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Research article

Mid upper arm circumference as screening tool of overweight or obesity among adult employees of Mizan Tepi University, Southwest Ethiopia

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ABSTRACT

Background: Overweight or obesity is an excessive fat accumulation that impairs the health and wellbeing of the adult population throughout the world. Recently Mid upper arm circumference (MUAC) was suggested as a screening index for overweight or obesity among adolescents, but its utilization for the assessment of overweight or obesity in the adult population is not clear yet. In addition, little is known about the screening ability of MUAC for overweight or obesity in the adult population of Ethiopia. Therefore, this study aimed to evaluate the utility of MUAC for screening overweight or obesity among adult employees of Mizan Tepi University, Southwest Ethiopia.
Method: A Facility -based cross-sectional study was carried out from February 21 to March 20, 2020, at Mizan Tepi University. About 585 study participants were selected by gender-based stratified sampling technique. Anthropometric data like weight, height, and MUAC were collected. Pearson's correlation between MUAC, body mass index (BMI), and age was calculated to see a relationship between them. The Receiver operating characteristics (ROC) curve was calculated to identify the screening ability of MUAC for overweight or obesity. The appropriate MUAC cutoff point for both men and women established using the Youden index. Additionally, sensitivity, specificity, positive, and negative predictive values were calculated.
Result: The prevalence of overweight and obesity among the study participants was 18.1% and 4.8%, respectively. MUAC had a strong positive correlation with BMI, r = 0.65 (95% CI; 0.56–0.69). According to ROC analysis, MUAC is an excellent screening tool for male and female employees with excellent accuracy (AUC = 0.9 with 91.4% sensitivity and 76.4% specificity) and good accuracy (AUC = 0.83 with 67.2% sensitivity and 83.5% specificity), respectively. Based on the youden index, the cutoff point of MUAC to screen overweight or obesity among male and female employees was 26.91cm.
Conclusion: Mid-upper arm circumference (MUAC) has an equal ability with BMI to screen overweight or obesity among adults. Therefore, MUAC can be utilized as an alternative index to screen overweight and obesity in resource-limited setups.

1. Introduction

Overweight and obesity defined as abnormal or excessive fat accumulation that may impair the health of an individual. Obesity and overweight are preventable conditions that are becoming prevalent and have tripled since 1975. Globally, in 2016, overweight affected more than 1.9 billion adults, and obesity affected more than 650 million adult populations. Most peoples in the world reside in countries where overweight and obesity kills more peoples than underweight [1].

The prevalence of overweight and obesity in Africa is increasing, ranging from 3.5% in Eritrea to 64% in Seychelles among men and 3.7% in Ethiopia to 74% in Seychelles among women in 2010 (2). Those people who reside in an urban area of Africa are at risk of overweight and obesity than those living in rural areas. Globalization was responsible for an increased rate of obesity in the continent since it affects the food market. Nowadays, processed foods containing a larger amount of sugar, fat, and salt is being imported to Africa, which decreased the culture of consuming non-processed and healthy foods [2, 3, 4].

Pieces of evidence showed that obesity or overweight is the most common risk factor for hypertension, diabetes, and hypercholesterolemia in developing and developed nations. These will lead to morbidity, mortality, and reduced quality of life [2, 5, 6, 7, 8].

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Anthropometric measurements are the measurement of physiological and anatomical features of humans. Practically, it refers specifically to morphological traits which can be externally measured [9]. The body mass index (BMI) was indicated as the most commonly utilized index to show the link between the weight of an individual and his/her health status in the population [10]. Evidence indicates that, BMI is clinically important since it has a good correlation with total body fat and is a good predictor of cardiovascular-related morbidity and mortality [11, 12, 13, 14]. However, studies revealed BMI is not a reliable measure of body composition, especially in young and older adults. This is due to its inability to differentiate fat mass and fat-free mass. Therefore, it fails to recognize individuals which have high visceral fat deposits that put them a health risks [15, 16, 17]. It was stated that measurement of height and weight for BMI assessment were difficult to perform on patients who had a difficulty of standing [18]. Moreover, BMI requires relatively expensive equipment and it is less practical especially in resource-limited areas [19]. Due to this reason, identifying less expensive and more practical tool that can be used in alternative to BMI is very important [20].

MUAC (Mid upper arm circumference) is a simple and relatively inexpensive measurement to be utilized among adolescents and adults in clinical or field settings. In addition, MUAC only demands minimal equipment and doesn't need calculation compared to other anthropometric indices such as BMI and skin fold thickness. The utilization of MUAC enhances the capacity of health professionals to diagnose malnutrition by increasing the accessibility and quality of Community-Based Management of Acute Malnutrition (CMAM) services [21, 22]. MUAC can be used if BMI can't be calculated due to inaccurate height measurement or if correct weight measurement is affected by fluid retention in the body [23]. Previous studies showed there is a positive correlation between MUAC and BMI [18, 24, 25, 26].

Previous cross-sectional studies conducted in India, Poland, Turkish, Dutch, South Africa, and Ethiopia among children and adolescents revealed that MUAC has an excellent screening ability for screening overweight or obesity among adolescents of both sexes [20, 27, 28, 29, 30, 31, 32]. A cross-sectional study conducted among adolescents suggested that, the utility of MUAC for screening health risks should be explored in other age groups both in poor and affluent society [20]. Different studies conducted in China, India, and Sudan revealed that, MUAC is an effective alternative tool to predict overweight or obesity among the adult population [33, 34, 35]. In comparison to BMI, MUAC is inexpensive, easily measured, and doesn't require highly skilled professionals. MUAC is very important for early community-level detection of malnutrition, especially among women who don't have good access to the health facility in rural settings [33].

The utilization of MUAC for the assessment of undernutrition is well established, but its utilization for assessment of overweight or obesity in the adult population is not well known yet. In addition, population-specific, sex-specific, and age-specific cutoff points for MUAC are not well established [22, 27]. Similarly, little is known about the screening ability of MUAC for overweight or obesity in the adult population of Ethiopia. Therefore, this study aimed to evaluate the potential of MUAC to screen for overweight or obesity among adult employees of Mizan Tepi University, Southwest Ethiopia.

2. Methods

2.1. Study design, setting, and participants

The study was carried out at Mizan Tepi University, Southwest Ethiopia from February 21 to March 20, 2020. About 2478 people work in the university, of which 658 are hospital professionals, 1028 are administrative employees, and 792 are academic employees. On duty were about 544 employees, while among the academic personnel, 248 were on study leave.

2.2. Study design

A cross-sectional fascility-based study was carried out.

2.3. Population

All adult workers of the university were the source population, and randomly selected individuals were the study population of this study.

2.4. Inclusion criteria

The study only included those workers who were found in their place of employment at the time of data collection.

2.5. Exclusion criteria

Women who self-reported being pregnant and hypertensive patients were not included in the study.

2.6. Sample size determination and sampling technique

The sample size was calculated elsewhere using the sensitivity estimation formula [36]. It was calculated by considering 90.9% sensitivity, confidence interval of 95%, and margin of error (5%). The final sample size was 608. There are 2230 adult employees at Mizan Tepi University including, 544 academic, 1028 administrative staff, and 658 hospital staff. Employees were stratified by sex as 1299 males and 931 females. Then, using the allocation ratio, 354 men and 254 women were obtained from 608 samples. Then, the payroll received from the human resource management of the university was used to create a distinct sampling frame for males and females. Finally, using a computer-generated simple random sampling approach, random numbers were generated to choose participants.

2.7. Study procedure and measurement

Data were collected by 4 BSC nurses using a structured questionnaire, and one health officer supervised the process. Mid-upper arm circumference was measured by non-stretchable plastic tape at the midway between the acromial process and olecranon on the non-dominant hand. The arm flexed 90° from the elbow, and then the tape was placed around the mid point neither too tight nor too loose. The MUAC measurement was recorded to the nearest 0.1cm. A portable stadiometer (Seca) was used to measure the height with a precision of 0.1 cm. The stadiometer was examined using calibration rods before measurements. When taking measurements, subjects were requested to remove their shoes and stand at the Frankfurt plane such that their shoulder, buttocks, calf, heel, and back of the head were in contact with the stadiometer's vertical stand. Body weight was determined using a digital scale (UNICEF SECA) with 0.1 kg of precision. By weighing a known-weight object each morning, the scale's accuracy was verified. To determine BMI, body weight in kilograms was divided by height in meters square, with a cutoff of 25 kg/m^2 for both males and females [37]. Each anthropometric measurement was measured three times by the same measurer. The intraclass correlation coefficient was calculated for the repeated measurements of MUAC, height, and weight, and it was found to be excellent (ICC>0.94) [38]. Then the average of the three repeated measurements was taken for analysis. To define overweight/obesity, BMI $\geq$25 kg/m^2 was considered for both males and females [39]. A standardization exercise was done to reduce inter and intra-observer error. The four data collectors took a repeated measurement of MUAC, height, and weight of ten individuals. The first data collector measured the MUAC, height, and weight of a participant and recorded it on the data collection form. Then MUAC, height, and weight of a study participant were measured by the second, third, and fourth data collectors and each observer registered the data in separate forms. Then the second measurement was taken in the same process by all data collectors and they recorded it on another form. Then the relative technical error measurement (TEM) for intra and inter-observer reliability for each measurement was calculated and compared to the reference values. All relative TEMs of height, weight, and MUAC were within an acceptable range [40].

2.8. Statistical analysis

The data were checked for consistency and completeness and entered to Epi data version 3.1. The data then exported to SPSS version 22 and cleaned by correcting missing values and checking outliers. Kolmogrove-Smirnov test was done to check the normality of continuous variables and all of them were normally distributed (P-value>0.05). Descriptive analysis such as percentage, mean and standard deviation were calculated to show the characteristics of study participants. Pearson's correlation was conducted between age, BMI, and MUAC. The area under the curve (AUC) was calculated from the receiver operating characteristic curve (ROC) based on BMI as yes (BMI≥ 25 kg/m^2) and no (BMI< 25 kg/m^2). The AUC was interpreted based on predetermined criteria as excellent accuracy (0.9–1.0), good (0.8–0.9), fair (0.7–0.8), poor (0.6–0.7) and fail (0.5–0.6) [41]. The optimal cutoff point for MUAC was also developed based on the youden index. This study is reported per the STARD (Standards for Reporting Diagnostic accuracy studies) 2015 statement [42]. It has a 30-item checklist to give guidance for reporting diagnostic accuracy (Table 1 in supplementary text).

2.9. Data quality control

The questionnaire was pretested on 5 % (30) samples of similar study subject. Data collectors and supervisors were recruited based on their previous experience in data collection. And they received training and a standardization exercise for two days on interview techniques and measurement procedures. Each questionnaire was checked for completeness and consistency after completion of the data collection on daily basis. Double data entry validation was done using Epi data version 3.1.

2.10. Ethical consideration

The study was approved by ethical review board of Jimma University Institute of health (IRB00065/2020) and written permission letter was received from Mizan Tepi University. The participants signed written informed consent, and their privacy and confidentiality were kept. The participants were informed their right to withdraw from the interview at any time. In order to hinder the transmission of coronavirus, personal protective materials including gloves, face mask and sanitizer were distributed for data collectors. During the assessment, participants with higher BMI were linked to a nearby health facility for further diagnosis and treatment. Those study participants with higher BMI during the screening were sent to the nearby health facility.

3. Result

An aggregate of 585 employees participated in the study with a response rate of 96.3%. More than half, 333 (56.9%) of study participants were males, and the mean (±SD) of age, BMI, and MUAC of the study participants were 32.26 (6.60) years, 22.96 (3.24) Kg/m2, and 25.99 (2.60) cm, respectively (Table 1).

Table 1. Characteristics of the study participants stratified by sex at Mizan Tepi University Southwest Ethiopia (N = 585).

Variables	Male (n = 333)	Female	Total (n = 585)
	Mean (±SD)	Mean (±SD)	Mean (±SD)
Age (Year)	32.17 (6.69)	32.37 (6.48)	32.26 (6.60)
Weight (Kg)	64.16 (10.04)	59.57 (9.63)	62.18 (10.12)
Height (cm)	167.43 (7.69)	160.60 (6.68)	164.49 (8.01)
BMI	22.87 (3.11)	23.08 (3.40)	22.96 (3.24)
MUAC(cm)	26.12 (2.60)	25.82 (2.59)	25.99 (2.60)

3.1. Prevalence of overweight and obesity

The prevalence of overweight and obesity among our study participants were 106 (18.1%) and 28 (4.8%), respectively. About 56 (16.8%) and 14 (4.2%) male employees were overweight and obese, respectively. About 19.8 % (50) of female participants were overweight, and 145.6 % (14) of them were obese (Figure 1).

3.2. Correlation between MUAC, BMI and age

In this study, MAUC had a strong positive correlation with BMI, r = 0.65 (95% CI; 0.56–0.69, p < 0.001). But MAUC had a moderate positive correlation with the age of the employees = 0.27 (95% CI; 0.19–0.35, p < 0.001).

3.3. ROC curve of MUAC to screen overweight and obesity

Among male employees, MUAC had an excellent predictive ability for overweight or obesity with an AUC of 0.90 (95% CI; 0.86–0.93) (Figure 2). Similarly, MUAC had a good discriminatory ability for overweight or obesity among female employees with an AUC of 0.83 (95% CI; 0.77–0.89) (Figure 3). We have also developed the optimal cutoff point for MUAC to screen overweight or obesity for both sexes considering youden index (sensitivity + specificity – 1). Among males, the developed optimal cutoff point of MUAC to screen overweight or obesity was 26.91cm with maximum sensitivity and specificity of 91.4% and 76.4%, respectively. A similar optimal cutoff point (26.91cm) was developed for MUAC to screen for overweight or obesity among female employees with maximum sensitivity and specificity of 67.2% and 83.5%, respectively (Table 2).

4. Discussion

This is the first study that evaluated the utility of MUAC for overweight or obesity among both the male and female populations of Ethiopia. In this study, the discriminatory ability of MUAC for overweight or obesity among adult employees of Mizan Tepi University was evaluated. In the meantime, the prevalence of overweight and obesity in the study area was also assessed. The prevalence of overweight and obesity was 18.1% and 4.8%, respectively.

Our study revealed that MAUC has a strong positive correlation with BMI, which is indicative of MUAC screening capacity for overweight and obesity in adults. Previous similar studies affirmed that MUAC has a strong positive correlation with BMI [21, 28, 32, 43, 44, 45, 46, 47, 48, 49, 50]. This strong positive correlation between MUAC and BMI suggests that these indices could give us comparable measurements while being utilized to assess the nutritional status of the adult population. MUAC had a moderate positive correlation with the age of the employees. A similar finding was observed in the study conducted among adolescents in Addis Ababa [32].

In this study, MUAC has excellent screening ability for screening overweight or obesity among adults against BMI. In males, MUAC has an excellent predictive ability for overweight or obesity with excellent accuracy (AUC = 0.90). Similarly, MUAC has good discriminatory ability with an AUC of 0.83 for overweight and obesity among females. These findings are supported by previous studies conducted in China, India, Japan, Tanzania and Mozambique, South Africa, and Juba which revealed that MUAC is an effective alternative tool to predict overweight or obesity among the adult population [34, 35, 47, 49, 50, 51]. The study

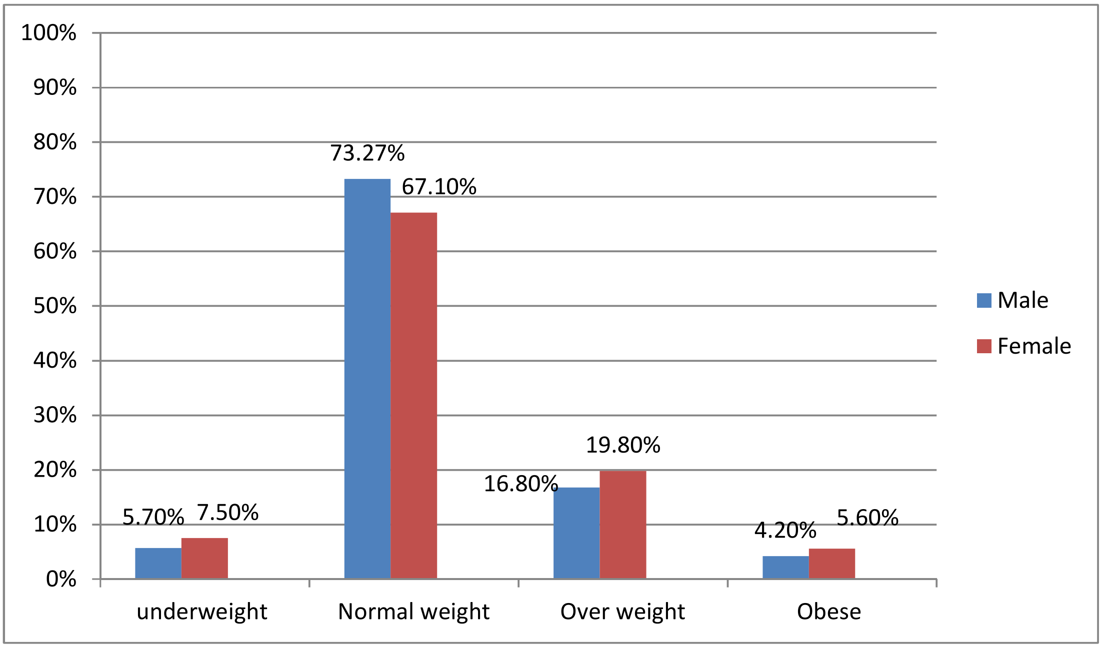

Figure 1. Nutritional status of study participants at Mizan Tepi University, Southwest Ethiopia, 2020.

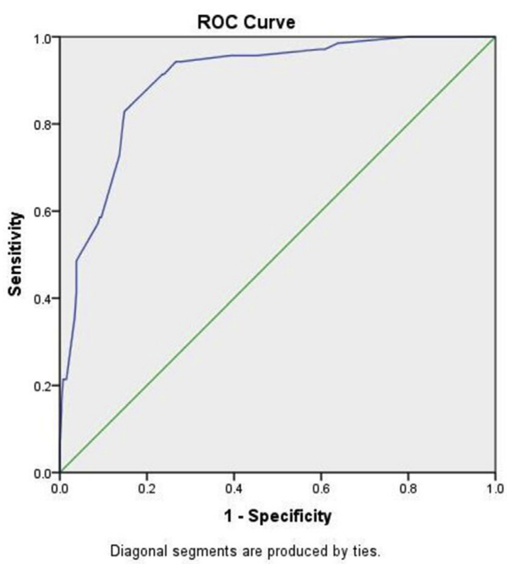

Figure 2. ROC curve for MUAC among male study participants at Mizan Tepi University, Southwest Ethiopia, 2020.

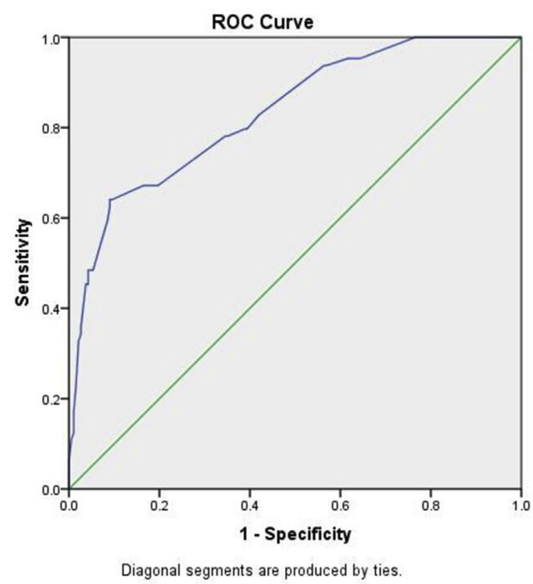

Figure 3. ROC curve for MUAC among female study participants at Mizan Tepi University, Southwest Ethiopia, 2020.

conducted in Japan stated that MUAC is a cheap and easily measurable tool to assess overweight or obesity than BMI [51]. The screening ability of MUAC could be due to the fact that MUAC has a positive strong correlation with arm fat mass and total fat mass [51, 52] and it also used to assess subcutaneous fat accumulation [53].

Utilizing MUAC has advantages, it is inexpensive, measurement can be easily done in the field and it can be done using only a tape meter [32]. Evidence suggests that it can be utilized alternatively for the assessment of body weight measurements in resource-limited settings in a situation where there is an imprecise measurement of weight or if weight cannot be measured. It was indicated that utilization of MUAC could improve the accuracy of weight-based nutritional assessment in resource-limited settings [27]. Increased MUAC is also indicative of the presence of metabolic syndromes and risk of mortality in adults [53, 54].

The developed optimal cutoff point of MUAC to screen overweight or obesity among males was 26.91cm with maximum sensitivity and specificity of 91.4% and 76.4%, respectively. Likewise, the optimal cutoff point developed for MUAC to screen overweight or obesity in females was 26.91cm with maximum sensitivity and specificity of 67.2% and 83.5%, respectively. A previous study conducted in South Africa developed a higher optimal cutoff point than our cutoff point to screen for overweight/obesity in adults, which is $>$ 29 for males and $>$28 for females [50]. This discrepancy could be due difference in body frame of Ethiopians and other blacks [55].

The following limitation should be considered while interpreting the result of our study. One of our limitations is that we haven't considered the gold standard techniques to assess the percentage of body fat due to the absence of this equipment in our setup. We have utilized BMI, which

Table 2. The area under the curve (AUC), sensitivity, specificity, youden index, positive and negative predictive values of MUAC among the study participants at Mizan Tepi University, Southwest Ethiopia 2020.

Antropo-metric index	Sex	AUC (95% CI)	Optimal cut-off	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Youden Index (J)
MUAC	Male	0.90 (0.86–0.93)	26.91cm	91.4	76.4	50.8	97.1	0.68
	Female	0.83 (0.77–0.89)	26.91cm	67.2	83.5	58.1	88.2	0.51

is a common index to assess nutritional status in adults, but it may fail to differentiate the fat mass and fat-free mass. In addition, we have developed a single optimal cut-off point for MUAC to screen both overweight/obesity, even though obesity is more correlated with health risks than overweight.

5. Conclusion

Our study indicated that mid-upper arm circumference (MUAC) had equal accuracy with BMI to screen overweight or obesity among the adult population. The optimal cutoff point was also developed for males (26.91cm) and females (26.91cm). Therefore, MUAC can be utilized as an alternative index to screen overweight or obesity in adults living in resource-limited setups.

Declarations

Author contribution statement

Rahel Dereje: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Abel Girma: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Abebaw Molla: Analyzed and interpreted the data.

Asnake Simieneh: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

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