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RESEARCH PAPER

Adult body dimension and determinants of chronic energy deficiency among the Shabar tribe living in urban, rural and forest habitats in Orissa, India

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Abstract

Aims: This study was conducted to examine variation of adult body dimension and prevalence of chronic energy deficiency (CED) with its determinants (socio-economic, nutrient and morbidity) among the Shabar tribe living in urban, rural and forest areas of Orissa, India.

Subjects and methods: Anthropometric measurements along with socio-economic, nutrient consumption and morbidity patterns of 444 males and 489 females aged 20–60 years were collected from the Khurda and Cuttack districts.

Results: Major differences were found in fat mass rather than muscle mass between habitats, and the urban group showed higher values compared to rural and forest counterparts. The highest prevalence of undernutrition was observed among forest-dwelling males and rural females. Gender difference was higher in the rural area. Higher prevalence of CED was observed among illiterates, within larger families, economically poorer groups, those with inadequate nutrient consumption, and those who had experienced morbid conditions. However, sex and habitation-wise, the risk factors associated with CED were different. Notably, economic disparity and morbidity conditions were a significant risk factor of CED among rural females.

Conclusion: Body fat content was found to be the major difference in body dimension across different habitats and rural women may be a vulnerable group.

Keywords: *Body dimension, chronic energy deficiency, determinants, socio-economic, habitat, Shabar tribe, India*

Introduction

Anthropometric measurements have assumed a major role in exploring body dimension and nutritional status of populations over time and space (Gorstein and Akre 1988) – specifically, the use of body mass index (BMI), which can be utilized for assessing differences in standard of living between population groups or for monitoring change (Nube et al. 1998). However,

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BMI contains both fat mass and fat-free mass, where human body fat has physiological and medical importance (Durnin and Womersley 1974). Distribution of body fat is a significant marker of nutrition and chronic diseases (Garn 1955; Vague 1956). Conversely, the amount of body fat composition varies habitation-wise and it is generally shown that urban groups possess a higher amount of body fat compared to their rural counterparts (Devi et al. 2008). Therefore, it is important to conceptualize the differences in BMI between populations not only in absolute terms of undernutrition or obesity but also to analyse the relative contribution of fat mass and muscle mass.

In South and South East Asian countries, undernutrition is still a major health issue and concern (Nube and Van Den Boom 2003). In India, a national level study has shown prevalence of undernutrition among different social groups, where tribes are the most vulnerable segments (NFHS II 1998–1999 – International Institute for Population Sciences 1998–1999). They constitute 8.20% of the total population of India (Census of India 2001). Traditionally, Indian tribes live in rural and forest areas but recently they have begun to live in different habitats (like urban, rural and forest, etc.) due perhaps to the influence of urbanization and migration. The consequences of these changes contribute to building up a strong socio-economic gradient in way of life specifically among the urban living group, which may be reflected in their body dimension and nutritional status (Subramanian et al. 2006). Therefore, habitation-specific body dimension and nutritional status among populations including Indian tribes is worthy of study (Planning Commission of India 2002).

Several investigations have been carried out to understand the major determinants of undernutrition in different populations, such as socio-economic inequalities (Ahmed et al. 1998), nutrient consumption (Ramachandran 2007), physical activity (Croppenstedt and Muller 2000), morbidity (Khongsdier 2002), etc. However, most of the studies pay little attention to the variability of undernutrition determinants across populations or within populations along with their place of residence (Slifkin et al. 2000). In most Indian states, although the prevalence of undernutrition among women was higher in rural compared to urban areas, the magnitude of determinants was found to vary habitation-wise (Bharati et al. 2008). Consequently, factors responsible for undernutrition in urban areas may not be similar in rural and forest counterparts, and differences may also be shown in both sexes. Comparison of both body dimension and undernutrition based on anthropometric parameters in a single tribe across residences is also important to minimize genetic predisposition of differences in anthropometric variables (Lohman et al. 1988).

The present study aims to investigate variation of body dimension and prevalence of CED among Shabar tribes living in urban, rural and forest habitats, and also to examine the habitation and sex-wise determinants of CED with some selected socio-economic, nutrient consumption and morbidity parameters.

Materials and methods

Population and study area

The study area was located in the Khurda and Cuttack districts of Orissa, India in view of the largest concentration of Shabar settlements, with the hamlets and villages being selected on the basis of the geographical location, like urban hamlets of Bhubaneswar City, rural villages of Jatani block area and forest villages inside the Chandaka–Domapara Elephant Sanctuary (until recently known as the Asian Elephant Research Center). The study was conducted between June and September 2007.

The data for the present study were collected from three hamlets in urban areas (Baragad, Nayapalli and Siripur Shabar *Shai*), three rural villages (Jamujhari, Chatabar and Bindhagiri Shabar *shai*) and three forest villages (Dahangadia, Behenta *Shai* and Nuakua). Overall 473 families were included from three habitats (178 from urban, 141 from rural and 154 from forest). The total sample of the present study was 933 individuals aged 20–60 years (444 male and 489 female) from three habitats. At least one individual was included in the sample from each family. We did not consider higher age group (> 60 years), because it would have created some error in estimating anthropometric measurements due to ageing (World Health Organization 1995), also the sample size in the study population was very small.

The hamlets and villages were selected, firstly, based on their geographical location as urban, rural and forest areas and, secondly, on the availability of the Shabar population. Complete enumeration was done during socio-economic data collection from all the families of nine settlements of the three habitats. For the other investigations at individual level, complete enumeration was not possible due to unavailability or unwillingness. Statistical sampling was not feasible because of obvious operational difficulties in the field. All those who agreed to cooperate were included in the sample, which consisted of more than 75% of the total population.

The study was approved by the ethical committee of the Indian Statistical Institute, Kolkata. Written informed consent about their willingness to participate in the study was obtained from all adult individuals prior to the actual commencement of the study. We collected thumb impressions from those who agreed to participate who were illiterate.

Socio-economic data

Socio-economic data were collected using a pre-tested household schedule from all three habitats. Schedules were completed using information on age, sex, occupation, education, income, expenditure, food expenditure, housing condition, household landholding, household assets, etc. collected from household heads and cross-checked from several sources.

The present study is not entirely free from estimation and/or approximation in determining age. However, adult age was calculated through the birth certificates or horoscopes or in relation to specific festivals or to some important local events, natural calamities, etc. and cross-checked with elderly individuals to reduce the chance of error of reporting.

Anthropometric measurements

Anthropometric measurements were taken following the standard techniques (Weiner and Lourie 1981). A portable weighing machine (Edryl India) and anthropometer (GPM, Swiss made) were used for the measurements of weight (kg) and height (cm). Harpenden skinfold caliper (British Indicator Ltd) was used for the skinfolds measurement. Height measurement was recorded to the nearest 0.1 cm and weight was recorded to the nearest 0.5 kg. Efforts were made to exclude subjects with any physical deformities. Technical errors of measurements were computed and found to be within acceptable limits (Ulijaszek and Kerr 1999). Two repeated measurements were made on 15 subjects for every anthropometric variable. No ill individuals, lactating and/or, pregnant women were included in the sample.

Diet survey

A one day dietary survey was conducted in each household during an average day in a week. Each raw food item to be cooked for each meal was weighed in a Salter pan type balance prior to cooking. Household members not taking meal at home or guest(s) taking meal in the household were also recorded. Respondents were asked on the next day whether any food had been left over or consumed by their livestock or shared with a neighbour. If yes, the amounts were recorded. Approximate amounts (weight) of food items consumed by member(s) outside the home during that day were also recorded. In order to minimize overestimation of the average consumption of some nutrient(s), we avoided the day of special cuisine.

Self-reported morbidity

A structured schedule was used to collect self-reported morbidity (information about type and occurrence of diseases); both qualitative symptoms of disease as well as diagnosed diseases in similar three months prior to survey, as suggested by Khongsdier (2002).

Estimation of poverty and expenditure level

Poverty level was calculated based on per capita income (Rs) of the families they belonged to, as suggested by Dev and Ravi (2007) in urban (Rs 525.48) and rural (Rs 325.46) households of Orissa state in the year 2005–2006. Rural poverty standard was also used for the forest group due to the fact that the forest group was dependent on market economy as in the rural area. Percentages of per capita total expenditure and food expenditure from income were measured. The percentage values were classified as shown in Table I.

Economic classification based on the ratio of total expenditure and food expenditure groups shown in Table I is certainly arbitrary. It may, however, be noted that the main purpose of such classification is to unravel the effect of economic conditions on nutritional status in the present population as shown in other populations (Bharati 1983).

Estimation of nutrient consumption

Nutritional values were estimated from food composition tables, prepared by the Indian Council of Medical Research (ICMR) (Gopalan et al. 2007). Calorific need of an individual was taken as the basis of estimation of consumption unit. The consumption unit (cu) per household was calculated. Consumption of calories, protein and fat were classified on the basis of Recommended Dietary Allowances (RDA) of India; 2875 calories (kcal), 60 g proteins and 20 g fats were considered as the cut-off values for assessing 'less than' and 'above' consumption in respect of RDA (Indian Council of Medical Research 2004).

Table I. Classification of economic condition among the Shabar.

	Economic condition
Per capita total expenditure	
< 80% from per capita income	high
≥ 80% from per capita income	low
Per capita food expenditure	
< 80% from per capita income	high
≥ 80% from per capita income	low

Anthropometric indices for body dimension

Some of the following indices were computed for adult males and females in order to assess the body composition:

(i) Body mass index (BMI) = Weight (kg)/Height (m^2) (James et al. 1988)

Estimation of body dimension:

(ii) Total upper arm area (TUA) = $C^2/(4 \times \pi)$ (Frisancho 1990)

(iii) Upper arm muscle area (UMA) (cm^2) = $[C - (T_s \times \pi)]^2/(4 \times$ï $\pi)$ (Frisancho 1990)

where C is upper arm circumference and T_s is triceps skinfold

(iv) Upper arm fat area (UFA) (cm^2) = TUA – UMA (Frisancho 1990)

(v) Arm fat index (AFI) = (UFA/TUA) × 100 (Frisancho 1990)

(vi) Density = $c - m \times$ log skinfold (biceps + triceps + subscapular + suprailiac) (Durnin and Womersley 1974)

where c and m = standard age and sex specific coefficient

(vii) Percentage body fat (PBF) = [(4.95/density) – 4.50] × 100 (Siri 1956)

Nutritional gradation based on BMI among adult

The subjects were classified on the basis of chronic energy deficiency (CED) (James et al. 1988, World Health Organization 1995) as shown in Table II. BMI <18.50 kg/m^2 was considered as undernutrition condition (World Health Organization 1995).

Statistical analysis

Descriptive analysis of the anthropometric parameters was carried out. Difference in indicators of anthropometry among the groups living in three ecological settings was compared using one-way analysis of variance (ANOVA) as well as between two specific settings using t-test. In addition, to estimate the prevalence of CED, contingency χ^2 test was used to understand the association between the prevalence of CED and habitation as well as between CED and factors. Stepwise multiple logistic regressions (binary) were performed to identify the independent factors associated with CED, respectively for the males and females of the three habitats, separately, where BMI < 18.5 kg/m^2 = 1 and BMI ≥ 18.5 kg/m^2 = 0 were considered as dependent variables. Log_{10} transformation was done for discontinuous data set, specifically skinfold measurement and its related indices. p<0.05 was considered statistically significant. Analysis was carried out using SPSS 11.0 version.

Backgrounds of the subjects

Socio-economically, urban-living Shabar were better off than rural and forest counterparts. But intra-household socio-economic inequalities were higher in urban followed by rural and

Table II. Classification of Body Mass Index (BMI).

Classification	Cut-off points (BMI = kg/m^2)
CED grade III (severe thinness)	<16.00
CED grade II (moderate thinness)	16.00–16.99
CED grade I (mild thinness)	17.00–18.49
Low weight normal	18.50–20.00
Normal	20.01–24.99
Overweight	25.00–29.99
Obese	≥ 30.00

forest areas. Literacy was highest among both urban children and adults compared to other groups. The highest illiteracy was noted among rural Shabar females. Habitation-wise opportunity and utilization of resources were marked on their occupation. Urban males and females were engaged more in certain income-generating activities like daily wages and services. On the other hand, opportunities for getting daily wages in the rural area were very uncertain. The influence of sanctuary law on the forest group had altered their way of living but abundant natural resources like dry wood helped them to earn money in a regular basis by selling it in the nearby market. The reflection of such occupational difference along with their needs was observed through income, expenditure and food expenditure patterns. The level of poverty was more or less similar in all three habitats but variation was noticed in expenditure patterns. Majorities of the rural and forest households spent to consume food and earned money according to their needs for their survival. In contrast, urban households spent to secure household amenities, electricity and health, etc. rather than only to acquire food.

Results

Adult body dimension through anthropometric measurements and indices of muscle and fat mass indicated that although the males of the three habitats were found to differ in height (cm), weight (kg) and BMI (kg/m^2), the differences were not statistically significant (Table III). The highest mean BMI (19.25) was observed among urban males followed by rural (19.12) and forest (18.72) males. Males of the three habitats were significantly

Table III. Descriptive statistics of anthropometric measurements and indices among adult males.

Anthropometric measurements and indices	Urban			Rural			Forest			
	Mean age (years): 36.10 ± 11.15			Mean age (years): 36.40 ± 10.05			Mean age (years): 37.45 ± 11.02			
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*F*-value
Height (cm)	204	159.41	5.02	134	160.67	5.38	106	159.71	5.76	2.33
Weight (kg)	204	48.94	7.16	134	49.46	6.78	106	47.81	6.07	1.80
Body mass index (kg/m^2) (BMI)	204	19.25	2.62	134	19.12	2.13	106	18.72	2.06	1.76
Circumferences (cm)										
Mid upper arm	204	24.57	2.24	134	25.04	2.58	106	24.56	1.71	2.08
Minimum waist	204	69.98	6.74	134	69.61	5.58	106	68.94	5.90	0.98
Maximum hip	204	80.63	5.42	134	79.25	4.67	106	77.70	4.72	12.03**
Calf	204	30.50	2.63	134	30.55	2.41	106	30.49	1.94	0.02
Log of skinfolds thickness (mm)										
Biceps	204	3.34	0.98	134	3.06	0.75	106	2.88	0.53	19.40**
Triceps	204	6.15	2.56	134	5.79	2.56	106	5.52	2.28	4.53*
Subscapular	204	9.91	3.68	134	9.66	3.26	106	9.08	2.94	4.07*
Suprailiac	204	6.82	3.47	134	6.56	3.30	106	6.59	2.74	0.91
Medial calf	204	4.59	2.11	134	4.37	1.78	106	4.20	1.59	4.45*
Abdominal	204	7.21	3.65	134	6.94	3.61	106	6.43	2.55	12.76**
Body fat and muscle composition										
Upper arm muscle area (cm^2)	204	40.61	6.67	134	42.96	9.75	106	41.20	4.99	4.14*
Log of upper arm fat area (cm^2)	204	7.20	3.65	134	6.93	3.60	106	6.42	2.55	3.26*
Log of arm fat index	204	15.11	4.84	134	14.03	4.88	106	13.50	4.09	6.16**
Log of percentage body fat	204	11.73	4.23	134	11.17	3.86	106	10.64	3.58	3.43*

*$p < 0.05$; **$p < 0.01$; all log transformed means are geometric means.

different in most of the skinfolds and the urban males possessed higher values compared to rural and forest counterparts. For instance, the highest mean of triceps skinfold was observed among urban males (6.15 mm) followed by rural (5.79 mm) and forest (5.52 mm) males. It was noted that males were significantly ($p < 0.05$) different in upper arm muscle area (cm^2), where the rural males had highest value (42.96). It was observed that males of the three habitats were significantly different in all the fat indices like upper arm fat area, arm fat index and percentage body fat. In contrast, females of the three habitats indicate significant difference in weight (kg), BMI (kg/m^2) and skinfolds thickness rather than height (Table IV), where lower mean BMI was observed among rural females (17.90) compared to forest (18.12) and urban (19.00) females. A similar trend was noticed in waist and hip circumferences as well as in all the skinfold thicknesses (biceps, triceps, subscapular, suprailiac, medial calf and abdominal) including the anthropometric indices (upper arm fat area, fat mass index and percentage body fat). Highest mean value of upper arm muscle area (31.94 cm^2) was found among rural females but the differences were not significantly varied habitation-wise.

The differences between two specific residential areas are shown in Table V. A higher significant difference was observed between forest and urban males in most of the anthropometric measurements and indices compared to urban and rural as well as forest and rural males. On the other hand, there were higher significant differences between females in urban and rural areas compared to forest and rural females.

Age group and sex-wise distribution of some relevant anthropometric measurements and indices show that there were insignificant differences in most of the anthropometric variables

Table IV. Descriptive statistics of anthropometric measurements and indices among adult females.

	Urban			Rural			Forest			
	Mean age (years): 36.29 ± 10.75			Mean age (years): 37.22 ± 11.47			Mean age (years): 37.34 ± 10.71			
Variable	*n*	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*F*-value
Height (cm)	203	148.23	4.95	186	148.81	5.33	100	149.55	4.57	2.35
Weight (kg)	203	41.78	7.17	186	39.73	7.60	100	40.54	5.27	4.21*
Body mass index (kg/m^2) (BMI)	203	19.00	3.03	186	17.90	2.98	100	18.12	2.21	7.73**
Circumferences (cm)										
Mid upper arm	203	22.89	2.58	186	22.46	2.76	100	22.59	2.01	1.47
Minimum waist	203	64.67	7.98	186	59.80	7.43	100	60.77	5.53	22.69**
Maximum hip	203	80.99	6.41	186	76.65	6.67	100	78.09	4.58	24.03**
Calf	203	28.59	2.59	186	28.39	2.67	100	28.57	1.94	0.35
Log of skinfolds thickness (mm)										
Biceps	203	4.09	1.76	186	3.29	1.31	100	3.34	0.88	27.53**
Triceps	203	9.14	3.73	186	7.46	3.43	100	8.68	3.17	14.76**
Subscapular	203	10.69	4.61	186	9.51	4.93	100	10.29	3.57	4.91**
Suprailiac	203	8.36	4.72	186	7.32	4.58	100	7.65	3.82	4.41*
Medial calf	203	7.49	3.54	186	5.82	3.16	100	6.64	2.58	18.21**
Abdominal	203	11.87	5.30	186	10.03	5.84	100	10.57	5.03	7.27**
Body fat and muscle composition										
Upper arm muscle area (cm^2)	203	31.52	6.14	186	31.94	6.64	100	31.09	4.39	0.65
Log of upper arm fat area (cm^2)	203	9.71	4.91	186	7.88	4.94	100	9.15	4.17	11.35**
Log of arm fat index	203	23.56	6.81	186	19.89	5.96	100	22.69	5.88	18.29**
Log of percentage body fat	203	21.76	5.14	186	19.58	4.97	100	20.86	4.05	10.77**

*$p < 0.05$; ** $p < 0.01$; all log transformed means are geometric means.

Table V. Test of significance between two habitats on anthropometric measurements and indices among adult males and females.

	t-value					
	Urban vs Rural		Rural vs Forest		Forest vs Urban	
Variable	Male	Female	Male	Female	Male	Female
Height (cm)	-2.19*	-1.10	1.32	-1.18	0.48	2.24*
Weight (kg)	-0.67	2.74**	1.96*	-0.95	-1.39	-1.54
Body mass index (kg/m^2) (BMI)	0.46	3.60**	1.47	-0.66	-1.80	-2.56*
Circumferences (cm)						
Mid upper arm	-1.77	1.61	1.64	-0.43	-0.03	-1.02
Minimum waist	0.53	6.13**	0.90	-1.13	-1.35	-4.33**
Maximum hip	2.42*	6.47**	2.54*	-1.90	-4.71**	-3.97**
Calf	-0.16	0.75	0.20	-0.61	-0.03	-0.05
Log of skinfolds thickness (mm)						
Biceps	3.62**	6.51**	2.56*	-0.27	-5.85**	-5.21**
Triceps	1.56	5.21**	1.42	-3.31**	-2.94**	-1.15
Subscapular	0.77	2.98**	2.08*	-1.76	-2.81**	-0.87
Suprailiac	0.91	2.87**	0.33	-1.17	-1.22	-1.31
Medial calf	1.38	5.89**	1.67	-2.33*	-2.90**	-2.76**
Abdominal	3.63**	3.75**	1.07	-0.87	-4.68**	-2.23*
Body fat and muscle composition						
Upper arm muscle area (cm^2)	-2.63**	-0.63	1.69	1.14	0.80	-0.63
Log of upper arm fat area (cm^2)	0.90	4.57**	1.66	-2.80**	-2.52*	-1.12
Log of arm fat index	2.30*	5.79**	1.04	-3.85**	-3.34**	-1.08
Log of percentage body fat	1.38	4.48**	1.20	-2.33*	-2.55*	-1.57

$^*p < 0.05$; $^{**}p < 0.01$.

among the males and females in the three habitats across age groups (Tables VI and VII). Only urban males showed significantly higher waist circumference, triceps skinfold, arm fat area and percentage body fat in 41–60 years compared to 20–40 years. A similar trend was observed among rural males in triceps skinfold. Conversely, significant differences in fat mass between habitats among males were found in 31–40 years. Similarly, females of the three habitats were significantly different in BMI, waist circumference, triceps skinfold, arm fat area and percentage body fat in the lower age group compared to 51–60 years.

The highest prevalence of undernutrition (BMI < 18.50 kg/m^2) was observed among forest males (48.11%) compared to urban (45.59%) and rural (40.30%) males (Figure 1). However, the difference was not statistically significant. Unlike males, the highest prevalence of undernutrition was among rural females (66.67%) and the difference was statistically significant ($p < 0.01$). Females of all three habitats showed higher prevalence of undernutrition compared to males, where the highest difference was noticed between rural males and females (26.37%).

The highest percentage of severe chronic energy deficiency (CED III) and moderate chronic energy deficiency (CED II) was observed among rural females (24.73% of CED III and 18.82% of CED II) compared to urban (15.27% of CED III and 11.33% of CED II) and forest females (15.00% of CED III and 13.00% of CED II) (Table VIII). A similar trend was noted among the forest males for moderate (CED II) and mild (CED I) chronic energy deficiency. The prevalence of overweight and obesity was very low, and both the urban males (2.45%) and females (3.45%) indicated higher percentages than their rural and forest counterparts.

Table VI. Age group-wise distribution of anthropometric variables among males.

Age group (years)	Urban			Rural			Forest			
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD	*F*-value
BMI (kg/m²)										
20–30	76	18.93	2.07	43	19.14	1.83	34	18.46	1.35	1.29
31–40	54	19.42	2.00	46	18.90	2.05	38	18.81	1.68	1.44
41–50	46	19.57	3.37	32	19.57	2.45	19	18.67	2.42	0.73
51–60	28	19.23	3.52	13	18.77	2.57	15	19.17	3.47	0.09
F-value	0.69			0.75			0.43			
Waist circumference (cm)										
20–30	76	67.45	4.99	43	68.74	4.66	34	67.74	3.81	1.07
31–40	54	71.01	5.51	46	69.29	5.15	38	69.35	4.90	1.73
41–50	46	72.42	7.84	32	71.09	6.45	19	68.22	6.96	2.25
51–60	28	70.96	8.95	13	69.93	7.30	15	71.51	9.47	0.12
F-value	6.670**			1.17			1.60			
Log of triceps skinfold (mm)										
20–30	76	5.44	2.07	43	5.52	2.10	34	5.22	1.89	0.35
31–40	54	6.39	2.33	46	5.42	1.86	38	5.35	1.60	5.36**
41–50	46	6.78	3.10	32	6.53	3.39	19	5.42	1.96	2.52
51–60	28	6.75	2.72	13	6.36	3.19	15	6.89	3.84	0.14
F-value	5.528**			2.85*			1.67			
Log of upper arm fat area (cm²)										
20–30	76	6.32	2.84	43	6.66	2.64	34	6.15	2.44	0.62
31–40	54	7.66	3.08	46	6.51	2.62	38	6.33	2.14	4.56*
41–50	46	8.03	4.53	32	7.81	5.15	19	6.43	2.52	1.97
51–60	28	7.68	4.36	13	7.40	4.37	15	7.48	3.57	0.04
F-value	4.85**			1.96			1.19			
Log of percentage body fat										
20–30	76	10.68	3.23	43	11.52	3.14	34	10.43	3.48	1.44
31–40	54	12.36	4.28	46	10.56	3.37	38	10.36	3.07	4.48*
41–50	46	12.57	4.96	32	11.85	4.81	19	10.30	2.85	2.35
51–60	28	12.26	4.62	13	10.63	4.94	15	12.44	5.20	0.95
F-value	3.55*			1.14			1.55			

*$p < 0.05$; ** $p < 0.01$; all log transformed means are geometric means.

The relationship between socio-economic condition, nutrient intake and morbidity pattern with CED (BMI <18.50 kg/m^2) are shown in Table IX. Age group-wise distribution of CED indicated that a higher prevalence of CED was observed among the males in the age group of 20–40 years than above 40 years except forest males, whereas females of all three habitats showed higher prevalence of CED in the above 40 years of age group. However, the differences were not statistically significant. A higher prevalence of CED was noticed among illiterate males and females than in literate groups (up to class IV, and class V and above) except for urban males and forest females. Illiterate rural females had a significantly ($p < 0.05$) higher prevalence of CED (72.26%) than those who went to school (up to class IV, 53.57% and class V and above, 47.62%). The prevalence of CED was higher ($p < 0.05$) among the urban males (52.29%), who live in a large family (≥ 6 members). A similar trend was also found among the rural and forest males and the forest females. Significantly ($p < 0.05$) higher percentages of CED were observed in the below poverty level among the urban males (55.21%) and females (58.16%) as well as rural females (74.16%). A similar but insignificant trend was observed among the rural males and forest females, whereas forest males showed the opposite result. A higher prevalence of CED was noted among economically higher expenditure group (per capita expenditure ≥ 80% and per capita

Table VII. Age group-wise distribution of anthropometric variables among females.

Age group (years)	Urban *n*	Urban Mean	Urban SD	Rural *n*	Rural Mean	Rural SD	Forest *n*	Forest Mean	Forest SD	*F*-value
BMI (kg/m²)										
20–30	75	18.77	2.42	63	18.15	2.56	31	18.17	1.77	1.37
31–40	62	19.55	2.93	55	18.39	2.95	32	18.15	2.35	3.60*
41–50	40	19.08	3.47	37	17.00	2.83	25	18.38	2.43	4.68*
51–60	26	18.21	3.97	31	17.58	3.76	12	17.40	2.53	0.29
F-value	1.44			1.93			0.54			
Waist circumference (cm)										
20–30	75	62.85	6.68	63	59.30	6.55	31	60.02	4.21	5.73**
31–40	62	65.72	7.86	55	60.62	6.99	32	60.50	5.59	9.24**
41–50	40	66.15	8.68	37	59.09	6.85	25	62.11	5.75	8.81**
51–60	26	65.00	9.86	31	60.18	10.16	12	60.50	7.65	1.95
F-value	2.12			0.44			0.70			
Log of triceps skinfold (mm)										
20–30	75	8.69	3.18	63	7.67	2.73	31	8.49	2.22	2.70
31–40	62	9.44	4.03	55	7.51	3.99	32	8.09	2.76	4.82**
41–50	40	10.06	3.79	37	6.77	3.50	25	9.46	3.92	11.82**
51–60	26	8.43	4.15	31	7.79	3.62	12	9.24	4.21	0.73
F-value	1.84			1.11			1.19			
Log of upper arm fat area (cm²)										
20–30	75	9.10	4.03	63	8.07	3.61	31	8.82	2.58	1.87
31–40	62	10.23	5.25	55	8.10	5.83	32	8.53	3.70	3.92*
41–50	40	10.79	5.31	37	7.01	4.92	25	10.23	2.27	10.24**
51–60	26	8.75	5.43	31	8.17	5.64	12	9.67	5.82	0.45
F-value	2.03			1.01			1.22			
Log of percentage body fat										
20–30	75	21.52	4.22	63	20.54	4.49	31	20.60	2.61	1.22
31–40	62	22.21	5.45	55	19.75	5.19	32	19.89	4.22	4.32*
41–50	40	22.65	5.17	37	18.10	4.88	25	22.10	4.50	10.84**
51–60	26	20.18	6.48	31	19.25	5.37	12	21.72	5.21	0.89
F-value	1.54			2.49			1.65			

*$p < 0.05$; ** $p < 0.01$; all log transformed means are geometric means.

food expenditure ≥ 80%) in both the males and females of all three habitats except forest males. The distribution of CED with nutrient consumption based on RDA showed that nutritionally lower energy, protein and fat (<RDA) consumption groups had a high prevalence of CED compared to higher consuming group and a significant relationship was found among the urban males in case of protein ($p < 0.05$) and fat ($p < 0.01$) consumption. Surprisingly, forest males and females showed the opposite result in fat consumption, i.e. the nutritionally higher consumption group (above RDA) experienced more CED than the nutritionally lower consumption group (<RDA). Generally, it was observed that higher prevalence of CED occurred among those males and females who reported having experienced 'sore throat or running nose with fever', 'coughed more than a week' and 'repeated pain over the chest'. It was noted that 79.37% ($p < 0.01$) of rural females who reported having 'coughed more than a weeek' suffered from CED. A similar significant relationship was observed among the rural males and females who reported having experienced 'repeated pain over the chest'. Irrespective of habitats, poverty, per capita food expenditure group and morbidity pattern played significant roles in increasing prevalence of CED among males. On the other hand, age group, level of education, poverty, per capita food expenditure group and morbidity pattern played significant roles in increasing

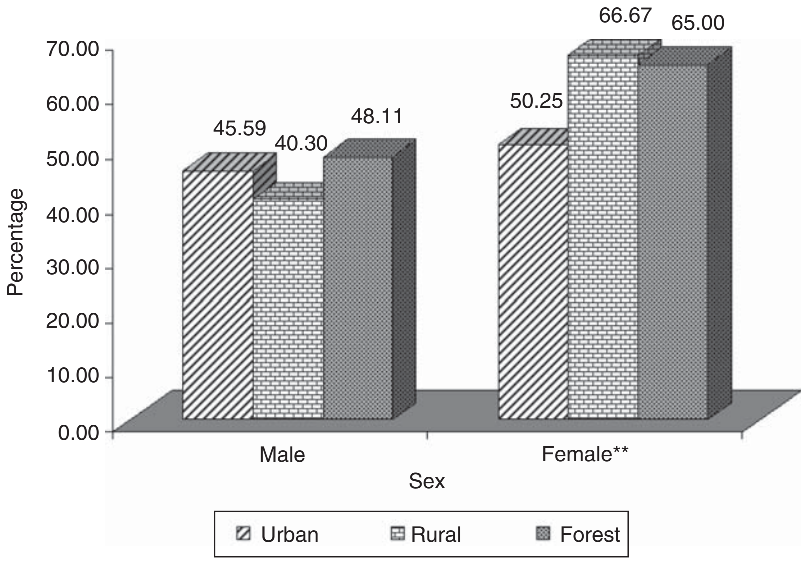

Figure 1. Habitation and sex-wise prevalence of undernutrition (BMI < 18.5 kg/m^2) among adults. $^{**}p < 0.01$.

prevalence of CED among females. Due to high correlation coefficient values between economic factors (poverty, expenditure and food expenditure groups) as well as nutrient factors (per capita calories, protein and fat consumption groups), only per capita expenditure group and per capita fat consumption group along with morbidity factors were considered for step-wise logistic regression analysis. Step-wise logistic regression also confirmed the results, where the urban males were more likely to be undernourished in <RDA fat consumption (OR = 2.855, $p < 0.01$) and coughed more than a week positive group (1.932, $p < 0.05$) as shown in step 2 (Table X). Urban females, rural males and rural females were more likely to be undernourished in per capita expenditure group (≥ 80%), where odds ratio was highest among rural females (OR = 2.832, $p < 0.01$). A similar higher risk of becoming undernourished was noticed in rural males and females that suffered from illness. The forest group did not show any significant factors related to the undernourished condition.

Discussion

The purpose of this study was to assess the variation of adult body dimension along with prevalence of CED and its determinants of a single tribe (Shabar) living in urban, rural and forest habitats in a tribal dominated state in India such as Orissa. It is one of the rare cases where the population is distributed throughout the habitats but each has maintained their traditional nature of group endogamy. Therefore, major differences between habitats in terms of body composition and nutritional status may be due to the effect of varied ways of life such as economic and subsistence activities as well as physical activities rather than genetic dissimilarity between groups. In the present study, major differences were found in skinfolds and fat mass among both the males and females in the three habitats rather than height and muscle mass. Both urban males and females showed higher BMI compared to rural and forest groups. These differences may be due to higher possession of fat mass rather

Table VIII. Nutritional status among adults.

	Urban		Rural		Forest		Total	
BMI (kg/m^2) grades	*n*	%	*n*	%	*n*	%	*n*	%
Male								
<16 (CED III)	9	4.41	6	4.48	4	3.77	19	4.28
16–16.99 (CED II)	26	12.75	11	8.21	15	14.15	52	11.71
17.00–18.49 (CED I)	58	28.43	37	27.61	32	30.19	127	28.60
18.50–20.00 (low weight normal)	44	21.57	42	31.34	36	33.96	122	27.48
20.01–24.99 (normal)	62	30.39	37	27.61	18	16.98	117	26.35
≥ 25.00 (overweight and obese)	5	2.45	1	0.75	1	0.94	7	1.58
Total	204	100.00	134	100.00	106	100.00	444	100.00
Chi-square				14.018				
Female								
<16 (CED III)	31	15.27	46	24.73	15	15.00	92	18.81
16–16.99 (CED II)	23	11.33	35	18.82	13	13.00	71	14.52
17.00–18.49 (CED I)	48	23.65	43	23.12	37	37.00	128	26.18
18.50–20.00 (low weight normal)	30	14.78	25	13.44	20	20.00	75	15.34
20.01–24.99 (normal)	64	31.53	31	16.67	13	13.00	108	22.09
≥ 25.00 (overweight and obese)	7	3.45	6	3.23	2	2.00	15	3.07
Total	203	100.00	186	100.00	100	100.00	489	100.00
Chi-square				31.955**				

** $p < 0.01$.

than fat-free mass, because BMI contains both fat mass and fat-free mass (Durnin and Womersley 1974). The possession of higher fat mass may be due to high consumption of fat-rich diet and comparatively lower physical activities among the urban group compared to their rural and forest groups. Ulijaszek and Lofink (2006) reported that fat-rich diet and activity level may closely associate with body dimension through anthropometric characters. In contrast, rural males and females were found to have higher muscle mass as revealed through upper arm muscle area and fat-free mass index, which may be due to their higher level of physical activities and consumption of more protein and carbohydrate diet than the urban group. Differences in anthropometric traits between two specific habitats were higher between forest and urban males, which may be due to wide differences in socio-economic, nutritional and activity patterns between the two groups. The higher differences in anthropometric traits between the urban and rural females compared to forest and rural females may be due to the fact that most rural and forest females were involved in more physical activity than urban counterparts. Beside these above consequences, the differences in fat mass and muscle mass between age groups are also important factors. However, there were least age differences in BMI, waist circumference, triceps skinfold, fat mass and fat-free mass across the age groups among both the males and females of the three habitats. This may be due to similar nature of activity and consumption throughout the ages. Only urban males showed significantly increased fat mass throughout age groups, but on most occasions the differences in measure of body dimension between habitats were observed in working age group, specifically in 30–40 years rather than 50–60 years in both the males and females of the three habitats.

Results of prevalence of CED provide compelling evidence of marked variation between different habitations, with factors acting with different magnitudes. In the present study, a broadly similar prevalence of undernutrition (BMI < 18.50 kg/m^2) among males of the three habitats may be associated with the unhealthy condition of the Shabar males as a whole, with

Table IX. Prevalence (%) of CED according to age, SES, nutrient intake and morbidity in different residential groups.

	Male						Female						Total			
	Urban (n = 204)		Rural (n = 134)		Forest (n = 106)		Urban (n = 203)		Rural (n = 186)		Forest (n = 100)		Male (n = 444)		Female (n = 489)	
Variables	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Age group (years)																
20–40	61	46.92	38	42.70	33	45.83	65	47.45	72	61.02	39	61.90	132	45.36	176	55.35*
Above 40	32	43.24	16	35.56	18	52.94	37	56.06	52	76.47	26	70.27	66	43.14	115	67.25
Literacy status																
Class V and above	68	43.04	26	40.63	30	44.12	20	44.44	10	47.62*	8	72.73	124	42.76	38	49.35**
Up to class IV	22	56.41	14	36.84	12	54.55	33	47.83	15	53.57	17	58.62	48	48.48	65	51.59
Illiterate	3	42.86	14	43.75	9	56.25	49	55.06	99	72.26	40	66.67	26	47.27	188	65.73
Family members																
≤5	36	37.89*	24	38.71	22	47.83	46	50.55	69	69.00	23	58.97	82	40.39	138	60.00
≥6	57	52.29	30	41.67	29	48.33	56	50.00	55	63.95	42	68.85	116	48.13	153	59.07
Poverty																
Above poverty	40	37.04**	25	35.21	26	50.98	45	42.86*	58	59.79*	28	59.57	91	39.57*	131	52.61**
Below poverty	53	55.21	29	46.03	25	45.45	57	58.16	66	74.16	37	69.81	107	50.00	160	66.67
Per capita expenditure group																
<80% from income	33	38.82	11	27.50*	11	57.89	30	35.71**	26	52.00*	13	65.00	55	38.19	69	44.81**
≥80% from income	60	50.42	43	45.74	40	45.98	72	60.50	98	72.06	52	65.00	143	47.67	222	66.27
Per capita food expenditure group																
<80% income	52	40.31*	15	30.61	20	48.78	57	44.53*	38	57.58*	23	62.16	87	39.73*	118	51.08**
≥80% income	41	54.67	39	45.88	31	47.69	45	60.00	86	71.67	42	66.67	111	49.33	173	67.05
RDA group (energy)																
≥ RDA	8	30.77	8	30.77	28	58.33	15	46.88	19	59.38	25	60.98	44	44.00	59	56.19
< RDA	85	47.75	46	42.59	23	39.66	87	50.88	105	68.18	40	67.80	154	44.77	232	60.42
RDA group (protein)																
≥ RDA	13	30.95*	7	25.00	36	53.73	20	44.44	23	60.53	36	63.16	56	40.88	79	56.43
< RDA	80	49.38	47	44.34	15	38.46	82	51.90	101	68.24	29	67.44	142	46.25	212	60.74

Table IX (*Continued*)

Variables	Male						Female						Total			
	Urban (n = 204)		Rural (n = 134)		Forest (n = 106)		Urban (n = 203)		Rural (n = 186)		Forest (n = 100)		Male (n = 444)		Female (n = 489)	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
RDA group (fat)																
≥ RDA	43	35.25**	25	41.67	28	54.90	60	46.88	57	63.33	34	68.00	96	41.20	151	56.34
< RDA	50	60.98	29	39.19	23	41.82	42	56.00	67	69.79	31	62.00	102	48.34	140	63.35
Sore throat or running nose with fever																
No	32	38.10	18	30.51*	16	38.10	40	54.05	48	59.26	17	58.62	66	35.68**	105	57.07
Yes	61	50.83	36	48.00	35	54.69	62	48.06	76	72.38	48	67.61	132	50.97	186	60.98
Coughed more than a week																
No	54	40.00*	25	31.65*	35	44.87	70	48.28	74	60.16**	42	61.76	114	39.04**	186	55.36**
Yes	39	56.52	29	52.73	16	57.14	32	55.17	50	79.37	23	71.88	84	55.26	105	68.63
Repeated pain over the chest																
No	69	43.67	36	35.29*	36	45.00	85	49.13	96	62.75*	51	62.20	141	41.47*	232	56.86**
Yes	24	52.17	18	56.25	15	57.69	17	56.67	28	84.85	14	77.78	57	54.81	59	72.84

*$p < 0.05$; ** $p < 0.01$.

Table X. Stepwise logistic regression analyses of socio-economic and other factors on CED.

Habitation	Group		OR	95% confidence interval Lower	Upper
Urban	*Male*				
	Step 1	RDA group (Fat)			
		<RDA	2.870**	1.609	5.120
		≥ RDA†			
	Step 2	RDA group (Fat)			
		<RDA	2.855**	1.590	5.127
		≥ RDA†			
		Coughed more than a week			
		Yes	1.932*	1.053	3.544
		No†			
	Female				
	Step 1	Expenditure group			
		≥ 80% from income	2.757**	1.547	4.916
		<80% from income†			
Rural	*Male*				
	Step 1	Coughed more than a week			
		Yes	2.409*	1.184	4.903
		No†			
	Step 2	Expenditure group			
		≥ 80% from income	2.360*	1.033	5.390
		<80% from income†			
		Coughed more than a week			
		Yes	2.522*	1.220	5.214
		No†			
	Female				
	Step 1	Coughed more than a week			
		Yes	2.547*	1.253	5.175
		No†			
	Step 2	Expenditure group			
		≥ 80% from income	2.553**	1.280	5.093
		<80% from income†			
		Coughed more than a week			
		Yes	2.717**	1.314	5.621
		No†			
	Step 3	Expenditure group			
		≥ 80% from income	2.832**	1.388	5.778
		<80% from income†			
		Coughed more than a week			
		Yes	2.277*	1.082	4.794
		No†			
		Repeated pain over the chest			
		Yes	3.214*	1.115	9.265
		No†			
Forest	*Male*				
		-	-	-	-
	Female				
		-	-	-	-

†Reference group; *$p < 0.05$; ** $p < 0.01$.
BMI <18.5 kg/m^2 = 1 and BMI ≥18.5 kg/m^2 = 0 are considered as dependent variable.

forest males showing the poorest condition. Unlike males, the prevalence of undernutrition in females was markedly different among the three habitats. Rural females showed poorer condition compared to forest females. Urban females were of comparatively better nutritional status than the others. Similar findings were reported among Garhwali females, where rural Garhwalis were more undernourished than urban counterparts in the Garhwal Himalayas in India (Dutta and Pant 2003). The population living adjacent to the present study area, the Savar of Keonjhar district of rural Orissa, had lower prevalence of undernutrition in both males (38.0%) and females (49.0%) than the present adult Shabar in all three habitats (Bose et al. 2006). The prevalence of undernutrition was higher among females than males in all three habitats. The highest gender difference in terms of undernutrition was found among the rural group, which may be due to strong gender bias towards males in the provision of medical care (Kulkarni and Chintamani 1999; Sundar and Sharma 2002), education (Balakrishnan 1994; Chakraborty 2001), food and nutrition (Ghosh et al. 2001; Gopalan and Aeri 2001) and food distribution (Basu et al. 1986; Levinson et al. 2003). All these studies clearly show that in Indian society, there is a generalized tendency to give preferential treatment to boys over girls. In south Asian countries, gender bias and female undernutrition are distinctive features (Osmani and Sen 2003). However, a study based on an anthropological field survey on intra-household food distribution among selected tribal and non-tribal groups of West Bengal concluded that the traditional Hindu system of male dominance and associated against-female familial bias was absent among Indian tribes (Basu et al. 1986). Food consumed, cooking methods and also their eating outside show a trend for the tribals to come out from their traditional mode of life. Their heavy work and lower consumption, especially the women, not getting an equal share of the food while their workload is heavier than that of men, makes them nutritionally very poor among the tribals of southern India (Dash and Naidu 2007). The gender equation among Indian tribes has historically been more balanced and egalitarian; an unfortunate trend of tribal gender bias conforming to the mainstream against-female pattern (along with acculturation, assimilation and similar 'modernizing' processes) is increasingly discernible under current circumstances (Maharatna 2000). A similar picture was noticed in the severity of undernutrition based on CED. Rural females and forest males also indicated higher prevalence of chronic energy deficiency (CED III and CED II) than others. In the present study, overweight and obesity was not a major problem but urban males and females showed higher prevalence (1% urban males and 0.5% urban females) than the other two habitats as shown in some Indian tribes like Bhutia living in urban area of Sikkim (Sarkar 2006) and scheduled tribes from Delhi, Hariyana and Punjab states (Agrawal 2002). The relationship between socio-economic condition, nutrient consumption and morbidity with undernutrition (BMI <18.50 kg/m^2) revealed no significant difference. This may be due to similar activity levels across the age groups among males and females of the three habitats. In all the three habitats there was a higher prevalence of CED among illiterates, family member ≥ 6, below poverty level, economically higher expenditure, nutritionally lower energy, protein and fat (<RDA) consumption groups and have experienced sore throat or running nose with fever, coughed more than a week and repeated pain over the chest to 3 months during survey in all three habitats. However, sex and habitation-wise, the risk factors associated with CED in the Shabar adults were different. The urban males that consumed a low amount of fat (<RDA) and were found to suffer from cough more than a week, had significantly higher prevalence of CED. Importantly, consumption of fat from edible oil may have influenced urban males to suffer a comparatively lower prevalence of CED. Per capita expenditure was significantly associated with CED among urban females and rural males as well as rural females along with morbid conditions. Kimhi (2003) also suggested that economic condition

was positively associated with undernutrition as assessed through BMI gradation. In the present study, highest association (OR = 2.832) was noted among the most vulnerable rural females. However, there were no significant associations of socio-economic, nutritional and morbidity factors with CED among the forest group. This may be due to lower economic, nutritional and disease prevalence inequalities in the forest area compared to the other two residences. Similar findings have also been reported in other Indian populations regarding the interrelationships of socio-economic status, BMI, CED and morbidity (Campbell and Ulijaszek 1994; Naidu and Rao 1994; Ahmed et al. 1998; Reddy 1998; Khongsdier 2002; Mahmud et al. 2006). Therefore, although economic condition and morbidity pattern may play a significant role in determining adult undernutrition (Bose et al. 2007) in the present study, the relative contribution of those factors was found to vary from urban to rural and to forest habitats, where rural females were the most vulnerable segment with highest economic disparity. However, some sampling errors existed in this study due to the inclusion of some related individuals from the same family in the analysis.

It can therefore be inferred from the present study that place of residence has played a major role in habitat specific bio-social interaction as revealed through variation in body dimension in terms of fat mass along with the prevalence of CED and its determinants. Therefore, such micro-level population-based studies in anthropological research may highlight not only a local problem specifically among Indian tribes but also the nature of transformation in a population who are undergoing rapid change in their economic pursuits.

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