Original Article

Association between mid-upper arm circumference and body mass index in pregnant women to assess their nutritional status

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Abstract

Background: Underweight/ Undernourished is a state when the body mass index (BMI) falls below 18.5 kg/m2 and as per National Family and Health Survey-4, 22.9% of women in the reproductive age group fall into this category. Despite being considered as an important anthropometry marker, it is not measured in most of the healthcare facilities across India due to lack of basic amenities and resources. In such instances, how helpful other indicators like mid-upper arm circumference (MUAC) can be to measure the undernourished status of pregnant needs to be determined. **Objectives:** To estimate the prevalence of undernutrition in pregnant women (PW) based on baseline BMI and MUAC and to determine the association between them. **Materials and Methods:** A cross-sectional study was conducted in Tangi Block of Odisha among 440 PW (in the first trimester) from July 2018 to November 2018 using a pre-tested, validated questionnaire and anthropometric instruments. **Results:** PW having BMI <18.5 kg/m2 were found to be 16.6% and having MUAC <23.5 cm were 19.5%. A significant association was found between BMI and MUAC [aOR 7.91 (4.27–14.65)]. Also, a moderate correlation was established between the indicators (r = 0.57). **Conclusion:** MUAC can be used instead of BMI as it is easier to measure, cheaper, does not require any training or calculations, and insensitive to changes during the period of gestation unlike BMI. This can be beneficial to the healthcare workers at primary level who are in resource-limited settings.

Keywords: Anthropometry, body mass index, maternal health, maternal nutrition, mid-upper arm circumference, pregnant women, undernutrition

Introduction

Nutritional requirement of a women in pregnancy increases due to the needs of growing fetus as well as to maintain the physiological changes associated during the phase.[1] Previous studies have related nutritional status during pregnancy with higher incidence of pregnancy/birth-related complications.[2-4] As per World Health Organization (WHO), body mass index (BMI) less than 18.5 kg/m^2 is categorized as underweight.[5] National Family and Health Survey-4 (NFHS-4) using the same classification has reported the proportion of underweight women in reproductive age group (15–49 years) to be 22.9% in India and 26.4% in Odisha.[6-9] Measurement of BMI requires a weighing scale, a stadiometer, and calculation of the formula (weight/height^2). A recent study conducted by the Ministry of Women and Child Development, Government of India, found that only 51.6% Anganwadi centers (AWCs) have functional adult weighing scales indicating constraint in the availability of those at the periphery level in India. This reflects that most of the weights are not recorded during pregnancy and evidence on measurement of height of pregnant women (PW) is also lacking. Hence, BMI despite being considered as a marker for underweight is not measured in most of the healthcare facilities across India.[10] In such instances, mid-upper arm circumference (MUAC) can

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be used as a means to measure the undernourished status of PW as it is easy to use, convenient, and less costly.[11-13] It is also scale-independent and can be used in different health programs for maternal health.[14] The study was conducted with the objective to find out whether any one of the two indicators (BMI and MUAC) can provide the undernourished status of PW, whether there is any association between them, and whether they can serve as an indicator to predict maternal undernutrition in the absence/failure of other. In this background, this study aims to estimate the prevalence of undernutrition in PW based on MUAC and baseline BMI and to determine the association between BMI and MUAC.

Materials and Methods

A cross-sectional study was conducted in Tangi Block of Khordha district of Odisha, India, from July 2018 to November 2018. The district of Khordha is located in the eastern part of the state of Odisha. As per census 2011, the total population of Khordha district was 2,251,673 with urban population of 1,084,316 and rural of 1,167,357. Tangi Block is one of the 10 blocks under Khordha district that has a population of 167,561. The study was conducted in six sectors under it, namely, Tangi, Bhusandapur, Kuhudi, Badapokharia, Olasingh, and Nirakarpur. The study participants consisted of the PW in first trimester. Due to the absence of many studies on maternal undernutrition, the prevalence of underweight PW was taken to be 50%. The sample size was calculated to be 385 within 5 percentage points of the true value with 95% confidence interval (CI). Considering an attrition rate of 10%, the final sample size was calculated to be 428. A line-listing of all PW in the first trimester registered in each subcenter was obtained with the help of frontline workers [Multi-Purpose Health Workers (MPHW) and Accredited Social Health Activist (ASHA)] of all 24 subcenters. Data collection was done 4 days a week at the Community Health Centre (CHC), Tangi OPD. PW who did not turn up to CHC Tangi were tried to be recruited through Village Health and Nutrition Day (VHND) sessions and at Immunization points. Participants who could not be approached even through VHND sessions/Immunization points were contacted again through personal house visits with the help of ASHA of that subcenter. This process was then continued in all subcenters of Tangi Block till the sample size was achieved. In the visit, the weight, height, and MUAC were measured. Apart from these measurements, all the other details such as sociodemographic details, morbidity profile, and obstetric history were taken. Statistical analysis was done using SPSS Version 20.0. Descriptive statistics were applied and the reported proportion was with 95% CI or mean ± standard deviation, wherever applicable.

Results

The study conducted in Tangi Block of Odisha had a total of 440 participants who were in the first trimester of their pregnancy (within 12 weeks of pregnancy) recruited in the first visit distributed over all the 24 subcenters of Tangi Block. The mean weeks of pregnancy of the PW during recruitment were 10.41 ± 1.48 weeks.

More than half of the participants, that is, 260 (59.1%), were 20–25 years old and 41 (9.3%) of them had teenage pregnancy. Majority of the participants, (73.6%), had higher secondary education and above and almost all of them were home-makers. About 65% of the participants had an extended type of family and most of them (71.6%) belonged to lower middle class family as obtained by the Udai Pareekh scale [Table 1].

As depicted in Table 2, the mean age of attaining menarche among the study participants was 11.7 ± 0.6 years and the mean age of marriage was 20.4 ± 2.3 years. Nearly 79.3% of the pregnancies were unplanned, of which 47% were primigravida. Among the multigravid women (53%), 40.3% had their pregnancy within 1–2 years of last childbirth. The morbidity profile of the study participants was insignificant, though only 4.1% reported thyroid disorders. The distribution of weight of the PW was found to be highest in the range of 40–49.9 kg (47.9%) and more than half of them (60%) had a height between 145 and 154.9 cm. Nearly half of them (54.3%) had BMI between 18.5 and22.9 kg/m^2. The mean MUAC was found to be 25.93 ± 2.76 cm. Taking a cut-off of MUAC as 23.5 cm, 19.5% (15.8%–23.3%) of the participants were found to be underweight as described in Table 3.

Table 1: Distribution of study participants by sociodemographic details (*n*=440)

Characteristics	*n* (%)
Age of participants (in years)	
≤19	41 (9.3)
20-25	260 (59.1)
26-30	116 (26.4)
>30	23 (5.2)
Mean age (in years)	24.03±3.89
Education	
Primary	62 (14.1)
Middle	55 (12.5)
Higher secondary	280 (63.6)
Senior secondary	28 (6.4)
Graduate and above	15 (3.4)
Mean years of completed schooling	8.8±2.7
Occupation of the participants	
Home-maker	437 (99.3)
Self-employed	3 (0.7)
Decision-maker of the family in relation to study participants	
Father-in-law	311 (70.7)
Mother-in-law	62 (14.1)
Husband	60 (13.6)
Any elder member	7 (1.6)
Type of family	
Extended	286 (65.0)
Nuclear	154 (35.0)
Socioeconomic status (Udai Pareekh scale)	
Lower middle	315 (71.6)
Middle	122 (27.7)
Upper middle	3 (0.7)

A significant association was found between maternal baseline BMI and MUAC (χ^2 = 74.63, P < 0.001), weight at recruitment (χ^2 = 58.80, P < 0.001), and height at recruitment (P = 0.02) [Table 4], though, as shown in Table 5, the association was significant only with weight at recruitment when MUAC was considered. (χ^2 = 17.75, P < 0.001).

Using a multivariate regression model and adjusting for potential confounders (P < 0.2) associated with BMI (weight at recruitment, height at recruitment, gravid status), the odds of having BMI < 18.5 kg/m^2 with PW having MUAC <23.5 cm was found to be 7.91 (4.27–14.65); P < 0.001.

A moderate positive correlation was found between baseline BMI and MUAC with (r = 0.57, P < 0.001). The correlation equation was found to be y = 0.413x + 16.92, y being the dependent variable – MUAC – and x being the independent variable – BMI [Figure 1].

Discussion

Maternal undernutrition is a growing concern in various low-income and middle-income countries like India.[15] In this study, the total number of PW recruited were 440 at an average of 10.41 weeks of pregnancy. The delay in recruitment might be due to the delay in confirmation of pregnancy. This might be attributed to the fact that PW usually delay in seeking healthcare because they are not the decision-makers in the family as reported in this study. The sociodemographic findings of this study are similar to a study done by Patel *et al.* in rural Maharashtra.[16]

Furthermore, the anthropometric findings of this study such as the height, mean weight, and BMI of the PW were similar to the findings of a study in rural Sri Lanka by Adhikari *et al.*[1] The findings are representative of the general population mean as provided by NFHS-4 suggesting that the study population had similar characteristics to the general population.[6,7]

The prevalence of undernutrition (BMI <18.5 kg/m^2) in this study was found to be 16.6% similar to various international studies.[17-19] However, as per a study conducted by Patel, *et al.* in rural Maharashtra, the prevalence (BMI <18 kg/m^2) was 33.3%.[16] This might be due to a cluster sampling method used in the study in a hospital setting. According to NFHS-4, the prevalence of undernutrition among women in the reproductive age group was 22.9% and 28.4% in rural areas in India and Odisha, respectively.[6,7] However in NFHS-4, 18–49 years were considered as women in the reproductive age group and the time of recruitment is not specified resulting in the difference in prevalence of undernutrition. There have been no similar studies in Odisha till date that reflects upon the undernutrition status of PW based on BMI.

The prevalence of undernutrition among PW based on MUAC <23.5 cm was found to be 19.8%. Under Swabhimaan Programme, Odisha, in Pallahara Block of Angul District, the prevalence of MUAC <23 cm was found to be 45.9%.[20] Under the same programme in Koraput Block of Koraput District, the prevalence of MUAC <23 cm was found to be 24.6%.[21] The results are variable in both the projects and differ from this study which might be accounted to the difference in geographical regions, as those may act as a significant factor in affecting

Table 2: Distribution of study participants by obstetric history (*n*=440)

Characteristics	*n* (%)
Mean age at menarche (in years)	11.7±0.6
Mean age at marriage (in years)	20.4±2.3
Consanguineous marriage	
No	435 (98.9)
Yes	5 (1.1)
Planned pregnancy	
No	349 (79.3)
Yes	91 (20.7)
Gravida	
1	207 (47.0)
2	186 (42.3)
≥3	47 (10.7)
Last pregnancy (n=233)	
Within 1 year	4 (1.7)
1-2 years	94 (40.3)
2-3 years	57 (24.5)
>3 years	78 (33.5)

Table 3: Distribution of study participants by anthropometric measurements in the first trimester (*n*=440)

Characteristics	*n* (%)
Weight (in kg)	
<40	25 (5.7)
40-49.9	211 (47.9)
50-59.9	128 (29.1)
≥60	76 (17.3)
Mean weight (in kg)	50.7±9.15
Height (in cm)	
<145	33 (7.5)
145-154.9	264 (60)
≥155	143 (32.5)
Mean height (in cm)	152.5±5.15
BMI (in kg/m^2) (Asian Criteria)	
<18.5 (underweight)	73 (16.6)
18.5-22.9 (normal)	239 (54.3)
23-24.9 (overweight)	36 (8.3)
25-29.9 (preobese)	79 (17.9)
≥30 (obese)	13 (2.9)
Mean BMI (in kg/m^2)	21.81±3.87
MUAC (in cm)	
<23.5	86 (19.5)
23.5-24.9	87 (19.8)
25-27.9	173 (39.3)
28-29.9	55 (12.5)
≥30	39 (8.9)
Mean MUAC (in cm)	25.93±2.76

Table 4: Association between baseline BMI and other maternal characteristics (*n*=440)

	Category	No. of participants, *n* (%)	BMI (kg/m^2)		Chi-square	*P*
			<18.5	≥18.5		
Maternal MUAC (in cm)	<23.5	86 (19.5)	41 (47.6)	45(52.4)	74.63	**<0.001***
	≥23.5	354 (80.5)	32 (9.0)	322(91.0)		
Weight (in kg)	<40	25 (5.7)	18 (72.0)	7 (28.0)	58.80	**<0.001***
	≥40	415 (94.3)	55 (13.2)	360 (86.8)		
Height (in cm)	<145	33 (7.5)	1 (3.1)	32 (96.9)		**0.02****
	≥145	407 (92.5)	72 (17.7)	335 (82.3)		
Maternal age (in years)	≤19	41 (9.3)	4 (9.7)	37 (90.3)	3.95	0.26
	20-25	260 (59.1)	47 (18.1)	213 (81.9)		
	26-30	116 (26.4)	16 (13.8)	100 (86.2)		
	>30	23 (5.2)	6 (26.1)	17 (73.9)		
SES	Upper†	125 (28.4)	19 (15.2)	106(84.8)	0.24	0.62
	Lower‡	315 (71.6)	54 (17.1)	261(82.9)		
Gravida	1	207 (47.0)	42 (20.2)	165 (79.8)	4.45	0.10
	2	186 (42.3)	23 (12.3)	163 (87.7)		
	≥3	47 (10.7)	8 (17.1)	39 (82.9)		
Last pregnancy (in years) (*n*=233)	No	424 (96.6)	68 (16.1)	356 (83.9)	1.18	0.55
	<2	98 (42.0)	11 (11.2)	87 (88.8)		
	2-3	57 (24.5)	7 (12.2)	50 (87.8)		
	>3	78 (33.5)	13 (16.7)	65 (83.3)		

†Upper SES includes upper, upper middle, and middle SES. ‡Lower SES includes lower middle and lower SES. **Fisher's exact test

Table 5: Association between baseline MUAC and other maternal characteristics (*n*=440)

	Category	No. of participants, *n* (%)	MUAC (cm)		Chi-square	*P*
			<23.5	≥23.5		
Maternal BMI (in kg/m^2)	<18.5	73 (16.5)	41 (56.1)	32 (43.9)	74.63	**<0.001***
	≥18.5	367 (83.5)	45 (12.2)	322 (87.8)		
Weight (in kg)	<40	25 (5.7)	13 (52.0)	12 (48.0)	17.75	**<0.001***
	≥40	415 (94.3)	73 (17.6)	342 (82.4)		
Height (in cm)	<145	33 (7.5)	4 (12.1)	29 (87.9)		0.36**
	≥145	407 (92.5)	82 (20.1)	325 (79.9)		
Maternal age (in years)	≤19	41 (9.3)	11 (26.8)	30 (73.2)	3.12	0.37
	20-25	260 (59.1)	50 (19.2)	210 (80.8)		
	26-30	116 (26.4)	23 (19.8)	93 (80.2)		
	>30	23 (5.2)	2 (8.7)	21 (91.3)		
SES	Upper†	125 (28.4)	19 (15.2)	106 (84.8)	2.09	0.14
	Lower‡	315 (71.6)	67 (21.3)	248 (78.7)		
Gravida	1	207 (47.0)	45 (21.7)	162 (78.3)	1.47	0.48
	2	186 (42.3)	34 (18.2)	152 (81.8)		
	≥3	47 (10.7)	7 (14.8)	40 (85.2)		
Last pregnancy (in years) (*n*=233)	<2	98 (42.0)	19 (19.3)	79 (80.7)	1.47	0.47
	2-3	57 (24.5)	7 (12.3)	50 (87.7)		
	>3	78 (33.5)	15 (19.2)	63 (80.8)		

†Upper SES includes upper, upper middle, and middle SES. ‡Lower SES includes lower middle and lower SES. **Fisher's exact test

maternal health as given in a demographic and health survey by Dahlui *et al.*[22] However, similar findings were derived from studies by Karim *et al.* (Bangladesh), Kalanda *et al.* (Malawi), and Ojha *et al.* (Nepal).[23-25] Studies regarding the prevalence of undernutrition based on MUAC were limited.

A significant association [(OR) =7.91, (4.27-14.65); $P < 0.001$] was found in this study between maternal BMI and MUAC. This is supported in the study conducted by Kumar *et al.* where non-PW were considered as the study participants with correlation coefficient of $r = 0.860$ ((0.831-0.883); $P < 0{\cdot}001$) and Das *et al.* who also found a significant positive correlation between BMI and MUAC ($r = 0.81$, $P < 0.0001$).[12,26] Elshiby *et al.* had also in their study observed that social class did not affect the BMI.[27] However, in some studies it has been reported that BMI is significantly associated with age, gravid status, and disease conditions.[28-30] Low SES and illiteracy might affect the health-seeking behavior leading to poor nutrition of the PW as reported by Agrawal *et al.* and Nair *et al.*[31,32]

A moderate correlation was also found out between BMI and MUAC. As per current practices, BMI is taken as a measure to

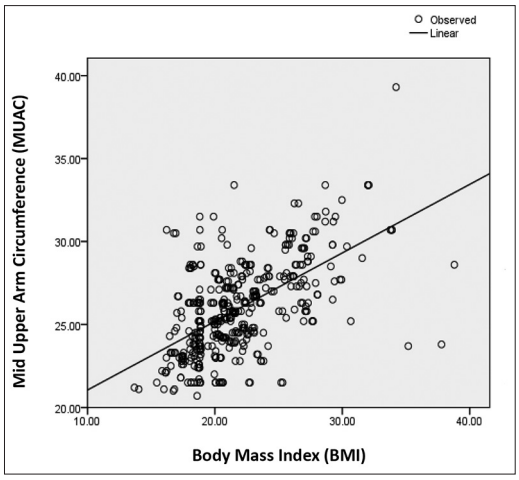

Figure 1: Graph showing correlation between MUAC and BMI. X-axis: Body Mass Index (BMI), Y-axis: Mid Upper Arm Circumference (MUAC); $r = 0.57$; $R^2 = 0.334$; $p < 0.001$; [y = 0.413x + 16.92; 0.413 is the slope and 16.92 is the y-intercept (i.e., the value of y when x = 0)]; r = correlation coefficient; R^2 – coefficient of determination

determine undernutrition in pregnancy. This study suggests that MUAC can be replaced as a marker to determine undernutrition, as it is an easier and convenient method independent to the changes during the period of gestation with lesser cost, easy to carry in field settings, and does not require many instruments or any expertise, training, or calculations as also supported by Das *et al.*[26] [Appendix 1]

Strengths of the study

- The study is a first of its kind in predicting the underweight/undernutrition status of PW on the basis of MUAC.
- The study is a first of its kind in predicting the association between BMI and MUAC.
- The measurement of various anthropometric indicators has been done directly by the researcher and the reliability of measurements was verified by measuring each of the variables such as weight, height, and MUAC twice.
- There was no interobserver bias.

Limitations of the study

- The distribution of the study participants was not uniform across all the six sectors.

Conclusion

This study was done among 440 PW, and the prevalence of undernutrition based on BMI (< 18.5 kg/m^2) and MUAC (<23.5 cm) was estimated to be 16.6% and 19.8%, respectively. MUAC was significantly associated with BMI even after adjusting for potential confounders. MUAC also showed a positive correlation with BMI with a correlation coefficient of 0.57. Thus, it is evident from the results that MUAC can be used instead of BMI in resource-limited field settings where functional weighing scales and stadiometers are not available. It is easy to measure and does not require any training or complex calculations. Moreover, no specific equipment is required except a simple and easy-to-use measuring tape to measure MUAC. It is less costly and can be used anytime during pregnancy. It is also insensitive to the changes during the period of gestation unlike BMI. This will be beneficial to the healthcare workers at primary level who are not able to assess the nutritional status of PW accurately and many cases go unnoticed which might lead to deterioration in the health of the baby.

Ethical statement

Ethical approval was taken from Institutional Ethics Committee (IEC) of the All India Institute of Medical Sciences, Bhubaneswar and informed written consent was taken from the participants.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Appendix 1: Differences between BMI and MUAC

Sl. No.	Characteristics	BMI	MUAC
1.	Instruments used	• Weighing Machine • Stadiometer	Measuring Tape
2.	Dependent on	• Weight • Height	Muscle mass
3.	Reflects body composition of pregnant woman	Only during pre-pregnancy/1st trimester	Anytime during pregnancy
4.	Ease of doing	Requires measurement of two variables and calculation	Measured anywhere
5.	Cost	Moderate	Low
6.	Problem in measurement	Non-functional weighing scales	Wrong placing and pressure
7.	Disease conditions affecting	• Edema • Weight loss	Severe weight loss affecting muscles