

## ANTHROPOMETRIC CHARACTERISTICS AND NUTRITIONAL STATUS BASED ON BODY MASS INDEX OF ADULT PAUDI BHUYAN: A PVTG POPULATION IN ODISHA, INDIA

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**Abstract:** Anthropometry, particularly the Body Mass Index, is widely used, cost-effective method for assessing nutritional status and is correlated more with nutritional factors than with genetic influences. This study focuses on Paudi Bhuyan, a Particularly Vulnerable Tribal Group in Odisha, India, where specific techniques were employed to evaluate their nutritional status amidst socioeconomic challenges. Data are collected from 2 districts i.e. Keonjhar (Banspal Block) and Deogarh (Barkot Block) of Odisha, India. The methodology involved anthropometric measurements from 521 adults, revealing significant findings related to gender and height differences across districts and emphasizing the need for targeted interventions to address malnutrition in vulnerable tribal communities.

**Keywords:** Anthropometry, Paudi Bhuyan, PVTG, BMI, Underweight, CED.

### Introduction

The anthropometric variables of height and weight have been used in a variety of ways to assess nutritional status in numerous populations (Aryal B, 2020, Tur and Bibiloni, 2019). Anthropometry is acknowledged as the most widely applicable, affordable, and noninvasive technique for determining the size, composition, and proportions of the human body (Keys et al., 1956, WHO, 2011). It serves as a valuable tool in the nutritional assessment of a population or an individual. Genetic factors, environmental features, social and cultural circumstances, lifestyle, functional status and health are closely associated with anthropometric values. The most accurate anthropometric measure of body fatness currently available for public health purposes is the Body Mass Index (BMI). It has to do with things such as general mortality, long-term physical illnesses, mental disorders, etc. that are related to both physical and psychological health (Luppino et al., 2010, Petry et al., 2008).

BMI is regarded by the World Health Organization (WHO) as a predictor of malnutrition and obesity in any community. The BMI of an individual is determined by dividing their kilogram weight by their height in metres squared. Hence, its

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unit is  $\text{kg/m}^2$ , and it also provides nutritional status in adults (Henriques et al., 2019). Different scholars have shown that BMI is more nutritionally related than genetically related (Casadei and Kiel, 2020, Ingoles et al. 2014, Tan 2004). Chronic Energy Deficiency (CED) can also be defined on the basis of BMI. CED is defined as a steady-state at which a person is in energy balance, although at a “cost” either in terms of health risk or as an impairment of functions and health (Mahanty et al., 2024). CED during adulthood is linked to a variety of detrimental functional outcomes. Together with a decline in mental and cognitive development, it raises the risk of disease and death, which lowers labor productivity and educational attainment. In adults, infection, socioeconomic status, and inadequate dietary intake are the most frequent contributing factors to CED. (Chakraborty et al., 2009).

Worldwide, there are 90 countries home to more than 302.45 million indigenous peoples (Anderson et al., 2016). The term indigenous refers to the first people of the country, who are also referred to as Native people or the Tribal people (Farrell et al., 2021). The term scheduled tribes (STs) refers to the native population of India, it is essentially an administrative designation. Among the 1.44 billion people living in India, 104.3 million are considered tribal. With 8.6% of the country's total population being tribal, India has the largest tribal population in the world. India is home to approximately 705 schedule tribes and 75 Particularly Vulnerable Tribal Groups (PVTG), each with their own unique social and cultural customs (PIB, 2024). Out of the 64 notified STs reside in Odisha, India, only 13 are categorized as PVTGs (Sahoo and Singh, 2024).

With a total population of 42.0 million, scheduled tribes (22.85%) and scheduled castes (17.13%) make up a sizable component of Odisha's population (NFHS-5). These groups continue to be the most socioeconomically disadvantaged and backward in India, with the lowest health results. According to the Multidimensional Poverty Index report (MPI 2021), Odisha has an estimated poverty rate of 32.6%. The distribution of poverty is a reflection of social, economic, nutritional, and ultimately health-related inequality. Owing to their remote location, erratic food supplies, unavailability of suitable medical facilities, and ingrained cultural and spiritual practices, tribal groups are especially susceptible to malnutrition. Paudi Bhuyan is one such PVTG found only in the state of Odisha, which is located in the eastern part of India.

### **Area and People**

Paudi Bhuyan- are found in the districts of Sundargarh, Keonjhar, Mayurbhanj, Sambalpur, and Angul of Odisha and are also well-known as Hill-Bhuyan. They exhibit their own socio-cultural characteristics and constitute one of the State's recognized Primitive Tribal Groups. The Odia-An Indo-Aryan language is the main language spoken by everyone. The population of Bhuyan was 42,590 in 2019,

with 21,170 males and 21,420 females, with a sex ratio of 1012 (Ota AB, 2020). The literacy rate among Paudi Bhuyan is 44.0% in total i.e. 50.64% in males and 37.43% in females (Ota AB, 2020). The Paudi Bhuyan people are primarily found in remote, hilly, and forested places. In the studied locations of Keonjhar and Deogarh, Paudi Bhuyan villages are located on hilly terrains with scarce forests surrounding the village. Due to geophysical limitations, many Paudi Bhuyan communities lack all-weather roadways. Owing to the slash and burn style of rotation farming, there is no dense forest in the areas surrounding the Paudi Bhuyan hamlet.

The settlement pattern found among them is scattered type. The houses are rectangular in shape with thatched roofs supported by wooden pillars and walls are plastered with red mud. The Goat and Cow sheds are always separated from the main house. Each family has a kitchen garden where they grow vegetables and other crops. Paudi Bhuyan were previously shifting cultivators, but now, they are employed in diverse fields of wage labors some in the service sector etc. They are employed regardless of their gender or socioeconomic standing. The food patterns of these are affected mostly by the seasonal production of crops. In addition, they gather small forest products such as mangos, *mahua* flowers, jackfruit, and various fruits and nuts. During the rainy season, fishing is performed and fish frequently dried for later use. The alcoholic beverages consumed are locally produced i.e. *Mohuli*- prepared from Mohua flower, *Tadi*- juice of the date plant, *Rashi* and *Handia*- prepared from rice. The festivals observed by Paudi Bhuyan are Magha Pudi, Gaisri Puja, Bisri Osha, Dhola (Othei) Jatra.

The present study was conducted in 2 districts of Odisha i.e. the Banspal Block of Keonjhar district and Barkot Block of Deogarh district. The objective of this study was to determine the anthropometric distinctiveness of the community in both the studied areas and their nutritional status on the basis BMI of the adults.

### Methodology

Data for this study were collected jointly by the Centre of Excellence in Studies on Tribal and Marginalized Communities (CoE in STMC) and the Post Graduate Department of Anthropology, Utkal University, Bhubaneswar, in the Karangadihi Gram Panchayat of the Banspal block of Keonjhar district and Kaliapal and Kalla Gram Panchayats of the Barkot block of Deogarh district. Keonjhar district spread across an area of 8240 km<sup>2</sup>, with a sex ratio of 988 females per 1000 males (Census 2011) and an average literacy of 68.24%. Deogarh covers an area of 2782 km<sup>2</sup> having sex ratio 975 females per 1000 males (Census 2011) and average literacy rate of 44.81%.

The adult male and female ( $\geq 18$  years) residents of all the houses in the study villages were contacted. Demographic data pertaining to the socioeconomic profile and population structure were collected through an ethnographic method using

interviews, case studies and pre-structured schedule. A total of 521 adults were studied, out of which 211 were males and 310 were females. The anthropometric data (height and weight) were collected only from men and women who volunteered to provide their measurements.

Necessary ethical approval was obtained from the Department Research Committee (DRC) of the Post Graduate Department of Anthropology and the Institutional Ethical Committee (IEC) of Utkal University. Necessary permissions were obtained from the community to carry out the fieldwork.

| <i>Sl. No.</i> | <i>District</i> | <i>Block</i> | <i>Gram Panchayat</i> | <i>Distance from District Headquarter</i> | <i>Distance from Bhubaneswar</i> |
|----------------|-----------------|--------------|-----------------------|-------------------------------------------|----------------------------------|
| 1              | Keonjhar        | Banspal      | Karangadihi           | 30.3 Km                                   | 245Km                            |
| 2              | Deogarh         | Barkot       | Kaliapal              | 7.2Km                                     | 222Km                            |
| 3              | Deogarh         | Barkot       | Kalla                 | 6.2Km                                     | 215Km                            |

Table 1: Distance of the villages from the district headquarter and state capital (Bhubaneswar)

Data on nutritional anthropometry were collected from both men and women. Height and weight were measured following the standard procedures, with an anthropometric rod for height and a weighting machine for weight.

Body mass index (BMI) was computed via the following standard equation:

$$\text{BMI} = \text{weight (kg)} / \text{height (m}^2\text{)}$$

Nutritional status was evaluated using Asia-Pacific guidelines. The following cutoff points were used:

Chronic energy deficiency (CED) Grade III: BMI < 16.0

CED Grade II: BMI = 16.0 – 16.9

CED Grade I: BMI = 17.0 – 18.4

Normal: BMI = 18.5 – 22.9

Overweight: BMI = 23-24.9

Obese: BMI =  $\geq 25$

The subjects were further classified on the basis of Asia-Pacific BMI classification (Girdhar et al. 2016) to access their BMI and CED grades. This categorizes the prevalence of undernutrition according to the percentage of the population with BMI < 18.5 kg/m<sup>2</sup>.

1. Low (5–9%): warning sign, monitoring required
2. Medium (10–19%): poor situation
3. High (20–39%): serious situation
4. Very high ( $\geq 40\%$ ): critical situation

Various statistical tests were performed to analyze the data. The means and standard deviations (SDs) of all the anthropometric variables were computed for each sex separately.

Student's *t*-test was performed to test for differences in the mean BMI between area specific males and females. And  $\chi^2$  value is also calculated to evaluate the significance of proportional differences.

## Results and Discussion

| Measurements             | Male (N=211) |       | Female (N=310) |       | <i>t'</i> test |
|--------------------------|--------------|-------|----------------|-------|----------------|
|                          | Mean         | SD    | Mean           | SD    |                |
| Age in years             | 43.0         | 15.81 | 40.0           | 15.96 |                |
| Height in cm             | 157.0        | 5.80  | 147.0          | 5.36  | -20.217***     |
| Weight in kg             | 48.0         | 7.61  | 41.0           | 6.77  | -11.013***     |
| BMI in kg/m <sup>2</sup> | 20.0         | 2.73  | 19.0           | 2.87  | -3.982**       |

Table 2: Sex specific age and anthropometrics differences

Table 2 shows the sex specific mean age and anthropometric differences between the males and females. The mean ages of the males and females were  $43 \pm 15.81$  years and  $40 \pm 15.96$  years respectively. The mean height of males was  $157 \pm 5.80$  cm whereas it was significantly ( $t = -20.217$ ,  $p < 0.001$ ) lower among the females i.e.  $147 \pm 5.36$  cm. The mean weight of the males was  $48 \pm 7.61$  kg and that of the females was  $41 \pm 6.77$  kg. The mean female weight was comparably lower than the male weight ( $t = -11.013$ ,  $p < 0.001$ ). The mean BMI differed significantly in terms of sexual dimorphism ( $t = -3.982$ ,  $p < 0.001$ ) between males ( $20 \pm 2.73$  kg/m<sup>2</sup>) and females ( $19.0 \pm 2.87$  kg/m<sup>2</sup>).

| Measurements             | Deogarh male (N=134) |       | Keonjhar male (N=77) |       | <i>t'</i> test |
|--------------------------|----------------------|-------|----------------------|-------|----------------|
|                          | Mean                 | SD    | Mean                 | SD    |                |
| Age in years             | 43.9                 | 15.50 | 41.6                 | 16.33 |                |
| Height in cm             | 155.8                | 5.45  | 158.0                | 6.14  | 2.694**        |
| Weight in kg             | 47.7                 | 6.81  | 48.8                 | 8.83  | 1.011          |
| BMI in Kg/m <sup>2</sup> | 19.6                 | 2.53  | 19.5                 | 3.06  | -0.256         |

Table 3: District specific anthropometric differences among adult males

Table 3 shows the comparison of the anthropometric characteristics of the males between Keonjhar and Deogarh. In the present study, the mean ages of Deogarh and Keonjhar males were  $43.9 \pm 15.50$  years and  $41.6 \pm 16.33$  years respectively. The district specific height measurements among the male participants revealed that the Keonjhar males ( $158.0 \pm 6.14$  cm) were significantly taller ( $t = 2.694$ ,  $p < 0.01$ ) than the Deogarh males ( $155.8 \pm 5.45$  cm). A similar result was found for the mean weight

where the mean weight of Keonjhar males was greater i.e.  $48.8 \text{ kg} \pm 8.83$  than that of Deogarh males  $47.7 \text{ kg} \pm 6.81$ , although the difference was not significant ( $t=1.011$ ). The mean BMI was slightly greater among Deogarh males i.e.  $19.6 \pm 2.53$  than among Keonjhar males  $19.5 \pm 3.06$ .

| Measurements             | Deogarh female (N=198) |       | Keonjhar female (N=112) |       | t' test  |
|--------------------------|------------------------|-------|-------------------------|-------|----------|
|                          | Mean                   | SD    | Mean                    | SD    |          |
| Age in years             | 39.1                   | 15.69 | 41.3                    | 16.41 |          |
| Height in cm             | 145.8                  | 4.91  | 148.9                   | 5.57  | 5.084*** |
| Weight in kg             | 40.3                   | 6.47  | 42.1                    | 7.17  | 2.262*   |
| BMI in Kg/m <sup>2</sup> | 19.0                   | 2.86  | 18.9                    | 2.89  | -0.295   |

Table 4: District specific anthropometrics differences of adult female

Table 4 shows the district specific comparison of the anthropometric characteristics of females between Keonjhar and Deogarh. The upper limit of the mean age was  $41.3 \pm 16.41$  years whereas the lower limit of the mean age was  $39.1 \pm 15.69$  years. The mean height of Keonjhar females was greater i.e.  $148.9 \text{ cm} \pm 5.57$  than that of Deogarh females  $145.8 \text{ cm} \pm 4.91$  with a significant t value of 5.084. A similar result was found for the mean weight of females where the mean weight of Keonjhar females was higher i.e.  $42.1 \text{ kg} \pm 7.17$  than that of Deogarh females  $40.3 \text{ kg} \pm 6.47$ , with a significant difference ( $t=1.011$ ). The mean BMI was slightly greater among Deogarh females i.e.  $19.0 \pm 2.86$  than among Keonjhar females  $18.9 \pm 2.89$ .

| Nutritional status | Sex of the individuals |       |                |       | Comparison | Sex combined (N=521) | %     |
|--------------------|------------------------|-------|----------------|-------|------------|----------------------|-------|
|                    | Male (N=211)           | %     | Female (N=310) | %     |            |                      |       |
| CED-III            | 9                      | 4.27  | 33             | 10.65 | 6.878**    | 42                   | 8.06  |
| CED-II             | 20                     | 9.48  | 35             | 11.29 | 0.435      | 55                   | 10.56 |
| CED-I              | 45                     | 21.33 | 83             | 26.77 | 2.001      | 128                  | 24.57 |
| Total CED          | 74                     | 35.07 | 151            | 48.71 | 9.502**    | 225                  | 43.19 |
| Normal             | 114                    | 54.03 | 135            | 43.55 | 5.516*     | 249                  | 47.79 |
| Overweight         | 23                     | 10.90 | 24             | 7.74  | 1.525      | 47                   | 9.02  |

Table 5: Sex specific prevalence of CED of adult Paudi Bhuyan

Table 5 shows the sex specific prevalence of CED in adult Paudi Bhuyan. CED-III (severe thinness) was found in 9 males and 33 females accounting for 8.06% of the overall sample. The  $\chi^2$  values of CED-III were 6.878. CED-II (moderate thinness) was detected in 20 males and 35 females accounting for 10.56% of the sample. CED-I (mild thinness) is prevalent among both males 45 and females 83

accounting for 24.57% of all cases. Overall, 74 (35.07%) of the males and 151 (48.71%) of the females were undernourished, combining the sex it is nearly half of the sample 225 (43.19%) were undernourished. The  $\chi^2$  values of the total CED is 9.502. The normal BMI accounts for nearly the remaining half, in males it is represented by 114 (54.03%) and in females it is 135 (43.55%) which accounts for a total of 249 (47.79%) of the total sample. The difference between males and females with normal BMI was significant, and the  $\chi^2$  was 5.516. Overweight was also found in 23 (10.9%) males and 24 (7.74%) females, combined sex with 47 (9.02%).

| Nutritional status | District name           |       |                         |       | Comparison |
|--------------------|-------------------------|-------|-------------------------|-------|------------|
|                    | Deogarh male<br>(N=134) | %     | Keonjhar male<br>(N=77) | %     |            |
| CED-III            | 5                       | 3.73  | 4                       | 5.19  | 0.254      |
| CED-II             | 10                      | 7.46  | 10                      | 12.99 | 1.735      |
| CED-I              | 28                      | 20.90 | 17                      | 22.08 | 0.04       |
| Total CED          | 43                      | 32.09 | 31                      | 40.26 | 1.427      |
| Normal             | 77                      | 57.46 | 37                      | 48.05 | 1.735      |
| Over               | 14                      | 10.45 | 9                       | 11.69 | 0.077      |

Table 6: District specific prevalence of CED in adult male Paudi Bhuyan

Table 6 shows the district specific prevalence of CED in adult males. CED-III is found in 5 and 4 males of Deogarh and Keonjhar districts respectively with  $\chi^2$  values of 0.254. Equal numbers of males i.e. 10 show CED-II in both districts with  $\chi^2$  values of 1.735. CED-I was slightly higher in Deogarh males 28 (20.90%) than in Keonjhar males 17 (22.08%). The total CED among Deogarh males was 43 (32.09%) and that among Keonjhar males was 31 (40.26%) with a  $\chi^2$  value of 1.427. A normal BMI was found in 77 (57.46%) adult males in the Deogarh district and 37 (48.05%) males in the Keonjhar district. Overweight was found in 14 (10.45%) males and 9 (11.69%) males in the Deogarh and Keonjhar districts respectively.

| Nutritional status | District name             |       |                            |       | Comparison |
|--------------------|---------------------------|-------|----------------------------|-------|------------|
|                    | Deogarh female<br>(N=198) | %     | Keonjhar female<br>(N=112) | %     |            |
| CED-III            | 19                        | 9.60  | 14                         | 12.50 | 0.63       |
| CED-II             | 21                        | 10.61 | 14                         | 12.50 | 0.254      |
| CED-I              | 56                        | 28.28 | 27                         | 24.11 | 0.632      |
| Total CED          | 96                        | 48.48 | 55                         | 49.11 | 0.011      |
| Normal             | 87                        | 43.94 | 48                         | 42.86 | 0.034      |
| Over               | 15                        | 7.58  | 9                          | 8.04  | 0.021      |

Table 7: District specific prevalence of CED in adult female Paudi Bhuyan

Table 7 presents the district specific prevalence of CED of adult females. CED-III was found in 19 (9.60%) females in Deogarh and 14 (12.50%) females in Keonjhar with a  $\chi^2$  of 0.63. CED-II is shown by 21 (10.61%) females in Deogarh and 14 (12.50%) females in Keonjhar with a  $\chi^2$  of 0.254. CED-I was slightly higher in Deogarh females 56 (28.28%) than in Keonjhar females 27 (24.11%) with  $\chi^2$  values of 0.632. The total CED among Deogarh females was 96 (48.48%) and that among Keonjhar females was 55 (49.11%) with a  $\chi^2$  value of 0.011. A normal BMI was found in 87 (43.94%) adult females in the Deogarh district and 48 (42.86%) adult females in the Keonjhar district. Overweight was found in 15 (7.58%) females and 9 (8.04%) females in Deogarh and Keonjhar districts respectively with a  $\chi^2$  value of 0.021.

Table 8 shows the comparison of male body height and weight among different ethnic groups across India. Nearly all of the ethnic groups have a taller mean male height than the currently studied Paudi Bhuyan population. The mean male height of Paudi Bhuyan is  $157 \pm 5.80$  cm. The highest t value was of the Nicobarese population ( $t = 43.46$ ) studied by Kapoor A.K. in 2010. Other ethnic groups with significantly taller populations are Bhumija ( $t = 7.40$ ), Mina ( $t = 17.731$ ), Bhil ( $t = 8.204$ ), Sahariya ( $t = 7.963$ ), Garasia ( $t = 10.467$ ), Damor ( $t = 8.101$ ), Kathodi ( $t = 8.581$ ), Gond ( $t = 8.112$ ), Naga ( $t = 14.614$ ), Baniya Caste ( $t = 18.198$ ), Ezhava ( $t = 18.67$ ) and Nolia ( $t = 12.759$ ). Only the Kharwar population is relatively shorter with a t value of -5.201.

Paudi Bhuyan had a mean male weight of  $48 \pm 7.61$  kg. Other reviewed ethnic groups have either higher or lower body weights than the current study, with the highest mean male body weight being in the Baniya Caste Group i.e.  $72.8 \pm 13.12$  kg ( $t = 24.439$ ). Tangkhul Naga has a mean weight of  $59.1 \pm 8.3$  kg ( $t = 14.942$ ) and Nicobarese has a mean weight of  $54.5 \pm 0.71$  kg ( $t = 10.931$ ). The Garasia has the lowest mean weight i.e.  $43.0 \pm 3.35$  kg ( $t = -5.678$ ).

Table 9 shows the mean body height and weight of the females in the different ethnic groups. The result of present study revealed that the mean female height of Paudi Bhuyan is  $147 \pm 5.36$  cm. The other studied populations mostly presented a taller mean height with the greatest height in Ezhava i.e.  $155.9 \pm 5.3$  ( $t = 14.90$ ). Other taller populations are Mina (mean-  $155.04 \pm 4.95$ ,  $t = 11.891$ ), Garasia (mean-  $153.62 \pm 4.32$ ,  $t = 9.997$ ), Tangkhul Naga (mean-  $153 \pm 5.6$ ,  $t = 13.98$ ), Baniya Caste (mean-  $152.1 \pm 5.51$ ,  $t = 11.654$ ) and Kalita Caste (mean-  $154.3 \pm 5.45$ ,  $t = 18.571$ ).

The mean body weight of female of Paudi Bhuyan was  $41 \pm 6.77$  kg. Among the Baniya females in the studied population, the highest mean weight was  $68.1 \pm 11.47$  kg ( $t = 35.780$ ) and the lowest was of Kathodi ( $36.95 \pm 4.26$  kg,  $t = -3.817$ ). The mean weights of the other significant populations were as follows: Mina (mean-

| Sl No | Year | Author          | State               | Ethnic Group | Male | Height | SD   | t' test   | Weight | SD    | t' test   |
|-------|------|-----------------|---------------------|--------------|------|--------|------|-----------|--------|-------|-----------|
| 1     | 2007 | Bhasin M. K.    | Rajasthan           | Mina         | 89   | 169.26 | 4.59 | 17.731*** | 51.85  | 4.81  | 4.413***  |
| 2     | 2007 | Bhasin M. K.    | Rajasthan           | Bhil         | 66   | 163.19 | 3.52 | 8.204***  | 44.21  | 3.67  | -3.903*** |
| 3     | 2007 | Bhasin M. K.    | Rajasthan           | Sahariya     | 50   | 164.2  | 5.68 | 7.923***  | 47.31  | 6.15  | -0.596    |
| 4     | 2007 | Bhasin M. K.    | Rajasthan           | Garasia      | 81   | 164.7  | 5.15 | 10.467*** | 43.02  | 3.35  | -5.678*** |
| 5     | 2007 | Bhasin M. K.    | Rajasthan           | Danor        | 41   | 164.9  | 5.24 | 8.101***  | 43.85  | 4.42  | -3.379*** |
| 6     | 2007 | Bhasin M. K.    | Rajasthan           | Kathodi      | 43   | 164.95 | 3.97 | 8.581***  | 44.07  | 4.23  | -3.281**  |
| 7     | 2008 | Bisai S.        | West Bengal         | Kora Mudi    | 250  | 158.94 | 6.21 | 3.444***  | 47.35  | 6.39  | -0.997    |
| 8     | 2010 | Goswami M.      | Odisha              | Bhumija      | 66   | 163.44 | 7.24 | 7.40***   | 50.68  | 7.85  | 2.478*    |
| 9     | 2010 | Kapoor A.K.     | Haryana             | Tadavi       | 50   | 150.8  | 5.3  | -6.905*** | 44.8   | 6.8   | -2.726**  |
| 10    | 2010 | Kapoor S.       | Maharashtra         | Mina         | 120  | 160.4  | 5    | 5.383***  | 45.3   | 4.23  | -3.583*** |
| 11    | 2010 | Kapoor A.K.     | Andaman and Nicobar | Nicobarese   | 165  | 180.6  | 4.38 | 43.462*** | 54.5   | 0.71  | 10.931*** |
| 12    | 2010 | Kapoor A.K.     | Andaman and Nicobar | Nolia        | 155  | 163.2  | 2    | 12.759*** | 47.7   | 0.64  | -0.489    |
| 13    | 2011 | Gupta S.        | Delhi               | Baniya (SC)  | 271  | 166.7  | 5.81 | 18.198*** | 72.8   | 13.12 | 24.439*** |
| 14    | 2012 | Goswami M.      | Odisha              | Bhuyan       | 303  | 159.5  | 6.97 | 4.279***  | 46.5   | 7.65  | -2.192*   |
| 15    | 2012 | Mungreiphy N.K. | Manipur             | Naga         | 257  | 164.8  | 5.7  | 14.614*** | 59.1   | 8.3   | 14.942*** |
| 16    | 2014 | Basa A.         | Kerala              | Ezhava       | 92   | 170.6  | 5.9  | 18.670*** | 56.9   | 10.3  | 8.368***  |
| 17    | 2015 | Saini M.        | Madhya Pradesh      | Gond         | 89   | 162.8  | 5.3  | 8.112***  | 52.1   | 6.2   | 4.491***  |
| 18    | 2015 | Saini M.        | Madhya Pradesh      | Baiga        | 88   | 160.2  | 6.07 | 4.299***  | 48.3   | 5.21  | 0.338     |
| 19    | 2015 | Goswami M.      | Odisha              | Mankidias    | 124  | 158.4  | 5.84 | 2.128*    | 48.5   | 3.87  | 0.681     |
| 20    | 2018 | Jaiswal A.      | Uttar Pradesh       | Kharwar      | 75   | 152.81 | 6.51 | -5.201*** | 48.98  | 6.53  | 0.993     |
| 21    | 2024 | Present study   | Odisha              | Paudi Bhuyan | 211  | 157.0  | 5.80 |           | 48.0   | 7.61  |           |

Table 8: Comparison of male body height and weight from previous studies

| <i>Sl No</i> | <i>Year</i> | <i>Author</i>  | <i>State</i>  | <i>Ethnic Group</i> | <i>Female</i> | <i>Height</i> | <i>SD</i> | <i>t' test</i> | <i>Weight</i> | <i>SD</i> | <i>t' test</i> |
|--------------|-------------|----------------|---------------|---------------------|---------------|---------------|-----------|----------------|---------------|-----------|----------------|
| 1            | 2007        | Bose K.        | Odisha        | Bathudi             | 183           | 148.59        | 6.93      | 2.847**        | 38.76         | 5.56      | -3.785***      |
| 2            | 2007        | Bhasin MK.     | Rajasthan     | Mina                | 76            | 155.04        | 4.95      | 11.891***      | 45.88         | 3.18      | 6.116***       |
| 3            | 2007        | Bhasin MK.     | Rajasthan     | Bhil                | 66            | 151.93        | 4.06      | 7.051***       | 38.48         | 6.79      | -2.744**       |
| 4            | 2007        | Bhasin MK.     | Rajasthan     | Sahariya            | 39            | 153.35        | 5.31      | 6.980***       | 41.86         | 6.3       | 0.753          |
| 5            | 2007        | Bhasin MK.     | Rajasthan     | Garasia             | 76            | 153.62        | 4.32      | 9.997***       | 38.33         | 3.52      | -3.327**       |
| 6            | 2007        | Bhasin MK.     | Rajasthan     | Damor               | 37            | 153.29        | 4.84      | 6.813***       | 40.65         | 3.7       | -0.309         |
| 7            | 2007        | Bhasin MK.     | Rajasthan     | Kathodi             | 43            | 152.21        | 5.26      | 5.986***       | 36.95         | 4.26      | -3.817***      |
| 8            | 2008        | Bisai S.       | West Bengal   | Kora Mudi           | 250           | 147.6         | 5.62      | 1.289          | 39.98         | 5.4       | -1.937         |
| 9            | 2010        | Goswami M.     | Odisha        | Bhumija             | 73            | 150.26        | 3.93      | 4.894***       | 41.86         | 5.01      | 1.021          |
| 10           | 2010        | Kapoor AK.     | Haryana       | Tadavi              | 50            | 148.5         | 4.9       | 1.857          | 41.9          | 9.6       | 0.818          |
| 11           | 2011        | Gupta S.       | Delhi         | Baniya (SC)         | 307           | 152.1         | 5.51      | 11.654***      | 68.1          | 11.47     | 35.780***      |
| 12           | 2012        | Goswami M.     | Odisha        | Bhuyan              | 324           | 154.02        | 7.01      | 14.120***      | 40.2          | 6.31      | -1.540         |
| 13           | 2012        | Mungreiphy NK. | Manipur       | Naga                | 346           | 153           | 5.6       | 13.980***      | 49.6          | 7.4       | 15.468***      |
| 14           | 2013        | Bordoloi T.    | Assam         | Kalita (SC)         | 482           | 154.3         | 5.45      | 18.517***      | 52.2          | 7.7       | 20.929***      |
| 15           | 2014        | Basa A.        | Kerala        | Ezhava              | 108           | 155.9         | 5.3       | 14.903***      | 47.5          | 8.1       | 8.152***       |
| 16           | 2014        | Singh HS.      | Chattishgarh  | Bhaina              | 100           | 149.33        | 4.88      | 3.861***       | 44.84         | 6.99      | 4.893***       |
| 17           | 2015        | Goswami M.     | Odisha        | Mankidias           | 136           | 148.1         | 6.04      | 1.918          | 40.8          | 4.63      | -0.314         |
| 18           | 2018        | Jaiswal A.     | Uttar Pradesh | Kharwar             | 76            | 148.82        | 4.46      | 2.736**        | 45            | 7.55      | 4.510***       |
| 19           | 2024        | Present study  | Odisha        | Paudi Bhuyan        | 310           | 147.0         | 5.36      |                | 41.0          | 6.77      |                |

Table 9: Comparison of female body height and weight from previous studies

| <i>Sl No</i> | <i>Year</i> | <i>Author</i>   | <i>State</i>        | <i>Ethnic Group</i> | <i>Male</i> | <i>Mean</i> | <i>SD</i> | <i>t' test</i> | <i>Female</i> | <i>Mean</i> | <i>SD</i> | <i>t' test</i> |
|--------------|-------------|-----------------|---------------------|---------------------|-------------|-------------|-----------|----------------|---------------|-------------|-----------|----------------|
| 1            | 2008        | Bisai S.        | West Bengal         | Kora Mudi           | 250         | 18.69       | 1.84      | -7.263***      | 250           | 18.33       | 1.06      | -3.503***      |
| 2            | 2010        | Goswami M.      | Odisha              | Bhumija             | 66          | 18.9        | 2.41      | -3.669***      | 73            | 18.4        | 1.87      | -1.702         |
| 3            | 2010        | Kapoor A.K.     | Haryana             | Tadavi              | 50          | 17.9        | 2.3       | -6.407***      | 50            | 18.9        | 3.5       | -0.221         |
| 4            | 2010        | Kapoor A.K.     | Andaman and Nicobar | Nicobarese          | 165         | 21.9        | 0.87      | 11.240***      |               |             |           |                |
| 5            | 2010        | Kapoor A.K.     | Andaman and Nicobar | Nolia               | 155         | 17.9        | 0.42      | -12.677***     |               |             |           |                |
| 6            | 2011        | Gupta S.        | Delhi               | Baniya (SC)         | 271         | 26.1        | 4.28      | 19.095***      | 307           | 29.4        | 4.77      | 32.851***      |
| 7            | 2012        | Goswami M.      | Odisha              | Bhuyan              | 303         | 18.2        | 2.71      | -8.181***      | 324           | 17          | 2.98      | -8.601***      |
| 8            | 2012        | Mungreiphy N.K. | Manipur             | Naga                | 257         | 21.7        | 2.6       | 7.753***       | 346           | 21.2        | 2.2       | 11.081***      |
| 9            | 2013        | Bordoloi T.     | Assam               | Kalita (SC)         |             |             |           |                | 482           | 21.8        | 2.8       | 13.601***      |
| 10           | 2014        | Basa A.         | Kerala              | Ezhava              | 92          | 19.5        | 2.7       | -1.776         | 108           | 19.5        | 3.05      | 1.534          |
| 11           | 2014        | Singh H.S.      | Chattishgarh        | Bhaina              |             |             |           |                | 100           | 20.06       | 2.67      | 3.265*         |
| 12           | 2015        | Goswami M.      | Odisha              | Mankidias           | 124         | 19.3        | 2.15      | -2.981**       | 136           | 18.6        | 2.81      | -1.364         |
| 13           | 2016        | Kshatriya G. K  | West Bengal         | Santhal             | 123         | 19.9        | 2.6       | -0.391         | 122           | 19.5        | 3.2       | 1.577          |
| 14           | 2016        | Kshatriya G. K  | West Bengal         | Kora                | 114         | 18.9        | 2         | -4.686***      | 121           | 17.6        | 2.9       | -4.537***      |
| 15           | 2016        | Kshatriya G. K  | West Bengal         | Oraon               | 112         | 19.6        | 2.5       | -1.552         | 124           | 18.1        | 2.8       | -2.972**       |
| 16           | 2016        | Kshatriya G. K  | Odisha              | Santhal             | 121         | 20.2        | 2.8       | 0.750          | 119           | 20.3        | 3         | 4.148***       |
| 17           | 2016        | Kshatriya G. K  | Odisha              | Bhumij              | 116         | 20.9        | 3.1       | 3.162**        | 122           | 19.7        | 2.9       | 2.275*         |
| 18           | 2016        | Kshatriya G. K  | Odisha              | Bathudi             | 119         | 19.5        | 2.8       | -1.867         | 121           | 18          | 2.8       | -3.273*        |
| 19           | 2016        | Kshatriya G. K  | Odisha              | Dhodia              | 121         | 20.5        | 3.2       | 1.741          | 120           | 20.7        | 3.5       | 5.170***       |
| 20           | 2016        | Kshatriya G. K  | Odisha              | Kukna               | 120         | 20.3        | 3.1       | 1.062          | 120           | 19.9        | 2.9       | 2.908*         |
| 21           | 2016        | Kshatriya G. K  | Gujarat             | Choudhari           | 120         | 19.8        | 3.1       | -0.708         | 121           | 18.9        | 2.9       | -0.324         |
| 22           | 2017        | Kapoor S.       | Maharasta           | Meena               | 120         | 17.7        | 1.7       | -10.492***     |               |             |           |                |
| 23           | 2018        | Jaiswal A.      | Uttar Pradesh       | Kharwar             | 75          | 20.37       | 2.81      | 1.218          | 76            | 20.33       | 3.4       | 3.486***       |
| 24           | 2024        | Present study   | Odisha              | Paudi Bhuyan        | 211         | 20.0        | 2.73      |                | 310           | 19.0        | 2.87      |                |

Table 10: Comparison of BMI from previous studies

45.8  $\pm$  3.18,  $t = 6.116$ ), Naga (mean- 49.6  $\pm$  7.4,  $t = 15.468$ ) and Kalita (mean- 52.2  $\pm$  7.7,  $t = 20.929$ ).

Table 10 represents the mean BMI of different previously studied ethnic groups and of the current study. The mean male BMI in the current study was 20  $\pm$  2.73. Baniya males had a higher mean BMI 26.1  $\pm$  4.28 ( $t = 19.095$ ), followed by Nicobarese males 21.9  $\pm$  0.87 ( $t = 11.24$ ). A mean BMI lower than that in the current study was shown in Nolia males i.e. 17.9  $\pm$  0.42 ( $t = -12.677$ ), Kora Mudi (mean- 18.69  $\pm$  1.84,  $t = -7.263$ ) and Tadavi (mean- 17.9  $\pm$  2.3,  $t = -6.407$ ).

The mean BMI of the females in the current study was 19.0  $\pm$  2.87. Among the other study populations Baniya women had the highest mean of 29.4  $\pm$  4.27 ( $t = 32.85$ ), followed by Kalita women (mean-21.8  $\pm$  2.8,  $t = 13.601$ ) and Naga women (mean-21.2  $\pm$  2.2,  $t = 11.081$ ). Those populations with lower BMIs than those in the current study were Kora (mean-17.6  $\pm$  2.9,  $t = -4.537$ ) and Bathudi (mean-18  $\pm$  2.8,  $t = -3.273$ ).

Table 11 shows the proportional differences in the prevalence of undernutrition reported in previous studies. In the present study 35.07% of the males and 48.71% of the females were undernourished. Among the other studied populations undernutrition among males was 82.45% among Nolia ( $t = 80.872$ ), 78.57% among Munda ( $t = 23.343$ ), 49.91% among the Kora Mudi ( $t = 10.252$ ), 48.4% among Mankidias ( $t = 5.765$ ), 51.9% among Juang ( $t = 15.901$ ) and 54.5% among Lodha ( $t = 19.222$ ).

The rate of undernutrition among the females from the previously studied populations are as follows: 77.7 among Bhuyan ( $t = 40.021$ ), 33.3% among Kalita ( $t = 18.751$ ), 16.2% among Naga ( $t = 79.88$ ), 64.5% among Bathudi ( $t = 8.409$ ) and 62.9% among Oraon ( $t = 5.522$ ) etc.

## Conclusion

Compared with previous studies on anthropometric indices across the country, the Paudi Bhuyan males and females presented shorter heights and lower BMIs. This finding suggests that nutritional challenges persist; hence there is a need for a targeted approach in intervention programs to promote dietary improvement, healthcare accessibility, and uplift. Finally, although both districts suffer from under anthropometric and nutritional variations, Keonjhar males and females possessed slightly healthier anthropometric signs than did their counterparts in Deogarh. The differences result from variations in ecology, food availability, livelihood patterns, healthcare access, and physical workload between the two districts. The Paudi Bhuyan show short stature, low body weight and BMI, clear sexual dimorphism, and a high prevalence of chronic energy deficiency, indicating long-term nutritional stress. This study highlights the pressing demand for appropriate

| Sl No | Year | Author          | State               | Ethnic Group             | Prevalence of Underweight |       |        |           |           |
|-------|------|-----------------|---------------------|--------------------------|---------------------------|-------|--------|-----------|-----------|
|       |      |                 |                     |                          | Male                      | %     | Female | %         |           |
| 1     | 2007 | Bose K.         | Odisha              | Bathudi                  | 226                       |       | 183    | 64.5      | 8.409**   |
| 2     | 2008 | Bisai S.        | West Bengal         | Kora Mudi                | 250                       | 49.91 | 250    | 10.252**  | 11.033*** |
| 3     | 2010 | Goswami M.      | Odisha              | Bhumija                  | 66                        | 48.5  | 73     | 3.824     | 0.727     |
| 4     | 2010 | Kapoor S.       | Maharasta           | Meena                    | 120                       | 36    |        | 0.029     |           |
| 5     | 2010 | Kapoor A.K.     | Andaman and Nicobar | Nicobarese               | 165                       | 6.6   |        | 42.822*** |           |
| 6     | 2010 | Kapoor A.K.     | Andaman and Nicobar | Nolia                    | 155                       | 82.45 |        | 80.872*** |           |
| 7     | 2011 | Biswas S.       | West Bengal         | Dhimal                   | 100                       | 40    | 100    | 0.708     | 16        |
| 8     | 2012 | Goswami M.      | Odisha              | Bhuyan                   | 303                       | 58.7  | 324    | 27.738*** | 77.7      |
| 9     | 2012 | Mungreiphy N.K. | Manipur             | Naga                     | 257                       | 14.4  | 346    | 27.303*** | 16.2      |
| 10    | 2013 | Bordoloi T.     | Assam               | Kalita (Caste Group)     |                           |       | 482    |           | 33.3      |
| 11    | 2014 | Basa A.         | Kerala              | Ezhava                   | 92                        | 38.7  | 108    | 0.364     | 36.2      |
| 12    | 2015 | Saini M.        | Madhya Pradesh      | Gond                     | 89                        | 23    |        | 4.213*    |           |
| 13    | 2015 | Saini M.        | Madhya Pradesh      | Baiga                    | 88                        | 36.4  |        | 0.048     |           |
| 14    | 2015 | Jain Y.         | MP and CH           | Gond, Baiga, Oraon       | 527                       | 47.7  | 678    | 9.737*    | 54.4      |
| 15    | 2015 | Goswami M.      | Odisha              | Mankidias                | 124                       | 48.4  | 136    | 5.765*    | 59.5      |
| 16    | 2015 | Dehury B.       | Odisha              | Munda                    | 35                        | 78.57 | 16     | 23.343*** | 62.5      |
| 17    | 2016 | Kshatriya G.K   | Odisha              | Bhumji, Santhal, Bathudi | 1066                      | 37.4  | 1090   | 0.410     | 41.5      |
| 18    | 2016 | Kshatriya G.K   | West Bengal         | Santhal                  | 123                       | 30.1  | 122    | 0.862     | 45.1      |

| Sl No | Year | Author        | State         | Ethnic Group | Male | Prevalence of Underweight |           |       |
|-------|------|---------------|---------------|--------------|------|---------------------------|-----------|-------|
|       |      |               |               |              |      | %                         | Female    | %     |
| 19    | 2016 | Kshatriya G.K | West Bengal   | Kora         | 114  | 41.2                      | 1.187     | 62    |
| 20    | 2016 | Kshatriya G.K | West Bengal   | Oraon        | 112  | 34.8                      | 0.002     | 62.9  |
| 21    | 2016 | Kshatriya G.K | Odisha        | Santhal      | 121  | 28.1                      | 1.697     | 31.1  |
| 22    | 2016 | Kshatriya G.K | Odisha        | Bhumij       | 116  | 19                        | 9.290*    | 37    |
| 23    | 2016 | Kshatriya G.K | Odisha        | Bathudi      | 119  | 39.5                      | 0.641     | 62.8  |
| 24    | 2016 | Kshatriya G.K | Odisha        | Dhodia       | 121  | 28.1                      | 1.697     | 29.2  |
| 25    | 2016 | Kshatriya G.K | Odisha        | Kukna        | 120  | 28.3                      | 1.590     | 40    |
| 26    | 2016 | Kshatriya G.K | Gujarat       | Choudhari    | 120  | 40                        | 0.796     | 48.8  |
| 27    | 2017 | Dash N. C.    | Odisha        | Lodha        | 319  | 54.5                      | 19.222*** | 49.2  |
| 28    | 2018 | Jaiswal A.    | Uttar Pradesh | Kharwar      | 75   | 21.6                      | 4.634*    | 32.53 |
| 29    | 2020 | Dash A.       | Odisha        | Juang        | 95   | 12.5                      | 16.476*** | 13.6  |
| 30    | 2020 | Kanrar P.     | Odisha        | Juang        | 414  | 51.9                      | 15.901*** | 62.9  |
| 31    | 2022 | Mahanty B.    | Odisha        | Bondo        | 266  | 32                        | 0.498     | 39.3  |
| 32    | 2024 | Present study | Odisha        | Paudi Bhuyan | 211  | 35.07                     |           | 48.71 |

Table 11: Proportional differences of prevalence of Underweight from previous studies

region-specific nutrition and health interventions alongside improvements in healthcare infrastructure along with programmes for community education to check for malnutrition and chronic energy deficiencies among the Paudi Bhuyan tribe.

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