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MID-UPPER ARM BASED NUTRITIONAL STATUS AND BODY FAT PATTERN AMONG ADULT MAHALIS OF BANKURA DISTRICT, WEST BENGAL, INDIA

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Abstract: Our community-based cross-sectional study was undertaken to assess age and sex differences in nutritional status based on mid-upper arm circumference (MUAC) as well as fat free mass index (FFMI), body fat mass index (BFMI) and percent body fat (PBF) among adult Mahali population of Bankura District, West Bengal, India. The sample size consisted of 220 adult Mahalis, aged above 18 years from selected villages. The mean age of 102 males (36.5±14.75 years) and 118 females (34.0±12.89 years) were similar. Participants were further classified into two age groups: ≤ 59 years, and ≥ 60 years. Logistic regression analysis showed that age group categories and sex were significantly associated with nutritional status and three indices of body fat. Results revealed that females and ≥ 60 years participants had significantly higher prevalence of undernutrition compared to their respective counterparts. Females had a significantly higher prevalence of low FFMI and ≥ 60 years individuals were more affected by low FFMI. Significantly higher prevalence of low BFMI was also observed among females and ≥ 60 years individuals Similarly, significantly more females had low PBF with ≥ 60 years participants having a higher prevalence. Thus, there existed a strong relationship between nutritional status (based on MUAC) and body fat which was mediated by age and sex. Theremay be several possible causes for these age and sex differences.

Keywords: India; Tribe; Mid-upper arm circumference; Nutritional Status; Fat pattern

INTRODUCTION

Nutritional status and body composition are two important indictors which are used for determining health status in population studies. Such assessment can investigate the effects of nutrition on health and disease of individuals (Posner et al., 1993; Peter et al., 2015; Shidfar et al., 2016; Alamgir, 2018). Determination of nutritional status of populations has immense applications in human biology, primary health care, public health and biological anthropology (BDA, 2012; Park, 2009). Body composition studies are particularly important to understand fat/non fat (lean) content of the body. Such information is useful in understanding the deficiencies and excesses of fat. Useful insight on health risks like, on heart disease, diabetes, cancer and allied information on poor insulation, minimal energy stores, poor cardiovascular function, frailty, starvation, prone to illness, low testosterone, weak muscles, osteoporosis and other related morbidity can be obtained from such investigations (Howley and Franks, 2007; Falsarella et al., 2015; Speakman and

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Westerterp, 2013; Kalyani et al., 2014; Zhao et al., 2008). Although the human body can be divided into different components, according to the two-component model, human body composition can be subdivided into two parts: fat component and fat-free component (Behnke, 1942). Body fat could differ with age, sex, genetic, environmental and socio-economic conditions (Eveleth and Tanner, 1990; Reddon et al., 2016; Sharma et al., 2017). Moreover, the relationship between nutritional status and body composition also varies across to ethnic groups. This variation is of much interest to biological anthropologists.

Body mass index (BMI) is a computed anthropometric index and is considered as a convenient indicator to assess nutritional status and generalized adiposity (WHO, 1995; Bose, 1996).However in field settings, BMI has limitations because it involves multiple instruments like stadiometers and weighing scales (de-Onis, 2004; Ulijazek and Kerr, 1999; Himes, 2009; Schlegel-Pratt and Heizer, 1990) and also may lead to misleading estimates for participants with edema, limb amputation and decreased curvature of vertebral column and who are pregnant. Thus, many researchers prefer to use mid-upper-arm circumference (MUAC) as a reasonable alternative measure for the detection of undernutrition among children and adults and subsequently to identify individuals with morbidity and risk of mortality (WHO, 1986; Briend, 1987; Alam et al., 1989; Briend et al., 1989; Vella et al., 1994).

In general, the tribal populations of India, who represens 8.6 % of the population (Census of India, 2011) are socially, marginaliged communities and are most vulnerable to health and nutritional problems. Hitherto, scanty research reports are available on FMI, FFMI (Bhat et al., 2005; Bose et al., 2008; Khongsdier, 2005; Verma et al., 2016; Rao et al., 2012; Bose et al., 2006) and MUAC (Bose et al., 2007; Bose et al., 2006; Bisai et al., 2009; Chakraborty et al., 2009) from India. From the state of West Bengal only a few studies (Das and Bose, 2006; Bisai et al., 2008; Das and Bose, 2012; Das et al., 2013; Ghosh et al., 2001; Banik, 2007; Kuiti and Bose, 2015) have been reported earlier. To the best of our knowledge, no previous investigation has dealt with MUAC based undernutrition and body composition among the Mahalis.

Our objective was to examine the body composition pattern and evaluate the MUAC based nutritional status among Mahali adults living in rural areas of Bankura District, West Bengal, India. We also wanted to explore the age and sex differences in the relationship between MUAC based nutritional status and body composition.

PARTICIPANTS AND METHODS

This community-based cross-sectional study was conducted at four villages: Bagdiha, Rajamela, Harivanga and Gorurbasa. These villages are located under Chhatna and Gangajolghati blocks of Bankura District, West Bengal, India. These villages are situated 15 km of Bankura town and 215 km from Kolkata, the state capital of West Bengal. The Mahalis, also known as Mahle or Mahila are inhabitants of Chotonagpur region of Bihar and in the adjoining areas of Odisha and West Bengal. They belong to the Dravidian linguistic group. Originally, the name Mahalis derived from the Santal word ‘mat’ meaning bamboo. The Mahali language has originated from the Santali language. On the hierarchy of traditional occupation, the Mahalitribes are segregated in 5 sub-groups, i.e., Patar Mahalior, Ghasi Mahali (basket making and cultivation), Tanti Mahali (carrying palanquins), Munda Mahali (cultivators), Bansphor Mahali (basket making), and Sulukhi Mahali (cultivation and labour). According to 2011 census, a total 81,594 Mahalis are inhabitants of West Bengal of whom 49.93% are males. The sex ratio is 1002.80. The Mahalis constitute 2.38% of the total population of Bankura District.

A total of 220 adult Mahalis, aged above 18 years residing in these village were included for the study. Socio-economic and anthropometric data were collected in a pre-tested questionnaire schedule. Data were collected during the period 2017-2018. The majority of the participants were non-literate, earn very low wages (<INR 3000 per month). Around 80% of the participants were practicing their traditional occupation of basket making. Appropriate ethical clearance was obtained from Vidyasagar University authorities and necessary permission was also obtained from local community leaders before the study was conducted.

For all the participants, the same measuring equipments were used, which were calibrated daily for standardisation to reduce bias or error. All anthropometric measurements were made by two trained investigators (SB and MG) using the standard techniques of Lohman et al. (1988). Height, circumference measurements and weight were recorded to the nearest 0.1 cm and 0.5 kg, respectively. Technical errors of measurements (TEM) were computed and were found to be within acceptable limits (Ulijaszek and Kerr, 1999).

Nutritional status was evaluated using recently proposed MUAC cutoffs (Tang et. al.2017). Pregnant women and lactating mothers were excluded from our study. The following cut-off points were used:

$$\text{Undernutrition: MUAC} \leq 24.0 \text{ cm}$$

$$\text{Normal: MUAC} > 24.0 \text{ cm}$$

Percentage body fat (PBF) was calculated using Deurenberg’s equation (Deurenberg et al., 1991). The equation is:

$$PBF = 1.20 \times BMI + 0.23 \times age - 10.8 \times sex^{*} - 5.4$$

(*sex: male = 1, female = 0)

Fat mass (FM), fat free mass (FFM), fat mass index (FMI) and fat free mass index (FFMI) were computed using following standard equations:

$$FM\ (kg) = (PBF/100) \times Weight\ (kg)$$

$$FFM\ (kg) = Weight\ (kg) - BFM\ (kg)$$

$$BFMI\ (kg/m^2) = BFM\ (kg) / height^2\ (m^2)$$

FFMI (kg/m^2) = FFM (kg)/ $height^2$ (m^2).

For body composition pattern, we followed the Kylee classification (Kyle et al., 2003) for classificatory purposes (FFMI kg/m^2; BFMI kg/m^2 and PBF). The following cut-off points were used:

For Men, FFMI category: Low FFMI: FFMI ≤ 16.7 kg/m^2

Normal FFMI: FFMI > 16.7 kg/m^2

For women, FFMI category:

Low FFMI: FFMI ≤ 14.6 kg/m^2

Normal FFMI: FFMI > 14.6 kg/m^2

For men, BFMI category:

Low BFMI: BFMI ≤1.8 kg/m^2

Normal BFMI: BFMI >1.8 kg/m^2

For women, BFMI category:

Low BFMI: BFMI ≤ 3.9 kg/m^2

Normal BFMI: BFMI > 3.9 kg/m^2

For men, PBF category:

Low PBF: PBF ≤13.4 %

Normal PBF: PBF >13.4 %

For women, PBF category:

Low PBF: PBF ≤ 24.6 %

Normal PBF: PBF > 24.6 %

All statistical analyses were undertaken using the Statistical Package for Social Science (SPSS16) program.

RESULTS

The age and sex specific anthropometric and body composition characteristics of the participants are presented in ***Table 1***. The mean age of males (36.5±14.75 years) and females (34.0±12.89 years) were similar. The mean of three anthropometric measurements i.e. height, weight and MUAC among males (158.0±6.78cm; 47.9±7.19kg and 24.16±2.50cm, respectively) were significantly higher (t = 14.752, p<0.001; t = 11.052, p<0.001and t = 5.652, p<0.001 respectively) than females (145.9±5.42cm; 38.2±5.42kg & 22.19±2.63cm. respectively). The derived measurements of body composition (PBF, FM, FFM, FMI and FFMI) also displayed significant sexual dimorphism. Mean FFM and FFMI of males (42.0±5.25kg & 16.8±1.82 kg/m^2 respectively) were significantly (t = 20.195, p<0.001 and t = 12.628, p<0.001, respectively) higher (29.8±3.63kg and 14.0±1.47kg/m^2, respectively). However, for PBF, FM and FMI, means were significantly (t = -14.108, p<0.001; t = -6.139, p<0.001 & t = -9.200, p<0.001, respectively), more among females (21.4±5.40; 8.4±3.12kg and 3.9±1.40kg/m^2, respectively) compared with males (11.9±4.43; 5.9±2.75kg and 2.3±1.06kg/m^2, respectively).

TABLE 1: DESCRIPTIVE STATISTICS OF ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES AND INDICES

Age and anthropometric variables	*Male (n =102)*		*Female (n =118)*		*t' value*
	Mean	*SD*	*Mean*	*SD*	
Age in year	36.5	14.75	34.0	12.89	1.335
Height (cm)	158.0	6.78	145.9	5.42	14.752***
Weight (kg)	47.9	7.19	38.2	5.83	11.052***
MUAC (cm)	24.16	2.50	22.19	2.63	5.652***
PBF	11.9	4.43	21.4	5.40	-14.108***
FM (kg)	5.9	2.75	8.4	3.12	-6.139***
FFM (kg)	42.0	5.25	29.8	3.63	20.195***
FMI (kg/m^2)	2.3	1.06	3.9	1.40	-9.200***
FFMI (kg/m^2)	16.8	1.82	14.0	1.47	12.628***

Results of Pearson's Correlation studies ***(Table 2)*** showed that age had significant negative association with weight (*r* = -0.223, p<0.05), MUAC (*r* = -0.247, p<0.05), FFM (*r* = -0.241, p<0.05) and FFMI (*r* = -0.309, p<0.01) among men. Among females, significant negative associations were found with height (*r* = -0.204, p<0.05), weight (*r* = -0.237, p<0.01), FFM (*r* = -0.324, p<0.001) and FFMI (*r* = -0.235, p<0.05). In general, the correlation of age with body fat variables and indices were stronger among women.

TABLE 2: CORRELATION OF AGE WITH ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES AND INDICES

Anthropometric Variables	*Male (n = 102)*	*Female (n = 118)*
Height	0.038	-0.204*
Weight	-0.223*	-.0237**
MUAC	-0.247*	-0.163
Fat Mass	-0.124	-0.066
Fat Free Mass	-0.241*	-0.324***
PBF	-0.096	0.022
Fat Mass Index	-0.145	-0.04
Fat-Free Mass Index	-0.309**	-0.235*

Linear regression analyses were undertaken to estimatethe influence of age on these anthropometric variables and body composition indices. It was observed that in males ***(Table 3)*** age was inversely associated with weight (t = -2.288, p<0.05), MUAC (t = -2.544, p<0.05), FFM (t = -2.482, p<0.05) and FFMI (t = -3.255, p<0.01). The amount of variation explained by age ranged from 0.09% (PBF) to 8.7% (FFMI). Among females ***(Table 4)***, age was inversely associated with height (t = -2.244, p<0.05), weight (t = -2.633, p<0.05), FFM (t = -3.688, p<0.001) and FFMI (t = -2.600, p<0.05). The amount of variation explained by age ranged from 0.4% (height) to 9.7% (FFM).

TABLE 3: LINEAR REGRESSION ANALYSIS OF AGE WITH ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES AND INDICES AMONG MEN

Variable/Index	*β*	*Seβ*	*Beta*	*T*	*AdjR²*
Height	0.018	0.046	0.038	0.382	-0.009
Weight	-0.109	0.048	-0.223	-2.288*	0.040
MUAC	-0.042	0.016	-0.247	-2.544*	0.051
PBF	-0.029	0.030	-0.096	-0.968	0.000
Fat Mass	-0.023	0.019	-0.124	-1.246	0.005
Fat Free Mass	-0.086	0.035	-0.241	-2.482*	0.049
Fat Mass Index	-0.010	0.007	-0.145	-1.469	0.011
Fat Free Mass Index	-0.038	0.012	-0.309	-3.255**	0.087

TABLE 4: LINEAR REGRESSION ANALYSIS OF AGE WITH ANTHROPOMETRIC AND BODY COMPOSITION VARIABLES AND INDICES AMONG WOMEN

Variable/Index	*β*	*Seβ*	*Beta*	*T*	*AdjR²*
Height	-0.086	0.038	-0.204	-2.244*	0.033
Weight	-0.107	0.041	-0.237	-2.633*	0.048
MUAC	-0.033	0.019	-0.163	-1.781	0.018
PBF	-0.009	0.039	0.022	0.233	-0.008
Fat Mass	-0.016	0.022	-0.066	-0.717	-0.004
Fat Free Mass	-0.091	0.025	-0.324	-3.688***	0.097
Fat Mass Index	-0.004	0.010	-0.040	-0.431	-0.007
Fat Free Mass Index	-0.027	0.010	-0.235	-2.600*	-0.047

The prevalence of under-nutrition and low body fat composition pattern are presented in ***Figures 1, 2, 3 and 4.*** Results revealed that ***(Figure 1)*** 57.7% of the participants belonged to the undernutrition category. Association of MUAC based nutritional status and sex was highly significant (χ^2 = 29.608, p<0.001). The prevalence of undernutrition was much higher in females (74.6%) compared to males (38.2%). The prevalence of low FFMI (60.0%), low BFMI (46.8%) and low PBF (66.8%) are presented in ***Figures 2, 3 and 4***. Sex-specific prevalence of low FFMI, BFMI and PBF, among females (70.34%, 61.17% and 73.73%, respectively) were significantly more than males (48.04%, 31.37% and 58.82%, respectively). There existed a significant association between sex and categories of these three indices (χ^2= 11.336, p<0.01; χ^2 = 18.221, p<0.001 and χ^2 = 5.482, p<0.05, respectively).

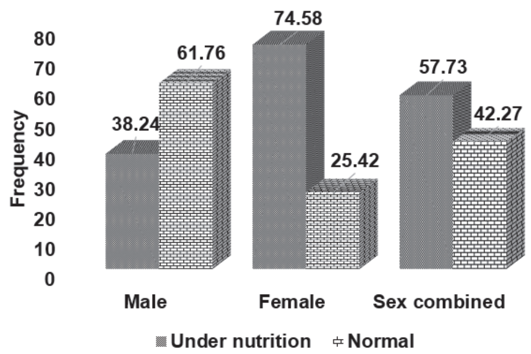

Figure 1: Sex-specific prevalence of MUAC based under nutrition

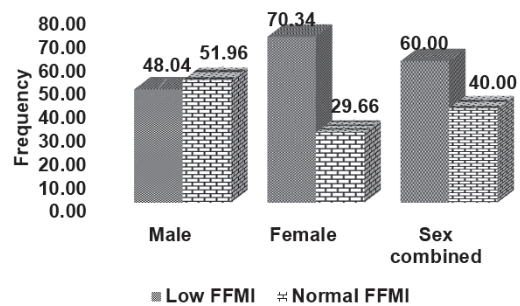

Figure 2: Sex-specific prevalence of low FFMI

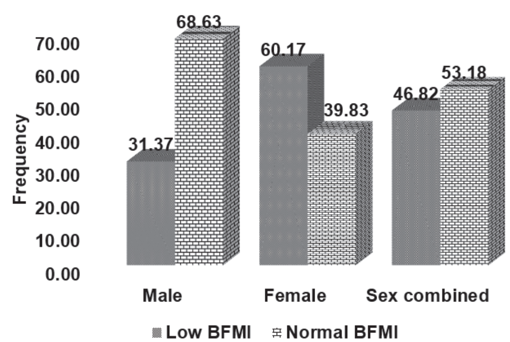

Figure 3: Sex-specific prevalence of low BFMI

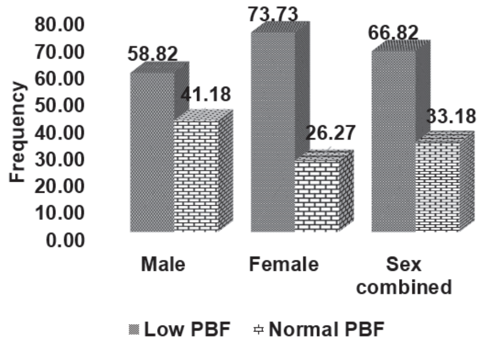

Figure 4: Sex-specific prevalence of low PBF

The logistic regression analysis was utilized to examine the contribution of age groups (18-59 years and ≥60 years) including sex on undernutrition and three indices of body fat composition pattern ***(Tables 5, 6, 7 and 8)***. Results ***(Table 5)*** revealed that females had higher prevalence of undernutrition [(Odd Ratio (OR) = 5.309; 95% Confidence Interval (CI) = 2.935-9.606)] and ≥60 years participants were more affected by undernutrition (OR = 5.396; CI = 1.396-20.645). When two variables were entered into the model, they significantly predicted undernutrition (χ^2= 262.130; p<0.001; R^2= 0.211). The overall correct prediction was 70.5% (74.8% undernutrition; 64.5% normal).

TABLE 5: BINARY LOGISTIC REGRESSION ANALYSIS OF MUAC BASED UNDERNUTRITION PREDICTED BY SEX AND AGE

MUAC based nutritional status with sex and age	*Sub-groups*	*Undernutrition*		χ^2	*Odd-ratio*	*95% CI*
		N	*%*			
Sex	Male®	39	38.20	30.456***		
	Female	88	74.60		5.309	2.935-9.606
Age	18- 59 Years®	114	55.90	5.981*		
	≥60 Years	13	81.20		5.396	1.396-20.645

TABLE 6: BINARY LOGISTIC REGRESSION ANALYSIS OF LOW FFMI PREDICTED BY SEX AND AGE

Fat-free mass index status with sex and age	*Sub-groups*	*Low FFMI*		χ^2	*Odd-ratio*	*95% CI*
		N	*%*			
Sex	Male®	49	48.00	12.888***		
	Female	83	70.30		2.828	1.603-4.988
Age	18- 59 Years®	118	57.80	5.775*		
	≥60 Years	14	87.50		6.559	1.415-30.413

TABLE 7: BINARY LOGISTIC REGRESSION ANALYSIS OF LOW BFMI PREDICTED BY SEX AND AGE

Body fat mass index status with sex and age	*Sub-groups*	*Low BFMI*		χ^2	*Odd-ratio*	*95% CI*
		N	*%*			
Sex	Male®	32	31.40	18.384***		
	Female	71	60.20		3.443	1.957-6.059
Age	18- 59 Years®	94	46.10	1.499		
	≥60 Years	9	56.20		1.962	0.667-5.773

TABLE 8: BINARY LOGISTIC REGRESSION ANALYSIS OF LOW PBF PREDICTED BY SEX AND AGE

PBF status with sex and age	*Sub-groups*	*Low PBF*		χ^2	*Odd-ratio*	*95% CI*
		N	*%*			
Sex	Male®	60	58.80	5.772*		
	Female	87	73.70		2.018	1.183-3.578
Age	18- 59 Years®	135	66.20	0.856		
	≥60 Years	12	75.00		1.75	0.535-5.726

Result revealed that females hada higher prevalence of low FFMI (OR= 2.828; CI= 1.603-4.988) and ≥60 years participants were more affected with low FFMI (OR = 6.559; CI = 1.415-30.413). When these two variables were entered into the model, they significantly predicted low FFMI (χ^2 = 276.488; p<0.001; R^2= 0.115). Overall 65.5% of participants were correctly predicted (69.7% of low FFMI and 59.1% of normal). A higher prevalence of low BFMI was observed among females (OR = 3.443; CI = 1.957-6.059) and among ≥60 years participants (OR = 1.962; CI = 0.667-5.773) ***(Table 7)***. When these two variables were considered in the model, they significantly predicted low BFMI (χ^2 = 284.047; p<0.001; R^2=0.116). Overall 64.1% of participants were correctly classified (68.9% of low BFMI and 59.8% of normal). The cumulative effect of age group and sex on PBF is displayed in ***Table 8.*** Females had a higher prevalence of low PBF (OR= 2.018; CI = 1.183- 3.578) and similar to the other indices, the prevalence of low PBF was higher among the ≥60 years age group (OR = 1.750, CI = 0.535-5.726). The two variables model significantly predicted low PBF (χ^2 = 273.197; p<0.001; R^2= 0.040). The overall and low PBF prediction rates were 66.8% and 100%, respectively.

DISCUSSION

The MUAC is a useful indicator for determining acute undernutrition of individuals and also useful for detecting the prevalence of undernutrition at a population level

(Collins et al. 2000). Measuring MUAC does not require any expensive equipment. Moreover, since it is not an index, (like BMI, Waist-Hip Ratio, Waist-Height Ratio, Conicity Index, etc.) no mathematical computations are required. Thus, it is most suitable for the identification of adult undernutriiton in large scale population surveys (Khadivzadeh, 2002).

Our study also showed ***(Figure 5)*** that MUAC based undernutrition among different ethnic groups. The Mahalis of Bankura were experiencing more nutritional stress (57.73%) than Kora Mudis (51.2%) of Paschim Medinipur (Basu and Banik, 2009), slum dwellers (43.5%) of Paschim Medinipur (Bose et al., 2007), Santal adults (33.4%) of Bankura (Bose et al., 2006) and Telegas (32.7%) of Paschim Medinipur (Banik, 2007). However, they had a lower prevalence of undernutrition than Santals (60.4%) of Purulia (Das and Bose, 2012).

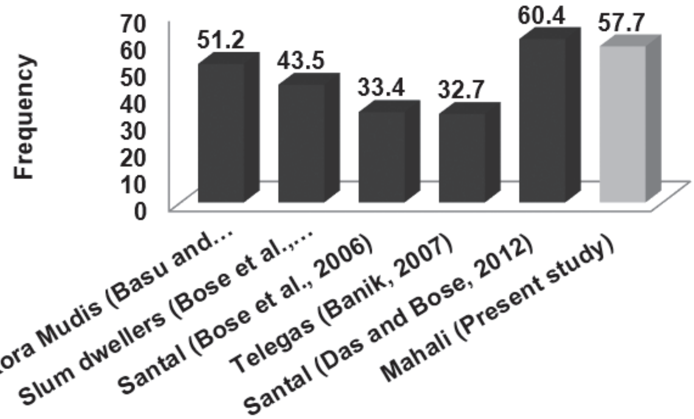

Figure 5: Comparison of MUAC base nutritional status among different population

Earlier studies have shown that MUAC reflects adult nutritional status as defined by BMI (Collins 1996) and body composition patterns are strongly associated with BMI related health outcomes (Price et al., 2006;Kuiti and Bose, 2015). In the present study, MUAC based nutritional status also had a strong association with body composition patterns. ***Table 9*** showed that the most of the undernourished adults belonged to low FFMI (OR: 8.568, 95% CI: 4.624-15.875), low BFMI (OR: 10.467, 95% CI: 5.432-20.168) and low PBF (OR: 9.793, 95% CI: 5.070-18.915) categories. Another noteworthy observation was that MUAC based nutritional status predicted the overall percentage and had strong association with FFMI (75.0%; χ^2 = 242.942, p<0.001, R^2 = 0.290 respectively), BFMI (74.5%; χ^2 = 243.640, p<0.001, R^2 = 0.321 respectively) and PBF (75.5%; χ^2 = 225.005, p<0.001, R^2 = 0.305 respectively). MUAC based undernutrition correctly predicted low FFMI (77.3%), low BFMI (84.5%) and lowPBF (74.8%).

TABLE 9: BINARY LOGISTIC REGRESSION ANALYSIS OF LOW FFMI, BFMI AND PBF PREDICTED BY MUAC BASED UNDERNUTRITION

	Low FFMI	*%*	*χ^2*	*Odd-Ratio*	*95%CI*
Undernutrition®	102	77.27	46.602***	8.568	4.624-15.875
Normal	30	22.73			
	Low BFMI	%	χ^2	Odd-Ratio	95%CI
Undernutrition®	87	84.47	49.243***	10.467	5.432-20.168
Normal	16	15.53			
	Low PBF	%	χ^2	Odd-Ratio	95%CI
Undernutrition®	110	74.83	46.154***	9.793	5.070-18.915
Normal	37	25.17			

Our study clearly demonstrated that there existed sexual dimorphism in the age trend. Age had a much stronger negative association with anthropometric measures in males. Sexual dimorphism in age trends have been reported by many researchers from India (Singal and Sidhu, 1983; Singal et al., 1988; Ghosh et al., 2001; Bose and Chaudhuri, 2003). The possible causes for this sex difference may be because of the factors like, levels of physical activity and sex hormones (Bowen et al., 2011; Edwards and Sackett, 2016; Sood and Bharmoria, 2016; Corella et al., 2019).

The present study was cross sectional. Future research should utilize longitudinal studies which would give an insight into the mechanism and interaction between age, sex, MUAC based undernutrition and body composition. To the best of our knowledge, no such study exists from India. India is a subcontinent with enormous ethnic heterogeneity. Thus, the nutritional status of each of the ethnic groups, particularly the tribal populations, who are nutritionally vulnerable needs to be estimated.

Some of the limitations of our study were the small sample size and coverage of participants from limited geographical area. The cross-sectional nature of the study also provided limited information about the study population.

CONCLUSION

Our study unequivocally demonstrated that there existed a very strong relationship between MUAC based nutritional status and body fat which was mediated by age and sex. There may be several possible causes for these age and sex differences. Further investigations, longitudinal in nature, are required to better understand the mechanism of these differences.

Abbreviations used

MUAC: Mid Upper Arm Circumference; FFMI: Fat-Free Mass Index; BFMI: Body Fat Mass Index; PBF: Percentage of Body Fat; OR: Odd Ratio; CI: Confidence

Interval; BDA: British Dietetics Association; WHO: World Health Organization; GOI: Government of India.

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