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ORIGINAL ARTICLE

Investigation of the Relationship Between Upper Middle Arm Circumference Measurement and the Gomez, Waterlow and World Health Organization Classifications Used in the Diagnosis of Malnutrition in Turkish Children Aged 1-5

Üst Orta Kol Çevresi Ölçümünün 1-5 Yaş Arası Türk Çocuklarda Malnütrisyon Tanısında Kullanılan Gomez, Waterlow ve Dünya Sağlık Örgütü Sınıflandırmaları ile Bağlantısının Araştırılması

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ABSTRACT

Aim: Waterlow, Gomez, and WHO Classification are used all over the world as reliable methods in the evaluation of malnutrition in children's age group. In our study, the purpose was to evaluate the usability of Upper Middle Arm Circumference measurement in malnutrition diagnosis between the ages of 1-5 in the children of our country by investigating the relation with the other three methods.
Material and Methods: A total of 1500 children, who were between the ages of 1 and 5, and admitted to the clinics of Selçuk University, Faculty of Medicine, Department of Child Health and Diseases were included in the study. Anthropometric measurements that consisted of height, weight, and Upper Middle Arm Circumference were made for all children who participated in the study.
Results: Among the 1.500 children, who were included in the study, a total of 704 were girls (46.93%), and 796 (53.07%) were boys. Upper Middle Arm Circumference measurement values were similar in girls and in boys. It has been determined in our study that Upper Middle Arm Circumference has better compatibility with Gomez classification in respect of sensitivity and specificity. When the cut-off point value of the compatibility of Upper Middle Arm Circumference with other malnutrition classifications was accepted as 11.5 cm in respect of sensitivity, specificity, positive predictive values, and negative predictive values in severe diagnosis of malnutrition, it was seen that it produced better results than 11.0 cm.
Conclusion: Early recognition of an important public health problem such as malnutrition is very important for taking precautions and identifying treatment modalities. Although the Upper Middle Arm Circumference cut-off point differs among countries and regions for the diagnosis of severe malnutrition, our study showed that it would be appropriate to prefer 11.5 cm for our country.

Keywords: Children, Malnutrition, Mid-upper arm circumference, Malnutrition classification

ÖZ

Amaç: Çocuk yaş grubunda malnütrisyonun değerlendirilmesinde tüm dünyada güvenilir yöntemler olarak Waterlow, Gomez ve WHO Sınıflandırması kullanılmaktadır. Çalışmamızda ülkemizdeki çocuklarda 1-5 yaş arası malnütrisyon tanısında Üst Orta Kol Çevresi ölçümünün diğer üç yöntemle ilişkisi araştırılarak kullanılabilirliğinin değerlendirilmesi amaçlanmıştır.
Gereç ve Yöntemler: Çalışmaya Selçuk Üniversitesi Tıp Fakültesi Çocuk Sağlığı ve Hastalıkları Anabilim Dalı polikliniğine başvuran 1-5 yaş arası toplam 1500 çocuk dahil edildi. Çalışmaya katılan tüm çocukların boy, kilo ve Üst Orta Kol Çevresi ölçümünden oluşan antropometrik ölçümler yapıldı.
Bulgular: Araştırmaya dahil edilen 1500 çocuğun 704'ü (%46,93) kız, 796'sı (%53,07) erkekti. Üst Orta Kol Çevresi ölçüm değerleri kızlarda ve erkeklerde benzerdi. Çalışmamızda duyarlılık ve özgüllük açısından Üst Orta Kol Çevresi ölçümünün Gomez sınıflamasına daha iyi uyum gösterdiği saptanmıştır. Ciddi malnütrisyon tanısında Üst Orta Kol Çevresi ölçümünün diğer malnütrisyon sınıflamaları ile uyumluluğunun duyarlılık, özgüllük, pozitif prediktif değerler ve negatif prediktif değerler açısından 11,5 cm olarak kesme noktası değeri kabul edildiğinde, 11,0 cm'den daha iyi sonuçlar verdiği görülmüştür.
Sonuç: Malnütrisyon gibi önemli bir halk sağlığı sorununun erken tanınması, önlem alınması ve tedavi yöntemlerinin belirlenmesi açısından oldukça önemlidir. Ağır malnütrisyon tanısı için Üst Orta Kol Çevresi kesme noktası ülkeler ve bölgeler arasında farklılık gösterse de çalışmamız ülkemiz için 11,5 cm'nin tercih edilmesinin uygun olacağını göstermiştir.

Anahtar Kelimeler: Çocuklar, Malnütrisyon, Orta-üst kol çevresi; Malnütrisyon sınıflandırması

Introduction

Malnutrition is a complex pathological condition with structural deficiencies in tissues and dysfunctions in organs occurring as a result of insufficient, unbalanced or excessive intake of macro and micronutrients, which are necessary for the continuity of the functions of the body tissues and organs. World Health Organization (WHO) defines malnutrition as an imbalance in the intake of nutrients and energy, which are required by an individual to grow, survive, and perform some special functions (1). Nutrition problems are often found in preschool and school-age children of mothers who work in cities and rural areas because of the inability

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to eat regularly, eat well, and have good care and follow-up. The most frequently affected age group is the children who are between the ages of 6 months and 5 years. Early diagnosis, proper treatment, and careful follow-up are important elements in preventing and treating malnutrition (2).

The prevalence of malnutrition varies according to different societies that live in different parts of the world. Many factors, such as local and private beliefs, traditions, economic status, social characteristics, breastfeeding habits, and the age of breastfeeding affect the social prevalence and clinical characteristics. It is more prevalent especially in children from broken families that have low socioeconomic status, and cannot benefit from education and health services. Malnutrition is frequent in rural areas of developing countries because an important part of the society is poor and feed heavily on grain. According to the data released by the WHO, the rate of children that have malnutrition in developing countries decreased from 29% to 18% between 1990 and 2010, and the related mortality rate under the age of 5 decreased at a rate of 35%. Among the approximately 500 million children who are under the age of 5 on a worldly scale, nearly 100 million have malnutrition, and the number of children with severe and acute malnutrition is predictive to be around 20 million (3).

Waterlow, Gomez, and WHO Classification are used all over the world as reliable methods in the evaluation of malnutrition in children's age group. However, trained medical personnel is required for all these three methods to be used successfully. It is recommended in various publications that Upper Middle Arm Circumference (UMAC) measurement should be used as a simple and practical alternative method in the evaluation of malnutrition (4,5). Although UMAC increases at significant levels in the first year of life, it is like an absolute value between the ages of 1 and 5 in children, and changes very little. It was argued that arm circumference was a good marker in the evaluation of the nutritional status in children (6).

According to UMAC measurement, different values are accepted as limits for severe malnutrition in the evaluation of malnutrition in different countries. In our study, the purpose was to evaluate the usability of UMAC measurement in malnutrition diagnosis between the ages of 1-5 in the children of our country by investigating the relation with the other three methods.

Material and Methods

A total of 1500 children, who were between the ages of 1 and 5 (12-60 months), and admitted to the clinics of Selçuk University, Faculty of Medicine, Department of Child Health and Diseases between June 1, 2014 and September 30, 2014, were included in the study.

Anthropometric measurements that consisted of height, weight and UMAC were made for all children who participated in the study. All anthropometric measurements were made by the same person (an experienced pediatric health and diseases junior doctor) by using the same measurement tools. Stature measurement was made without shoes with a wall-mounted 0.1 cm-sensitive stadiometer (Holtain Limited, Crymych, Dyfed, Made in Britain) for children who could stand upright. The height measurements of the children who could not stand upright were made with a special height measuring tape with a measuring band on its edge and a moving part applied to the child's feet. Body weight measurements were made with 100-gram precision scales (Oncomed Electronic body scale SC-105 and Charder model MS3500, made in China) with thin clothes on children who could stand upright, and the measurements of the children who could not stand upright were made in lying position. UMAC was measured with a non-flexible but curling measurement tape by taking the left arm to 90 degrees of flection from the elbow. The arm was placed in neutral position after the exact midpoint of the distance between the acromion and olecranon protrusions was marked, and the arm circumference was measured from this point with the measuring tape. The weight-for-age (WFA), height-for-age (HFA) and weight for height (WFH) percentages were calculated by using the body weight and stature reference values in Turkish Children reported in the study conducted by Neyzi et al. in the Journal of Child Health and Diseases in 2008 (7). The Z-scores for height and weight (SS score) were determined by using the SS data for height and weight based on the study conducted by Neyzi et al (7).

Malnutrition degrees were determined according to Gomez, Waterlow, and WHO Classifications. The YGA percentage in Gomez class was calculated with the following formula: (Child's Weight/50th percentile value of the same age and gender) X 100; and between 110 and 90 percent were evaluated as normal, 89 to 75 percent moderate (1st degree), 74 to 60 percent moderate (2nd degree), and below 60 percent as severe (3rd degree) malnutrition.

The YGB Percentage in Waterlow classification was calculated with the following formula: (Child's Height/50th percentile value in the same age and gender) X 100; and 95 percent and above was evaluated as normal, between 94 and 90 percent moderate, 89 percent and 85 moderate, and 85 percent and below as severe malnutrition.

The BGA percentage, which is the other parameter of Waterlow Classification, was calculated with the following formula: (Child's Weight/The Weight of the Child corresponding to the 50th Percentile Value) X 100; and 90-110 percent were considered to be normal, 89-80 percent were considered mild, 79 to 70 percent moderate, 70 percent and below severe malnutrition. Weight and Height Z-scores (SSS) were calculated as WHO Classification. SSR scores were defined as normal if between -2 and +2, moderate if between -2 and -3, and -3 and below were defined as severe malnutrition.

The limit of 12.5 cm was taken as the limit value for the diagnosis of malnutrition in the evaluation of UMAC.

Since two values were reported in the literature for severe malnutrition diagnosis, the limit values of 11.5 cm and 11.0 cm were used (8-10). In our study, in terms of malnutrition diagnosis of children, UMAC cut-off values were determined separately with ROC analysis for Gomez (WFA), Waterlow (HFA, WFH), and WHO Classifications.

The specificity, sensitivity, positive and negative predictive values were determined for Gomez (WFA), Waterlow (HFA, WFH), and WHO Classifications of UMAC measurement for malnutrition diagnosis. Linear Regression Analyses were made to examine the relations between UMAC and the other three classifications.

Statistical Analysis

The SPSS 20.0 Package Program was used in statistical analyses. Frequency and percentage distributions of the data were determined. As a result of the normality test, the Mann Whitney U-Test was used for the variables that were not normally distributed in binary groups when the differences between the groups were examined. The Kruskal Wallis H-Test with Bonferroni Correction was used in more than two groups for the variables that were not normally distributed. The inter-variable relations were investigated with the Chi-Square Test. P<0.05 was taken as the level of significance.

Results

Among the 1.500 children, who were included in the study, a total of 704 were girls (46.93%), and 796 (53.07%) were boys. The mean age was 35.28±14.82 months in girls (median 36 months; age range 12-60 months), and the mean age was 34.77±14.72 months in boys (median 35 months; age range 12-60 months). UMAC measurement values were similar in girls (mean 15.18±1.97 cm, median value 15 cm, range 10-24 cm) and in boys (mean 15.26±1.8 cm, median 15.3 cm, range 10.4-21.1 cm) (p:0.328). However, the mean values of both genders in 48-60-month age group were higher compared to in other age groups (p:0.001). The distribution of upper middle arm circumference measurements according to age groups is shown in Table 1.

In the evaluation that was made by using the Gomez (WFA) Malnutrition Classification it was found that 623 out of 1.500 children had normal (41.53%), 438 (29.20%) mild, 147 (9.8%) moderate, and 34 (2.27%) had severe malnutrition. The WFA values were above the normal values in 258 children (17.20%). In Gomez Classification, it was seen that the frequency of malnutrition was similar in both genders (p:0.147). The gender distribution of the cases according to the Gomez, Waterlow (HFA, WFH), WHO (Weight, Height) Classifications is shown in Table 2. When malnutrition levels and age groups of the Gomez Classification were compared, decreases were detected in the frequency in all malnutrition levels as age increased (p:<0.001). The distributions of Gomez, Waterlow (HFA, WFH), WHO (Weight, Height) Classifications according to age groups are shown in Table 3.

Table 1: The distribution of upper middle arm circumference measurements according to age groups

Gender	Age (Month)	n	Median	Min	Max	p
Female	12-23	191	13.90	10.00	17.60	<0.001
	24-35	153	15.00	10.00	19.50	
	36-47	166	15.40	12.00	19.40	
	48-60	194	16.50	12.50	24.00	
Male	12-23	216	14.50	10.40	20.50	<0.001
	24-35	191	15.30	11.00	19.50	
	36-47	178	15.50	12.00	21.10	
	48-60	211	16.00	12.70	21.00	
Total	12-23	407	14.00	10.00	20.50	<0.001
	24-35	344	15.20	10.00	19.50	
	36-47	344	15.50	12.00	21.10	
	48-60	405	16.00	12.50	24.00	

When the degrees of malnutrition and UMAC measurements of Gomez classification were compared, it was found that UMAC values decreased as malnutrition degrees increased in both genders (p:<0.001). The comparison of Gomez, Waterlow (HFA, WFH), WHO (Weight, Height) Classification and UMAC measurements is given in Table 4. When the degrees of malnutrition obtained based on the HFA parameter of Waterlow Classification and UMAC measurements were compared, it was seen that UMAC values decreased as the malnutrition degree increased in both genders (p:<0.001). When the degrees of malnutrition obtained based on the WFH parameter of Waterlow Classification and UMAC measurement were compared, it was determined that UMAC values decreased as malnutrition degrees increased in both genders (p:<0.001). When the malnutrition degrees obtained based on the weight parameter of WHO Classification and UMAC measurement were compared, it was observed that UMAC values decreased as malnutrition degrees increased in both genders (p:<0.001). When the malnutrition degrees obtained on the basis of the height parameter of WHO Classification and UMAC measurement were compared, it was found that UMAC values decreased as malnutrition degrees increased in both genders (p:0.001).

The relations between UMAC measurement and WFA, HFA, WFH and WHO Classification was investigated. Also, sensitivity, specificity, and positive and negative predictor values of UMAC were determined. When the cut-off point of the UMAC measurement was taken as 11.0 cm for severe malnutrition, the sensitivity was 17.6% compared to Gomez (WFA) Classification; however, the specificity was 98.9%. The positive predictive value was 28.5%, and the negative predictive value was 98.1%. The comparison of Gomez, Waterlow (HFA, WFH) and WHO (Weight, Height) Classification and UMAC measurements is shown in Table 5. When the cut-off point of UMAC measurement was taken 11.5 cm for severe malnutrition, the sensitivity was found as 52.9%, and the specificity was 98.1% compared to

Table 2: The gender distribution of the cases according to the Gomez, Waterlow (HFA, WFH), WHO (Weight) and WHO (Height) Classifications

		Female		Male		Total			
n		%	n	%	n	%	Ki-Kare	p	
GOMEZ (WFA)	Normal	307	43.61	316	39.7	623	41.53	6.792	0.147
	Mild (1.)	202	28.69	236	29.65	438	29.20		
	Moderate (2.)	56	7.95	91	11.43	147	9.80		
	Severe (3.)	14	1.99	20	2.51	34	2.27		
	Above-Normal	125	17.76	133	16.71	258	17.20		
	Total	704	100	796	100	1500	100.00		
WATERLOW (HFA)	Normal	453	64.35	505	63.44	958	63.87	5.956	0.202
	Mild (1.)	167	23.72	179	22.49	346	23.07		
	Moderate (2.)	42	5.97	72	9.05	114	7.60		
	Severe (3.)	31	4.4	27	3.39	58	3.87		
	Above-Normal	11	1.56	13	1.63	24	1.60		
	Total	704	100	796	100	1500	100.00		
WATERLOW (WFH)	Normal	395	56.11	456	57.29	851	56.73	9.017	0.061
	Mild (1.)	146	20.74	160	20.1	306	20.4		
	Moderate (2.)	39	5.54	37	4.65	76	5.07		
	Severe (3.)	1	0.14	12	1.51	13	0.87		
	Above-Normal	123	17.47	131	16.46	254	16.93		
	Total	704	100	796	100	1500	100		
WHO (Weight)	Normal	601	85.37	661	83.04	1262	84.13	4.373	0.358
	Moderate	48	6.82	61	7.66	109	7.27		
	Severe	18	2.56	35	4.4	53	3.53		
	Above-Normal	37	5.26	39	4.9	76	5.07		
	Total	704	100	796	100	1500	100		
WHO (Height)	Normal	575	81.68	614	77.14	1189	79.27	12.764	0.012
	Moderate	64	9.09	88	11.06	152	10.13		
	Severe	50	7.1	69	8.67	119	7.93		
	Above-Normal	15	2.13	25	3.14	40	2.67		
	Total	704	100	796	100	1500	100		

Table 3: The age groups distribution of the cases according to the Gomez, Waterlow (HFA, WFH), WHO (Weight) and WHO (Height) Classifications

		Age Groups (Month)											
	12-23		24-35		36-47		48-60		Total		Ki-Kare	p	
	n	%	n	%	n	%	n	%	n	%			
WFA	Normal	147	36.12	155	45.06	135	39.24	186	45.93	623	41.53	70.088	<0.001
	Mild (1.)	143	35.14	101	29.36	102	29.65	92	22.72	438	29.20		
	Moderate (2.)	60	14.74	20	5.81	28	8.14	39	9.63	147	9.80		
	Severe (3.)	18	4.42	6	1.74	9	2.62	1	0.25	34	2.27		
	Above-Normal	39	9.58	62	18.02	70	20.35	87	21.48	258	17.20		
HFA	Normal	218	53.56	230	66.86	231	67.15	279	68.89	958	63.87	43.914	<0.001
	Mild (1.)	106	26.04	79	22.97	72	20.93	89	21.98	346	23.07		
	Moderate (2.)	46	11.30	18	5.23	22	6.40	28	6.91	114	7.60		
	Severe (3.)	27	6.63	13	3.78	15	4.36	3	0.74	58	3.87		
	Above-Normal	10	2.46	4	1.16	4	1.16	6	1.48	24	1.60		
WFH	Normal	222	54.55	200	58.14	203	59.01	226	55.80	851	56.73	19.502	<0.001
	Mild (1.)	77	18.92	51	14.83	72	20.93	106	26.17	306	20.40		
	Moderate (2.)	20	4.91	18	5.23	18	5.23	20	4.94	76	5.07		
	Severe (3.)	3	0.74	0	0.00	9	2.62	1	0.25	13	0.87		
	Above-Normal	85	20.88	75	21.80	42	12.21	52	12.84	254	16.93		
WHO (Weight)	Normal	321	78.87	287	83.43	289	84.01	365	90.12	1262	84.13	50.451	<0.001
	Moderate	45	11.06	26	7.56	23	6.69	15	3.70	109	7.27		
	Severe	27	6.63	11	3.20	15	4.36	0	0.00	53	3.53		
	Above-Normal	14	3.44	20	5.82	17	4.94	25	6.17	76	5.07		
WHO (Height)	Normal	269	66.09	280	81.40	292	84.88	348	85.93	1189	79.27	62.184	<0.001
	Moderate	55	13.51	36	10.47	26	7.56	35	8.64	152	10.13		
	Severe	63	15.48	22	6.40	21	6.10	13	3.21	119	7.93		
	Above-Normal	20	4.92	6	1.74	5	1.45	9	2.22	40	2.67		

Table 4: The comparison of Gomez, Waterlow (HFA, WFH), WHO (Weight), and WHO (Height) Classification and UMAC measurements

				Upper Middle Arm Circumference				
n **Median**				Min	Max	p		
Gomez (WFA)	Female	Normal		307	15.50	11.00	19.50	<0.001
		Mild (1st degree)		202	14.00	10.00	20.00	
		Moderate (2nd degree)		56	12.95	10.10	15.00	
		Severe (3rd degree)		14	11.20	10.00	15.00	
		Above-Normal	125		17.00	13.00	24.00	
	Male	Normal		316	15.65	13.00	19.00	<0.001
		Mild (1st degree)		236	14.50	11.50	17.50	
		Moderate (2nd degree)		91	12.90	10.40	17.00	
		Severe (3rd degree)		20	12.05	10.50	13.40	
		Above-Normal		133	17.50	14.50	21.10	
Waterlow (HFA)	Female	Normal		453	15.80	10.00	23.00	<0.001
		Mild (1st degree)		167	14.20	10.50	19.50	
		Moderate (2nd degree)		42	14.00	10.80	18.00	
		Severe (3rd degree)		31	11.40	10.00	16.50	
		Above-Normal		11	16.10	11.00	24.00	
	Male	Normal		505	15.70	10.40	21.10	<0.001
		Mild (1st degree)		179	14.80	10.50	20.00	
		Moderate (2nd degree)		72	13.70	10.40	17.50	
		Severe (3rd degree)		27	12.10	11.00	15.20	
		Above-Normal		13	17.00	14.00	21.00	
Waterlow (WFH)	Female	Normal		395	15.50	10.10	19.50	<0.001
		Mild (1st degree)		146	14.00	10.00	20.00	
		Moderate (2nd degree)		39	13.40	10.00	17.80	
		Severe (3rd degree)		1	14.50	14.50	14.50	
		Above-Normal		123	16.50	10.40	24.00	
	Male	Normal		456	15.50	11.50	20.00	<0.001
		Mild (1st degree)		160	14.50	10.40	19.00	
		Moderate (2nd degree)		37	14.30	10.40	17.00	
		Severe (3rd degree)		12	12.20	10.50	14.00	
		Above-Normal		131	17.20	13.50	21.10	
WHO (Weight)	Female	Normal		601	15.20	10.00	20.00	<0.001
		Moderate		48	13.00	10.10	15.00	
		Severe		18	11.25	10.00	13.80	
		Overweight		24	17.80	14.00	22.50	
		Above-Normal		13	20.00	16.00	24.00	
	Male	Normal		661	15.50	11.50	20.00	<0.001
		Moderate		61	13.00	10.40	17.00	
		Severe		35	11.90	10.80	13.20	
		Overweight		24	18.00	15.00	21.00	
		Above-Normal		15	19.40	18.00	21.10	
WHO (Height)	Female	Normal		575	15.40	10.00	23.00	<0.001
		Moderate		64	14.00	11.00	19.50	
		Severe		50	12.55	10.00	18.00	
		Lengthy		6	16.80	15.00	24.00	
		Above-Normal		9	16.10	11.00	20.00	
	Male	Normal		614	15.50	10.40	21.10	<0.001
		Moderate		88	14.30	10.40	19.00	
		Severe		69	12.90	11.00	16.20	
		Lengthy		21	17.00	13.50	21.00	
		Above-Normal		4	15.75	15.50	19.00	

Table 5: The comparison of Gomez, Waterlow (HFA, WFH), WHO (Weight) and WHO (Height) Classification and UMAC measurements

	UMAC	Present*	Absent*	TOTAL	Sensitivity	Specificity	PPV**	NPV***
GOMEZ	<11.0 cm	6	15	21				
	>11.0 cm	28	1451	1479	17.60%	98.90%	28.50%	98.10%
	TOTAL	34	1466	1500				
	<11.5 cm	18	27	45				
	>11.5 cm	16	1439	1455	52.90%	98.10%	40.00%	98.90%
	TOTAL	34	1466	1500				
	≤ 12.5 cm	125	2	127				
	> 12.5 cm	494	879	1373	20.20%	99.70%	98.40%	64.00%
	TOTAL	619	881	1500				
	≤14.95 cm	396	223	619				
	>14.95 cm	136	745	881	74.00%	77.00%	64.00%	84.60%
	TOTAL	532	968	1500				
Waterlow (HFA)	<11.0 cm	9	12	21				
	>11.0 cm	49	1430	1479	15.50%	99.10%	42.80%	96.60%
	TOTAL	58	1442	1500				
	<11.5 cm	9	12	21				
	>11.5 cm	49	1430	1479	36.20%	98.30%	46.60%	97.40%
	TOTAL	58	1442	1500				
	≤ 12.5 cm	95	32	127				
	> 12.5 cm	423	950	1373	18.00%	96.70%	74.80%	69.10%
	TOTAL	518	982	1500				
	≤14.95 cm	324	136	460				
	>14.95 cm	295	745	1040	70.40%	71.60%	52.30%	84.60%
	TOTAL	619	881	1500				
Waterlow , (WFH)	<11.0 cm	1	20	21				
	>11.0 cm	12	1467	1479	7.60%	98.60%	4.70%	99.10%
	TOTAL	13	1487	1500				
	<11.5 cm	3	42	44				
	>11.5 cm	10	1445	1455	23.10%	97.10%	6.60%	97.10%
	TOTAL	13	1487	1500				
	≤ 12.5 cm	82	45	127				
	> 12.5 cm	313	1060	1373	20.70%	95.90%	64.50%	77.20%
	TOTAL	395	1105	1500				
	≤14.95 cm	324	295	619				
	>14.95 cm	136	745	881	68.00%	67.20%	40.00%	86.80%
	TOTAL	460	1040	1500				
WHO (Weight)	<11.0 cm	7	14	21				
	>11.0 cm	46	1433	1479	13.20%	99.00%	33.30%	96.80%
	TOTAL	53	1447	1500				
	<11.5 cm	19	26	45				
	>11.5 cm	34	1421	1455	35.84%	98.20%	42.20%	97.60%
	TOTAL	53	1447	1500				
	≤ 12.5 cm	79	48	127				
	> 12.5 cm	83	1290	1373	48.70%	96.40%	62.20%	93.90%
	TOTAL	162	1338	1500				
	≤13.95 cm	105	213	318				
	>13.95 cm	22	1160	1182	82.60%	84.40%	33.00%	98.10%
	TOTAL	127	1373	1500				
WHO (Height)	<11.0 cm	10	11	21				
	>11.0 cm	109	1370	1479	8.40%	99.20%	47.60%	92.60%
	TOTAL	119	1381	1500				
	<11.5 cm	28	17	45				
	>11.5 cm	91	1364	1455	23.50%	98.70%	62.20%	93.70%
	TOTAL	119	1381	1500				
	≤ 12.5 cm	74	53	127				
	> 12.5 cm	197	1176	1373	27.30%	95.60%	58.20%	85.60%
	TOTAL	271	1229	1500				
	≤14.55 cm	178	362	540				
	>14.55 cm	56	904	960	76.00%	71.40%	33.00%	94.10%
	TOTAL	234	1266	1500				
All Classifications	≤15.15 cm	554	191	745				
	>15.15 cm	183	572	755	75.20%	75.10%	74.40%	75.80%
	TOTAL	737	763	1500				

*Malnutrition; ** PPV: Positive Predictor Values; *** NPV: Negative Predictor Values

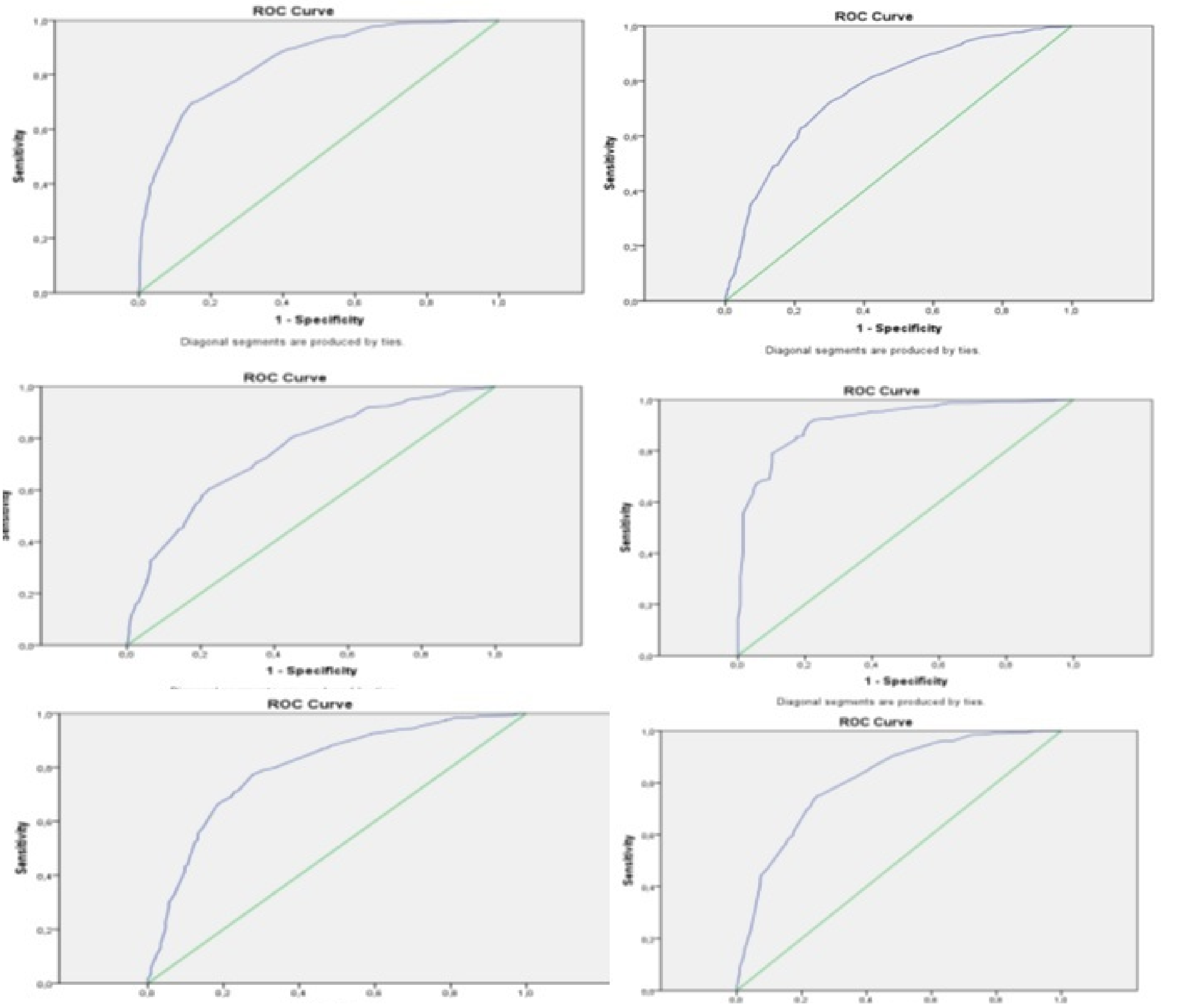

Figure 1: UMAC cut-off values in respect of malnutrition were found for Gomez, Waterlow and WHO classifications by the means of ROC analysis.

Gomez (WFA) Classification. The positive predictive value was 40%, and the negative predictive value was 98.9%.

Regression Test was made to investigate the relation between UMAC and WFA, HFA, WFH and WHO Classifications. The variable that had the highest agreement with the arm circumference was identified as Gomez (WFA) Classification (p:<0.001).

The cut-off value of UMAC was 14.95 cm in children who were found to have malnutrition according to Gomez (WFA) Classification. The sensitivity was 74%, and the specificity was 77%. The positive predictive value was determined as 64%, and the negative predictive value was 84.6%. The specificity and sensitivity of the cut-off value detected for Gomez, Waterlow (HFA, WFH), WHO (Weight, Height) are given in Figure 1. The cut-off value of UMAC was 14.95 cm in children with malnutrition according to Waterlow (HFA) Classification. The sensitivity was 70.4% and specificity was 71.6%.

Discussion

Since any situation, which affects child health adversely, might also affect the growth process adversely, each child should be monitored and evaluated with regular intervals after birth (11). Monitoring growth by using standard growth curves is necessary to take precautions without any adverse conditions in the child with early detection of deviations from normal growth pattern. The method that will be used in such a growth monitoring should be proven in terms of validity, have high sensitivity, yield results in a short time, and have low economic cost. All the methods employed to monitor growth are based on anthropometric measurements (12). The main anthropometric criteria used in this respect are body weight, stature, head circumference, arm span, sitting height, neck and waist circumference, upper middle arm circumference, skin fold thickness, and Body Mass Index.

From anthropometric measurements, UMAC is frequently used in epidemiological studies. The reason why it is especially preferred in field studies is that the measurement is easy, does not require special expertise, and can be interpreted without the need to evaluate with percentile curves.

In our present day, the cut-off values of 125 mm (malnutrition) and 110 mm (severe malnutrition) were used in children who were under 5 years of age (10). With the common use of WHO growth standards, the NOCD cut-off point was changed to 115 mm in the diagnosis of severe acute malnutrition according to the results of the study from African countries (13). It was questioned in a study conducted in India with 1879 children who were aged 0-6 from the Madhya Pradesh Region whether the upper middle arm circumference could be a simple method for acute serious malnutrition screening in the society. It was emphasized in this study that the 115 mm cut-off point value recommended as the upper middle arm circumference for the diagnosis of severe acute malnutrition in line with the studies from African countries had low sensitivity (17.5%) and low positive prediction value (30.4%); and this measurement value should be questioned again (14).

In a study conducted in Senegal, a total of 5751 children under the age of 5 who had malnutrition were compared with UMAC and WHO's WFH Z-score to predict severe malnutrition. According to the height, the specificity of those who were under the weight of -3 SS and under 115 mm was 99% in terms of severe malnutrition, but the sensitivity was found as 5.9%. The specificity was 96.9% in those with weight below -3 SS or under UMAC 115 mm according to the height, but the sensitivity was 13.2%. In the present study, it was emphasized that the UMAC measurement that was lower than 115 mm and/or the WFH Z-score lower than -3 SS was not a useful result in defining severe malnutrition, and only UMAC measurement was more valuable in severe malnutrition diagnosis (15).

UMAC was measured along with the heights and weights of the children in a study conducted with 205 children in the Hanoi Region in Vietnam, and these children were monitored at regular intervals. The measurements of children who were between 0-12 months were followed-up monthly, the measurements of children between 12-36 months were followed-up every 3 months, the measurements of children between 36-72 months were followed-up every 6 months, and children over 72 months were followed-up yearly. The purpose of the study was to monitor the increase in UMAC in children. The increase in UMAC between the ages of 1-5 was 1 cm in girls, and 1 cm in boys. Only when the cut-off point value was taken as 13.5 cm in malnutrition definition in children 6-12 months of age, it yielded high specificity and sensitivity; 14 cm in 13-24 months, 14.5 cm at 25-36 months, and 15 cm in 37-60 months. It was emphasized in the study that if 13.5 cm was not accepted as the UMAC cut-off value for malnutrition screening in children under 5 years of age, the cut-off point value would increase with age (16). In a study conducted with 24.792 children at a center that applied a treating feeding program in Burkina Faso, it was concluded that UMAC was more effective than WFH Z-score as a criterion for admission and discharge to/from the center (17). In a study conducted with 1.166 children in Kenya, when the UMAC's WHO's WFH Z-scores were compared by considering the visible severe weight loss for severe acute malnutrition identification, the diagnostic performance was reported to be better in terms of specificity and sensitivity (18).

In a study conducted with 319 children who were aged between 12 and 59 months in Nigeria, when the cut-off point value of UMAC was taken as 13.5 cm for malnutrition, sensitivity was 20% and specificity was 95.3%; and when it was taken as 15.5 cm, the sensitivity increased to 80%; however, the specificity decreased to 53.5%, and the cut-off point value should be increased to a further value to increase sensitivity7. In another study, UMAC, triceps skin fold thickness and arm and whole body fat mass were compared in the UK. In this study, which included 110 healthy children and 49 children with cystic fibrosis, UMAC measurement results and triceps skin fold thickness had a good correlation level with all body fat mass results (19).

Very few studies were conducted in Turkiye on the upper middle arm circumference, which is one of the anthropometric investigation topics. The first studies were conducted in children who were between the ages of 0-3 in Istanbul, and the results of the study showed low values compared to British and Swedish standards (20).

Two studies have been conducted in recent years regarding UMAC in our country in Kayseri Region. A total of 5553 children and adolescents who were aged 6-17 years were included in the first study, and left UMAC, triceps skin fold thickness, and arm fat circumference reference values were determined. Regarding the upper middle arm circumference, the 50th percentile were 17 cm at age 6 and 23.6 at age 17 in boys, and 15.6 cm at age 6 and 20.9 cm at age 17 in girls (2). In the second study, the role of left UMAC measurements in addition to waist circumference was investigated to define obesity; and was conducted with 2.621 boys and 2.737 girls who were aged 6-17; and it was speculated that the left UMAC threshold values, which show obesity, could be used as an additional parameter in the diagnosis of obesity in PEM diagnosis used so far (21).

A study was conducted in Çankırı City Center to evaluate the nutritional status with anthropometric measurements for 12-48-month-old children; and 258 children were included in the study. The age groups were classified as 12-24 months, 24-36 months, and 36-48 months. The mean UMAC value of boys was 20±0.14 cm, and 20±0.13 cm in girls (9).

No studies were detected in the literature showing the data of our country on the relations of UMAC with Gomez, Waterlow, and WHO Classifications used in malnutrition diagnosis.

In our study, it was also found that UMAC measurement values were similar in girls (mean 15.18±1.97 cm, median value 15 cm, range 10-24 cm) and in boys (mean 15.26±1.8 cm, median 15.3 cm, range 10.4-21.1 cm). It was seen that the UMAC measurement values decreased as the malnutrition degree increased in all classifications.

In the present study of ours, it was determined that UMAC's compliance with other malnutrition Classifications in terms of sensitivity, specificity, positive prediction value, and negative prediction value in severe malnutrition diagnosis for children who are between the ages of 1-5 yielded better results than 11.0 cm when the cut-off point value was taken as 11.5 cm.

The agreement between UMAC and Gomez (WFA) Classification was found better than other classifications in terms of sensitivity and specificity. The relation of UMAC with all classification groups in terms of negative predictive value was high, which suggests that children aged 1-5 years who are UMAC 11.0 cm and 11.5 cm and above may move away from severe malnutrition. It was noteworthy in terms of positive predictor value of UMAC that Waterlow (WFH) was the least associated classification. When the cut-off point of UMAC was 11.0 cm and 11.5 cm for severe malnutrition diagnosis, its specificity was high. The best agreement was with Gomez Classification when the cut-off point was 11.5 cm in terms of the sensitivity of UMAC in severe malnutrition detection. It was noted that the sensitivity increased 3-fold when the cut-off point was increased to 11.5 cm from 11.0 cm. When the sensitivity of UMAC in detecting severe malnutrition was increased to 11.5 cm from 11.0 cm, its compliance with Waterlow (HFA, WFH) and WHO (WFA, HFA) Classification increased at a rate of 2.3, 3, 2.71, and 2.8-fold.

When the 12.5 cm and below cut-off values of UMAC were considered as the criterion for malnutrition diagnosis, it was found that the highest compliance was with WHO's YGA classification in terms of sensitivity, and the compliance with all classification methods was good in terms of specificity. It is worth noting that the highest compliance was with Gomez (WFA) Classification in terms of positive predictor value; and the compliance in terms of negative predictive value was with WHO's WFA and HFA.

According to the results of our study, considering the previously reported studies showing that the sensitivity and specificity increased when the limit value increased in diagnosing malnutrition with UMAC, the cut-off points of UMAC were determined for each classification. The cut-off point was 14.95 cm for Gomez and Waterlow (HFA and WFH) Classifications of UMAC for malnutrition diagnosis in children aged 1-5 years, 13.95 cm for WHO WFA, 14.55 cm for WHO HFA, and 15.15 cm for all classifications. It is noteworthy that the sensitivity and negative predictive value increased when UMAC cut-off point value was increased to the values detected in our study for classifications; however, specificity and positive predictive value decreased. This suggests that it would be more appropriate to use the cut-off point values that were found in our study in terms of the sensitivity of UMAC for not to overlook malnutrition cases in children between the ages of 1 and 5 in our country.

It was found in our study that UMAC showed the best correlation with Gomez (WFA) Classification among the other three classifications (Gomez, Waterlow, and WHO) (R2=0.631, p:0.001).

Conclusion

Early recognition of an important public health problem, such as malnutrition is very important for taking precautions and identifying treatment modalities. Although the UMAC cut-off point differs among countries and regions for the diagnosis of severe malnutrition, our study showed that it would be appropriate to prefer 11.5 cm for our country. Similarly, it was concluded that the sensitivity would increase if the cut-off point values defined in our study were used instead of 12.5 cm cut-off point value that is used for the diagnosis of malnutrition with UMAC. It was also found that UMAC was most compatible with Gomez (WFA) among the other three classification methods. It was also concluded that UMAC measurement alone would not be adequate for malnutrition diagnosis, and that it would be more appropriate to evaluate it together with Gomez, Waterlow, and WHO Classifications by making other anthropometric measurements in physical examinations. Multi-centered studies are required in our country to determine UMAC malnutrition and severe malnutrition limit values to prevent delayed diagnosis and treatment of children with malnutrition between the ages of 1 and 5.

Ethical Approval: The study was conducted with the approval of the Local Ethics Committee of the Ethics Committee of Selçuk University, Faculty of Medicine (No: 10.06.2014 and 2014/12).

Author Contributions: Conceptualization, HHE and MSÖ.; Methodology, HHE, MSÖ and ME.; Formal analysis, HHE, MSÖ and ME.; Investigation, HHE and MSÖ.; Resources, MSÖ, ME, FK. and AY; Writing—original draft preparation, MSÖ and AY.; Writing—review and editing, HHE, MSÖ and AY. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study was performed according to the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Institutional Review Board at Selçuk University Medical Center (no:2021/6).

Conflicts of Interest: There are no financial and non-financial conflicts of interest for any of the authors regarding specific financial interests that are relevant to the work conducted or reported in this manuscript.

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