AND METHODS

Jawaharlal Nehru Medical College runs a health centre in a periurban locality of Aligarh in a northern state of India. We collected anthropometric information from 300 consecutive children, aged 12-59 months, who visited the health centre with minor ailments or accompanied their mothers during antenatal visits. Informed consent was taken from the mother/accompanying person of each child; those not consenting were excluded from the study. Severely ill children and those with oedema were also excluded from the study. Data collection was completed

Table-1: Prevalence (%) of undernutrition in the study population

	WAZ* <-2	WAZ* <-3	HAZ† <-2	HAZ† <-3	WFA‡ ≤80.0%	WFA‡ ≤60.0%	HFA¶ ≤95.0%	HFA¶ <85.0%
Total (n=294)	36.7	21.8	55.8	35.4	46.3	5.4	76.2	5.4
Age in months								
12-23 (n=78)	28.2	12.8	43.6	23.1	41	5.1	92.3	10.3
24-35 (n=44)	31.8	22.7	68.2	40.9	45.5	9.1	90.9	0.0
36-47 (n=60)	46.7	33.3	66.7	33.3	56.7	3.3	76.7	10.0
48-59 (n=112)	39.3	21.4	53.6	42.9	44.6	5.4	58.9	1.8
Sex								
Male (n=134)	32.8	22.4	55.2	32.8	37.3	1.5	73.1	1.5
Female (n=160)	40	21.2	56.2	37.5	53.8	8.8	78.8	8.8

*Weight-for-age Z score; †Height-for-age Z score; ‡Weight-for-age; ¶Height-for-age

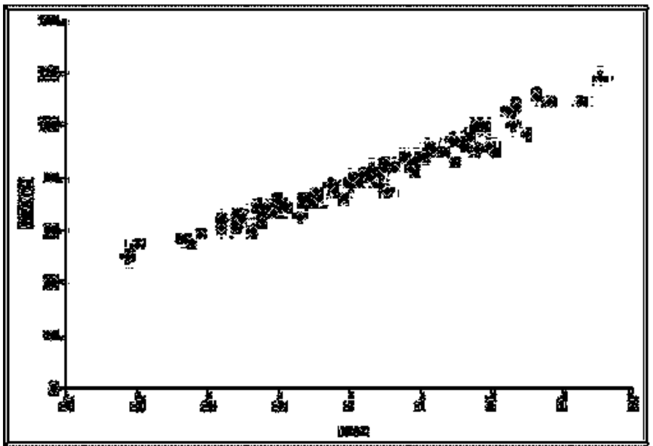

Fig. 1. Scatterplot representing a linear relationship between weight-for-age Z score (WAZ) and weight-for-age (WFA) as calculated by Weech's formulae. r=0.975

in three months from August 2009 to October 2009. All children belonged to one of the four localities served by the health centre. The health centre maintains birth records of children for the population it serves.

Date of birth of the children was taken from their birth records maintained by the health centre. Age of a child was recorded in completed months as well as in completed years. Children whose birth record could not be traced or accurately known from reliable records were excluded from the study. Children <12 completed months and >59 months were not included in our study. Birth record could not be traced for six children; they were excluded from the study which left a total of 294 children for further analysis.

Weight of the children was measured with minimal clothing using a digital weight scale which was checked every week using known 3, 5, 10 and 20 kilogram weights. The zero error of the scale was checked and adjusted, if needed, before each measurement. Children who could stand alone were weighed standing on the scale. In case of children who could not stand alone the mother was weighed alone, then the mother and child was weighed together and the mother's weight subtracted to determine the child's weight. Weight was recorded to the nearest 100 grams.

An infantometer was used to measure the recumbent length of children <24 months old. For children between 24 and 59 months height was measured using a stadiometer. Length and height were recorded to the nearest 0.1 centimeter.[7]

Table-2: Sensitivity and specificity of Weech's formulae in detecting undernutrition

WFA*	**WAZ†** <-2	≥-2	<-3	≥-3	**HFA‡**	**HAZ¶** <-2	≥-2	<-3	≥-3
≤80%	108	28	-	-	<95%	164	60	-	-
>80%	0	158	-	-	>95%	0	70	-	-
≤60%	-	-	16	0	<85%	-	-	16	0
>60%	-	-	48	230	≥85%	-	-	88	190
Sensitivity %	100		25			100		15.4	
(95% CI§)	(95.8-100)		(16.4-37.1)			(97.2-100)		(10-23.9)	
Specificity %	**84.9**		**100**			**53.8**		**100**	
(95% CI§)	**(78.9-89.2)**		**(98-100)**			**(45.3-62.1)**		**(97.5-100)**	

*Weight-for-age; †weight-for-age Z score; ‡Height-for-age; ¶Height-for-age Z score, § Confidence Interval

Table-3: Sex-wise sensitivity and specificity of Weech's formulae in detecting undernutrition

Sex	WFA*	WAZ† <-2	≥-2	<-3	≥-3	HFA‡	HAZ¶ <-2	≥-2	<-3	≥-3
Males	≤80%	44	6	-	-	≤95%	74	24	-	-
	>80%	0	84	-	-	>95%	0	36	-	-
	≤60%	-	-	2	0	<85%	-	-	2	0
	>60%	-	-	28	104	≥85%	-	-	42	90
	Sensitivity % (95% CI§)	**100 (90.2-100)**		**6.7 (2.5-22.8)**			**100 (93.9-100)**		**4.5 (1.7-16.4)**	
	Specificity% (95% CI§)	93.33 (87.7-96.6)		100 (95.6-100)			60 (47.3-71.2)		100 (95-100)	
Females										
	≤80%	64	22	-	-	≤95%	90	36	-	-
	>80%	0	74	-	-	>95%	0	34	-	-
	≤60%	-	-	14	0	<85%	-	-	14	0
	>60%	-	-	20	126	≥85%	-	-	46	100
	Sensitivity % (95% CI§)	**100 (93-100)**		**41.2 (26.8-57.8)**			**100 (95-100)**		**23.3 (14.8-35.8)**	
	Specificity % (95% CI§)	**77.1 (67.5-84.1)**		**100 (96.3-100)**			**48.57 (37.3-60)**		**100 (95.4-100)**	

*Weight-for-age; †weight-for-age Z score; ‡Height-for-age; ¶Height-for-age Z score, § Confidence Interval

WHO Anthro[8] was used to calculate the weight-for-age Z scores (WAZ) and the height-for-age Z scores (HAZ) of children. Children having a WAZ <-2.00 were classified as "underweight" and those having a WAZ <-3.00 were classified as "severe underweight". Children with HAZ <-2.00 were classified as "stunted" and those with a HAZ <-3.00 were classified as "severe stunted". Prevalence of underweight, severe underweight, stunted and severe stunted was estimated using these criteria.

Weech's formulae were used to calculate the expected weight and height of the children given their age in completed years. The formulae used are given below[6]:

(a) Expected weight=(Age of the child (years)X2)+8 in kilograms

(b) Expected height=(Age of the child (years)X6)+77 in centimeters; for children between two and five years

(c) Expected height was taken as 75 centimeters for children who had completed one year of their life.

Weight-for-age (WFA) was calculated as (Observed weight/Expected weight)X100 in percentages. Height-for-age (HFA) was calculated as (Observed height/Expected height)X100 in percentages. Children with a WFA ≤80.0% were labeled as underweight and those with a WFA ≤60.0% were labeled as severe underweight as suggested by the Indian Academy of Pediatrics.[9] Stunting and severe stunting was defined as a HFA ≤95.0% and <85.0%, respectively.[10]

Correlation between WAZ and WFA and between HAZ and HFA was evaluated using Pearson product-moment correlation coefficient.[11] Sensitivity and specificity of Weech's formulae in diagnosing undernutrition was calculated using standard formulae.[12] For calculation of sensitivity and specificity WAZ<-2, WAZ<-3, HAZ<-2 and HAZ<-3 were used as 'gold standard' to define underweight, severe underweight, stunted and severe stunted, respectively. Sensitivity was calculated as the percentage of true positives among total positives; specificity was calculated as the percentage of true negatives among total negatives. Ninety five percent confidence intervals for sensitivity and specificity were calculated using an online statistical calculator[13] as recommended by Guyatt *et al*.[12]

RESULTS

Out of a total of 294 children between 12-59 months of age included in this study, 134 were males and 160 were females. The age- and sex-wise prevalence of undernutrition based on WAZ and HAZ is given in Table-1. The overall prevalence of underweight (WAZ<-2) and stunting (HAZ<-2) was 36.7% and 55.8%, respectively. Table-1 also presents age- and sex-wise comparison of prevalence of undernutrition when measured with reference to WHO MGRS (based on WAZ and HAZ) and Weech's formulae (based on WFA and HFA). It was observed that Weech's formulae tend to overestimate the prevalence of underweight and stunting through all age and sex groups but at the same time underestimating

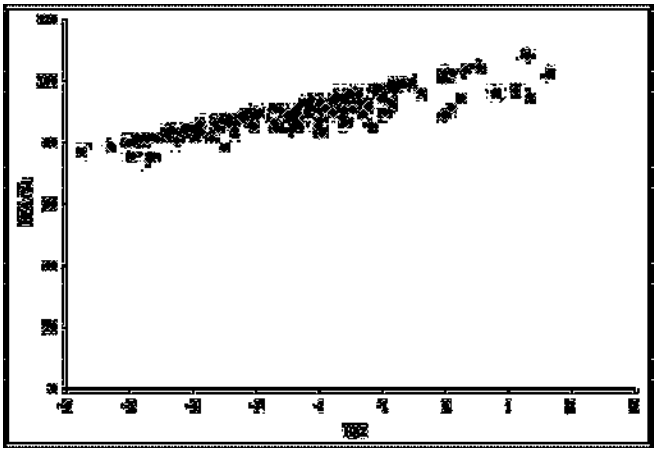

Fig. 2. Scatterplot representing a linear relationship between height-for-age Z score (HAZ) and height-for-age (HFA) as calculated by Weech's formulae. r=0.874

the prevalence of severe underweight and severe stunting.

WAZ (calculated using WHO Anthro) and WFA (calculated using Weech's formulae) were found to be strongly correlated with a correlation coefficient, r=0.975 (Fig. 1). Strong correlation was also observed between HAZ (calculated using WHO Anthro) and HFA (calculated using Weech's formulae) (r=0.874) (Fig. 2).

Sensitivity and specificity of Weech's formulae in diagnosing undernutrition are given in table 2. Weech's formulae were found to be 100% sensitive in detecting underweight and stunting; they had a higher specificity in detecting underweight (84.9%) than in detecting stunting (53.8%). The specificity of Weech's formulae in detecting underweight and stunting was more in males compared to females (Table-3). When evaluating severe underweight and severe stunting, Weech's formulae were found to be 100% specific. However, the sensitivity for detecting severe underweight and severe stunting was very low (25.0% and 15.4% respectively) (Table-2), especially in males (Table-3).

DISCUSSION

The selection, use and interpretation of anthropometric indices for diagnosing undernutrition depends on availability of reference growth standards and growth curves, area of application, validity of the indices and the time available for assessment. Weight-for-height Z scores are generally preferred to detect wasting and indicate undernutrition. Primary care physicians in developing countries frequently need a rapid method to evaluate the nutritional status of children. Apart from clinical manifestations of undernutrition and micronutrient deficiencies age-dependent anthropometric indices (weight-for-age and height-for-age) provide an easy method for assessment of undernutrition. Weech's formulae are frequently used by primary care physicians to estimate the expected weight and height of children with known age.

In the present study we found that weight-for-age and height-for-age calculated using Weech's formulae correlated highly with WAZ and HAZ, respectively. Weech's formulae were highly sensitive in detecting underweight and stunting but were insensitive in case of severe underweight and severe stunting, especially in males. The specificity of Weech's formulae for detecting underweight was considerably higher than for detecting stunting. When sensitivity and specificity was considered for males and females the results were favourable for males. Weech's formulae were specific but insensitive in detecting severe forms of undernutrition. The results of our study are different from those reported by Joseph *et al*[14] who have reported a lower sensitivity (73.8% and 48.7% respectively for weight and height formulae compared to 100% and 100% in our study) and higher specificity (86.9% and 98.5% respectively for weight and height formulae compared to 84.9% and 53.8% in our study). However they have computed sensitivity and specificity of weight formulae compared to weight-for-height and they have used the NCHS reference standards.

The prevalence of stunting was high in our population when compared to other Indian studies.[4,14] We assessed stunting using the WHO MGRS which might have led to a higher prevalence of stunting.[15]

Based on the findings of our study, Weech's formulae appear to be a sensitive tool to detect underweight and stunting in both males and females between 12-59 months of age. These formulae are however insensitive in diagnosing severe forms of undernutrition and should therefore be used with caution especially in males.

LIMITATIONS AND FUTURE IMPLICATIONS

Our study was done on a health centre-based data and may thus not truly represent the catchment area of the health centre. Further, Weech's formulae are based on age in completed years; validity of such formulae may improve when age is rounded off to the nearest quarter year as suggested by Joseph *et al*.[14] More refined formulae based on age in months may be developed and evaluated in future.

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