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Original Research Article

Comparison between body mass index and mid upper arm circumference for classifying nutritional status of pregnant women: a prospective cohort study

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ABSTRACT

Background: BMI is used to assess nutritional status of pregnant women however weight gain during pregnancy confounds the nutritional status later in pregnancy. Unlike weight, MUAC does not undergo significant change as the pregnancy advances. We aim to compare the changes in BMI and MUAC in pregnant women over various trimesters to assess whether change in MUAC is less compared to weight.
Methods: In this prospective observations study, BMI and MUAC measurements were taken of 300 pregnant women during different trimesters. Chi-square tests were conducted to assess associations between socio-demographic indicators and nutritional status. Correlation coefficients were calculated between BMI and MUAC over three trimesters. ANOVA tests were conducted on BMI and MUAC to assess their respective mean differences over three trimesters.
Results: Mean difference of 0.43 cm (3.2%) was noted in MUAC compared to 5.32 kg/m^2 (23.14%) in BMI from first to third trimester. No significant differences were observed in mean MUACs between first and second ($p=0.326$) and second and third trimesters ($p=0.143$) but, it was significantly different between first and third trimesters ($p=0.003$). Significant differences were observed in mean BMIs between first and second ($p=0.05$), second and third ($p<0.001$) and first and third trimesters ($p<0.001$). Correlation between BMI and MUAC were positive and significant in all three trimesters.
Conclusions: Positive correlations were found between BMI and MUAC. Less change was observed in MUAC than BMI over three trimesters. MUAC seems to be a reliable tool for assessing nutritional status of antenatal women.

Keywords: BMI, MUAC, Pregnant women, Malnutrition

INTRODUCTION

Maternal malnutrition has three aspects; over nutrition, under nutrition and micronutrient deficiencies. Maternal under nutrition and anemia influence fetal growth adversely and increase the risk of perinatal and maternal mortality.[1] At present 23% of women of reproductive age suffer from low body mass index (BMI) (<18.5 Kg/m^2).[2]

On the other hand, maternal over nutrition and obesity in India have significantly increased from 2005 through 2016 as evident by National Family Health Survey (NFHS) 3 and 4 data. According to NFHS 4 (2015-2016), 20.7% adult women had a BMI>25 kg/m^2.[2] Hence, India is faced with a dual burden of malnutrition.

Obesity during pregnancy is associated with increased risk of gestational diabetes, hypertensive disorders, spontaneous abortion, increased caesarean sections, venous thromboembolism, post-partum hemorrhage and sepsis in the mother and associated macrosomia, fetal growth restriction and iatrogenic prematurity in the new-born.[3]

Over the past few years, many guidelines have been introduced by the Ministry of Health and Family Welfare (MoHFW), Government of India (GoI) to address the nutritional problems in pregnant women including revised strategy for micronutrient supplementation of folic acid, calcium and deworming and management of severe anemia. MoHFW, GoI includes severe anemia and low pregnancy weight gain as one of the criteria for high-risk pregnancies.

BMI has been used as the gold standard to classify nutritional status of pregnant women, which should ideally be calculated by pre-pregnancy weight. However, many women belonging to poor socio-economic status and from areas where access to medical facilities are not available, register late in pregnancy due to which the pre-pregnancy or early pregnancy weight is not available. Furthermore, pregnancy associated weight gain and pedal edema decreases reliability of BMI to assess nutritional status in advanced pregnancy. Hence, accurate assessment of nutrition based on BMI in these women is not possible.

There is a need for other reliable tools, for assessing the nutritional status of women who seek ante-natal care for the first time in advanced pregnancy. Mid upper arm circumference (MUAC) has been used as an effective tool for assessment of malnutrition in infants and children. MUAC is gradually being recognised as an effective tool for identification of wasting among pregnant women.

Studies from South Africa have compared MUAC and BMI for maternal nutrition and concluded that MUAC does not change significantly during pregnancy unlike BMI. However, there is paucity of evidence in Indian population assessing the effectiveness of MUAC as a marker of maternal malnutrition during pregnancy. Moreover, classification of malnutrition based on BMI is different in Asian population.[4] Hence the validity of studies tested in non-Asian population needs to be further tested in Asian population. This study evaluates MUAC as marker for assessment of maternal nutrition.

METHODS

The prospective observational study was conducted between November 2018 to March 2020 in antenatal Outpatient Department (OPD) of Obstetrics and Gynaecology at Lady Hardinge Medical College, Smt Sucheta Kriplani Hospital, New Delhi. Diagnosed cases of multiple fetal gestation were excluded. The study was initiated after obtaining ethical clearance from the Ethics Committee of Human Research (ECHR) and participants were recruited after taking a written informed consent. Three hundred antenatal women were participated in this study. At their first antenatal visit detailed history including dietary and socioeconomic history was taken and filled in a predesigned performa. Detailed dietary history was taken by 24-hour recall method and deviation from normal was calculated after taking into account the level of physical activity.[5] Women were classified into various socioeconomic status by using modified Kuppuswamy scale.[6]

The nutritional status of all pregnant women was classified in first trimester between 8-12 weeks based on BMI using the Asian classification and MUAC using the guidelines developed by United Republic of Tanzania and Fanta, 2016.[4,7] These measurements were repeated at 20-24 weeks and at 32-36 weeks. Chi-square tests were conducted to assess associations between socio-demographic indicators and nutritional status of pregnant women.

Differences in mean BMIs and MUACs over the three trimesters were assessed using analysis of variance (ANOVA) to find if differences were statistically significant. Tukey test was applied to assess mean difference separately between first and second trimester, second and third trimester and first and third trimester. Correlation coefficients were calculated between first trimester BMI and MUAC over three trimesters. Since the two variables increase in nonlinear manner, spearman correlation coefficient was calculated.

Statistical analysis was performed using Statistical package for social sciences (SPSS) software for windows version 22.

RESULTS

The age of the pregnant women participated in the study was between 18-44 years with the mean age of 25.96 year±3 SD. Majority (80.0%) of the study participants were from the age group of 21-30 years. Age-groups did not show any significant associations with nutritional status of pregnant women (p=0.91). It was found that 34.3% women were educated till middle school and 42.9% completed education of high school and above. 12.3% women were found uneducated. It was observed that the normal nutritional status was less (34.7%) in the uneducated group compared to 42.9% in the group who completed high school and above education.

Table 1: Socio-demographic profile of the study participants and their nutritional status using their first trimester BMI.

Parameters	Categories	N (%)	Normal; n(%)	Overweight; n(%)	Underweight; n(%)	Chi-square test
Age (in years)	Upto 20	28 (9.3)	10 (35.7)	14 (50.0)	4 (14.3)	0.98, p=0.91
	21-30	240 (80.0)	100 (41.7)	110 (45.8)	30 (12.5)	
	More than 30	32 (10.7)	11 (34.4)	17 (53.1)	4 (12.5)	
Education	Uneducated	37 (12.3)	14 (37.8)	19 (51.4)	4 (10.8)	7.94; p=0.24
	Primary School	31 (10.3)	13 (41.9)	13 (41.9)	5 (16.1)	
	Middle School	103 (34.3)	35 (34.0)	49 (47.6)	19 (18.4)	
	High school and above	129 (42.9)	59 (45.7)	60 (46.5)	19 (18.4)	
Socio-Economic Status	Lower	27 (9.0)	15 (55.6)	10 (37.0)	2 (7.4)	6.75; p=0.56
	Upper lower	89 (29.7)	34 (38.2)	42 (47.2)	13 (14.6)	
	Lower middle	106 (35.3)	39 (36.8)	54 (50.9)	13 (12.3)	
	Upper lower	75 (25.0)	31 (41.3)	35 (46.7)	9 (12.0)	
	Upper	3 (1.0)	2 (66.7)	0 (0.0)	1 (33.3)	

Table 2: Mean BMI across different trimesters.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
First trimester	300	22.92	3.84	0.22	22.48	23.35
Second trimester	300	24.48	3.83	0.22	24.05	24.92
Third trimester	300	28.24	13.39	0.77	26.72	29.76

Table 3: ANOVA test of BMIs over three trimesters.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4485.64	2	2242.82	32.23	.000
Within Groups	62417.17	897	69.58		
Total	66902.80	899			
Multiple Comparisons					
Dependent Variable: BMI; Tukey HSD					
(I) BMI	(J) BMI	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval
First trimester	Second Trimester	-1.56	0.68	.057	-3.16 to 0.03
	Third Trimester	-5.32*	0.68	.000	-6.92 to -3.72
Second trimester	First Trimester	1.56	0.68	.057	-0.03 to 3.16
	Third Trimester	-3.76*	0.68	.000	-5.35 to -2.16
Third trimester	First Trimester	5.32*	0.68	.000	3.72 to 6.92
	Second Trimester	3.76*	0.68	.000	2.16 to 5.35

Table 4: Mean MUAC across different trimesters.

	N	Mean	Std. Deviation	SE	95% CI for Mean	
					Lower Bound	Upper Bound
First trimester	300	24.26	3.09	0.18	23.90	24.61
Second trimester	300	24.61	3.03	0.18	24.27	24.96
Third trimester	300	25.08	3.07	0.18	24.74	25.43

Table 5: ANOVA test of MUACs over three trimesters.

	Sum of Squares	df	Mean Square	F	Sig.	
Between groups	103.83	2	51.91	5.533	.004	
Within groups	8415.49	897	9.38			
Total	8519.31	899				
Multiple comparisons						
Dependent Variable: MUAC; Tukey HSD						
(I) MUAC	(J) MUAC	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	Lower Bound
First trimester	Second Trimester	-0.36	.25	.326	-0.94 to 0.23	
	Third Trimester	-0.83*	.25	.003	-1.42 to -0.24	
Second trimester	First Trimester	0.36	.25	.326	-0.23 to 0.94	
	Third Trimester	-0.47	.25	.143	-1.06 to 0.12	
Third trimester	First Trimester	0.83*	.25	.003	0.24 to 1.42	
	Second Trimester	0.47	.25	.143	-0.12 to 1.06	

However, here again, we did not observe any significant association of women's nutritional status with respect to their educational status (p=0.24).

Majority (35.3%) of the study participants were from lower middle class, 29.7% were from upper lower, and 25% were from upper middle. Very few (9%) were from lower socioeconomic strata and only 1% was from upper socioeconomic status. The prevalence of normal, underweight and overweight women did not show any significant association with respect to their socio-economic status (p=0.56) (Table 1).

Mean difference in BMIs over three trimesters

The mean BMI of women in this study was 22.92 kg/m2±3.84 in the first trimester, 24.48 kg/m2±3.83 in the second trimester and 28.24 kg/m2±3.39 in the third trimester; depicting a shift from normal to obese category. Mean difference in BMI from first to third trimester was 5.32 Kg/m2 (Table 2).

Overall, there was statistically significant difference in mean BMIs of first, second and third trimesters (F=32.23, p<0.001). When the differences in mean BMIs were analyzed between first and second, second and third and first and third trimesters separately, we found a statistically significant difference in mean BMI between first and second trimesters (p=0.05) and statistically significant differences in mean BMIs between second and third trimesters (p<0.001) and first and third trimesters (p<0.001) (Table 3).

Mean difference in MUACs over three trimesters

The mean MUAC was 24.26±3.09 cm in first trimester, 24.61±3.03 cm, in second trimester and 25.09±3.07 cm in third trimester. Mean difference of 0.43 cm was noted from first to third trimester (Table 4).

Overall there was statistically significant difference in mean MUACs of first, second and third trimesters (F=5.533, p=0.004). When the differences in mean MUACs were analyzed between first and second, second and third and first and third trimesters separately, we found no statistically significant differences in mean MUACs between first and second trimesters (p=0.326) and between second and third trimesters (p=0.143) however, a statistically significant difference was found in mean MUACs between first and third trimesters (p=0.003) (Table 5).

Changes in BMI categories over three trimesters

In the first trimester, it was found that 40.3% women belonged to normal category with BMI between 18-22.9 kg/m2. 47% women were over nourished with BMI more than 23 kg/m2 and 12.7% were underweight with BMI less than 18 kg/m2.

In the second trimester, percentage of women in normal category decreased from 40.3% to 29.0% while percentage of women in overnourished category increased from 47.0% to 58.7% and in underweight category decreased from 12.7% to 6%. No change was noted in the obese 3 category with 0.7% remained in the same category.

In the third trimester, none of the women remained in the underweight category. Only 11.7% had normal BMI and 88.4% were either overweight or obese. Percentage of women belonging to obese 3 category also increased from 0.7% to 3.3%.

Changes in MUAC categories over three trimesters

Using guidelines developed by United Republic of Tanzania and Fanta, 2016 for classifying malnourished, in the first trimester, 56.7% belonged to normal category, 37.0% belonged to moderate acute malnutrition category

and 6.0% belonged to obese category. There was only one woman in severe malnourished category.

In the second trimester, number of women in normal category increased from 56.7% to 66.0% while the percentage of moderately malnourished decreased from 37.0% to 28.3%. There was none in severe malnourished category. Also, the percentage of women in obese category marginally decreased from 6.0% to 5.7%.

In the third trimester, those in normal category increased further to 71.3% and those in moderately malnourished category decreased to 21.7%. Women in obese category increased marginally to 7.0%.

BMI category noticed a greater shift in women from both underweight to normal and normal to obese category. This could be attributed to weight gain during pregnancy. Overall, nutritional category according to BMI changed in 84% women from first to third trimesters compared to only 28% according to MUAC. Hence, for confounding the assessment of nutritional status in women accessing late antenatal care, MUAC appears to be a reliable indicator to identify women at high risk due to malnutrition during pregnancy.

Correlation between BMI and MUAC over three trimesters

Spearman correlation coefficient between first trimester BMI and first trimester MUAC was found to be 0.51 ($p<0.001$) which was positive and statistically significant. Similarly, correlation coefficient between first trimester BMI and second trimester MUAC was found to be 0.62 ($p<0.001$) and between first trimester BMI and third trimester MUAC was found to be 0.56 ($p<0.001$). These correlations were also positive and statistically significant, implying that MUAC can also be used in late trimesters as a tool for assessing nutritional status of women in place of BMI.

DISCUSSION

MUAC and BMI of all 300 antenatal women were measured using the standard guidelines. Spearman rho correlation coefficient between first trimester BMI and first trimester MUAC was found to be positive and statistically significant. To find out if change in MUAC over various trimesters affected its association with BMI, Spearman rho coefficient was calculated between first trimester BMI and second trimester MUAC (0.617 $p<0.001$) and between first trimester BMI and third trimester MUAC (0.563, $p<0.001$). It was again positive and statistically significant, implying that MUAC can be used even in late trimesters as a tool for assessing nutritional status of pregnant women. Our results corroborate with other studies. Khadivzaden et al found a strong positive correlation (0.83) between BMI and MUAC.[8] Similarly, Gupta AD et al 2012 conducted a descriptive epidemiological study among adolescent girls and found a strong correlation (0.82) between BMI and MUAC.[9]

Mean BMI differences between first and second trimester and between second and third trimester were found to be statistically significant unlike mean MUAC differences which were non-significant during the corresponding periods. The findings also show that BMI category noticed a greater (84%) shift in nutritional status of women compared to only 28% according to MUAC. This shows that MUAC is a more reliable indicator to identify women at high risk due to malnutrition during pregnancy. Ricalde et al also observed marginal shift in MUAC from first trimester (24.0 cm) to second (24.2 cm) and third trimester (24.8 cm).[10] Similarly, in a study conducted by Oreke et al found MUAC the best predictor of maternal nutritional status. They also observed MUAC to be relatively stable over different trimesters.[11] Bcartiz et al in a prospective cohort study found marginal increase in mean MUAC over the three trimesters.[12]

At present MUAC is being used to identify undernourished children and has a limited role in adults. Cut off values are not well defined for MUAC in adults for categorization of nutritional status. Ververs et al found that appropriate MUAC cutoff for antenatal women was <23 for identifying undernourished women who are at high risk of having low birth weight babies. MUAC is insensitive to changes over the total period of pregnancy in adult women, is easy to measure, and requires only one measurement. More research is needed whether different cut-off values should be used for the Asian or African continent, but current data suggest that <23 cm appears appropriate for both continents. It is also the most conservative cut-off value ensuring that most pregnant women at risk for LBW are captured.[13]

Bcartriz 2011 conducted a prospective cohort study on 1066 pregnant women in Argentina found that MUAC cut-off points of 24.5, 25.5 and 26.5 at 16th, 28th and 38th weeks respectively were significant predictors of delivering low birth weight babies.[12] Nguyen in 2014 found MUAC cutoff of <23.5 cm as best predictor of undernutrition among women in Vietnam. Similarly, Kumar et al 2019 found MUAC cut-offs for wasting (BMI <18·5 kg/m2) and severe wasting (BMI <16·0 kg/m2) as 23.2 cm and 21.5 cm, respectively among Indian women.[14] Another Indian study showed that MUAC cutoffs of 23.0 cm and 21.0 cm are the best predictors of wasting and severe wasting among women.[15]

Strength and limitations of study: As this study was conducted in a large government run hospital in the country the findings represent a wide range of population and can therefore be generalized for all pregnant women. However, a multicentric study with large sample size needs to be conducted in future to evaluate which anthropometric criteria more accurately assess nutritional status among pregnant women. To the best our knowledge, this is the

first study to find correlation between BMI and MUAC among pregnant women in Indian setting.

CONCLUSION

Positive correlation was found between BMI and MUAC. Significant change was observed in mean BMI over three trimesters. However, no significant difference was observed in mean MUAC between first and second and second and third trimester. Therefore, MUAC can be recommended for nutritional assessment of antenatal women with added advantage of low cost, simplicity and convenience.

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