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Use of neck circumference as a predictor to assess undernutrition: a study among the adult Sabar males of West Bengal, India

K. Das[1], S. S. Bagchi[2], S. Pal[3], S. Ganguli[4] and K, Mukherjee[5]

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[1]Kaustav Das, Department of Anthropology, Bangabasi College, Kolkata – 700009. Email: kaustavanthro@gmail.com
[2]Subrata Sankar Bagchi, Department of Anthropology, Bangabasi College, Kolkata – 700009. Email: ssbagchi2005@yahoo.co.in
[3]Somosree Pal, Department of Anthropology, Bangabasi College, Kolkata – 700009. Email: somosree.2013@gmail.com
[4]Sayak Ganguli, Theoretical and Computational Biology Unit, AIIST - Palta and The Biome, Kolkata – 700064 Email: sayakganguli1@gmail.com
[5]Koel Mukherjee, Anthropological Survey of India, Andaman & Nicobar Regional Centre, Port Blair- 744 101. Email: koelanthro@gmail.com
Corresponding Author: Koel Mukherjee, Anthropologist (Physical Anthropology Division), Anthropological Survey of India, Government of India, Ministry of Culture, Andaman and Nicobar Regional Centre, Port Blair. Email: koelanthro@gmail.com

ABSTRACT

Undernutrition is a major concern particularly for the tribal people who are living in remote areas. For last two decades neck circumference (NC) is being used as an alternative tool to access obesity and over weight for Body Mass Index (BMI). But scholarly works regarding the use of neck circumference to evaluate undernutrition are not available till the date. The aim of this pioneering study is to find out the efficacy of neck circumference to determine undernutrition among Indian adults. A cross-sectional study was conducted among 198 adult Sabar males in the Purulia District of West Bengal, India. Anthropometric variables like height (cm), weight (kg), neck circumference (cm) were measured and BMI (kg / m^2) was calculated. One way ANOVA and Pearson's correlation were performed and Receiver Operating Characteristics (ROC) curve analysis was done to find out best cut off threshold of neck circumference against BMI. P value of ≤0.05 was considered statistically significant. Results revealed that BMI was better correlated to neck circumference (r= 0.616) than weight. NC 32.65 cm (AUC 0.792; 95% CI= 0.724-0.861) may be regarded as best cut off for determining undernutrition (BMI<18.5 kg/m^2) among adult Sabar males. In the context of this study, neck circumference showed significant association with BMI for community based screening of undernourished subjects. Neck circumference is a feasible method to identify adult malnutrition. Thus NC might be considered as a screening tool for malnutrition and key nutritional status indicator among the tribal population.

Keywords: *Neck Circumference, Body Mass Index, Undernutrition, Sabar.*

INTRODUCTION

Even after seven decades of Independence, India still faces a serious threat of undernutrition (The Global Nutrition Report, 2017). According to Global Hunger Index (2018), India scores 31.3 (comes under 'serious' category in the GHI scale) and ranks 103rd out of 119 countries—a position even lower than its poorer neighbouring nations like Sri Lanka, Myanmar, Nepal, Bangladesh. Insufficient intake of dietary energy coming from carbohydrate, protein, fat, vitamins and minerals, is regarded as the primary cause of undernutrition leading to a series of metabolic abnormalities, physiological changes, delayed physical and mental development, recurring illnesses, increasing the risks of infection, changes in body mass, increasing risks of mortality and morbidity (Ghosh *et al.* 2018, Shetty and James 1994). Undernourishment in India is prevalent both among the males and females and across all the ages (Gragnolati *et al.* 2006, Siddiqui and Donato 2016). Undernourishment among the adult males in India has seldom been a subject of study as the researchers have concentrated mostly on the undernourishment among women, infants and children. A study based on data of National Family Health Survey-3 revealed that 28.6% of Indian men are underweight and among the younger age group (15-49 years) the figure reaches a staggering 52.5% (Patil and Shinde 2014). In 2016, Kshtriya and Acharya studied on tribal males belonging 20 to 60 years of age distributed among nine major tribes from three states of India and reported that an overall 32.1% of tribal males can be categorised as undernourished.

The tribal population in India constitutes 8.6% of the total population (Census of India 2011) and they are considered as the most socially and economically underprivileged (Annual Report 2017-18, Ministry of Tribal Affairs. Government of India). According to 2011 Census of India, the total tribal population of West Bengal is 52, 96,953 which constitutes 5.08% of the State's population and 5.1% Indian tribal population (Census of India 2011). The decadal growth rate of tribal population in West Bengal during 2001-2011 is 20.2% which is higher than the decadal growth rate of state (13.9%) and national (17.69%) population (Bisai *et al.* 2014). But there is a serious dearth of data on the nutritional status of various Indian tribes and it has been recommended by various scholars that we need to study the nutritional status of them on an urgent basis (Ghosh *et al.* 2018, Kshtriya and Acharya 2016, Bose *et al.* 2006a, 2006b). Amidst various reports of starvations among the Sabars of West Bengal, it became imperative for the present workers to study the nutritional status of the Sabars as well as to develop a handy tool of measuring undernutrition in a remote field. The numeric strength of the Sabars is 43,599 in West Bengal according to the Census of India of 2001. They have dark brown skin colour, curly black hair, long head, medium stature and probably belong to Proto-Australoid group (Roy 2005). They mainly live in the Districts of Purulia, Medinipur and Bankura. Sabars were earlier considered as a 'Criminal Tribe' under Criminal Tribes Act, 1871—an act annulled by the Government of India after getting Independence (Bhandari *et al.* 2019). Thus after independence their "criminal" label has been replaced and since 1952 they were put under the group known as "Denotified Tribes (DNTS)". Unfortunately, they still face the social stigma of criminality (Ghosh and Guchhait 2017). Traditionally, they were largely dependent on foraging forest

products but after rigorous implementation of the legal provisions related to the protection and preservation of Indian forests, they are being displaced and barred from their prolific foraging activities. Nowadays, most of them earn their livelihoods by working as wage labourers in agricultural fields, tea plantations, construction of roads, mines etc (Ghosh and Guchhait 2017).

The Body Mass Index (BMI) is the most established anthropometric indicator of nutritional status and widely used because of its non-invasive and inexpensive nature which is suitable for large scale survey (Ferro-Luzzi *et al.* 1992, James *et al.* 1994, Lee and Neiman 2003) especially for the adult population in developing countries (Shetty and James 1994, Khongsdier 2002). But scholars indicate that BMI has some drawbacks or practical limitations as a measurement tool particularly for debilitated, disabled, acutely ill patients even inappropriate for the pregnant women (Sultana *et al.* 2015). In recent years, some other anthropometric measurements are being used as alternatives to assess nutritional status and neck circumference (NC) is one of them (Sjostrom *et al*. 1997, Janssen *et al.* 2002). Jean Vague (1956) first used NC index to assess upper body fat distribution. Several other studies have shown positive correlations of NC with BMI (Jonosen *et al.* 2002, Ben-Noun *et al*. 2001, Ben-Noun and Laor 2003) as well as waist circumference (Hingorjo *et al.* 2012) which is associated with cardio metabolic risk factors (Ben-Noun *et al.* 2001, Zhou *et al*. 2013, Kumar *et al*. 2014) as well as insulin resistance (Hingorjo *et al*. 2012, Sjostrom *et al.* 1995; Ben-Noun and Laor 2006; Laakso *et al*. 2002). Researchers from all over the world, in recent years used NC as a screening tool to identify overweight and obese people in clinical practices or epidemiological surveys (Saka *et al*. 2014, Ozakaya and Tunckale 2016, Pei *et al*. 2018). But Neck circumference has not been used so far to identify undernutrition to the best of our knowledge. The present study is an attempt to find out whether a single measurement of NC might be used to identify undernourishment among the Sabar male adults of West Bengal, India.

MATERIALS AND METHODS

This is a cross-sectional study conducted at nine villages falling under three blocks (Purulia-I, Manbazar-I and Puncha) of Purulia district, West Bengal. A total of 198 adult Sabar males were selected for the study at random. All the participants were apparently healthy and not suffering from any disease during data collection period. Data were collected after obtaining the necessary approvals through verbal consent from the subjects. Ethical clearance was obtained from Institutional Research and Ethics Committee of the affiliating institute of the first author prior to the commencement of this study.

Anthropometric measurements of height (cm), weight (kg) and neck circumference (cm) were taken following standard methods recommended by International Society for the Advancement of Kinanthropometry (ISAK manual 2011). Height was measured by Matrin's anthropometer and the weight by using a digital weighing machine (Omron HN 289). NC was measured with a calibrated plastic tape (Gulick Anthropometric tape). Height and NC were recorded to the nearest 0.1 cm and weight to the nearest 0.5 kg. Body Mass Index was computed using the formula

BMI= Weight (kg) / Height (m^2). The Chronic Energy Deficiency (CED) status was defined as BMI <18.5. For assessing nutritional status Asia-Pacific cut off points (World Health Organization 2000) were used:-

CED III:	BMI < 16.00 kg/m^2
CED II:	BMI = 16.0-16.9 kg/m^2
CED I:	BMI = 17.0-18.4 kg/m^2
Normal:	BMI = 18.5-22.9 kg/m^2
Overweight:	BMI = 23.0-24.9 kg/m^2
Obese:	BMI ≥ 25 kg/m^2

Statistical data analysis was done by using SPSS Statistical Package (Windows Version 16.00) and the descriptive statistics was applied to find out the mean, SD, maximum and minimum value and percentiles. One way ANOVA (F-test) was performed to test for mean difference within and between groups. Pearson's correlation coefficient was used to explore the correlation between NC and other anthropometric variables. Receiver Operating Characteristics (ROC) curve analysis was employed to determine optimal cut off value of NC in relation to BMI for assessing undernutrition (<18.5). $P < 0.05$ was considered as statistically significant.

RESULTS

The descriptive statistics of age and anthropometric variables among 198 adult Sabar males of Purulia district of West Bengal reveals that the mean with the standard deviation of age, BMI and NC are 37.0±13.2, 19.5±2.6 and 33.3±2.2 respectively (Table 1). Apart from that the value of 25^{th}, 50^{th}, 75^{th} percentile on age and anthropometric variables has also been mentioned.

The distribution of studied population on the basis of nutritional status as assessed by BMI is presented in the Table 2. Overall malnutrition was found to be present among the 43.9% of the population and of them 35.3% is undernourished. The rate of CED III, II and I are 4.5%, 8.1% and 22.7% respectively.

Table 3 showing the mean value of NC at different BMI levels reveals that the mean NC value has gradually increased from low (31.04±1.51) to high (37.24±1.16) with BMI levels.

Table 4 represents Pearson's correlation coefficient between age, anthropometric variables and NC. NC shows the highest correlation with BMI followed by weight whereas age is inversely correlated with NC.

NC and BMI of adult Sabar males were found to be in a linear relationship (Figure 1). Apart from Pearson Correlation coefficient (r), the coefficient of determination (r^2) has been used as a measure of the meaningfulness of r to describe the proportion of the variation in the observed values of NC which can be explained by BMI.

ROC curve analysis was used here to determine the best cut off threshold of neck circumference in relation to BMI among Sabar adult males. This analysis shows that the area under curve (AUC) for NC and underweight is 0.792 with standard error of 0.035 and 95% Confidence Interval (CI) = 0.724-0.861. Thus this model has the chance to distinguish between the positive and negative classes with 70% accuracy with the incorporation of the calculated standard error.

NC ≤ 32.65 cm can be regarded as the best cut off point for determining the undernourishment (BMI < 18.5) with Positive Likelihood Ratio (LPR) of 3.466 (Table 5 and 6, Figure 2).

DISCUSSION

This study seeks to posit NC as a predictor of BMI in the context of undernourishment which is the first attempt of its kind in this field. The results of this study indicate that the prevalence of undernourished adult Sabar males is 35.3% which may be regarded as moderately high. Additionally, the mean NC gradually increases from low to high BMI levels having a F value of 20.284 which is greater than the F_c (2.28) at 0.05 level of probability. In addition, Pearson's correlation between Age, weight, BMI and NC shows that BMI is better correlated to NC than weight. It is observed from this study that NC of 32.65 cm (AUC = 0.792, 95% CI = 0.724–0.861) for adult men might be considered as the threshold for the identification of underweight (BMI <18.5kg/m^2) among the Sabar population in West Bengal.

As mentioned earlier that the tribal population in India is considered as the most vulnerable population and thus we considered that the determination of the nutritional status of tribal adult population should be considered as to be of prime significance while assessing the health and well being of Indian population. Studies also indicate that there are important racial/ethnic components which should be considered during the determination of underweight and chronic energy deficiency (Sulaiman *et al*. 2018, Kavosi *et al*. 2014, Meshram *et al.* 2012). Therefore, the diagnosis of the different ethnic specific health condition is of great importance in prevention and treatment of ailments related to undernourishment.

There is a dearth of enough volume of works on nutritional status of adult males of tribal and indigenous population in India which this study wants to fill. In the year 2008, Banik reported 53.1% and 38.2% of the Oraon adult men of Ranchi district of Jharkhand as undernourished on the basis of BMI and Mid Upper Arm Circumference (MUAC) standard cut off points respectively. A similar study using BMI and MUAC on the adult Santal males of Keonjhar district Orissa conducted by Bose *et al*. (2006b) showed 26.2% and 33.7% of the male population as undernourished. Cormic Index (sitting height to stature ratio) was also used along with BMI to assess undernutrition (Khongsdier 2009, Sahani *et al.* 2018). A recent study on the health condition of the Sabars of Bankura district of West Bengal depicted 46.8% of adult males were undernourished (Ghosh *et al*. 2018). Present study from Purulia district of West Bengal reveals that 35.3% of the adult male Sabars as undernourished which can be considered as a serious situation (World Health Organization 1995) and needs immediate intervention.

Literature is rich over the years with works which have used BMI and some other indices for the purpose of nutritional assessment in urban and rural areas (Bose *et al*. 2006, Ferro-Luzzi *et al*. 1992, James *et al*. 1994, Banik 2008, Sahani *et al*. 2018). But for those groups who are living in remote areas a genuine inconvenience is experienced at the time of carrying out nutritional assessment with too many measurements and tests. In this specific circumstance, the neck circumference estimation can become the most convenient benchmark for the estimation of

undernourishment. Further, NC correlates closely with BMI which signifies that NC can be used as a less demanding, dependable and quick measure for screening adult individuals having poor nutritional status. In addition, it is adequately practicable tool which provides appreciable added information to be used in the distinguishing the undernourished adults. Furthermore, there is a plethora of research articles on prediction and appraisal of overweight and obesity in different ethnic groups by NC, we found very few studies regarding the cut off levels of NC in Asian population for determining overweight and obesity ranging from 34.7-38.5cm (Mondal *et al*. 2016, Verma *et al*. 2017, Qureshi *et al*. 2017, Lin *et al*. 2018). But no literature was found regarding the cut off value of NC for the assessment of underweight particularly on the tribal and indigenous people in the Third World countries like India. In this context, this study represents the first endeavour to evaluate the neck circumference (32.65 cm) as an anthropometric measure of underweight and chronic energy deficiency (BMI<18.5 kg/m^2).

CONCLUSION

This pioneering study among the adult male Sabars of Purulia district of West Bengal indicates that they live under a serious threat of undernourishment. It also seeks to establish that the NC correlated closely with BMI and a cut off value of 32.65 cm may be used as a simpler alternative to detect undernutrition among adult tribal male population who are living in remote areas with minimal effort and technological expertise. We also recommend that further studies should be conducted to validate present NC cut off value or propose variable NC cut off values for different ethnic groups especially for South Asian population.

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Table 1: Descriptive statistics of Age and Anthropometric variables among the adult Sabar males of Purulia District, West Bengal, India.

Anthropometric variables					**Percentile**		
	Mean	**SD**	**Minimum**	**Maximum**	**25th**	**50th**	**75th**
N= 198							
Age (years)	37.0	13.2	18.0	63.0	25	35	47
Height (cm)	162.3	5.5	145.8	176.0	159.0	161.9	166.1
Weight (kg)	50.3	7.4	35.5	74.1	45.5	49.3	54.2
BMI (kg/m^2)	19.5	2.6	13.3	29.6	17.8	19.3	20.6
NC (cm)	33.3	2.2	24.1	41.8	32.1	33.2	34.5

N- Total number of individuals, BMI- Body Mass Index, NC- Neck circumference.

Table 2: Nutritional status as assessed by BMI of the adult Sabar males of Purulia District, West Bengal, India.

Nutritional Category (BMI)	**WHO Asia Pacific Guidelines**	
	N	**%**
CED III	9	4.5
CED II	16	8.1
CED I	45	22.7
Total Under Nutrition	70	35.3
Normal	111	56.1
Overweight	8	4.0
Obese	9	4.5
Total	198	100

CED- Chronic Energy Deficiency, N- Total number of individuals.

Table 3: Mean values for NC at different levels of BMI.

BMI Category (WHO Asia Pacific Guidelines)	Neck Circumference				
	N	Mean	SD	Minimum	Maximum
CED III	9	31.04	1.51	29.10	34.20
CED II	16	31.61	0.86	30.00	33.20
CED I	45	32.58	2.12	24.60	41.80
Normal	111	33.53	1.80	24.10	38.10
Overweight	8	35.88	1.21	33.90	37.80
Obese	9	37.24	1.16	35.70	39.00

Table 4: Pearson's correlation coefficient for neck circumference with age and anthropometric variables having significance.

Anthropometric Variables	Neck Circumference
	r
Age	-0.228^{**}
Weight	0.605^{**}
BMI	0.616^{**}

$^{**}p < 0.01$

Table 5: NC cut-off levels for determining the subjects with BMI <18.5kg/m^2 using ROC curve analysis.

Cut off	Sensitivity	1- Specificity
32.15	0.866	0.486
32.25	0.857	0.457
32.35	0.839	0.400
32.45	0.821	0.343
32.55	0.804	0.314
32.65	**0.795**	**0.286**
32.75	.0777	0.257
32.85	0.759	0.257
32.95	0.741	0.257
33.05	0.661	0.243
33.15	0.661	0.171

Table 6: The efficacy of NC for screening underweight population.

Population	Number	Sensitivity	Specificity	AUC (SE)	95% Confidence Interval		Cut off	Likelihood Ratio	PPV	NPV	POSITIVE LIKELIHOOD	NEGATIVE LIKELIHOOD	ACCURACY	P
					Lower Bound	Upper Bound								
Male	182	71.4%	79.5%	.792 (.035)	.724	.861	32.65	47.646	68.49	81.65	3.466	0.360	0.76	0.000

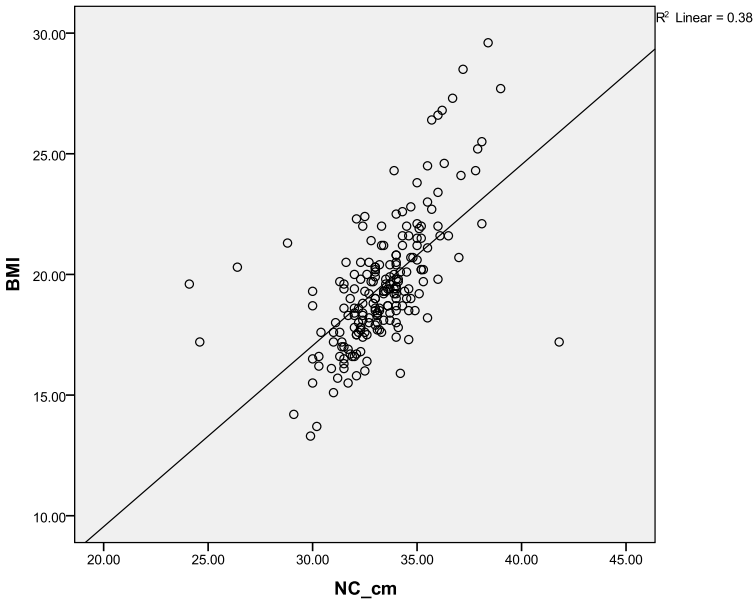

Fig 1. Scatter plot showing the correlation of neck circumference with Body Mass Index in Sabar adult male population

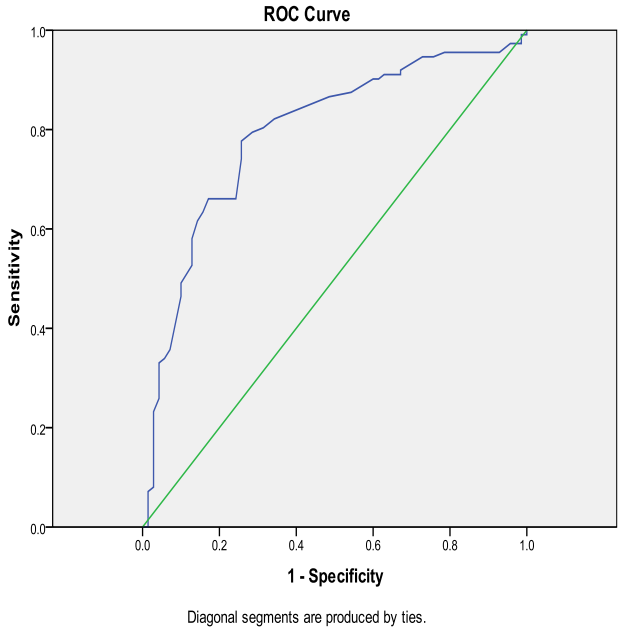

Fig 2. Receiver Operating Characteristic curve for NC in adult Sabar male with Body Mass Index (BMI $\leq$18.5kg/m^2)