Demography India
A Journal of Indian Association of Study of Population
Journal Homepage: https://demographyindia.iasp.ac.in/

Nutritional status and Adiposity: A Study of Koya and Matia women of Malkangiri district, Odisha, India

Kumud Kushwaha[1*], Meerambika Mahapatro[2] and Roumi Deb[3]

Abstract

India has a dual epidemic of malnutrition, including both undernutrition and obesity. Women of poor socio-economic household are particularly affected by chronic energy deficiencies and undernutrition. The objective of this study is to examine nutritional status based on Body Mass Index (BMI) and Percent Body Fat (PBF) among Matia and Koya tribal female of Malkangiri, Odisha. A total of 551 women of reproductive age (15 to 49 years) from more than 43 villages of 5 blocks named Maithili, Khairput, Kalimela, Podia, and Korkunda were anthropometrically measured. Out of 551 sample, 208 women were from Matia community and 343 were from Koya community during data collection. A pre-tested questionnaire was used to collect data on demographic, reproductive profiles and anthropometric measurements like stature, weight, MUAC, hip and waist circumferences along with skinfold thickness. This study shows Matia and Koya had comparable mean age (27.12 ± 9.83; 28.31 ± 10.52, respectively). The study found a huge deficit in weight among both community women compared to the weight suggested by the ICMR for tribal women. Matia (45.7%) and Koya (39.4%) women had a substantially high degree of BMI-based Chronic Energy Deficiency (CED). Similarly, based on Body Adiposity Index (BAI) 27.9% Matia and 38.2% Koya women were undernourished. To assess the correlation between dietary status and BMI and health status and PBF among indigenous populations in India and around the world, prospective studies are needed.

Keywords

Chronic Energy Deficiency, Percentage Body Fat, Skinfold Thickness, Matia, Koya, Malkangiri

* *Corresponding Author*
[1]*Ph. D. Scholar, Center for Anthropology, Amity University, Noida, Uttar Pradesh, Email:kushwahakumud101@gmail.com*
[2]Professor, *Head, Department of Social and Behavioural Sciences, National Institute of Health and Family Welfare, New Delhi. Email: meerambika.mahapatro@gmail.com*
[3]*Professor, Head, Center for Anthropology, Amity University, Noida, Uttar Pradesh. Email: rdev@amity.edu*

Introduction

India has recently achieved significant strides in the social and economic spheres, but the improvement in the nutritional quality of the population particularly women are still lagging behind(Bose & Chaudhuri, 2003). India suffers from a dual epidemic of malnutrition, encompassing both undernutrition and obesity (Bose & Chaudhuri, 2003). The most severe effects of poverty, which continue to plague millions of Indian households are chronic hunger and undernutrition where women are mostly affected (Mukhopadhyay, 2010). As it is obvious, nutritional state of a women has a significant impact on both her own health as well as on her children's health (Mohandas et al., 2019; Swaminathan et al., 2019). Poor nutritional status is indicated by Low Body Mass Index (BMI), anaemia, short stature or other micronutrient deficiencies, which increases the risk of obstructed labour, low birth weight babies, unfavourable pregnancy results, lower- quality breast milk, and mortality from illness and postpartum haemorrhage in both herself and her child (Ghosh, 2016a; Singh et al., 2014; Swaminathan et al., 2019). This has intensified the undernutrition cycle which affects generations to come (Kanrar & Goswami, 2020a). Fat is also the fundamental component that makes up body structure(Rao et al., 2012). Essential fat and Storage fat are two important components of total bodily fat. Storage fat found in adipose tissue and excessive deposition in central adipose tissue cause obesity (Wellens et al., 1996). The central nervous systems, lipid rich tissues, the marrow of bones, hearts, liver, spleen, lungs, kidneys, intestines, and muscles contain essential body fat. Essential fat is required for regular body processes. Women are physiologically disadvantaged as they require excess essential fat or "sex- specific fat", needed for childbirth and hormonal functions (Martorell et al., 2009; Rao et al., 2010). Consequently, women's body fat percentage is higher than men percentage of body fat. However, weight gain and fat deposition before, during and after pregnancy may cause obesity in later stages of life (Rokade et al., 2020). Therefore, body fat measurement will not only provide an overall health impression but also establish a baseline for a demography based nutritional program. There are fewer population-based studies that use anthropometry to link percentage body fat and Body Adiposity Index with other adiposity factors, particularly in India, where there is huge diversity in terms or ethnicity, availability of food resources, and disparities in nutritional status (Bisai et al., 2009; Deurenberg et al., 1991; Mukhopadhyay, 2010; WHO Expert Consultation, 2004). The BMI is considered as useful anthropometric indicator for assessing nutritional status and adiposity by measuring both lean body mass and body fat (Bergman, 2012). But individuals with substantial body fat and a low BMI will escape the obesity related measures. Although there is a strong correlation between BMI and percentage body fat but several studies establish that there is variation in both variables based on ethnicity, gender, and age groups (Deurenberg et al., 1991; Shetty et al., 1994; Ulijaszek & Kerr, 1999; Wang et al., 1994a). The WHO report also recommended studying the body composition of people living in Asia and the Pacific Islands population are needed to establish equivalent levels of adiposity and the correlation between BMI and body size (VanItallie et al., 1990). Anthropological research on Koya and Matia residing in Malkangiri district of Odisha is not available. Considering the foregoing context, the present paper is a preliminary report dealing with the level of anthropometric features and nutritional status of these two tribal groups.

The objective of this study is to provide an in-depth comparative analysis of body composition of Matia and Koya women aged 15-49 years. This study also evaluates the prevalence and nutritional status of Matia and Koya using BMI (kg/m^2), BAI (%) and PBF (%)

Material and Methods

To achieve the above objective, a cross- sectional study was conducted among Matia and Koya tribal women of Malkangiri, Odisha. The studied district is 634 km far from Bhubaneswar, Capital of Odisha. it is located between the eastern ghats hills on both the eastern and western sides. The administrative set up of Malkangiri district comprises of 7 blocks namely Malkangiri NAC, Maithili, Korukonda, Chitrakonda, Khairput,

Podia, Kalimela. As per 2011 Census, total population of Matia tribe was 30,169 out of which 15,020 were females, whereas overall population of the Koya tribe in Odisha is 1,47,137 out of which 76,123 are females.

In terms of numbers, Matia tribe is a small tribe of a lesser-known origin while Koya is an ancient warrior tribe. Matia lives Together with other ethnic/groups. Thus, they live in mixed communities and have exogamous totemic clans like Nag (cobra), Bagh (tiger), Kachim (tortoise) and Cheli (goat). As for marriage in this community, arranged marriage, capture marriage, marriage by elopement, cross-cousin marriage and marriage by service are practiced. As for livelihood and economic lives they are majorly engaged in cultivation of tobacco leaves, maize and vegetables, wage earning, forest collector and pot maker.

Koya inhabited the mountains and forests north of Godavari District of Andhra Pradesh and Malkangiri District of Malkangiri. The Koya tribe is dichotomized between two sorts of kin in groups named *kutumam* or consanguineal kin and *wiwalwand* or affinal kin. They are divided into five exogamous clan like Kowasi; Odi/ Sodi; Madkam; Madi, And Padiam. A Kowasi can marry from any four phratries excluding his own. Koya were shifting cultivators but they practice settled cultivation and cultivating primarily paddy, mandia, maize and tobacco leaf as well as collecting roots and fruits of Tumid (Kendu), tubers and herbs from forest.

A total of 551 women of reproductive age (15 to 49 years) from more than 43 villages of 5 blocks named Maithili, Khairput, Kalimela, Podia, and Korkunda were anthropometrically measured. Out of 551 sample, 208 women were from Matia community and 343 were from Koya community. The study was approved by the 10th Institute Ethical Committee (IEC) with Ref No.: AUUP/IEC/AUG/2021/09 Dated 15.12.2021 of Amity University, Noida, India. Before collection of data, participants and local authorities, Anganwadi and ASHA workers were informed about the objectives of present study. Village authorities informed participants orally in their regional dialects (Desia) then a written consent in Odia language was taken from participants. A pre-tested questionnaire used to collect data on demographic, reproductive variables. In addition to anthropometric measurements such as height (cm), weight (kg), waist circumference (cm), head circumference (cm), hip circumference (cm), mid-upper arm circumference (MUAC) (cm), and skinfold of triceps (mm), biceps (mm), suprailiac (mm), subscapular (mm), medial calf (mm) were measured according to the standard techniques established by International Society for the Advancement of Kin anthropometry (ISAK)(Norton, 2018). Measurements were taken to the nearest 0.1cm and 0.5 kg for height and weight, respectively. Technical errors of measurements were calculated and confirmed to be within limits that are acceptable("Physical Status: The Use and Interpretation of Anthropometry. Report of a WHO Expert Committee.," 1995). For measurement of stature and weight, Anthropometer rod and portable digital weighing balance were used. Circumference measurements was made by using a flexible non-stretchable steel tape in centimetres. Skinfold thickness was measured in millimetres using Harpender calliper to the nearest 0.1mm. Derived anthropometric indices and ratios were employed using standard equations and ratios. ICMR standard for tribal women was used to distribute population weight based on height.

BMI and PBF provide overall nutritional and adiposity level of an individuals and has been calculated by following formula:

$$BMI = Weight\ (in\ kg) / Height^2\ (in\ m^2)$$

The participants were classified according to WHO standard based on their BMI(Deurenberg et al., 1991). For undernutrition further population were classified in category of CED on basis of BMI value, CED III <16.0 kg/m^2, CED II values were 16.0 – 16.9 kg/m^2, CED I 17.0 -18.4 kg/m^2: BMI between 18.5 – 24.9 kg/m^2 was considered as normal. Based on adult population globally, we adhered to WHO categorization of Low BMI as a public health concern. This categorization uses the percentage of the

population having a BMI of less than 18.5kg/m^2 to classify the prevalence of undernutrition. A percentage between 5 – 9% indicates a warning indication and need for monitoring; 10 – 19 % indicates a poor situation; 20 – 39% indicates a serious scenario; and 40% or more indicates a critical condition.

The other formulae and equations used to derive the body composition and adiposity level among Matia women are as follow;

WHR: Waist circumference (cm)/ Hip circumference(cm)

WHTR: Waist circumference (cm)/ Height circumference(cm)

CI (Conicity Index) = $\frac{Waist\ circumference(m)}{0.109}\sqrt{Weight}(kg)/\sqrt{Height}(m)$

FM (Fat Mass) (kg) = Body weight (kg) x (PBF/100)

FMI (Fat Mass Index), (Kg/ m^2) = FM (kg)/ Height ^{2} (m^2)

BAI (Body Adiposity Index) = (Hip circumference (cm) / (Height x √Height))-18)

BF (Body Fat) determined using age and sex specific, Jackson-Pollock equations (1980) follows to calculate PBF (Percentage Body Fat)(Jackson et al., 2002);

PBF(JACKSON et al., 1980)= (1.61 x BMI) + (0.13 x Age) – (12.1 x Gender) -13.9

Where, Male=1 and Female = 0

Anthropometric variables were presented as mean ± SD; Students' t-test was done to examine for differences in mean anthropometric parameters and their derived measures for their cross validation. Pearson correlation coefficients (r) and linear regression are used to explore the interrelationship between age and anthropometric variables. For correlation (r), age was used to analyse the association between age with overall and central adiposity measurements. Prevalence of CED based on BMI, MUAC, PBF and BAI is also accessed by chi-square (χ^2) test and categorical variables were expressed as percentage, in both Matia and Koya women. All statistical analyses were done using the SPSS Statistical Package. Statistical significance was established at $p < 0.05$.

Result and Discussion

The mean age of the total sample is found to be 27.86 ± 10.28. Separately, the mean age in the Matia community is 27.12 ± 9.83 and that among Koya is 28.31 ± 10.53. Thus, they have a large overlap of confidence interval**.**

Table 1 depicts the mean and standard deviation of anthropometric parameters of Nutritional Status of both Matia and Koya community women. Student t-test and p value shows the significance of variables. There is a significant difference in the hip circumference between the two communities.

Table 2 shows distribution by weight for height of total sample of Koya and Matia tribes. The nutritional grades were computed using ICMR standard for tribal females. The weight for height classification for nutritional grades of Matia under 10-20% which is below the ICMR standard is found to be 27% among Koya it is 24%. This depicts that Koya have better weight as comparison to Matia. Around, 21% Matia and 18% Koya women are found between 20-30% below ICMR standard. Further 21% Matia women and 23% Koya women are found under category of 0-10% above standard. The -1 and +1 value are considered as normal range for weight for height distribution then 35% Matia are under normal range and 48% Matia women are undernourished. Similarly, for Koya community 40% women are under normal range and 41% are undernourished. The pooled sample represents that 73% Matia and 51% Koya women having height above 150 cm. The study findings reveal that there is slightly deficit in height of tribal women as compared to ICMR standard of 151cms average height for tribal and 55kg average weight for tribal women which is significant difference as the average weight in this study for Matia and Koya women were 44.10±7.53 and 44.85 ± 7.70 respectively**.** Women are underweighting despite the fact that various government projects are executed to provide better nutrition in tribal belt area and achieve the SDG 2, i.e., to eliminate hunger and provide food security and improve nutrition for all. Tribal women who were underweight were associated to have lower physical well-being, worse physical performance, and a lower quality of

life(Bose et al., 2006). This is going to affect their foetus also they may give birth to low-birth-weight child and undernutrition follows in next generation(Mohandas et al., 2019).

Table 3 represent the Mean ± SD, Student's t test and p value of both categories of overall adiposity and central adiposity calculated from anthropometric parameters for both the communities. Overall, the adult women population of this particular location demonstrates significantly high frequency of undernutrition.

Table 1 Descriptive Statistics with t- test of the anthropometric variables

Variables		N	MEAN	Std. Deviation	t	Sig.
	Matia	208	44.106	7.523	1.072	0.141
Weight (kg)	*Koya*	343	44.854	7.705		
	Matia	208	150.643	7.71	-1.344	0.819
Height (cm)	*Koya*	343	149.649	7.705		
Mid- Upper arm circumference	*Matia*	208	22.256	2.438	0.013	0.494
(cm)	*Koya*	343	22.277	3.459		
	Matia	208	52.683	1.988	-1.103	0.135
Head Circumference (cm)	*Koya*	343	52.361	3.797		
	Matia	208	74.629	8.995	0.368	0.356
Waist Circumference (cm)	*Koya*	343	74.912	8.573		
	Matia	208	82.164	9.909	-1.648	0.049
Hip Circumference (cm)	*Koya*	343	80.743	9.648		
	Matia	208	2.142	0.884	-0.931	0.176
Biceps Skinfold (mm)	*Koya*	343	2.072	0.874		
	Matia	208	3.307	0.696	-0.455	0.324
Triceps Skinfold (mm)	*Koya*	343	3.282	0.699		
	Matia	208	7.3	0.998	0.202	0.419
Subscapular Skinfold (mm)	*Koya*	343	7.316	1.030		
	Matia	208	5.125	0.947	-0.069	0.427
Suprailiac skinfold (mm)	*Koya*	343	5.120	1.005		
	Matia	208	4.971	0.681	0.046	0.481
Medial calf Skinfold (mm)	*Koya*	343	4.967	0.664		

Table 2 Distribution by weight for height of Matia Tribal Women

Height (cm)		(20 -30%) Below Standard (N)	(10 -20%) Below Standard (N)	(0 - 10%) Below Standard (N)	Weight as per ICMR (in Kg)	(0 - 10%) Above Standard (N)	(10 -20%) Above Standard (N)	(20 -30%) Above Standard (N)	Total (N)
		-3	-2	-1	0	1	2	3	
Below	*Matia*	3	3	1		3	2	1	13
140	*Koya*	4	5	7	40.5	4	5	9	34
140-	*Matia*	3	12	6		10	1	1	33
144.9	*Koya*	4	13	4	43	14	2	4	41
145 -	*Matia*	12	17	5		14	6	4	58
149.9	*Koya*	22	21	9	46	29	6	5	92
150 -	*Matia*	9	22	17		10	14	7	79
154.9	*Koya*	8	25	25	48.5	12	14	6	90
155 -	*Matia*	6	5	4		12	1	2	30
159.9	*Koya*	9	9	5	50.5	17	4	3	47
160 +	*Matia*	21	10	1		5	4	1	42
	Koya	13	7	9	52.5	2	4	4	39
Total	*Matia*	54 (21.17)	69 (27.05)	34 (13.33)		54 (21.17)	28 (10.98)	16 (6.27)	255
(N)(%)	*Koya*	60(17.49)	80 (23.32)	59 (17.20)		78 (22.74)	35 (10.20)	31 (9.03)	343

The Mean value of BMI of both communities Matia (19.529 ± 3.419) and Koya (20.118 ± 3.686) were almost similar. Among overall adiposity BMI (19.52 ± 3.41; t =-1.866, p < 0.05), FM (9.64 ± 4.05; t =1.809, p < 0.05), PBF (21.069 ± 5.75; t=2.041; p<0.05) BAI (26.68 ± 6.28; t = - 4.393, p < 0.05) shows significant difference while in Central Adiposity, , CI (1.27±0.14; t= - 4.770; p<0.05)WC (74.62 ± 8.99; t =-1.648, p < 0.05), WHtR (0.49 ± 0.06; t =-3.915, p < 0.05) shows significant difference.

Table 3 Descriptive Statistics with t- test of overall and central adiposity

	Variables		N	MEAN	Std. Deviation	t	Sig.
Overall adiposity	BMI (kg/m²)	*Matia*	208	19.529	3.419	1.866	0.031
		Koya	343	20.118	3.686		
	FM (kg)	*Matia*	208	9.649	4.052	1.189	0.035
		Koya	343	10.336	4.555		
	FMI (kg/m²)	*Matia*	208	4.305	1.924	2.045	0.020
		Koya	343	4.689	2.225		
	PBF (%)	*Matia*	208	21.069	5.755	2.041	0.020
		Koya	343	22.172	6.368		
	BAI	*Matia*	208	26.681	6.285	-4.393	0.000
		Koya	343	23.107	10.650		
Central adiposity	CI	*Matia*	208	1.271	0.144	-4.770	0.000
		Koya	343	1.168	0.290		
	WC (cm)	*Matia*	208	74.629	8.995	-1.648	0.049
		Koya	343	79.912	8.573		
	WHR	*Matia*	208	0.974	0.966	-0.338	0.367
		Koya	343	0.955	0.268		
	WHtR	*Matia*	208	0.496	0.064	-3.915	0.000
		Koya	343	0.462	0.116		

Table 4 Prevalence of health and nutritional status based on BMI, PBF. MUAC, and BAI among participants

Variables	Category	Cut-Off Values	Matia (n=208)	Koya (N=343)	Total (N=551)	χ^2	P Value
BMI (kg/m²)	CED III	<16.0	34 (16.34)	49(14.28)	83 (15.06)	3.654	0.454
	CED II	16.0 - 16.99	20 (9.61)	23 (6.70)	43 (7.80)		
	CED I	17 - 18.49	41 (19.71)	63 (18.36)	104 (18.87)		
	Total under nourished	16 - 18.49	95 (45.67)	135(39.35)	230 (41.74)		
	Normal	18.50 - 24.99	99 (47.59)	174(50.72)	273 (49.54)		
	Overweight	25-29.99	14 (6.73)	32(9.32)	46 (8.34)		
	Obese	>30	0	2(0.58)	2 (0.36)		
MUAC (cm)	Undernutrition	<23.0	121(58.17)	205(59.76)	326 (59.16)	0.136	0.712
	Normal	≥23.0	87 (41.82)	138(40.23)	225 (40.83)		
PBF (%)	Low	<15%	30(14.42)	44(12.82)	74(13.43)	9.661	0.021
	Medium	15-23%	118(56.73)	152(44.31)	270(49.00)		
	Normal	23-32%	56(26.92)	121(35.27)	177(32.12)		
	high	>33%	7(3.36)	23(6.70)	30(5.44)		
BAI	Undernutrition	<23%	58 (27.88)	131(38.19)	189(34.30)	6.336	0.096
	Normal	23-34.9%	134(64.42)	188(54.81)	322(58.43)		
	Overweight	35-40%	11 (5.28)	18(5.24)	29(5.26)		
	Obese	>40%	5 (2.40)	6(1.74)	11(1.990		

Table 4 illustrates the Nutritional and Health status of Matia and Koya women on the basis of BMI, MUAC, WHR, PBF and BAI. 46% Matia women and 39% Koya women are suffering from CED Grades on basis of BMI. In both epidemiology and clinical practices, BMI is a common method to determine general nutritional status in both individual and population(Shetty et al., 1994). This index was found to have positive correlation with health and longevity indicators. But literatures suggest that (Deurenberg et al., 1998) BMI has limited accuracy with similar percentage of body adiposity(Ghosh, 2016b; Kanrar & Goswami, 2020b).

This study revealed that Koya women has better nutritional status than Matia women on basis of BMI. Undernutrition in both communities is primarily caused by the marginalization of tribal women, who live far from the mainstream population, have low literacy rates, poor socioeconomic conditions, poor sanitation, a high physical workload are employed as labourers in farming or the collection of tendu, mahua leaves from the forested areas and adhere to cultural and social norms.

Overall, 58% Matia and 60% Koya women had < 23.0cm MUAC indicating undernutrition. Since changes in MUAC often correspond with the changes in muscle mass, make it helpful in diagnosing hunger or protein energy malnutrition in both adults and children. The study also shows the distribution of PBF and BAI among Matia and Koya participants. The results shows that 14% Matia and 13% Koya women have less than 15% PBF that is categorized as very low PBF level. Around 28% Matia and 38% Koya women are poorly nourished as per Body Adiposity Index. BAI is a new approach of measuring obesity since it considers body structures, ethnicities and muscle fat provide more precise values of fat- to- lean tissue than BMI(Wang et al., 1994b). It is based on height and hip measurements, whereas BMI focuses on height-to-weight ratio. The present study shows contrasting result in term of Nutritional status. BMI indicate a significant prevalence of CED, while BAI based classification suggests normal. These results demonstrated that BAI may underestimate the prevalence of CED while overestimating the prevalence of overweight when compared to more conventional measure of BMI. The Chi-square value states that there was no significant difference in both community in terms of nutritional status based on BMI ($\chi2$ = 3.654, p = 0.454), MUAC ($\chi2$ = 1.136, p = 0.712); BAI ($\chi2$ = 6.336, p = 0.096). The PBF ($\chi2$ = 9.661, p = 0.021) shows significant association between both communities. The health status of Koya women was found to be marginally higher by the PBF in normal cut-off than that of Matia women.

Table 5 illustrate the correlation matrix between age with overall adiposity (BMI, PBF, FM, FMI, BAI) and central adiposity (WC, WHR, WHtR, CI) for both Matia and Koya women. The results show significant positive correlation between age with PBF (r= 0.302, p<0.01); FM (r= 0.231, p<0.01); FMI (r= 0.200, p<0.01) and WC (r= -1.49, P<0.05) in Matia women. While Among Koya women results show significant positive correlation between Age and BMI (r= 0.203, p<0.01); FMI (r= 0.150, p<0.01); WHR (r= 0.176, p<0.01), WC (r= -1.56, P<0.01) and FM (r= -0.116, p<0.05); BAI (r= -0.102. p<0.05). It is important to consider that BMI cannot be used to measure body fat unless one assumes that there is a correlation between PBF and height.

Table 6 shows the linear regression analysis, in which age is taken as independent variable while central adiposity and overall adiposity variables are taken as dependent variable to examine the impact of age on Dependent variable of both Matia and Koya women. The findings show that age has substantial impact on all overall and central adiposity measure across both communities. The correlation values (table 5) and linear regression (table 6) indicate that overall adiposity and central adiposity measures declines with increasing age.

There is a lack of researches on the nutritional status based on adiposity and BMI of the Matia and Koya tribes residing in South Odisha. In view of this, the current study endeavours to offer distinctive insights into the nutritional status of women within these communities. It is suggested that similar studies on nutritional and

adiposity levels among diverse ethnic groups inhabiting this forest-covered district of Odisha are undertaken to help health planners in identifying nature and degree of nutritional deficiencies.

Table 5 Correlation matrix showing association between age with overall and central adiposity measures

		AGE	*BMI*	*WC*	*WHR*	*WHtR*	*CI*	*PBF*	*FM*	*FMI*	*BAI*
Matia	*AGE*	1.000	.099	.149*	.014	.081	-.006	.302**	.231**	.200**	.111
	BMI		1.000	.463**	.031	.398**	-.198**	.967**	.925**	.949**	.402**
	WC			1.000	.109	.667**	.394**	.403**	.431**	.384**	.225**
	WHR				1.000	.087	-.020	.036	.041	.026	-.463**
	WHtR					1.000	.284**	.415**	.362**	.411**	.361**
	CI						1.000	-.190**	-.178*	-.197**	.103
	PBF							1.000	.962**	.979**	.413**
	FM								1.000	.955**	.316**
	FMI									1.000	.423**
	BAI										1.000
		AGE	*BMI*	*WC*	*WHR*	*WHtR*	*CI*	*PBF*	*FM*	*FMI*	*BAI*
Koya	*AGE*	1.000	.203**	.156**	.176**	.035	-.051	-.019	.116*	.150**	-.102*
	BMI		1.000	.347**	.078	.100*	-.299**	-.028	.540**	.614**	.091*
	WC			1.000	.290**	.433**	.309**	.002	.331**	.230**	.118*
	WHR				1.000	.138**	.112*	-.038	.080	.052	-.498**
	WHtR					1.000	.910**	-.046	.001	.021	.707**
	CI						1.000	-.030	-.177**	-.216**	.614**
	PBF							1.000	.711**	.484**	-.034
	FM								1.000	.700**	-.097*
	FMI									1.000	-.011
	BAI										1.000

* Correlation is significant at the 0.05 level (2-tailed), **. Correlation is significant at the 0.01 level (2-tailed).

Table 6 Impact of Age on overall and central adiposity measure in Matia (n=208) and Koya (n=343) tribal women aged 15-49 years

Dependent Variable		***B***	***SEB***	***Beta***	***t***	***Sig***	***Adjusted R^2***
BMI	*Matia*	71.999	1.828	0.106	39.385	0.000	0.006
	Koya	71.308	1.315	0.156	54.213	0.000	0.022
WC	*Matia*	18.901	0.692	0.065	27.309	0.000	-0.001
	Koya	18.099	0.556	0.203	32.544	0.000	0.038
WHR	*Matia*	1.032	0.198	0.013	5.201	0.000	-0.005
	Koya	0.828	0.041	0.176	20.16	0.000	0.028
WHtR	*Matia*	0.292	0.100	0.076	2.921	0.004	0.001
	Koya	0.451	0.018	0.350	25.021	0.000	0.002
CI	*Matia*	1.081	0.055	0.006	19.802	0.000	-0.005
	Koya	1.209	0.045	-0.051	26.816	0.000	0.000
PBF	*Matia*	16.274	1.121	0.302	14.514	0.000	0.087
	Koya	15.136	0.901	0.412	16.797	0.000	0.167
FM	*Matia*	7.128	0.815	0.223	8.745	0.000	0.045
	Koya	6.154	0.665	0.341	9.254	0.000	0.114
FMI	*Matia*	3.287	0.386	0.192	8.519	0.000	0.037
	Koya	2.666	0.338	0.328	7.897	0.000	0.105
BAI	*Matia*	24.78	1.276	0.111	19.424	0.000	0.007
	Koya	26.035	1.646	-0.102	15.814	0.000	0.008

Where, B indicate regression coefficient, SEB refers to standard error of B, Beta refers to estimated regression coefficient, sig means level of significance

Conclusion

Nutritional status based on BMI and age, sex, and ethnicity have been extensively researched. This study provides a preliminary record of the anthropometric parameters and nutritional condition of the Matia and Koya women residing in Malkangiri district of Southern Odisha. The overall nutritional status of studied Matia and Koya women depicts that a significant section of both community women are undernourished and have low PBF. This study suggest that we can utilize both BMI and PBF to identify individuals undergoing nutritional stress. BMI suggests that 45.67% Matia and 39% Koya women are undernourished. On the other hand, PBF indicate 14% Matia and 13% Koya had low PBF. This study also indicates that, comparatively, Koya women have better nutritional status than Matia. This study emphasizes that is important for these community to involve in various development initiatives aimed at eradicating poverty, increasing female literacy rate and implementing awareness programme.

Prospective studies are requested to explore the association between PBF and BMI indicators to determine the health and nutritional status of tribal women population.

Acknowledgement

We sincerely acknowledge the support and cooperation of the all Koya and Matia participants for their sincere contribution to this research. We sincerely thank the Anganwadi centre, ASHA workers, and key informants of these villages for their cooperation in conducting the survey.

Conflict of Interest: Nil

Funding: Nil

Ethical Approval: The present study is subpart of PhD work, so the Institute Ethical Committee Clearance certificate Ref No.: AUUP/IEC/AUG/2021/09 dated 15.12.2021 issued on the name of Kumud Kushwaha's PhD title," Health status of Koya and Matia Tribal women of Malkangiri, Odisha" under the 10th IEC meeting held on 18 Aug, 2021 by Amity University, Noida, Uttar Pradesh.

References

Bergman, R. N. (2012). A better index of body adiposity. *Obesity (Silver Spring, Md.)*, *20*(6), 1135. https://doi.org/10.1038/oby.2012.99

Bisai, S., Bose, K., Khatun, A., & Bauri, H. (2009). Age-Related Anthropometric Changes and Undernutrition among Middle Aged and Older Savar Tribal Females of Keonjhar District, Orissa, India. *Journal of Life Sciences*, *1*(1), 21–26. https://doi.org/10.1080/09751270.2009.11885130

Bose, K., & Chaudhuri, A. B. (2003). Age variations in adiposity and body fat composition among older Bengalee Hindu women of Calcutta, India. *Anthropologischer Anzeiger; Bericht Uber Die Biologisch-Anthropologische Literatur*, *61*(3), 311–321.

Bose, K., Ganguly, S., Mamtaz, H., Mukhopadhyay, A., & Bhadra, M. (2006). High prevalence of undernutrition among adult Kora Mudi tribals of Bankura District, West Bengal, India. *Anthropological Science*, *114*(1), 65–68. https://doi.org/10.1537/ase.050306

Deurenberg, P., Weststrate, J. A., & Seidell, J. C. (1991). Body mass index as a measure of body fatness: age- and sex-specific prediction formulas. *British Journal of Nutrition*, *65*(2), 105–114. https://doi.org/10.1079/BJN19910073

Deurenberg, P., Yap, M., & van Staveren, W. (1998). Body mass index and percent body fat: a meta analysis among different ethnic groups. *International Journal of Obesity*, *22*(12), 1164–1171. https://doi.org/10.1038/sj.ijo.0800741

Ghosh, J. (2016a). Nutritional Status of Tribal Women: An Epidemiological Study Among Santal-Munda Tribes of North 24Th Parganas District of West Bengal, India Home Science Nutritional Status of Tribal Women: An Epidemiological Study Among Santal-Munda Tribes of North 24Th Parganas District of West Bengal, India. In *Original Research Paper* (Issue 5). https://www.researchgate.net/publication/305187638

Ghosh, J. (2016b). Nutritional Status of Tribal Women: An Epidemiological Study Among Santal-Munda Tribes of North 24Th Parganas District of West Bengal, India Home Science Nutritional Status of Tribal Women: An Epidemiological Study Among Santal-Munda Tribes of North 24Th Parganas District of West Bengal, India. In *Original Research Paper* (Issue 5). https://www.researchgate.net/publication/305187638

Jackson, a. S., Pollock, M. L., & Ward, A. (1980). Generalized equations for predicting body density of women. *Medicine & Science in Sports & Exercise*, *12*(3), 175???182. https://doi.org/10.1249/00005768-198023000-00009

Jackson, A. S., Stanforth, P. R., Gagnon, J., Rankinen, T., Leon, A. S., Rao, D. C., Skinner, J. S., Bouchard, C., & Wilmore, J. H. (2002). The effect of sex, age and race on estimating percentage body fat from body mass index: The Heritage Family Study. *International Journal of Obesity and Related Metabolic Disorders : Journal of the International Association for the Study of Obesity*, *26*(6), 789–796. https://doi.org/10.1038/sj.ijo.0802006

Kanrar, P., & Goswami, M. (2020a). Sociodemographic Profile, Reproductive Health and Nutritional Status Among the Juangs—A Particularly Vulnerable Tribal Group of Odisha, India. *The Oriental Anthropologist: A Bi-Annual International Journal of the Science of Man*, *20*(1), 135–149. https://doi.org/10.1177/0972558X20913730

Kanrar, P., & Goswami, M. (2020b). Sociodemographic Profile, Reproductive Health and Nutritional Status Among the Juangs—A Particularly Vulnerable Tribal Group of Odisha, India. *Oriental Anthropologist*, *20*(1), 135–149. https://doi.org/10.1177/0972558X20913730

Martorell, R., Ramakrishnan, U., Schroeder, D. G., & Ruel, M. (2009). Reproductive Performance and Nutrition During Childhood. *Nutrition Reviews*, *54*(4), S15–S21. https://doi.org/10.1111/j.1753-4887.1996.tb03893.x

Mohandas, S., Amritesh, K., Lais, H., Vasudevan, S., & Ajithakumari, S. (2019). Nutritional assessment of tribal women in Kainatty, Wayanad: A cross-sectional study. *Indian Journal of Community Medicine*, *44*(5), S50–S53. https://doi.org/10.4103/ijcm.IJCM_39_19

Mukhopadhyay, A. (2010). Anthropometric characteristics and undernutrition among adult Santal tribe of Birbhum District, West Bengal, India. *ANTHROPOLOGICAL SCIENCE*, *118*(1), 57–60. https://doi.org/10.1537/ase090226

Norton, K. I. (2018). Standards for Anthropometry Assessment. In *Kinanthropometry and Exercise Physiology* (pp. 68–137). Routledge. https://doi.org/10.4324/9781315385662-4

Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. (1995). *World Health Organization Technical Report Series*, *854*, 1–452.

Rao, K. M., Arlappa, N., Radhika, M. S., Balakrishna, N., Laxmaiah, A., & Brahmam, G. N. V. (2012). Correlation of Fat Mass Index and Fat-Free Mass Index with percentage body fat and their association with hypertension among urban South Indian adult men and women. *Annals of Human Biology*, *39*(1), 54–58. https://doi.org/10.3109/03014460.2011.637513

Rao, K. M., Balakrishna, N., Arlappa, N., Laxmaiah, A., & Brahmam, G. N. V. (2010). Diet and Nutritional Status of Women in India. *Journal of Human Ecology*, *29*(3), 165–170. https://doi.org/10.1080/09709274.2010.11906259

Rokade, S., Mog, M., & Mondal, N. A. (2020). Nutritional status among tribal women in Maharashtra, India: Spatial variations and determinants. *Clinical Epidemiology and Global Health*, *8*(4), 1360–1365. https://doi.org/10.1016/j.cegh.2020.05.012

Shetty, P. S., Soares, M. J., & James, W. P. (1994). Body mass index: its relationship to basal metabolic rates and energy requirements. *European Journal of Clinical Nutrition*, *48 Suppl 3*, S28-37; discussion S37-8.

Singh, H. S., Ghritlahre, M., & Das, S. (2014). Nutritional Status among Females of Bhaina Tribe of Bilaspur, Chhattisgarh, India: An Anthropological Insight. *Journal of Anthropology*, *2014*, 1–7. https://doi.org/10.1155/2014/897893

Swaminathan, S., Hemalatha, R., Pandey, A., Kassebaum, N. J., Laxmaiah, A., Longvah, T., Lodha, R., Ramji, S., Kumar, G. A., Afshin, A., Gupta, S. S., Kar, A., Khera, A. K., Mathai, M., Awasthi, S., Rasaily, R., Varghese, C. M., Millear, A. I., Manguerra, H., … Dandona, L. (2019). The burden of child and maternal malnutrition and trends in its indicators in the states of India: the Global Burden of Disease Study 1990–2017. *The Lancet Child and Adolescent Health*, *3*(12), 855–870. https://doi.org/10.1016/S2352-4642(19)30273-1

Ulijaszek, S. J., & Kerr, D. A. (1999). Anthropometric measurement error and

the assessment of nutritional status. *British Journal of Nutrition*, *82*(3), 165–177. https://doi.org/10.1017/S0007114599001348

VanItallie, T., Yang, M., Heymsfield, S., Funk, R., & Boileau, R. (1990). Height-normalized indices of the body's fat-free mass and fat mass: potentially useful indicators of nutritional status. *The American Journal of Clinical Nutrition*, *52*(6), 953–959. https://doi.org/10.1093/ajcn/52.6.953

Wang, J., Thornton, J., Russell, M., Burastero, S., Heymsfield, S., & Pierson, R. (1994a). Asians have lower body mass index (BMI) but higher percent body fat than do whites: comparisons of anthropometric measurements. *The American Journal of Clinical Nutrition*, *60*(1), 23–28. https://doi.org/10.1093/ajcn/60.1.23

Wang, J., Thornton, J., Russell, M., Burastero, S., Heymsfield, S., & Pierson, R. (1994b). Asians have lower body mass index (BMI) but higher percent body fat than do whites: comparisons of anthropometric measurements. *The American Journal of Clinical Nutrition*, *60*(1), 23–28. https://doi.org/10.1093/ajcn/60.1.23

Wellens, R. I., Roche, A. F., Khamis, H. J., Jackson, A. S., Pollock, M. L., & Siervogel, R. M. (1996). Relationships Between the Body Mass Index and Body Composition. *Obesity Research*, *4*(1), 35–44. https://doi.org/10.1002/j.1550-8528.1996.tb00510.x

WHO Expert Consultation. (2004). Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet (London, England)*, *363*(9403), 157–163. https://doi.org/10.1016/S0140-6736(03)15268-3