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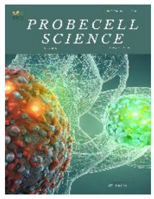

Anthropometric and Physiological Assessment of Tribal Populations in West Bengal: Gender Differences and Health Implications

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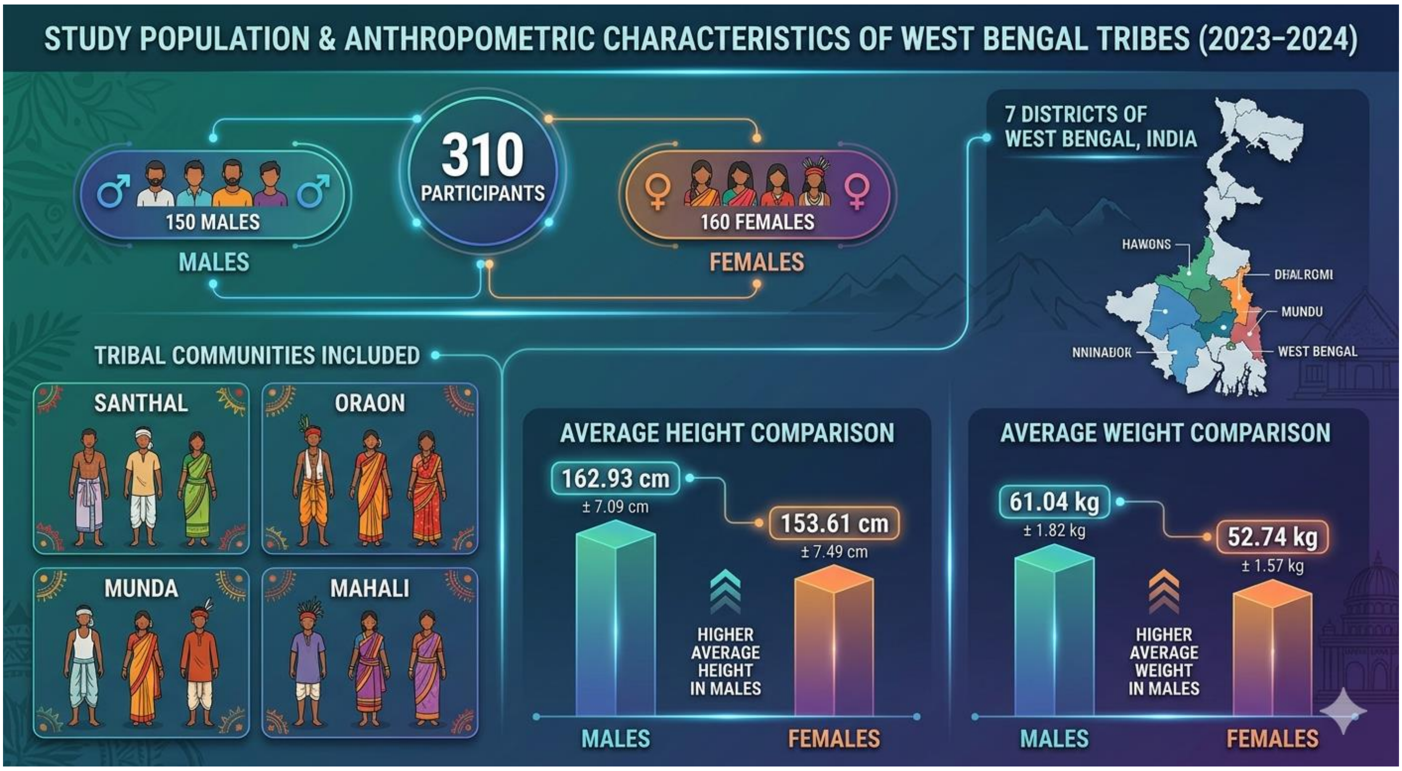
ABSTRACT

The eastern Indian state of West Bengal is home to a variety of tribes that contribute to the state's cultural, linguistic, and genetic diversity. The aim of this study was to determine gender based differences in the anthropometric and physiological characteristics of the tribal populations in West Bengal and their implications for health and nutrition. This study included 310 participants (150 males, 160 females) from Santhal, Oraon, Munda, and Mahali tribes from seven districts of West Bengal during 2023–2024. Height, weight, waist circumference (WC), and hip circumference (HC) were measured. Indices of Body Mass Index (BMI), Waist-to-Hip Ratio (WHR), and Conicity Index (CI) have been calculated. Physiological parameters including body fat percentage, visceral fat percentage, blood pressure, glucose levels, or resting metabolic rate-have also been measured. Large differences between males and females were obtained in the results. Males had a higher average height (162.93 ± 7.09 cm vs. 153.61 ± 7.49 cm) and weight (61.04 ± 1.82 kg vs. 52.74 ± 1.57 kg) compared to females. BMI values were similar between genders (22.78 ± 3.66 for males and 22.37 ± 0.94 for females). Females exhibited significantly higher body fat percentages (29.84 ± 1.11%) compared to males (23.49 ± 6.23%), whereas males had greater visceral fat (7.30 ± 4.06% vs. 5.34 ± 0.11%). Blood pressure was elevated in males (126.57 ± 14.57 mmHg systolic, 81.70 ± 1.45 mmHg diastolic) compared to females (120.81 ± 5.33 mmHg systolic, 79.91 ± 1.23 mmHg diastolic). Glucose levels, both fasting and postprandial, showed a slightly higher values in males compared to females: 82.58 ± 2.70 mg/dL versus 80.83 ± 1.33 mg/dL fasting levels, and 124.55 ± 11.72 mg/dL versus 119.65 ± 1.03 mg/dL postprandial glucose levels. The findings highlight gender-based disparities in health and nutrition arising from genetic, cultural, and lifestyle factors. The work provides insight into the health status of tribal populations and underscores the imperative and necessity for selective intervention in regard to the emerging health risks in the course of urbanization and socio-economic transitions.

Graphical Abstract:



1. Introduction

West Bengal is the state in the east of India, which has an ensemble of tribes inhabiting in its areas enriching cultural, linguistic, and genetic diversity of the state [1]. The tribes dwelling in the state have been staying in symbiosis with nature for thousands of years, deriving their livelihood from it while contributing highly to the state's cultural treasure. These communities include well over forty; major tribes among them includes Santhal, Oraon, Munda, Mahali, Lodha, Bhumij, and Kora, among many others [2-3]. Their distinctive patterns of living, languages, folklore, and traditional knowledge systems make them an important object for research in anthropology and sociology [4-5].

The tribal population of West Bengal amounts to approximately 8.15% of the state's population according to Census 2011. These communities mainly dwell in the hilly, forested, and rural regions with large populations in Purulia, Bankura, Paschim Medinipur, Jhargram, Birbhum, and parts of Jalpaiguri [6-7]. Though the communities are different from one another in terms of languages, rituals, and tradition-based professions, there remains a universality among them concerning reliance on agriculture, forest product collection, and hand-labouring activities [8].

Complex interaction of genetic, environmental, and socio-cultural factors determines anthropometric and physiological features of the population. However, from all of these categories, the most interesting category of human diversity is offered by tribal communities due to a specific way of life, nutrition, and cultural practices, developed in close association with the natural environment [9-11]. There are many tribes in the eastern Indian state of West Bengal, such as the Santhals, Oraons, Mundas, and Mahalis, which reflect much genetic and cultural wealth. However, socio-economic isolation, less access to health care, and disruption of traditional practices continue to increasingly raise health and nutritional status concerns in their communities [12].

Understanding anthropometric parameters and physiological differences within and between populations constitutes an important step toward reducing health disparities and improving public health interventions [13]. Such anthropometric measures as height, weight, waist circumference, and hip circumference are widely used for evaluation of nutritional status, composition of body, and health risks [14]. Derived indices such as Body Mass Index (BMI), Waist-to-Hip Ratio (WHR), and Conicity Index (CI) shed further light on obesity, fat distribution, and cardiovascular risk [15]. In the context of the increasing global burden of NCDs, all these aspects are ever more relevant [16]. While these measures are extensively documented in both urban and rural populations, their application in tribal communities, especially in India, remains relatively understudied because such groups frequently represent some of the most vulnerable sections of society [17].

This study adds further dimensions to understanding health and disease risk by examining physiological parameters like body fat percentage, blood pressure, and metabolic rate. The metrics with the assistance of anthropometric data can indicate critical patterns related to age, gender, and socio-environmental factors. Measurement of glucose metabolism by estimating fasting and postprandial glucose values also aids in the further assessment of this emerging burden of metabolic disorders like diabetes, increasingly encroaching upon non-urban populations [18-19].

This research has thus highlighted the importance of cultural and socio-economic contextures in the interpretation of health data. Tribal communities characteristically retain traditional diets and occupations with high levels of physical labor, all of which have a marked influence on their health profiles [20]. However, further socio-economic transitions, associated with increasing exposure to urban lifestyles, may change these patterns and result in a 'double burden of malnutrition,' whereby both undernutrition and obesity coexist along with related metabolic disorders [21].

The objective of the present study was to assess gender-based differences in the anthropometric and physiological characteristics of selected tribal populations in West Bengal (Santhal, Oraon, Munda, and Mahali). Such research is important not only for its anthropological and public health values but also in terms of practical concern to devise targeted health interventions and policies.

This paper, with its focus on the anthropometric measurements, physiological parameters, and derived health indices of tribal communities in West Bengal, would help fill the knowledge gaps of health and nutritional status; therefore, it would fulfill all the requirements for public health policies and sustainable community development initiatives. Research findings are not only educational on the health risk and resilience of such populations but also emphasize the necessity of conducting culturally sensitive approaches in dealing with the sole characteristics of their health challenges.

2. Methods

2.1 Study Location and Population

The study has been carried out in the Indian state of West Bengal. The study locations are Kalyani, Chandur, Polba, Burdwan, Bilsara, Karimpur, and Amarpur. The present study has been carried out among the tribal community groups, such as Oraon, Munda, Santal, and Mahali, during 2023–2024. The study participants included 150 males and 160 females, aged between 18 and 65 years.

2.2 Ethical Considerations

All participants received verbal or written informed consent prior to participation. All data collected during the study respected ethical standards and preserved the confidence of the respondents.

2.3 Data Collection for Anthropometric Measurement

Anthropometric measurements were conducted with standardized techniques. The parameters measured included height, weight, WC, and HC. These measurements were used in the computation of different indices, such as BMI [22].

2.4 Determination of Sample Size

While considering the logistical constraints and the requirements of valid statistical analysis, the sample size was decided to ensure that the resultant study is representative of the population under study. The study involved a total of 310 participants. Anthropometric measures made by calibrated measuring instruments like stadiometers and weighing scales. Blood pressure was recorded with automated sphygmomanometers, and the level of glucose was estimated with glucometers. The rest metabolic rate was calculated by standard metabolic analyzers.

2.5 Physiological and Biochemical Measurements

Some of the other physiological parameters measured include body fat percentage, percentage of visceral fat, blood pressure measured both systolic and diastolic, and glucose levels measured both fasting and 2 hours after meals. Resting metabolic rate and other indices were carried out to determine metabolism and body composition differences [23].

2.6 Statistical analysis

Forms structured were used in collecting data. After data collection, forms were validated and cleaned up where needed, then digitized. SPSS version 20.0 was used to key in data. Statistical analysis was carried out to meet the objectives of this study. Descriptive statistics, inferential statistics, and tests of significance [set at $p<0.05$] were applied to analyze the data.

3. Results

3.1 Physiological parameters

The table 1 describes the comparison of different physiological parameters between tribal male and female patients, which also reveals a number of differences and similarities. This data covers the broadest range of bodily measurements and health indicators, from simple metrics like age, weight, and height to more specific parameters like the body fat percentage, blood pressure, and glucose levels. The data contained within this table show a number of physiological differences between tribal male and female patients, most of which reflect well-described patterns of sexual dimorphism. In general, males have greater weight, height, muscle mass, and resting metabolism, with females presenting a higher percentage of body fat and a slightly faster pulse rate. The variability in body fat distribution, glucose metabolism, and blood pressure between men and women can also reflect larger physiological trends observed in many populations. Thus, the variability between genders is important in understanding gender-specific health risks and can be helpful in the structuring of targeted health interventions. However, it is also important to consider that such averages might also reflect extraneous sociocultural, environmental, and genetic factors specifically characteristic of the studied tribal population. Highly significant ($p < 0.001$) variables that include age, weight, height, percentage body fat, percentage visceral fat, resting metabolism, and pulse rate also exhibit gender-based distinction. These results indicate significant sexual dimorphism in the body composition and metabolic performance. Significant diastolic blood pressure at $p < 0.01$ describes a level of vascular physiology, sex-based disparities, and perhaps life style-related differences. Measurements of the waist, hip circumference, and digit length [2D and 4D] revealed some minor physiologic differences between genders. Not Significant variables were TS and BMI did not exhibit differences significant at $p < 0.05$, indicating consistency in the measurements of these two parameters across genders within the observed population.

3.1.1 Age

The mean age of the male patients is 39.58 ± 1.49 years, whereas females are relatively younger with a mean age of 37.38 ± 1.64 years. This could be a reflection of sociocultural or demographic differences occurring in the tribal communities studied, such as differing life expectancy or reproductive patterns. Although small, a difference of about 2 years might still be noteworthy; however, the small difference would not significantly affect the overall measured physiological parameters.

3.1.2 Weight and Height

The male population in this clinical study has a higher average weight (61.04 ± 1.82 kg) than the female population (52.74 ± 1.57 kg), with an approximately 8.3 kg difference between them. This is a general outcome found in most populations. In such populations, males often have more muscle mass and greater body weight compared to females. In addition, males have relatively more average height, which is at 162.93 ± 7.09 cm as opposed to females with a value of 153.61 ± 7.49 cm with a difference of about 9.3 cm. Such differences may be associated with the biological sex differences in growth patterns of skeletons, hormonal influence, and genetics.

3.1.3 Waist and Hip Measurements

Waist measurement is relatively a bit larger in males at 33.7 ± 3.12 cm than females at 32.89 ± 1.09 cm, though by a small margin. Hip circumference is also a little more in men (36.56 ± 3.15 cm) than in women (35.68 ± 1.11 cm). This again points to the fact that there could be a slightly greater spread of body mass in the abdominal and pelvic region in men in this population. However, the waist-to-hip ratios are not available in the table but would further elucidate fat distribution patterns, which are often more marked in women, especially with age.

3.1.4 TS

The TS thigh skinfold is an indication of subcutaneous fat thickness at the thigh, thus representing a measure of overall body fat reserves. In this study, males have an average TS of 35.54 ± 9.02 mm. However, females have a higher average, which is 36.55 ± 0.98 mm. This may show that the females in this population have slightly more fat deposited in the thigh area than the males. The small standard deviation in females suggests that there is more consistency with this measurement.

3.1.5 Arm and Finger Measurements

For the arm girth or circumference, which is indicative of lean body mass and overall musculature, the values for males are slightly higher at 10.69 ± 1.14 cm compared to females at 10.28 ± 0.04 cm. This should be expected since generally, males tend to have more muscle mass than females because of higher testosterone levels. Similarly, the 2D (second digit) and 4D (fourth digit) finger lengths, which sometimes are correlated with prenatal hormone exposure, are also different between genders by an insignificant margin. Males have, on average, a 2D of 7.45 ± 0.51 cm and a 4D of 7.07 ± 0.53 cm, whereas females have shorter digits: 2D = 7.28 ± 0.52 cm, 4D = 6.88 ± 0.55 cm. These measurements are often used as indicators of prenatal androgen exposure, and the differences are consistent with general findings across various populations.

3.1.6 Body Fat Percentage and Visceral Fat Percentage

Body fat percentage is notably higher in females (29.84 ± 1.11%) compared to males (23.49 ± 6.23%). This difference conforms to general sex differences in body composition, where women tend to have natural higher fat reserves due to hormonal influences, especially estrogen. Estrogen works by affecting fat storage, which can be particularly pronounced during reproductive years. Visceral fat, the fat deposited around internal organs, is also higher in males (7.30 ± 4.06%) than in females (5.34 ± 0.11%), thereby suggesting a greater concentration of abdominal organ fat reserves in males. Visceral fat poses higher metabolic disorder risks; thereby, this difference could consequently influence the health risks between the genders in this population.

3.1.7 Physiological Age

Physiological age is a measure of an individual's physical health with respect to chronological age. Therefore, the physiological age of male patients is 37.67 ± 1.40 years and that of female patients is 39.12 ± 1.00 years. This indicates that, on average, male patients are in slightly better physical condition relative to their actual age compared to female patients. This might be attributed to disparity in metabolic rates, lifestyle predispositions, or genetic factors that may have varied impacts on aging between the sexes.

3.1.8 Resting Metabolism [kcal]

Resting metabolism is the calories the body uses simply sitting there to preserve simple bodily functions. The patients being male, had a much-higher resting metabolism value. The male patients recorded 1391.31 ± 192.91 kcal as opposed to female patients who had

1158.44 ± 12.22 kcal. This is a common physiological difference, for men generally have greater amounts of muscle tissue than women do, and muscle tissue expends more calories at rest than fat tissue. So, the higher resting metabolism among males is expected with their greater average weight and the magnitude of muscle mass.

3.1.9 BMI

Average BMI of female patients = 22.37 ± 0.94. Both average values are within the normal weight range [18.5 to 24.9], meaning neither sex is underweight or overweight in an average sense. The minimal difference in BMI values between genders, however, may represent the differences in body composition; males generally have more muscle than females, which makes their higher BMI even if the body fat percentages may be lower.

3.1.10 Blood Pressure [BP]

Systolic blood pressure is more elevated in males (126.57 ± 14.57 mm Hg) compared with females (120.81 ± 5.33 mm Hg), and diastolic blood pressure was also marginally higher in men than in females (81.7 ± 1.45 mm Hg; 79.91 ± 1.23 mm Hg, respectively). These might be due to the differences in gender between the subjects involved and their impact on cardiovascular health as well as hormonal cause. The blood pressure of males is higher at an advanced age, but females generally have lower blood pressure levels until the time of menopause when it may increase, resulting from the decreased estrogen levels.

3.1.11 Pulse Rate

The average pulse rate for females is 87.21 ± 1.22 beats per minute, which is slightly higher than that observed in males (82.92 ± 1.93 bpm). Such trends are not unusual in general physiological conditions as women have relatively faster pulse rates than men due to variations in heart size and metabolic rates.

3.1.12 Glucose Levels (Fasting and Post-Meal)

Fasting glucose levels are comparable in males (82.58 ± 2.70 mg/dL) and females (80.83 ± 1.33 mg/dL), suggesting that insulin sensitivity or risk for diabetes may not vary much by gender in this population. The glucose level two hours postprandially is a bit higher in males (124.55 ± 11.72 mg/dL) than females (119.65 ± 1.03 mg/dL). However, in both cases, the values are within the normal postprandial range. This could suggest slight differences in glucose metabolism postprandial among gender, which might be due to hormonal or lifestyle factors.

Table 1 Anthropometric and Physiological Parameters of tribal male and female patients

S. No.	Physiological Parameters	Male	Female	t-value	p-value
1.	Age	39.58±1.49	37.38±1.64	8.221	<0.001
2.	Weight [Kg]	61.04±1.82	52.74±1.57	35.67	<0.001
3.	Height [cm]	162.93±7.09	153.61±7.49	11.29	<0.001
4.	Waist [cm]	33.7±3.12	32.89±1.09	2.51	<0.05
5.	Hip [cm]	36.56±3.15	35.68±1.11	2.41	<0.05
6.	TS [mm]	35.54±9.02	36.55±0.98	0.22	0.824
7.	Arm [cm]	10.69±1.14	10.28±0.04	3.53	<0.001
8.	2D [cm]	7.45±0.51	7.28±0.52	2.40	<0.05
9.	4D [cm]	7.07±0.53	6.88±0.55	2.46	<0.05
10.	Body fat [%]	23.49±6.23	29.84±1.11	16.31	<0.001
11.	Visceral fat [%]	7.30±4.06	5.34±0.11	7.13	<0.001
12.	Physiological Age	37.67±1.40	39.12±1.00	10.24	<0.001
13.	Resting Metabolism[kcal]	1391.31±19.91	1158.44±12.22	62.97	<0.001
14.	BMI	22.78±3.66	22.37±0.94	1.21	0.227
15.	BP - systolic	126.57±14.57	120.81±5.33	3.87	<0.001
16.	BP - diastolic	81.7±1.45	79.91±1.23	3.23	<0.01
17.	Pulse	82.92±1.93	87.21±1.22	14.14	<0.001

18.	Glucose- Fasting [mg/dL]	82.58±2.70	80.83±1.33	4.13	<0.001
19.	Glucose- 2h after meal [mg/dL]	124.55±11.72	119.65±1.03	5.13	<0.001

All values are presented as mean ± standard deviation [SD]. Statistical significance was assessed using independent sample t-tests: $p < 0.05$, $p < 0.01$, and $p < 0.001$.

3.2 Fat content in tribal patients

Body fat content is an important determinant of health and may provide some information about metabolic processes, hormonal influences, and possible health risks according to its distribution. Figure 1 and Figure 2 compares the fat distribution in tribal male and female patients across different body regions and elaborates on the proportions of both subcutaneous and skeletal fat, respectively. This analysis assesses multiple areas of fat storage—whole body (WB), trunk, arms, and legs—both for subcutaneous fat (fat stored just under the skin) and skeletal fat (fat stored around bones and muscles). The discrepancies of fat deposits between males and females reveal not only established biological sex differences but also meaningful health implications for each gender. The distribution of subcutaneous and skeletal fat percentages among tribal male and female patients demonstrates critical differences. The difference basically reflects general biological sex differences in body composition. Females have higher levels of subcutaneous fat across almost all body regions, particularly in the arms, legs, and trunk, reflecting the fat-storing effects of estrogen and the tendency for women to accumulate fat in the lower body.

In comparison, males tend to have more skeletal fats around the limbs and extremities, which could be attributed by the fact that they have a higher muscle mass, and fats tend to distribute more in the region around muscles and bones. More subcutaneous fat in females at the trunk and limbs suggests typical patterns of fat storage by females while males tend to store fats more so in abdominal cavities, which may collect as visceral fat that is linked to greater health risks. All the latter differences regarding fat distribution, in turn, together explain the existence of specific metabolic profiles and health risks for each gender and form a basis for the need for differentiated health interventions according to these physiological differences. Women showed significantly higher percentages of subcutaneous fat in all areas including whole body, trunk, arms, and legs than men.

The highest difference was found to be in the arms (40.47 ± 0.84% for women and 26.50 ± 9.40% for men), showing gender-specific patterns in fat deposition caused by sex hormones, estrogen. However, males had a significantly higher percentage of skeletal fat in all body areas (whole body, trunk, arms, and legs compared to females). The largest difference was found in the legs, with 44.95 ± 5.97 % in males and 36.99 ± 1.03% in females, due to higher muscle mass in males, which increases associated fat stores around muscles.

Divergent fat distribution patterns demonstrate coherence with known biological patterns: females have excess subcutaneous fat, particularly in the arms and legs, because of reproduction-related and hormonal influences. Males have a higher amount of skeletal fat, which is associated with higher lean muscle mass, often localized to the trunk and legs. These are important patterns in clarifying the particular health risks in tribal populations that can be addressed by intervention.

3.3 Subcutaneous Fat

Subcutaneous fat is the layer of fat right under the skin and plays roles in energy storage and insulation and protection of organs within the body. The percentage of subcutaneous fat in the different areas of the body is presented in the Figure 1. There are highly significant differences among genders.

3.3.1 Whole Body Subcutaneous Fat

Whole body subcutaneous fat percentage averaged 18.55 ± 6.05% for the males and was significantly higher at 25.64 ± 1.04% for the females. This is a difference of almost 7%. While certainly not new information, this finding does reflect the physiological tendency for women to have more body fat than men, especially of the subcutaneous form. Estrogen is a hormone that is found in women; it tends to retain fat around the hips, thighs, and abdomen. Compared to them, males having more testosterone tend to retain less subcutaneous fat, but they tend to gain more lean muscle mass.

3.3.2 Trunk Subcutaneous Fat

For the trunk region, males hold average percentage 16.18 ± 5.48%, and females stand at 21.99 ± 0.23%. Again, females have a greater percentage of fat reserve in the trunk region. The trunk includes regions such as the abdomen, chest, and back and is well known to be an important fat storage site, especially in women, who tend to concentrate more fat easily due to hormonal influences. In males, the percentage of fat storage in the trunk is usually less, and the abdominal cavity will be filled with visceral fat. This difference might have gender-related health consequences since abdominal fat [visceral fat] in males may present the threat of metabolic diseases such as diabetes and cardiovascular conditions.

3.3.3 Upper Arms Subcutaneous Fat

This region shows a very noticeable difference in the percentage of subcutaneous fat. Males have 26.50 ± 9.40%, while females have 40.47 ± 0.84%. With this highly significant difference in body fat percent, this characteristic tends to point towards the tendency of females having more subcutaneous fat on the upper parts of the human body, with particular emphasis on the arms and thighs. This would have been partly attributed to the effect of estrogen because it encourages fat deposit in these regions with the aim of preparing the female body for reproductive functions. In contrast, males tend to have fewer fatty arms, containing lower fat percentages because of their bigger muscle contents and less total body fat.

3.3.4 Legs Subcutaneous Fat

There is also a higher fat content in legs of females (37.12 ± 0.34%) compared to males (28.41 ± 10.96%). Female patients tend to deposit a relatively higher percentage of subcutaneous fat in legs and lower body regions, keeping in line with the generally expected female deposition pattern of body fat. Fats in the lower body in males are less marked, and the body tends to store more fat in the upper body and the abdominal region. These differences in fat distribution account for the characteristic "pear-shaped" body in women-more fat around the hips and thighs-compared to the "apple-shaped" body in men-more fat around the abdominal region.

3.4 Skeletal Fat

The role of skeletal fat, fat stored around muscles and bones, is somewhat different from that played by subcutaneous fat. It is less available for energy use but may affect muscle function and mobility. Figure 2 indicates the percentages of skeletal fat in different regions.

3.4.1 Whole Body Skeletal Fat

More skeletal fat percent was observed to exist in the male (28.32 ± 5.34%) as compared to the female (24.94 ± 1.01%). This means that while the percentage of males is higher, it may represent greater overall muscle mass and lean tissue so that there is a larger absolute amount of skeletal fat. Skeletal fat is placed mainly around the muscles and bones. Most men have more muscle mass than women, which means their absolute levels of stored fat may be higher, but still, the fat percentage may be lower in comparison to women, who characteristically have a higher overall body fat percentage.

3.4.2 Trunk Skeletal Fat

The trunk region, which comprises the chest, abdomen, and back, showed a higher percentage of skeletal fat in males 22.42 ± 5.24% compared to females 19.77 ± 0.12%. This conforms to the general rule that has been observed that males have higher fats deposited in the trunk region as opposed to females, but the fat in the trunk tends to be more concentrated in visceral fat rather than subcutaneous. In women, a larger percentage of trunk fat is subcutaneous, and less fat is stored in the skeletal region. Skeletal fat in the trunk could have less metabolic activity than visceral fat. Visceral fat relates to greater health risks like insulin resistance and hypertension.

3.4.3 Arms Skeletal Fat

The arms also show a difference in skeletal fat, with males having 33.59 ± 5.74% and females having 28.11 ± 1.09%. Though males have leaner arms overall, males have a slightly higher percentage of skeletal fat in the arms than females. This could be due to the fact that males have generally greater muscle mass than females, and this generally may increase their total amount of fat in the arms, though their arm fat percentage remains lower.

3.4.4 Legs Skeletal Fat

In the legs, the percentage of skeletal fat in males is also more than that in females (44.95 ± 5.97% vs 36.99 ± 1.03%). In the lower body, the males have more muscle mass and this translates to higher skeletal fat even though the subcutaneous fat in the legs is more in females. This increased muscle mass in men may account for the relatively greater skeletal fat content because muscle tissue itself needs fat for metabolic purposes.

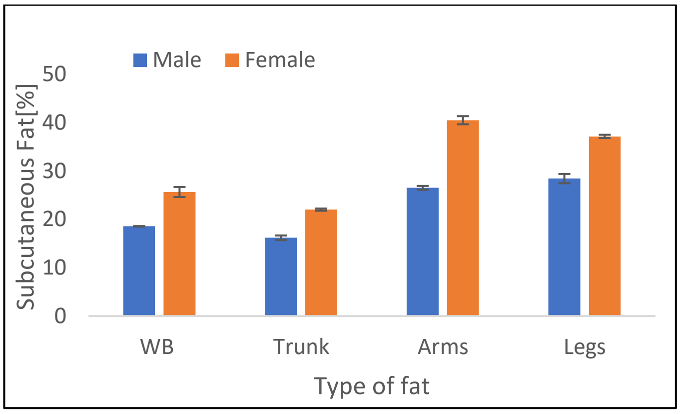


Figure 1 Subcutaneous fat of male and female

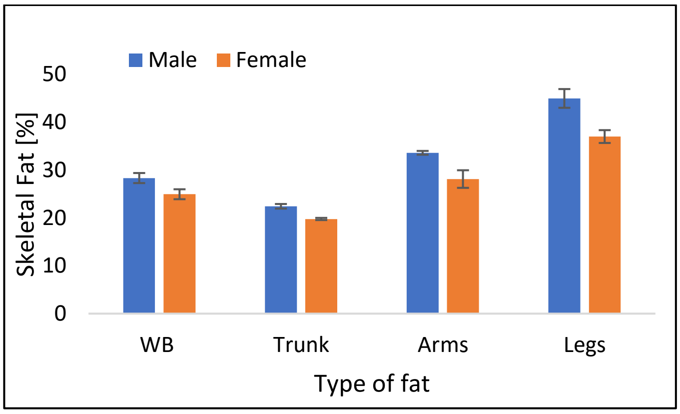


Figure 2 Subcutaneous fat of male and female

4. Discussion

The study covers a detailed evaluation of anthropometric and physiological characteristics of the tribes in West Bengal, clearly focusing on the intergender disparities as well as their health and nutrition implications. Analysis of key height, weight, body composition, and physiological parameters-findings of marked tendencies in these groups-increase knowledge regarding health conditions of Indian tribes [24-27].

There were differences in anthropometric variables among males and females, which correspond to general sexual dimorphism patterns reported on earlier studies. Males showed significantly higher mean height (162.93 ± 7.09 cm) and weight (61.04 ± 1.82 kg) compared with females (153.61 ± 7.49 cm and 52.74 ± 1.57 kg, respectively). This is in agreement with the findings of similar studies conducted among tribal populations in India, as found in those on Santhal and Munda tribes in Jharkhand and Odisha, where males had higher measures of height and weight because of increased muscle mass and skeletal growth influenced by hormonal activity [28-30].

Interestingly, BMI values for both genders were in the normal range as defined by WHO standards (22.78 ± 3.66 in males and 22.37 ± 0.94 in females), which again may imply that malnutrition is not as extreme as has been assumed in these populations. However, the greater variability in BMI in males suggests occupational physical activity or dietary intakes may differ between genders. Similar results have been documented by Bose et al., 2006, who established those tribal males indulging in labor-intensive exercises often have more variability of body composition indices [31].

Distributive pattern of body fat related to gender, which the present study found and agreed with established trends in human physiology, was on body fat percentage where females had a significantly higher percentage of body fat (29.84 ± 1.11%) than males (23.49 ± 6.23%). This is consistent with studies on other Indian tribal groups, like the Bhil and Gond tribes, where subcutaneous fat deposition was seen to be more pronounced in women due to estrogen hormone influence [32-33]. The percentage of visceral fat is significantly higher in males as compared to females, namely 7.30 ± 4.06% versus 5.34 ± 0.11%, which has been a serious concern because high visceral fat mass contributes to metabolic syndromes such as cardiovascular diseases and diabetes. Another study by Singh et al. [2018] among rural males in northern India reported some similar findings, necessitating the requirement of focused health interventions for these risks [34].

Blood pressure levels also revealed a significant gender gap, with males exhibiting higher systolic (126.57 ± 14.57 mmHg) and diastolic (81.70 ± 1.45 mmHg) blood pressures than females (120.81 ± 5.33 mmHg and 79.91 ± 1.23 mmHg, respectively). These results were comparable with those obtained from the earlier studies conducted in tribal populations over India. The men experience elevated blood pressure due to higher visceral fat, physical stress due to labor-intensive occupation, and lifestyle habits of smoking and alcohol consumption [35-36]. This further emphasizes the use of gender-sensitive interventions for cardiovascular diseases among tribal populations.

The glucose levels recorded in this study (fasting: 82.58 ± 2.70 mg/dL in males and 80.83 ± 1.33 mg/dL in females; postprandial: 124.55 ± 11.72 mg/dL in males and 119.65 ± 1.03 mg/dL in females) are within the normal range but have a slight male predominance. The similar results were also reported in studies by Kandpal et al. in 2016, who also reported similar trends of glucose in tribal populations in eastern India [37]. Possibly, lifestyle factors such as having higher caloric intake and lower physical activity could be responsible for marginally higher glucose levels among the males within the older age groups.

Traditional tribal diets and lifestyles have always protected populations against obesity and related disorders. However, the socio-economic transitions happening now in these communities are shifting this balance. Increased access to urban foods, diminutive physical activity, and changes in occupational patterns are likely drivers of the double burden of malnutrition, which is a coexistence between growing obesity rates and undernutrition. These trends have also been documented by the studies conducted by Jain et al. 2015 in tribal populations from central India, in which there is a critical need for targeted nutrition and health education programs [38].

This is one of the few comprehensive analyses on tribal health in West Bengal. It included both anthropometric as well as physiological parameters. However, it is not devoid of weaknesses [39-40]. The cross-sectional study does not afford inferences on causality, and sample size was representative but not sufficiently large to include the total biodiversity of tribal populations across the region. Socio-economic and dietary factors have not been examined in sufficient detail and could have added more insights into observed health patterns.

These longitudinal studies are essential to understand the dynamic relationships between lifestyle changes, socio-economic factors, and health outcomes of tribal populations [41]. Interventions in preventive healthcare, nutrition, and lifestyle modification must also be culture-specific to the challenges prevalent in the communities [42-44]. Finally, it generates a paramount gender-based difference in the anthropometric and physiological profile of tribal people in West Bengal, which in turn calls for appropriate strategies linked to the context for health improvement. Its finding adds to the ever-increasing evidence required for designing effective public health interventions among India's vulnerable groups.

5. Conclusion

This study deals at great length with the anthropometric and physiological profile of West Bengal tribal populations and reveals important gender differences with health implications. For example, males have reported high values for height and weight and resting metabolic rates, whereas females have reported higher body fat percentages and subcutaneous fat deposition. Health interventions targeted at males must be gender-specific, especially in males that are risk-differential for cardiovascular and metabolic diseases, with physiological differences such as hypertension and visceral fat, etc. It also brings to light the potential resilience of tribal communities in maintaining health despite adverse socio-economic conditions. In conclusion, this study is both describing a better understanding of health and nutritional dynamics relevant to tribal populations and providing a foundation for targeted approaches aimed at reducing health inequities and improving well-being in these communities.

Conflict of Interest

The author[s] declared no conflict of interest.

Ethical Compliance Standard

NA

Credit author statement

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