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Relationship Between Mid-Upper Arm Circumference (MUAC) and Body Mass Index (BMI) in Children Aged 6 - 12 Years: A Cross-sectional Study

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Abstract

Background: Obesity has become one of the most important health problems worldwide. Body Mass Index (BMI) is a clinical assessment of overweight and obesity in children, although Mid-Upper Arm Circumference (MUAC) assessment is more straightforward, especially for parents.
Objectives: This study aimed to investigate the relationship between MUAC and BMI in children aged 6 - 12 years.
Methods: This cross-sectional study was performed on 455 elementary school children aged 6 - 12, including 278 girls and 177 boys with a mean age of 8.8 $\pm$ 1.8 years selected using the census method. Our researcher was trained for anthropometric data collection. Data were analyzed by SPSS version 25 software using Mann-Whitney, Kolmogorov-Smirnov, and Kruskal-Wallis tests.
Results: The mean age was 9.19 $\pm$ 1.8 years, the mean height was 135 $\pm$ 12 cm, the mean weight was 31.85 $\pm$ 11 kg, the mean MUAC was 21 $\pm$ 3.1 cm, and the mean BMI was 17 $\pm$ 3.6 kg/m^2. There was a significant correlation between MUAC and BMI in both sexes, but it was stronger in girls than in boys (P-value $<$ 0.05). The MUAC cutoff point was 23.75 cm (77% sensitivity and 80% specificity) and 24.75 cm (93% sensitivity and 88% specificity) for overweigh and obesity in girls, respectively. Also, it was 23.25 cm (88% sensitivity and 83% specificity) and 25.25 cm (87% sensitivity and 90% specificity) for overweigh and obesity in boys, respectively.
Conclusions: We recommend MUAC as a predictor of early diagnosis of overweight and obesity.

Keywords: Body Mass Index (BMI), Mid-Upper Arm Circumstance (MUAC), Obesity

1. Background

Obesity is a harmful accumulation of body fat that has a detrimental effect on health and well-being. It results from a positive energy balance due to extra calorie intake and/or insufficient physical activity. It is a multifactorial disorder resulting from the interaction of genetics, environment, and lifestyle (1). Obesity in children and adolescents is associated with severe physical complications such as cardiovascular problems, metabolic disorders (hypertension, insulin resistance, and hyperlipidemia), orthopedic difficulties, night apnea, asthma, and psychosocial complications such as low self-esteem and isolation from society. If obesity is not identified and treated, its complications will continue to adolescence and cause lifetime problems (2).

In recent decades, rapid lifestyle changes have occurred due to the industrialization of societies. The global prevalence of obesity has doubled in the last four decades in childhood at the age of 5 - 19 and in the age group of 2 - 4 years (3). The World Health Organization has developed a plan to end childhood obesity (WHO ECHO) and created a comprehensive and integrated package of recommendations for addressing childhood obesity. In Iran, we are witnessing a growing trend of childhood obesity. National studies have measured the prevalence of overweight, obesity, and abdominal obesity. Therefore, the Iranian version of the program to end childhood obesity (IRAN ECHO) was adopted by examining children's habits, lifestyles, and nutrition and providing corrective suggestions (4).

In 2005, the US Preventive Services Task Force (USPSTF) found that Body Mass Index (BMI), adjusted for age and sex (calculated as weight in kilograms divided by height squared in meters), can be used as a reliable method for detecting overweight or obesity in children over six years and adults (5). Numerous studies have been performed to evaluate the accuracy and importance of this indicator in diagnosing overweight children. The Centers for Disease Control and Prevention (CDC) insisted on recording BMI in the growth chart for children after the age of two years. Since 2011, the International Cardiovascular Society has also stated the need for screening children aged two years and older for obesity based on BMI (6, 7). However, the need for training on calculating this index can be an obstacle to its widespread use, so they have always been looking for an easier way to identify the onset of obesity in children (8). Such an approach can help increase clinical assessment and public health surveillance of overweight and obesity, especially in developing countries because of the more prevalence of obesity in these communities (9).

Mid-Upper Arm Circumference (MUAC) is an easy, practical, and cost-effective method to identify children and adults with malnutrition. Although numerous studies have been done in this regard, there are limited articles on the possibility of using this index to identify obesity in children (10).

2. Objectives

This study aimed to investigate the relationship between MUAC and BMI in children aged 6 - 12 years.

3. Methods

This cross-sectional study was carried out at Lavizan primary schools in a residential area. All normal healthy students willing to cooperate were included in the study using a census method. The sample included 455 subjects, comprising 177 boys and 278 girls, in the age range of 6 - 12 years. The prevalence of normal BMI in Iranian children was considered 70% (3), and based on Cochran's sample size formula, we needed at least 322 subjects. We considered an accuracy level of 0.05 and a confidence level of 95% for our study.

First, the principals, school officials, and parents were justified. Also, the ethical code of IR.AJAUMS.REC.1397.084 was received. Our researcher was trained for sampling to collect anthropometric data (height, weight, BMI, and MUAC). In order to reduce errors, measurements were performed twice, and an average was calculated. Also, to validate the data, all measurements were made by the same person, scale, and tape measure with confirmed accuracy. All children aged 6 - 12 years were included in the study. Children who did not want to cooperate, had the severe disease in the last months, and had weight loss were excluded from the study.

For children, BMI is presented as a percentile, which plots the child's BMI next to other children's BMI of the same age and sex. The BMI between the fifth and 85th percentiles is considered normal and healthy. Falling below the fifth percentile is considered underweight. Falling between the 85th and 95th percentiles is considered overweight, and more 95th percentile is considered obesity. If BMI is more than the 120th percentile, it is considered excessive obesity (11).

Descriptive statistics, mean and standard deviation, were used to describe the data. Pearson's and Spearman's correlation coefficients in SPSS version 25 software were used to analyze the data. The Kolmogorov-Smirnov test was used to check the normality of the data. We used the Mann-Whitney U test to test the average height, weight, and BMI based on gender. The Kruskal-Wallis test was used to analyze arm circumference based on BMI class ($P < 0.05$). Receiver Operating Characteristic (ROC) curve was used to determine the cutoff points on the graphs. According to previous studies, the best area was placed below 0.1-0.9 on the ROC curve (12). Finally, the Youden index was used to evaluate the sensitivity and specificity of the cutoff point on the ROC curve (13).

4. Results

We collected and analyzed the data of 455 students aged 6 - 12 years, including 278 (61.1%) girls with an average age of 9.19 ± 1.8 years and 177 (38.9%) boys with an average age of 8.15 ± 1.6 years. The average height was 135 ± 12 cm, the average weight was 31.85 ± 11.2 kg, the average MUAC was 21 ± 3.1 cm, and the average BMI was 17 ± 3.6 kg/m^2 (Table 1).

Most children (73.7%) had normal BMI, which was 71.9% and 69.5% in girls and boys, respectively. The distribution of BMI was higher in girls than in boys. The distribution of BMI was significantly different among girls ($P = 0.034$),

Table 1. Descriptive Information of Participants in This Study

	Minimum	Maximum	Mean ± SD
Age (y)	6	12	8.79 ± 1.80
Height (cm)	106	165	135.05 ± 12.03
Weight (kg)	15	68	31.85 ± 11.2
MUAC (cm)	15	31	20.94 ± 3.15
BMI (kg/m^2)	11.54	30.18	17.03 ± 3.62

while both underweight and obesity were reported more in boys than in girls (Table 2).

Table 2. Interpretation of Weight Based on Body Mass Index by Gender

Sex/BMI	No. (%)
Female	
Underweight	44 (15.8)
Normal weight	200 (71.9)
Overweight	18 (6.5)
Obese	16 (5.8)
Male	
Underweight	31 (17.5)
Normal weight	123 (69.5)
Overweight	9 (5.1)
Obese	14 (7.9)

In both groups of girls and boys, there was a significant and direct correlation between age and height, age and weight, age and MUAC, age and BMI, height and weight, height and MUAC, height and BMI, weight and MUAC, weight and BMI, and MUAC and BMI (Table 3). There was a significant difference between the mean height of girls and boys, and girls were significantly taller than boys ($P < 0.05$).

The average weight was significantly higher in girls than boys ($P < 0.05$). The BMI was significantly higher in girls than boys ($P < 0.05$), and there was no significant difference between the mean MUAC of girls and boys in the same age group ($P > 0.05$) (Table 4).

There was a significant difference between BMI and MUAC in both sexes ($P < 0.001$).

The ROC curve was used to determine the cutoff point, and the Youden index was used to evaluate the sensitivity and specificity of the cutoff point on the ROC curve. The area below the ROC curve for underweight and normal weight was less than 0.6, which means the MUAC in these two ranges cannot predict BMI.

The ROC curve was acceptable for BMI in the overweight range (the area below the curve was 0.834), and the results were very desirable in the obesity range among girls (the area below the chart was 0.958).

The ROC curve was acceptable for BMI in the overweight range (area below chart was 0.908), and the results were very desirable in the obesity range (area below chart was 0.938) in boys.

The cutoff point of MUAC was 23.75 cm in the overweight BMI (77% sensitivity and 80% specificity) and 24.75 cm in the obesity range (93% sensitivity and 88% specificity) in girls aged 6 - 12 years. The cutoff point of MUAC was 22.25 cm in overweight BMI (88% sensitivity and 83% specificity) and 25.25 cm in the obesity range (87% sensitivity and 90% specificity) in boys aged 6 - 12 years (Table 5).

5. Discussion

Based on the present study, the correlation between all variables was significant (age and height, age and weight, age and MUAC, age and BMI, height and weight, height and BMI, weight and MUAC, weight and BMI, and MUAC and BMI) in both groups of girls and boys.

Determining the MUAC cutoff point from the ROC curve was not significant in children with underweight or normal weight, while in both sexes, it was significant in the range of overweight and obesity. A study in Pakistan on children aged 12 - 18 years showed that MUAC is a good indicator for screening obesity (14), so the results are similar to our study, but the age groups are different. The study on Polish school children (aged 7 - 18 years) indicated that MUAC was more accurate for screening than BMI (15). In that study, the researchers suggested MUAC as a socioeconomic predictor (15), which is somehow different from our study.

Another study in Nepal on adults showed that MUAC is a good tool for screening the underweight (16). Also, the age group and MUAC predicted the underweight, which is different from our study, but like our study, it showed the importance of MUAC. Also, a study in India explained the importance of MUAC in school-aged children as a predictor of BMI (17).

Measuring mid-upper arm circumstances is more straightforward than BMI estimation. Therefore, we recommend MUAC as a predictor of early diagnosis of overweight and obesity, especially for families, as a practical and cost-effective method.

Table 3. Investigating the Correlation Between Research Variables by Gender [a]

Variables	Age	Height	Weight	MUAC	BMI
Female					
Age	1	0.855*	0.728*	0.577*	0.467*
Height	0.855*	1	0.862*	0.702*	0.581*
Weight	0.728*	0.862*	1	0.894*	0.893*
MUAC	0.577*	0.702*	0.894*	1	0.878*
BMI	0.467*	0.581*	0.893*	0.878*	1
Male					
Age	1	0.797*	0.633*	0.371*	0.200*
Height	0.797*	1	0.840*	0.526*	0.351*
Weight	0.633*	0.840*	1	0.744*	0.772*
MUAC	0.371*	0.526*	0.744*	1	0.708*
BMI	0.200*	0.351*	0.772*	0.708*	1

[a] * There is a correlation ($P < 0.001$)

Table 4. The Average Height, Weight, Mid-Upper Arm Circumference, and Body Mass Index in the Same Age Category by Gender

Variables	No.	Minimum	Maximum	Mean ± SD	Mann-Whitney (P-Value)
Height					< 0.001
Female	278	112.0	165.0	137.47 ± 12.50	
Male	177	107.0	157.0	131.25 ± 10.16	
Weight					< 0.001
Female	278	15.0	68.0	33.77 ± 12.01	
Male	177	15.0	64.0	28.82 ± 8.92	
MUAC					0.34
Female	278	15.0	31.0	21.22 ± 3.28	
Male	177	15.0	30.0	20.50 ± 2.87	
BMI					0.011
Female	278	11.54	28.85	17.41 ± 3.78	
Male	177	11.54	30.18	16.44 ± 3.25	

Table 5. Body Mass Index Sensitivity and Specificity for Overweight and Obesity Diagnosis

BMI	ROC	Youden Index	SD	Sensitivity	Specificity	MUAC
Overweight						
Female	0.834	0.582	0.031	0.778	0.804	23.75
Male	0.908	0.728	0.025	0.889	0.839	22.25
Obese						
Female	0.958	0.82	0.014	0.938	0.882	24.75
Male	0.938	0.78	0.032	0.875	0.905	25.25

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Footnotes

Authors' Contribution: Banafshe Dormanesh (B.D.) conceived and designed the evaluation and drafted the manuscript, although Shahrzad Ebrahimi (S.E.) and Zahra Asadi (Z.A.) have also cooperated study concept and design include the development of the protocol. Acquisition of data was done by S.E. Analysis and interpretation of data was done by S.E. and Z.A.; Drafting of the manuscript was basically done by B.D. and Z.A.; Critical revision of the manuscript for important intellectual content was an important part which was done by Hossein Dini (H.D.) and B.D.; Administrative, technical, and material support was done by H.D.; This article is based on S.E. dissertation and B.D.,Z.A. and H.D. were study supervises.

Conflict of Interests: This article is based on Shahrzad Ebrahimi's dissertation (thesis), supported by the Deputy of Research and Technology of AJA University of Medical Sciences Research Unit. We are all AJA University of Medical Sciences employees. We do not have any personal financial interests because none of us have stocks or shares in companies, and none of us have received any consultation fees. No patent is raised in this research. None of us have any personal or professional relations with organizations and individuals. None of us are unpaid members of a government or non-governmental organization. We have not been one of the editorial board members or a reviewer of this journal yet.

Data Reproducibility: It was not declared by the authors.

Ethical Approval: This article is the result of research work and a student dissertation approved by the AJA University of Medical Sciences with an ethics code of IR.AJAUMS.REC.1397.084. (ethics.research.ac.ir/EthicsProposalView.php?id=44796)

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Informed Consent: Children were explained about their height and weight measurements, their parents' informed consent was obtained, and individuals consciously participated in the study.

References

1. Mittal M, Jain V. Management of Obesity and Its Complications in Children and Adolescents. *Indian J Pediatr*. 2021;**88**(12):1222–34. doi: 10.1007/s12098-021-03913-3. [PubMed: 34609654]. [PubMed Central: PMC8491444].
2. Ezzeddin N, Eini-Zinab H, Ajami M, Kalantari N, Sheikhi M. WHO Ending Childhood Obesity and Iran-Ending Childhood Obesity Programs Based on Urban Health Equity Indicators: A Qualitative Content Analysis. *Arch Iran Med*. 2019;**22**(11):646–52. [PubMed: 31823630].
3. Di Cesare M, Soric M, Bovet P, Miranda JJ, Bhutta Z, Stevens GA, et al. The epidemiological burden of obesity in childhood: a worldwide epidemic requiring urgent action. *BMC Med*. 2019;**17**(1):212. doi: 10.1186/s12916-019-1449-8. [PubMed: 31760948]. [PubMed Central: PMC6876113].
4. Sayyari AA, Abdollahi Z, Ziaodini H, Olang B, Fallah H, Salehi F, et al. Methodology of the Comprehensive Program on Prevention and Control of Overweight and Obesity in Iranian Children and Adolescents: The IRAN-Ending Childhood Obesity (IRAN-ECHO) Program. *Int J Prev Med*. 2017;**8**:107. doi: 10.4103/ijpvm.IJPVM_426_17. [PubMed: 29416836]. [PubMed Central: PMC5760845].
5. Barton M. Screening for obesity in children and adolescents: US Preventive Services Task Force recommendation statement. *Pediatrics*. 2010;**125**(2):361–7. doi: 10.1542/peds.2009-2037. [PubMed: 20083515].
6. No authors listed. 2016 Recommendations for Preventive Pediatric Health Care Committee on Practice and Ambulatory Medicine and Bright Futures Periodicity Schedule Workgroup. *Pediatrics*. 2016;**137**(3). e727. doi: 10.1542/peds.2015-2009. [PubMed: 26324870].
7. Expert Panel on Integrated Guidelines for Cardiovascular Health Risk Reduction in Children Adolescents National Heart Lung Blood Institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: Summary report. *Pediatrics*. 2011;**128 Suppl 5**:S213–56. doi: 10.1542/peds.2009-2107C. [PubMed: 22084329]. [PubMed Central: PMC4536582].
8. Craig E, Bland R, Ndirangu J, Reilly JJ. Use of mid-upper arm circumference for determining overweight and overfatness in children and adolescents. *Arch Dis Child*. 2014;**99**(8):763–6. doi: 10.1136/archdischild-2013-305137. [PubMed: 24890851]. [PubMed Central: PMC4112423].
9. Sisay BG, Haile D, Hassen HY, Gebreyesus SH. Performance of mid-upper arm circumference as a screening tool for identifying adolescents with overweight and obesity. *PLoS One*. 2020;**15**(6). e0235063. doi: 10.1371/journal.pone.0235063. [PubMed: 32574192]. [PubMed Central: PMC7310830].
10. Rerksuppaphol S, Rerksuppaphol L. Mid-Upper-Arm Circumference and Arm-to-Height Ratio to Identify Obesity in School-Age Children. *Clin Med Res*. 2017;**15**(3-4):53–8. doi: 10.3121/cmr.2017.1365. [PubMed: 29018004]. [PubMed Central: PMC5849437].
11. Chaput JP, Katzmarzyk PT, Barnes JD, Fogelholm M, Hu G, Kuriyan R, et al. Mid-upper arm circumference as a screening tool for identifying children with obesity: a 12-country study. *Pediatr Obes*. 2017;**12**(6):439–45. doi: 10.1111/ijpo.12162. [PubMed: 27238202].
12. Powers DM. Evaluation: from precision, recall and F-measure to ROC, informedness, markedness and correlation. *arXiv preprint arXiv:2010.16061*. 2020.
13. Gahagan S. Overweight and Obesity. *Nelson textbook of Pediatrics*. Canada: Elsevier; 2020. p. 345–60.
14. Asif M, Aslam M, Altaf S. Use of Mid-Upper Arm Circumference in Evaluation of Overweight and Obesity in the Pakistani Children and Adolescent, Aged 12-18 Years. *Pak Pediatr J*. 2018;**42**(1):42–7.

15. Nowak-Szczepanska N, Gomula A, Koziel S. Mid-upper arm circumference and body mass index as different screening tools of nutritional and weight status in Polish schoolchildren across socio-political changes. *Sci Rep*. 2019;**9**(1):12399. doi: 10.1038/s41598-019-48843-5. [PubMed: 31455783]. [PubMed Central: PMC6712029].
16. Thorup L, Hamann SA, Kallestrup P, Hjortdal VE, Tripathee A, Neupane D, et al. Mid-upper arm circumference as an indicator of underweight in adults: a cross-sectional study from Nepal. *BMC Public Health*. 2020;**20**(1):1187. doi: 10.1186/s12889-020-09294-0. [PubMed: 32727437]. [PubMed Central: PMC7391598].
17. Ashtekar SV, Padhyegurjar MS, Powar JD, Padhyegurjar SB. Mid-Upper-Arm-Circumference as a Growth Parameter and its Correlation with Body Mass Index and Heights in Ashram School Students in Nashik District in Maharashtra, India. *Indian J Community Med*. 2020;**45**(4):419–24. doi: 10.4103/ijcm.IJCM_446_19. [PubMed: 33623193]. [PubMed Central: PMC7877414].