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RESEARCH ARTICLE

Potential of mid-upper arm circumference to replace body mass index as a screening tool for assessment of nutritional status: A study among a rural elderly population in eastern India

Shobhit Garg, Bijit Biswas, Swanya P Maharana, Aparajita Dasgupta

Department of Preventive and Social Medicine, All India Institute of Hygiene and Public Health, Kolkata, West Bengal, India

Correspondence to: Swanya P Maharana, E-mail: swanyamaharana@gmail.com

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ABSTRACT

Background: Malnutrition in the form of undernutrition or overnutrition has reached epidemic proportions globally in all age groups assessment of which often becomes very difficult among the elderly since many of them cannot even stand for accurate measurement of their height and weight. **Aims and Objectives:** The aim of this study is to assess and to find the optimum cutoff of mid-upper arm circumference (MUAC) to predict overweight/obesity using receiver operating characteristic (ROC) curves. **Materials and Methods:** A community-based cross-sectional study was conducted in May 2017–August 2017 among 335 elderly, in two villages, West Bengal. Height, weight, and MUAC were measured for each subject. ROC curve analysis was used to estimate the cutoff values of MUAC. **Results:** Mean (standard deviation) age of the participants was 67.40 (6.19) years. More than half were overweight and 14 (4.2%) were obese. MUAC and body mass index (BMI) had strong significant positive correlation (r = 0.79). On ROC for MUAC to have overweight/obesity (BMI ≥25 kg/m^2), area under curve was 0.9133 which signifies MUAC as a excellent screening and predictive tool. With Youden's method as well with closest to top-left method, optimum cutoff of MUAC was found to be 21.75 cm. At this cutoff, an elderly individual will have BMI ≥25 kg/m^2 with a sensitivity of 87.30% and specificity of 78.49%. **Conclusion:** Our study suggests that MUAC has potential for surveillance of overweight/obesity and has a predictive tool to identify elderly who will need further assessment of obesity and its associated comorbidities.

KEY WORDS: Mid-upper Arm Circumference; Elderly, Obesity, Receiver Operating Characteristic Curve, Youden's Index

INTRODUCTION

The age distribution of the world's population is changing. With advances in medicine, the proportion of older people continues to rise worldwide.[1] By 2051, there will be 2 billion people over the age of 60 with 80% of them living in developing countries.[2] Globally, about 30% of people aged 65–74 have no natural teeth.[1] Elderly population in India has tripled in the past 51 years and will relentlessly increase in near future. In 2001, the proportion of older people was 7.7% which increased to 8.94% in 2016. This growth is staggering, posing tremendous challenges in caring for the ageing population.[3]

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Obesity is defined as an inappropriate growth of the adipose tissue because of an increase in size of fat cell (hypertrophic obesity) or an increase in number of fat cells (hyperplastic obesity) or a combination of both.[4] On the basis of the distribution of fat, obesity is of two types: Android and gynoid obesity. In first, there is deposition of fat in abdominal

region, and in gynoid obesity, fat is more evenly and peripherally distributed throughout the body. Android type is more dangerous than gynoid type. Prevalence of obesity is increasing in both developed and developing countries.[5] Obesity has reached epidemic proportions globally, with more than 1 billion people in the world are overweight adults, and there are around 300 million people who are obese. According to the World Health Organization (WHO), about 2.8 million individuals lose their life each year as a result of being overweight or obese. In addition, 44% of diabetes, 23% of ischemic heart disease, and 7–41% of certain cancers are attributable to overweight and obesity.[6]

In the 21st century, obesity has reached epidemic proportions in India, with morbid obesity affecting 5% of the country's population.[7] India also is moving fast toward the condition of other developing countries that are steadily becoming more obese. According to the National Family Health Survey (NFHS-4), the overall prevalence of overweight/obesity in India was 18.7% in men and 20.7% in women which is more than that of in NFHS-3.[8]

Elderly populations are among the vulnerable group as they face various challenges; health issues emerge as one of the important challenges faced by them. Among health issues, non-communicable diseases are much more common in older age, which requires large quantum of health and social care. Elderly people are vulnerable to overnutrition and obesity as aging almost always associated with lowered physical activity and increased sedentary lifestyle. Central obesity in elderly population of India is a major health problem which is supported by the studies done by Rajkamal *et al.* in South India and by Swami *et al.* in Chandigarh where they have found 41.4% and 33% obese elderly population.[9,10]

Nutritional assessment in low-resource settings like rural areas in our country often relies on non-invasive, simple, and affordable anthropometric methods. Anthropometric methods have been used to describe nutritional status and rapidly identify at-risk groups for appropriate interventions. These include body mass index (BMI), which relies on weight and height measurements, mid-upper arm circumference (MUAC), and skin-fold thickness measurements at different sites (triceps and subscapular).[11] Advanced clinical methods to assess body composition, such as dual-energy x-ray absorptiometry or air displacement (Bod Pod), are considered the gold standards for the assessment of body composition,[12] but they are expensive and unfeasible for large population-based studies and programs.

BMI corresponds to weight in kg/height in m^2 and is a good marker of malnutrition, present in the majority of existing nutritional screens. For calculating the BMI, one not only have to measure the height and weight of individuals but also have to do a mathematical calculation. Measuring height and weight during the field visits in rural area is cumbersome job. BMI measurement requires a trained work staffs. Carrying instruments such as weighing scale and stadiometer in the field surveys are also not smooth in terms of logistics. MUAC is a simple measurement which has been used for many years in nutritional evaluation, being an indicator of protein and energy reserves of the individual. Diverse studies have employed MUAC as a nutritional parameter in different population groups (as elderly, inpatients, infants, pre-school-age children, schoolchildren, pregnant women, or lactating women).[13] Further, diseases like scoliosis make it further difficult to measure BMI for these, and also with an increase in age, some people fail to follow the command necessary for height and weight measurement and hence BMI estimation.

As elderly population is rising, it will be in great favor for the health system to have a simpler screening tool than BMI to screen elderly population at risk and intervene timely. If MUAC will be found to a reliable tool in comparison to BMI, it will be very helpful in screening and also it will save the time and money. With this background, the present study was done to find the proportion of the elderly with overweight and obesity and to find the optimum cutoff of MUAC to predict overweight using receiver operating characteristic (ROC) curves and Youden's and Closest to top-left approach.

METHODS AND MATERIALS

This study was a rural community–based, cross-sectional study. It was done during May 2017–August 2017 among the elderly residing in a rural block of West Bengal, India. All those who had not given written informed consent and who were critically ill were excluded from the study.

The Rural Health Unit and Training Center, Singur (RHUTC), is the rural field practice area of All India Institute of Hygiene and Public Health (AIIHPH), Kolkata, which serves 64 villages through two of its Union Primary Health Center (UPHC). Each UPHC serves 32 villages. One village was selected from each UPHC conveniently. All the elderly in these two villages were approached, and finally, 335 elderly individuals had given consent for the participation.

The study was started after the due permission of the Institutional Ethics Committee of AIIHPH. Height, weight, and MUAC were collected by the researcher himself after taking written informed consent. At the end of the study, advice was given about preventive measures to the individuals who were found to be malnourished.

Height was measured in a standing position against a hard wall with occiput, shoulder blades, buttocks, and heel touching the wall without any footwear and head-wear with non-stretchable measuring tap with the precision of 0.1 cm. Weight was measured with properly calibrated digital weighing scale with a precision of 0.1 kg with participants standing in straight position with minimum respectable

clothings. MUAC was measured on the left hand with a right hand hanging downside the body and relaxed. MUAC was measured with a flexible measuring tape that was wrapped at the midpoint of the arm between the shoulder and the tip of the elbow around the mid-upper arm (between the shoulder and elbow) with the left arm bent.[14,15]

Operational Definition

- BMI: Each individual was classified into different BMI categories as per the Asian and WHO criteria, respectively.[16]

Statistical Analysis

Recorded data were analyzed using appropriate statistical methods and represented by various tables, graphs, diagrams, etc. Moreover, various statistical significant tests were applied accordingly with the use of R: A language and environment for statistical computing. ROC curves were utilized to find optimum cutoff for MUAC using Youden's index and closest to top-left method. Youden's index is considered as the most sensitive method and the cutoff by this method is the maximum value of J, where J = sensitivity + specificity-1. Kappa statistic was calculated for different MUAC cutoff and respected BMI cutoffs.[17-20]

RESULTS

Mean (standard deviation) age of the participants was 67.40 (6.19) years with the median of 66 years. Minimum age of the participant was 60 years, and maximum was 84 years. Of 335 participants, 103 (30.7%) were male.

Of 335 participants, 146 (43.6%) had normal BMI. More than half were overweight and 14 (4.2%) were obese. Correlation was 0.80 among males (black dots) and 0.79 in females (red dots) [Table 1].

On Mann–Whitney U-test, median MUAC among males and females was not differed significantly, and hence, we have investigated ROC curves simultaneously.

MUAC and BMI had strong significant positive correlation (r = 0.79, 95% confidence interval = 0.74–0.82) [Figure 1].

Table 1: Nutritional status among study participants (n=335)

BMI	n (%)
<23 kg/m^2	146 (43.6)
23<25 kg/m^2	63 (18.8)
25<30 kg/m^2	112 (33.4)
≥30 kg/m^2	14 (4.2)
Total	335 (100)

BMI: Body mass index

On ROC curve (ROC) for MUAC to have overweight/obesity (BMI ≥25 kg/m^2), the area under curve (AUC) was 0.9133 which signifies MUAC as a excellent screening and predictive tool.

With Youden's method as well with closest to top-left method, an optimum cutoff of MUAC was found to be 21.75 cm. At this cutoff, an elderly individual will have BMI ≥25 kg/m^2 with a sensitivity of 87.30% and specificity of 78.49% [Figure 2].

On ROC Curve for MUAC to have overweight/obesity (BMI ≥23 kg/m^2), AUC was 0.8697 which signifies MUAC as a good screening and predictive tool.

With Youden's method, an optimum cutoff of MUAC was found to be 20.25 cm. At this cutoff, an elderly individual will have BMI ≥23 kg/m^2 with a sensitivity of 93.12% and specificity of 63.01%.

With closest to top-left method, an optimum cutoff of MUAC was found to be 21.25 cm. At this cutoff, an elderly individual will have BMI ≥23 kg/m^2 with a sensitivity of 74.07% and specificity of 80.13% [Figure 3].

On ROC curve for MUAC to have obesity (BMI ≥30 kg/m^2), AUC was 0.7937 which signifies MUAC as a good screening and predictive tool.

With Youden's method as well as closest to top-left method, an optimum cutoff of MUAC was found to be 21.75 cm. At this cutoff, an elderly individual will have BMI ≥30 kg/m^2 with a sensitivity of 100% and specificity of 57% [Figure 4].

Kappa statistic showed fair and moderate agreement between MUAC and BMI at 25.00 and 23.00 kg/m^2, respectively [Table 2].

DISCUSSION

More than half were overweight and 14 (4.2%) were obese. MUAC and BMI had a strong significant positive correlation (r = 0.79). On ROC for MUAC to have overweight/obesity (BMI ≥25 kg/m^2), AUC was 0.9133 which signifies MUAC as a excellent screening and predictive tool. With Youden's method as well with closest to top-left method, an optimum cutoff of MUAC was found to be 21.75 cm. At this cutoff, an elderly individual will have BMI ≥25 kg/m^2 with a sensitivity of 87.30% and specificity of 78.49%.

Of the recruited participants, 56.4% of participants were found to have overweight or obesity which is in concurrence with the other studies done in Chandigarh by Swami *et al.*, in South India by Rajkamal *et al*., and in Delhi by Singh *et al*.[9,10,21]

After a fully comprehensive literature search, we believed that the present study is the first to examine if MUAC can be a useful, alternative, and practical screening and predictive

tool for obesity in a sample of the elderly from rural West Bengal, India.

The present study revealed AUCs for MUAC for different BMI values ranged from 0.79 to 0.91. All these findings clearly state that MUAC can be a simpler alternative to BMI for screening the elderly for overweight or obesity.

Although this aspect of MUAC was not investigated among the elderly, this was investigated among children, adolescents, pregnant women, and adults.[13,22-27] Most of the above-mentioned studies have investigated MUAC for undernutrition, and this might be due to the fact that still in low, middle-income countries, undernutrition is more important public health problem then overnutrition. Our results are in concurrence with one of currently available MUAC values for the elderly, i.e. mini nutritional assessment for the elderly which use 21 cm for overweight[28] and in contrary with a value of 23.5 cm for undernutrition in the Malnutrition Universal Screening Tool.[29]

Our study is limited by the fact that the optimal cutoffs in the MUAC distribution were not cross-validated in other independent samples which would be necessary to correctly establish the value of MUAC for the assessment of overweight/obesity. The present study was restricted to two villages only. These findings may not be representative of the whole country or even of the whole state of West Bengal. Finally, more such longitudinal studies will be needed to associate MUAC with not only obesity but also with its associated comorbidities. A strength of our study is that this is among few studies done on overweight/obesity elderly in a representative sample of Singur, an rural area of West Bengal. During the data collection, we have used a highly standardized measurement protocol, the use of objective measurements, and a rigorous quality control program to ensure high-quality data.

Overweight and obesity have become an epidemic not only in developed world but also in developing world that too also in rural areas. Overweight and obesity are among the top most attributing factors of disability-adjusted life years. Screening individuals, especially vulnerable population like the elderly, is the utmost important measure to get a opportunity to intervene timely. Measurement of MUAC has been used as a practical proxy for underweight, but our study suggests that it has the potential for surveillance of overweight and obesity, and as a predictive tool to identify elderly who will need further assessment and/or clinical management of obesity and its associated comorbidities. Colors of traffic light, i.e., red, yellow, and green may be used to triage the elderly

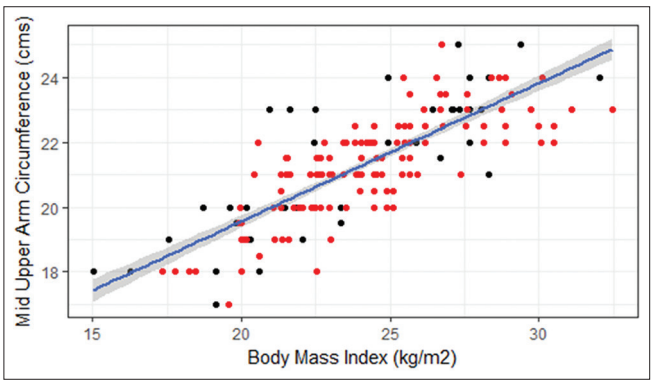

Figure 1: Correlation between mid-upper arm circumference and body mass index (*n*=335)

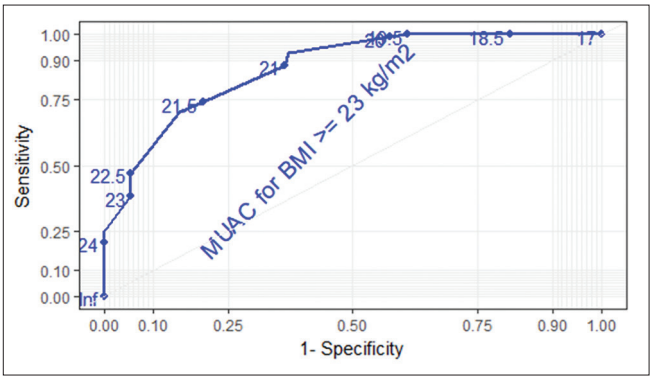

Figure 3: Receiver operating curve for mid-upper arm circumference for predicting overweight/obesity (body mass index a23 kg/m^2) (*n*=335)

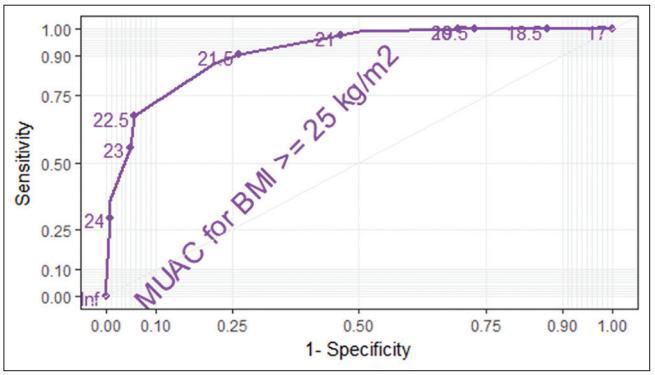

Figure 2: Receiver operating curve for mid-upper arm circumference for predicting overweight/obesity (body mass index ≥25 kg/m^2) (*n*=335)

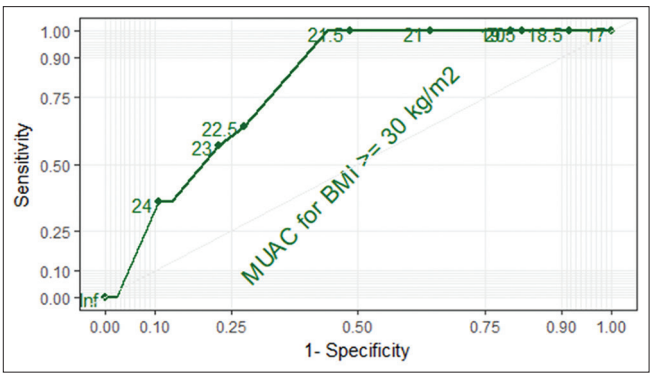

Figure 4: Receiver operating curve for mid-upper arm circumference for predicting obesity (body mass index ≥30 kg/m^2) (*n*=335)

Table 2: Agreement between overweight/obesity classification based on BMI and on MUAC (*n*=335)

Cutoff of MUAC (cm) No	BMI≥23 kg/m²		Agreement %	Kappa	*P*
	No	Yes			
≥20.25	92	13	80%	0.58 (Moderate)	<0.05
	54	176			
Cutoff of MUAC (cm) No	**BMI≥25 kg/m²**		**Agreement %**	**Kappa**	***P***
	No	**Yes**			
≥21.75	164	16	82%	0.63 (Fair)	<0.05
	45	110			
Cutoff of MUAC (cm) No	**BMI≥30 kg/m²**		**Agreement %**	**Kappa**	***P***
	No	**Yes**			
≥21.75	180	0	58%	0.1 (Slight)	<0.05
	141	14			

MUAC: Mid-upper arm circumference, BMI: Body mass index

as obese, overweight, and normal. MUAC was found to be a good/excellent predictive tool in the present study. Larger studies with all age groups are warranted to further enrich the existing literature and evidence to support a simpler screening tool, i.e., MUAC for overweight and obesity.

CONCLUSION

Our study suggests that MUAC has the potential for surveillance of overweight/obesity and as a predictive tool to identify the elderly who will need further assessment of obesity and its associated comorbidities.

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