ANTHROPOLOGIE • LX/3 • pp. 435–443 • 2022

SUDIP DATTA BANIK

ASSOCIATION OF BODY MASS INDEX WITH BLOOD PRESSURE AMONG ADULT LIMBU MEN IN DARJEELING, WEST BENGAL

ABSTRACT: Arterial hypertension is reported to be associated with high body mass index (BMI). However, it is also interesting to find the association between BMI-based undernutrition and blood pressure. Objective of the present study was to estimate prevalence of BMI-based thinness and excess weight (overweight and obesity) and their differential association with hypertension among adult men representing Limbu community in Darjeeling, West Bengal. A cross-sectional study in Darjeeling District of West Bengal, India selected 897 adult men aged 20 to 59 years, representing Limbu community. Hypertension was estimated as: systolic/diastolic ≥140/90 mmHg. Binomial logistic regression (BLR) analysis was done to predict hypertension from thinness (BMI <18.50 kg/m^2) and excess weight (BMI ≥25.0 kg/m^2) after adjusting for age. Mean value of age of the participants (n = 897) was 37.28 years. Hypertensive men had higher body weight (84.83 kg) and BMI (20.70 kg/m^2) compared to normotensive peers (80.10 kg and 19.09 kg/m^2, respectively). Prevalence of thinness (11.59%), overweight (24.41%), and obesity (48.72%) were remarkable in the sample; 48.49% of the participants were hypertensive. BLR Model 1 has shown that 1-unit (kg/m^2) increase in BMI had a chance of 68% rise in odds of being hypertension (Model 1). An adult man suffering from BMI-based thinness compared to normal weight was 2.8 times more likely to have hypertension (Model 2). Adult men with excess weight (n = 656) compared to the peers having normal BMI (n =137) were 3.45 times more likely to be hypertensive (Model 3). BMI-based malnutrition (undernutrition and excess weight) was observed to be a risk factor for hypertension that was higher in case of excess weight than thinness.

KEY WORDS: Thinness - Overweight - Obesity - Hypertension

Received 27 April 2021; Accepted 14 October 2021. Available online 23 May 2022.

DOI: https://doi.org.10.26720/anthro.22.05.09.1

INTRODUCTION

Cardiovascular diseases cause 31% of deaths globally (WHO 2020a). Body mass index (BMI) is useful to evaluate thinness (undernutrition), overweight and obesity (WHO 1995). Studies on interrelationships between the levels of BMI and blood pressure are not new and overweight and obesity were reported to be the risk factors for arterial hypertension (Chobanian *et al.* 2003, Dyer *et al.* 1989, Menke *et al.* 2007, Sharabi *et al.* 2004). Association of hypertension with undernutrition has also been reported (Kapoor *et al.* 2012, Tesfaye *et al.* 2007) but relatively less. Studies have documented that BMI and lifestyle habits were the principal risk factors for hypertension (Commodore-Mensah *et al.* 2018, Feng *et al.* 2012, Martín *et al.* 2016). Reports are available from Asia-Pacific (Ni *et al.* 2004), African and Asian countries (Tesfaye *et al.* 2007, Tuan *et al.* 2009), Italy (Landi *et al.* 2018), Norway (Droyvold *et al.* 2005) and the USA (Gelber *et al.* 2007). Association between blood pressure and BMI are reported from Asian countries namely, India (Dua *et al.* 2014, Gupta 2004, Gupta *et al.* 2007, Kapoor *et al.* 2012, Mungreiphy *et al.* 2011, Reddy *et al.* 2010), Pakistan (Khan *et al.* 2008), and China (Hu *et al.* 2000, Linderman *et al.* 2018).

Previous studies reported high degree undernutrition among adults of Dhimal, Mech, and Rajbanshi communities in Darjeeling District of West Bengal, India (Datta Banik, Dash 2013, Datta Banik *et al.* 2009b). A study from rural areas of Darjeeling also reported association of BMI-based nutritional status with blood pressure (Datta Banik 2014, Datta Banik *et al.* 2013). Association between high BMI and arterial hypertension is reported from other populations. However, differential magnitudes of the association of thinness and excess weight (overweight and obesity) with hypertension are not reported from a population where exist both extremes of BMI-based malnutrition that raised my interest to explore in the present study.

In this background, objective of the present study was to estimate prevalence of BMI-based thinness and excess weight (overweight and obesity) and their differential association with hypertension among adult men representing Limbu community in Darjeeling, West Bengal.

PARTICIPANTS AND METHODS

The present cross-sectional study was undertaken during 2011–2015 at Naxalbari and Matigara block regions (Block is an administrative division to execute community development programs) of Darjeeling District in West Bengal, India. Ethical clearance was issued by the institutional committee before the commencement of the study that was mandatory for the research project (see Acknowledgements) (Datta Banik, Dash 2013). The study was carried out in 18 settlements (villages and hamlets) at Nakshalbari, Maniram, Hatighisa, Lower Bagdogra and Upper Bagdogra village councils (*Panchayat* in Hindi) under Naxalbari block and 28 villages in the Matigara Block. Settlements were randomly selected from the Census 2011 data. People representing Dhimal, Limbu, Mech, Rai, Rajbanshi, and Muslim communities live in the region.

A survey carried out in the 46 villages (randomly selected) across the aforesaid blocks, recorded 3189 adult men aged 20 to 59 years in the selected households representing Limbu, an indigenous community (designated as "Scheduled Tribe" by the Government of India) of the region. For the present study, 897 adult Limbu men were selected from the list and the sample was probabilistic in nature. Primarily occupation of the Limbu community people is agriculture; they also work in the army and other government and non-government agencies. Some of the participants had own business in the nearest Siliguri town and small stores in the villages etc.

Anthropometric measurements were recorded by a trained researcher (see Acknowledgements) following standard methods (Lohman *et al.* 1988). Height (cm) was measured to the nearest 0.1 centimeter using a standard anthropometer and body weight was recorded to the nearest 0.05 kg using a standard scale (Libra, New Delhi). Body mass index (BMI) was calculated as weight (kg)/height squared (m^2). BMI was used to evaluate nutritional status based on the cut-off values for adults: thinness (<18.5 kg/m^2), normal (18.50–24.99 kg/m^2), overweight (≥ 25.00 kg/m^2), and obesity (≥30.00 kg/m^2) (WHO 1995, 1998). BMI cut-off values for Asian people recommended by the WHO displayed similar distributions of nutritional status in the present data (WHO 2004). Excess weight has been defined as overweight plus obesity. Blood pressure (systolic and diastolic, SBP and DBP respectively) was recorded using a standard mercury sphygmomanometer (Diamond, New Delhi). The diagnosis of hypertension (SBP/DBP ≥140/90 mmHg) followed standard criteria (WHO 2020b). Equipment had been calibrated before the use and measurements were recorded in the morning (between 8 and 11 A.M.). Participants were apparently

healthy and reported no diseases within three months prior to the survey.

Statistical Package for the Social Sciences (SPSS, version 15.0) was used for data analysis. Normality test for data (age, height, weight, BMI, SBP and DBP) followed the assumption of Shapiro-Wilk test ($p>0.05$). Descriptive statistics (mean values and standard deviation) of age, height, body weight, BMI, SBP, and DBP were computed. Student's *t*-test was used to find significant differences of mean values of the variables between normotensive and hypertensive groups. Correlation analysis was done to find association between variables. Binomial logistic regression analysis was done to predict hypertension from BMI (as a continuous variable and categorical for thinness, overweight and obesity), after adjusting for age. For all statistical tests, $p<0.05$ was considered as the significance level.

RESULTS

Mean value of age of the participants (n = 897) was 37.28 ± 14.59 years. No significant ($p>0.05$) differences have been observed between normotensive and hypertensive men with respect to age and height (*Table 1*). However, hypertensive men had higher body weight (84.83 ± 9.19 kg) and BMI (20.70 ± 2.17 kg/m^2) in comparison with normotensive peers (80.10 kg and 19.09 kg/m^2, respectively) with significant differences between the groups ($p<0.05$). As expected, SBP and DBP were high among hypertensive men. Mean and standard deviation values of SBP and DBP were presented as descriptive results (*Table 1*).

Prevalence of BMI-based thinness (11.59%), overweight (24.41%) and obesity (48.72%) were remarkable in the sample (n=897); 48.49% adult men were hypertensive. A combined prevalence of overweight and obesity (excess weight) was very high (73.13%) that raised interest for further data analysis of this group of adult men (n = 656). Among excess weight men (33.38% overweight, 66.62% obese), majority were hypertensive (54.42%, n = 357). Mean values of body weight (85.28 ± 9.45 kg) and BMI (32.32 ± 2.67 kg/m^2) were higher in hypertensive men of this group than normotensive individuals (77.88 kg and 29.85 kg/m^2, respectively) with significant differences ($p<0.05$) (*Table 2*). Body weight and BMI (as continuous and categorical variables) had significant correlations with SBP, DBP, and hypertension (yes or no) (correlation coefficient >0.42, $p<0.001$).

Binomial logistic regression models after controlling for age were used to predict hypertension (SBP/DBP = ≥140/90 mmHg) as outcome variable (dichotomous; normotensive = 0, hypertensive = 1) from BMI-based nutritional status as predictor (regression models 1, 2,

TABLE 1: Baseline characteristics of anthropometric parameters and blood pressure in adult Limbu men (n = 897). SD: Standard deviation; BW: Body weight; BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; EW: Excess weight (overweight + obesity).

Variables	Total (n = 897)	Normotensive (n = 462)	Hypertensive (n = 435)	t	p-value
	Mean (SD)	Mean (SD)	Mean (SD)		
Age (years)	37.28 (14.59)	38.18 (15.06)	36.33 (14.03)	1.90	0.06
Height (cm)	162.11 (6.23)	161.80 (6.19)	162.44 (6.27)	1.54	0.12
BW (kg)	82.39 (8.67)	80.10 (7.47)	84.83 (9.19)	8.48	<0.0001
BMI (kg/m^2)	19.87 (2.62)	19.09 (2.27)	20.70 (2.17)	10.85	<0.0001
SBP (mmHg)	133.23 (19.05)	121.97 (12.57)	165.19 (17.41)	42.81	<0.0001
DBP (mmHg)	84.23 (11.88)	75.16 (6.01)	103.86 (8.52)	58.57	<0.0001

TABLE 2: Baseline characteristics of anthropometric parameters and blood pressure in adult Limbu men with high BMI (>25.0 kg/m^2) (n = 656). SD: Standard deviation; BW: Body weight; BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; EW: Excess weight (overweight + obesity).

Variables	Total (n = 656)	Normotensive (n= 299)	Hypertensive (n= 357)	t	p-value
	Mean (SD)	Mean (SD)	Mean (SD)		
Age (years)	37.46 (14.46)	38.42 (14.97)	36.66 (13.99)	1.56	0.12
Height (cm)	161.98 (6.30)	161.54 (6.18)	162.35 (6.39)	1.64	0.10
BW (kg)	81.91 (8.90)	77.88 (6.13)	85.28 (9.45)	11.64	<0.0001
BMI (kg/m^2)	31.20 (2.64)	29.85 (1.87)	32.32 (2.67)	13.43	<0.0001
SBP (mmHg)	132.77 (21.67)	114.63 (7.73)	167.97 (17.48)	48.91	<0.0001
DBP (mmHg)	85.75 (13.11)	73.50 (6.28)	106.00 (7.18)	61.10	<0.0001

TABLE 3: Binary logistic regression of anthropometric parameters to predict hypertension in adult Limbu men. *Sample size (n): Model 1 = 897; Model 2 = 241; Model 3 = 793. Model 1: BMI: Body mass index as a continuous variable. Model 2: Thinness: BMI-based thinness = 1, normal BMI = 0. Model 3: OW/OB: BMI-based excess weight (overweight + obesity) = 1, normal BMI = 0. In the models, outcome variable was dichotomous (hypertensive = 1, normotensive = 0). B: Regression coefficient; S.E: Standard error; C.I.: Confidence interval.

Models	Predictors	B	S.E.	Wald	p-value	Exp(B)	95.0% C.I. for Exp(B)	
							Lower	Upper
Model 1*	Constant	-15.55	1.53	103.21	<0.0001	0.00		
	Age (years)	-0.01	0.01	2.02	0.16	0.99	0.98	1.00
	BMI (kg/m^2)	0.52	0.05	111.54	<0.0001	1.68	1.53	1.85
Model 2*	Constant	0.57	0.21	7.48	<0.01	1.77		
	Age (years)	0.01	0.01	2.01	0.16	0.99	0.98	1.00
	Thinness	1.03	0.28	13.19	<0.0001	2.80	1.61	4.89
Model 3*	Constant	-0.42	0.26	2.63	0.11	0.65		
	Age (years)	-0.01	0.01	1.07	0.30	0.99	0.98	1.01
	OW/OB	1.24	0.17	50.49	<0.0001	3.45	2.45	4.86

and 3) (*Table 3*). Regression models were significant and there were no missing data. Sample size and prevalence of hypertension were different in the models. Model 1: total = 897, normotensive = 462, hypertensive = 435; Model 2: total = 241 (137 men with normal BMI, 104 men with low BMI or thinness), normotensive = 97, hypertensive = 144; Model 3: total = 793 (137 with normal BMI and 656 men with excess weight)

normotensive = 381, hypertensive = 412. The Hosmer-Lemeshow goodness of fit test showed observed and predicted probabilities matched the assumption ($p>0.05$) and the models were good fit. Wald estimates in the models were significant ($p<0.05$). Prevalence of hypertension were 48.49%, 59.75% and 51.95% in the models 1, 2 and 3, respectively.

In the Model 1 (n = 897), BMI as a continuous variable significantly predicted hypertension after adjusting for age with correct classification rate (76.62%) and Youden Index (0.67). Nagelkerke R square showed 31% variation in the outcome variable (hypertension). Odds ratio interpreted that 1 unit (kg/m^2) increase in BMI had a chance of 67.9% (95% C.I. 52.5% to 84.9%) rise in the odds of being hypertension. The area under ROC curve (Figure available from the author on request) showed almost 77.0% of all possible pairs of normotensive and hypertensive men, the model for BMI would assign a higher probability to the hypertensive individuals.

The Model 2 (n = 241) included 104 men with low BMI or thinness (<18.45 kg/m^2) and 137 men with normal weight (18.50–24.99 kg/m^2). BMI-based nutritional status (thinness = 1, normal BMI = 0) significantly predicted hypertension (normotensive = 0, hypertensive = 1) with 59.64% correct classification rate and Youden index (0.52). Wald estimate 13.19 was significant. An adult man suffering from BMI-based thinness or undernutrition (chronic energy deficiency) compared to normal weight was 2.8 (95% C.I. 1.6 to 4.9) times more likely to have hypertension. The area under the receiver operating characteristic (ROC) curve was relatively low (0.56) (*Table 3*).

In the Model 3 (n = 793), the predictor was dichotomous, BMI-based excess weight (n= 656, code = 1) and normal BMI (n =137, code = 0). Correct classification rate was 64.94% and Youden index 0.62. Area under ROC curve (0.68) was lower than that has been estimated in the model 1 and higher than the estimated value in model 2. It was evident that an adult excess weight man compared to normal was 3.45 (95% C.I. 2.45 to 4.86) times more likely to be hypertensive (*Table 3*).

DISCUSSION

The results of the present study on adult men (20 to 59 years of age, n = 897) representing Limbu community in Darjeeling had shown remarkable rates of the coexistence of BMI-based thinness (11.59%) and excess weight (73.13%). High prevalence of hypertension (48.49%) and significant association ($p< 0.05$) with BMI-based thinness and obesity were the major health problems among the participants. In general, association of higher risk of arterial hypertension with excess weight has been reported earlier. The present study reports differential degrees of association of arterial hypertension with two extremes of BMI-based nutritional status (thinness and excess weight) among adult men representing Limbu, an endogamous community of Darjeeling. It was interesting to observe the coexistence of undernutrition (thinness) and excess weight (overweight and obesity) in the same community and to find the association of BMI with hypertension. These data are added to the existing literature on association between BMI and blood pressure among adults.

A study reported high frequencies of BMI-based thinness among Dhimal (27% men, 47% women), Rajbanshi (17% men, 29% women), and Mech (10% men, 17% women) communities in Darjeeling (Datta Banik *et al.* 2009b). Mean values of BMI among male participants aged 18 to 60 years from Dhimal (n = 159), Rajbanshi (n = 150) and Mech (n = 141) were 19.5 kg/m^2, 20.6 kg/m^2 and 22.0 kg/m^2, respectively. Mean value of BMI of adult men in the present study (19.87 kg/m^2) was like the value (19.5 kg/m^2) reported earlier from Dhimal men. In a study among adult Mech individuals (50 men, 50 women) from Naxalbari and Matigara regions of Darjeeling, prevalence of BMI-based chronic energy deficiency (CED) (10% and 17% among men and women respectively) and overweight (13% men, 14% women) have been reported (Datta Banik *et al.* 2013). Coexistence of the frequencies of thinness and overweight was remarkable. That study also reported rise of blood pressure at the levels of BMI (thinness, normal, and overweight). Mech men had mean value of BMI (22 kg/m^2), body fat mass (16.14 kg and 26.50%), and high level of low-density lipoprotein cholesterol (227.5 mg/dL). Fasting plasma glucose level was marginally high among overweight men (127 mg/dL) (Datta Banik *et al.* 2013).

Other studies from the eastern region of India reported low BMI and remarkable rates of CED among adult men from the communities namely, Bathudi (18.4 kg/m^2, CED 52.70%) (Bose, Chakraborty 2005) and Savar (19.3 kg/m^2, CED 38.0%) in Orissa (Bose *et al.* 2006b); Kora Mudi (18.7 kg/m^2, CED 48.0%) (Bose *et al.* 2006c) and Santal (20.0 kg/m^2, CED 31.5%) (Bose *et al.* 2006a) from West Bengal. However, none of these studies reported blood pressure levels of the participants. Adult men aged 18 to 75 years (mean value 37.43 years)

from Oraon and Sarak communities in Bundu of Jaharkhand in India had BMI 18.48 kg/m^2 and 20.27 kg/m^2, respectively. Frequencies of thinness (Oraon 53.10%, Sarak 27.85%) were very high (Datta Banik *et al.* 2009a). Estimated BMI among adult men (19.87 kg/m^2) in the present study was like the BMI values (±1 kg/m^2) reported in previous studies from Orissa, Jharkhand, and West Bengal.

Co-existence of high prevalence of underweight (45.3%) and hypertension (SBP 15.2%, DBP 25.5%) has been reported from indigenous communities in India who were socioeconomically underprivileged (Kapoor *et al.* 2012). The study reported BMI, other anthropometric characteristics (mid-upper arm, waist and hip circumferences, skinfolds), and blood pressure (SBP and DBP) of several indigenous communities namely, Car Nicobarese, Tadavi, Bhotia, Desia Khond, Minas, and Saharia from different regions of India. Overall mean values of BMI, SBP and DBP were 19.10 kg/m^2, 126.48 mmHg, and 84.10 mmHg, respectively. The corresponding values of BMI and DBP recorded in the present study were similar. A report from Meghalaya, a State in the North-Eastern region of India showed low BMI as an indicator of illness and morbidity in relation to other factors like age, poor socioeconomic conditions, sanitation, and hygiene (Khongsdier 2002). BMI (20.06 kg/m^2) and high prevalence of CED (35%) had been reported in that study among 575 adult men from War Khasi community in Meghalaya. Another study among adult men (20 to 70 years of age) from Naga community in Manipur reported BMI (20.9 kg/m^2), SBP (126.3 mmHg) and DBP (79.93 mmHg). Coexistence of CED (14.4%), excess weight (overweight/obesity 17.6%) and hypertension due to SBP (22%) and DBP (34.0%) were remarkable (Mungreiphy *et al.* 2011). Association between BMI and blood pressure was significant ($p<0.05$). Mean BMI of 11,496 adult men aged 18 to 62 years representing 38 communities from Central Indian States was 18.43 ± 2.18 kg/m^2 (Adak *et al.* 2006). A review on malnutrition among tribal communities in India (Das, Bose 2015) showed high rate of CED among adults (men 49.3%, women 52.0%) representing indigenous communities (Scheduled Tribe) from different States of India. Highest and lowest mean values of BMI have been recorded among males from Car Nicobarese (21.9 kg/m^2) of Andaman and Nicobar Islands (Kapoor *et al.* 2012) and Garasia (15.9 kg/m^2) of Rajasthan State (Bhasin, Jain 2007).

In addition to the reports from indigenous communities, studies of anthropometric characteristics and blood pressure in socioeconomically poor urban populations in India are also available (Chakraborty *et al.* 2006). A study among 191 adult male slum dwellers in Kolkata, West Bengal reported mean BMI 20.5 kg/m^2 and high prevalence of CED (33.5%). Another study from the same population with higher sample size (470 adult men aged 18 to 84 years) reported mean BMI 20.3 kg/m^2, SBP (121.6 mmHg) and DBP (79.6 mmHg) (Chakraborty *et al.* 2009). Hypertensive individuals from slum area in Kolkata had higher BMI than that estimated value in the present study. A study among adult men aged 20 to 60 years (mean age 35.7 years) from Kolkata, reported BMI (22.4 kg/m^2), SBP (118.77 mmHg), and DBP (78.10 mmHg) (Ghosh, Bandyopadhyay 2007). Significant correlation between BMI and blood pressure has been reported in the earlier studies from Kolkata like that observed in the present study. Mean values of BMI, SBP and DBP of adult Punjabi men from Delhi, India were 25.8 kg/m^2, 123.9 mmHg, and 82.5 mmHg, respectively (Dua *et al.* 2014). High degree CED (41.19%) coexisted with excess weight (4.4%) and hypertension 6.26%) among 670 adult men aged 20 to 70 years from Tirupati town of Andhra Pradesh, a South Indian State (Naik *et al.* 2012). Association of raised blood pressure with higher levels of BMI have been reported among adult men in these previous studies and others from different populations in India (Bhadra *et al.* 2002, Ghosh *et al.* 2000, Gupta *et al.* 2007, 2012, Venkataramana *et al.* 2001). Positive correlation between BMI and blood pressure has been reported from China (Linderman *et al.* 2018) and other countries (Droyvold *et al.* 2005, Gelber *et al.* 2007, Mokdad *et al.* 2003). The study from China reported mean BMI (24.7 kg/m^2), SBP (136.5 mmHg) and DBP (81.1 mmHg) of 1,727,411 adults (1,027,711 men, 699,700 women) aged 35 to 80 years (Linderman *et al.* 2018).

Huge population of India (more than 1.2 billion) with diverse ethnicity are the principal characteristics of the country. The scheduled tribe population (indigenous communities) accounts for more than 8.0% of the total population of the country (Census of India 2011); majority of them live in rural areas and are socioeconomically underprivileged (Adak *et al.* 2006, Kapoor *et al.* 2012). From the above discussion, it is evident that low BMI is common among indigenous communities in rural areas and underprivileged sections of the urban populations in India.

Some potential weaknesses in the present study are worth mentioning. The cross-sectional study presents data, representing Limbu, an indigenous community of a region in Darjeeling, West Bengal. Previous reports (Datta Banik, Dash 2013, Datta Banik *et al.* 2009b, 2013)

mentioned poor socioeconomic backgrounds of the neighboring communities in the region. However, the present study did not include those factors to observe their association with BMI and blood pressure that will be explored in future. In addition, elevated blood pressure due to the alterations of glucose metabolism and dyslipidemia might be other interesting aspects of study.

CONCLUSION

The present study reported the coexistence of high degree CED, excess weight, and hypertension among Limbu adults in Darjeeling, West Bengal. The results showed similar patterns of association between BMI and blood pressure as reported earlier from other populations in India and abroad. Poor nutritional status (thinness and excess weight) and hypertension were the major health problems of the adults representing Limbu community from Naxalbari and Matigara regions of Darjeeling District. In conclusion, excess weight (overweight and obesity) was observed to be a better predictor of hypertension in comparison with thinness.

ACKNOWLEDGEMENTS

The present study was based on a research project of the author, sanctioned by the Indian Council of Medical Research (I.C.M.R.), New Delhi (Sanction Memo no. - 5/9/63/2008-RHN Dated 23.11.2009). The author expresses unreserved gratitude to the participants and their family members for extending support for which the study could be completed successfully. The author is also thankful to Mr. Bimal Sain for field work and data collection and to the Vidyasagar University authority for providing facilities and ethical clearance.

DECLARATION OF CONFLICTING INTERESTS

The author declares no competing interest with respect to the research, authorship and/or publication of this article.

FUNDING

Research grant was available for the work. However, at present there is no financial support for the publication.

REFERENCES

ADAK D., GAUTAM R. K., BHARATI S., GHARAMI A. K., PAL M., BHARATI P., 2006: Body mass index and chronic energy deficiency of adult males of Central Indian populations. *Human Biology* 78, 2: 161–178.

BHADRA M., MUKHOPADHYAY A., BOSE K., 2002: Adiposity, central body fat distribution and blood pressure among young Bengalee adults of Kolkata, India: sexual dimorphism. *Journal of Physiological Anthropology and Applied Human Science* 21, 6: 273–276.

BHASIN M., JAIN K. S., 2007: Biology of the tribal groups of Rajasthan, India: Body mass index as an indicator of nutritional status. *Anthropologist* 93: 165–175.

BOSE K., BANERJEE S., BISAI S., MUKHOPADHYAY A., BHADRA M., 2006a: Anthropometric profile and chronic energy deficiency among adult Santal tribals of Jhargram, West Bengal, India: Comparison with other tribal populations of Eastern India. *Ecology of Food and Nutrition* 45: 1–11.

BOSE K., CHAKRABORTY F., 2005: Anthropometric characteristics and nutritional status based on body mass index of adult Bathudis: A tribal population of Keonjhar District, Orissa, India. *Asia Pacific Journal of Clinical Nutrition* 14: 80–82.

BOSE K., CHAKRABORTY F., BISAI S., KHATUN A., BAURI H., 2006b: Body mass index and nutritional status of adult Savar tribals of Keonjhar Dibstrict, Orissa, India. *Asia Pacific Journal of Public Health* 18: 3–7.

BOSE K., GANGULI S., MAMTAZ H., MUKHOPADHYAY A., BHADRA M., 2006c: High prevalence of undernutrition among adult Kora Mudi tribals of Bankura District, West Bengal, India. *Anthropological Science* 114: 65–68.

CENSUS OF INDIA, 2011: *Scheduled Castes and Scheduled Tribes.* New Delhi, Registrar General and Census Commissioner of India. From: <https://censusindia.gov.in/census_and_you/area_and_population.aspx> (Accessed on 7th July 2021).

CHAKRABORTY R., BOSE K., BISAI S., 2006: Body mass index and chronic energy deficiency among urban Bengalee male slum dwellers of Kolkata, India: Relationship with family income. *International Journal of Anthropology* 21: 209–215.

CHAKRABORTY R., BOSE K., BISAI S., 2009: Body mass index and blood pressure among adult Bengalee male slum dwellers of Kolkata, India. *Journal of Public Health* 17, 5: 301–308.

CHOBANIAN A. V., BAKRIS G. L., BLACK H. R., CUSHMAN W. C., GREEN L. A., IZZO J. L. JR., JONES D. W., MATERSON B. J., OPARIL S., WRIGHT J. T. JR., ROCCELLA E. J., 2003: The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *Journal of American Medical Association* 289: 2560–2572. DOI: 10.1161/01.HYP.0000107251.49515.c2

COMMODORE-MENSAH Y., SELVIN E., ABOAGYE J., TURKSON-OCRAN R. A., LI X., HIMMELFARB C. D., AHIMA R. S., COOPER L. A., 2018: Hypertension, overweight/obesity, and diabetes among immigrants in the

United States: An analysis of the 2010–2016 National Health Interview Survey. *BMC Public Health* 18: 773. DOI: 10.1186/s12889-018-5683-3

DAS S., BOSE K., 2015: Adult tribal malnutrition in India: an anthropometric and socio-demographic review. *Anthropological Review* 78, 1: 47–65. DOI: https://doi.org/10.1515/anre-2015-0004

DATTA BANIK S., 2014: Body mass index and blood pressure among men of three ethnic groups of Darjeeling, West Bengal, India. *Ecology of Food and Nutrition* 53, 3: 256–272. DOI: 10.1080/03670244.2013.814462

DATTA BANIK S., BARMAN R. K., MAITY S., SUKUL T., ROY V., 2009a: Ethnic variation in anthropometric characteristics and nutritional status – a comparative study among adult male Oraons and Saraks of Ranchi district Jharkhand India. *Anthropologie* XLVII/1-2: 95–106.

DATTA BANIK S., BHATTACHARJEE P., DAS S., BARMAN R. K., DAS S., GIRI S. P., JANA A., PURKAIT P., 2009b: Sexual dimorphism in health and nutritional status of three communities of Darjeeling district in West Bengal and comparison with some other populations of eastern India – an anthropometric appraisal. *Journal of Life Sciences* 1, 1: 27–34.

DATTA BANIK S., DASH S., 2013: *Dietary Habits, Assessment of Nutritional Status, Lipid Profile and Alcohol Induced Hepatic Function in Three Adult Endogamous Populations of Darjeeling District in West Bengal.* Technical report of the research project submitted to the Indian Council of Medical Research, Government of India, New Delhi.

DATTA BANIK S., SAIN B. K., DASH S., 2013: Anthropometric characteristics and nutritional status of adult Mech in Darjeeling, West Bengal: In relation with blood pressure, levels of haemoglobin, blood sugar, lipid profile and serum proteins. *South Asian Anthropologist* 13, 2: 137–144.

DROYVOLD W. B., MIDTHJELL K., NILSEN T. I., HOLMEN J., 2005: Change in body mass index and its impact on blood pressure: a prospective population study. *International Journal of Obesity* 29, 6: 650–655.

DUA S., BHUKER M., SHARMA P., DHALL M., KAPOOR S., 2014: Body Mass Index Relates to Blood Pressure Among Adults. *North American Journal of Medical Sciences* 6, 2: 89–95. doi: 10.4103/1947-2714.127751

DYER A. R., ELLIOTT P., INTERSALT Co-operative Research Group., 1989: The INTERSALT study: relations of body mass index to blood pressure. *Journal of Human Hypertension* 3: 299–308.

FENG R. N., ZHAO C., WANG C., NIU Y. C., LI K., GUO F. C., LI S. T., SUN C. H., LI Y., 2012: BMI is strongly associated with hypertension, and waist circumference is strongly associated with type 2 diabetes and dyslipidemia, in northern Chinese adults. *Journal of Epidemiology* 22: 317–323. doi: 10.2188/jea.JE20110120

GELBER R. P., GAZIANO J. M., MANSON J. E., BURING J. E., SESSO H. D., 2007: A prospective study of body mass index and the risk of developing hypertension in men. *American Journal of Hypertension* 20, 4: 370–377.

GHOSH A., BOSE K., DAS CHAUDHURI A. B., 2000: Comparison of anthropometric characteristics between normotensive and hypertensive individuals among a population of Bengalee Hindu elderly men in Calcutta, India. *Journal of Royal Society of Promotion of Health* 120, 2: 100–106.

GHOSH J. R., BANDYOPADHYAY A. R., 2007: Comparative evaluation of obesity measures: relationship with blood pressures and hypertension. *Singapore Medical Journal* 48, 3: 232–235.

GUPTA R., 2004: Trends in hypertension epidemiology in India. *Journal of Human Hypertension* 18: 73–78.

GUPTA R., RASTOGI P., SARNA M., GUPTA V. P., SHARMA S. K., KOTHARI K., 2007: Body-mass index, waist-size, waist-hip ratio and cardiovascular risk factors in urban subjects. *Journal of Association of Physicians of India* 55: 621–627.

GUPTA S. K., DIXIT S., SINGH A., NAGAONKAR S., MALIK N., 2012: Prevalence and predictors of hypertension: A cross sectional study among people coming from a tertiary health care facility in Garhwal-Uttarakhand. *Indian Journal of Community Health* 24: 275–279.

HU F. B., WANG B., CHEN C., JIN Y., YANG J., STAMPFER M. J., XU X., 2000: Body mass index and cardiovascular risk factors in a rural Chinese population. *American Journal of Epidemiology* 151: 88–97.

KAPOOR A. K., SALUJA K., VERMA D., KAPOOR S., 2012: Predictors of hypertension among adult tribal males of India. *International Journal of Tropical Diseases* 2: 241–256. DOI: 10.9734/IJTDH/2012/1750

KHAN A., HAQ F. U., PERVEZ M. B., SALEHEEN D., FROSSARD P. M., ISHAQ M., HAKEEM A., SHEIKH H. T., AHMAD U., 2008: Letter to the Editor: Anthropometric correlates of blood pressure in normotensive Pakistani subjects. *International Journal of Cardiology* 29: 259–262.

KHONGSDIER R., 2002: Body mass index and morbidity in adult males of the War Khasi in Northeast India. *European Journal of Clinical Nutrition* 56: 484–489.

LANDI F., CALVANI R., PICCA A., TOSATO M., MARTONE A. M., ORTOLANI E., SISTO A., D'ANGELO E., SERAFINI E., DESIDERI G., FUGA M. T., MARZETTI E., 2018: Body Mass Index is strongly associated with hypertension: Results from the Longevity Check-up 7+ Study. *Nutrients* 10, 12: 1976. DOI: 10.3390/nu10121976

LINDERMAN G. C., LU J., LU Y., SUN X., XU W., NASIR K., SCHULZ W., JIANG L., KRUMHOLZ H. M., 2018: Association of body mass index with blood pressure among 1.7 million Chinese adults. *JAMA Network Open* 1, 4: e181271. DOI: 10.1001/jamanetworkopen.2018.1271

LOHMAN T. G., ROCHE A. F., MARTORELL R., 1988: *Anthropometric Standardization Reference Manual.* Champagne, Illinois: Human Kinetics Books.

MARTÍN V., DÁVILA-BATISTA V., CASTILLA J., GODOY P., DELGADO-RODRÍGUEZ M., SOLDEVILA N., MOLINA A. J., FERNANDEZ-VILLA T., ASTRAY J., CASTRO A., GONZÁLEZ-CANDELAS F., MAYORAL J. M., QUINTANA J. M., DOMÍNGUEZ A., CIBERESP Cases and Controls in Pandemic Influenza Working Group, Spain., 2016: Comparison of body mass index (BMI) with the CUN-BAE body adiposity estimator in the prediction of hypertension and type 2 diabetes. *BMC Public Health* 16: 82. DOI: 10.1186/s12889-016-2728-3

MENKE A., MUNTNER P., WILDMAN R. P., REYNOLDS K., HE J., 2007: Measures of adiposity and cardiovascular disease risk factors. *Obesity (Silver Spring)* 15: 785–795.

MOKDAD A. H., FORD E. S., BOWMAN B. A., DIETZ W. H., VINICOR F., BALES V. S., MARKS J. S., 2003: Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *Journal of American Medical Association* 289, 1: 76–79.

MUNGREIPHY N. K., KAPOOR S., SINHA R., 2011: Association between BMI, blood pressure, and age: Study among Tangkhul Naga tribal males of Northeast India. *Journal of Anthropology* Article ID 748147, 6 pages. https://doi.org/10.1155/2011/748147

NAIK J. L., DUDEKULA A. B., REDDY K. S. N., 2012: Association between body mass index and hypertension: A cross-sectional study in an adult male population. *Asian Journal of Experimental Biological Sciences* 3, 2: 368–377. doi: 10.3945/ajcn.2008.26809

NI M. C., RODGERS A., PAN W. H., GU D. F., WOODWARD M., 2004: Asia Pacific Cohort Studies Collaboration. Body mass index and cardiovascular disease in the Asia-Pacific Region: an overview of 33 cohorts involving 310 000 participants. *International Journal of Epidemiology* 33: 751–758.

REDDY K. S. N., REDDY K. K., SUDHA G., 2010: Overall and abdominal adiposity on blood pressure: consistency and evaluation of their association in an adult Indian population. *Journal of Life Sciences* 2: 117–125. https://doi.org/10.1080/09751270.2010.11885161

SHARABI Y., GROTTO I., HUERTA M., GROSSMAN E., 2004: Susceptibility of the influence of weight on blood pressure in men versus women: lessons from a large-scale study of young adults. *American Journal of Hypertension* 17: 404–408.

TESFAYE F., NAWI N. G., VAN MINH H., BYASS P., BERHANE Y., WALL S., 2007: Association between body mass index and blood pressure across three populations in Africa and Asia. *Journal of Human Hypertension* 21, 1: 28–37.

TUAN N. T., ADAIR L. S., SUCHINDRAN C. M., KA H. E., POPKIN B. M., 2009: The association between body mass index and hypertension is different between East and Southeast Asians. *American Journal of Clinical Nutrition* 89, 6: 1905–12.

VENKATARAMANA P., GEETA VANI C., CHENGAL REDDY P., 2001: Association of body mass index, body fat distribution and fat patterning with blood pressure in two populations of Andhra Pradesh. *Journal of Human Ecology* 12: 63–68.

WHO, 1995: *Physical Status: The Use and Interpretation of Anthropometry.* Report of a WHO Expert Committee. (WHO Technical Report Series No. 854): World Health Organization. Geneva.

WHO, 1998: *Obesity: Preventing and Managing the Global Epidemic.* Report of a WHO Consultation (WHO Technical Report Series 894). World Health Organization. Geneva.

WHO, 2004: Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. (WHO expert consultation). *Lancet* 363: 157–163.

WHO, 2020a: *Cardiovascular Diseases.* World Health Organization. Geneva. Available from: <https://www.who.int/health-topics/cardiovascular-diseases/#tab=tab_1> (Accessed on 7th July 2021).

WHO, 2020b: *Hypertension.* World Health Organization. Geneva. From: <https://www.who.int/news-room/fact-sheets/detail/hypertension> (Retrievd on 6 July 2021).

Sudip Datta Banik*
Department of Human Ecology,
Centro de Investigación y de Estudios Avanazados del IPN (Cinvestav).
Km 6, Antigua Carretera a Progreso.
Merida, Yucatan, Mexico. Postal Code: 97310
E-mail: dattabanik@cinvestav.mx

*Corresponding author.