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Anthropometric Assessment and Height – Weight correlation among Rural and Urban population across Forested and Deforested area of Nabarangpur District, Odisha

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Abstract
Measurements based on height and weight are useful in indicating biological variation and nutritional status and can vary according to sex and environmental conditions. The present study examined the anthropometric characteristics and the relationship between height and weight in populations residing in forested and deforested regions of the Nabarangpur district, Odisha. A cross-sectional study was carried out among 960 participants (443 men and 517 women) from six blocks. The areas of Kosagumuda, Tentulikhunti, Nandahandi and Dabugam were forested, whereas Nabarangpur and Papadahandi were deforested. Height and weight were recorded and given as the mean ± SD. Karl Pearson's correlation coefficient was applied in order to investigate the association between height and weight. The mean height was greater in the group living in the forested areas (men: 138.50 ± 7.02 cm; women: 130.03 ± 7.49 cm) than in those in the deforested areas (men: 129.91 ± 4.33 cm; women: 122.14 ± 6.78 cm). There were very strong positive correlations between height and weight in both males and females. The results show a considerable amount of anthropometric variation between different environmental settings, together with a strong relationship between height and body weight.

Keywords: Anthropometry, height, body weight, Pearson correlation, forested area, deforested area, and population variation.

1. INTRODUCTION

Health is a basic part of human well-being and is the result of a complicated interaction between biological, social, nutritional, physical, and environmental factors. The health status of a population is not merely a matter of being free from disease, since it also depends on proper growth, body make-up, nutritional state, the quality of the living environment, and access to the resources which are needed to lead a healthy life. There are considerable differences between rural and urban communities in this respect due to variations

in socioeconomic conditions, occupation, way of life, eating habits, sanitation, health services, and exposure to the environment.

Anthropometric status is a key indicator of the physical growth and of the nutritional state both of individuals and of populations. Measurements like height and weight are simple, cheap, and commonly used when it comes to assessing growth patterns and body size. The connection between height and weight gives useful insights into physical condition and may help to detect variations in nutritional status among different population groups. It is for this reason that anthropometric evaluation is especially useful in studies based on populations since differences in living conditions and in the surrounding environment may affect growth and development.

An individual's physical condition is influenced by a number of factors such as genetic background, nutritional intake, level of physical activity, occupation, and general living conditions. People in rural areas may rely more on occupations that are physically demanding and on food resources that are locally available, while those in urban areas may have different levels of physical activity, different patterns of dietary consumption, and different access to health facilities. These differences can lead to variations in height, weight, and other anthropometric features. Examining these differences can offer insights into the wider determinants of population health.

The environment is also a significant factor capable of affecting anthropometric and nutritional results. There are differences between wooded and cleared areas in terms of vegetation, the availability of natural resources, land use, occupations, patterns of settlement, and exposure to environmental changes. The communities that live in or near wooded regions may have different methods of earning a living and different access to food resources than those who live in areas where deforestation has taken place and where the environment has been more greatly altered by humans. These environmental differences might in turn have an indirect effect on dietary habits, levels of physical activity, socioeconomic conditions, and finally on the nutritional and physical state of the population.

Nutritional status is closely linked to growth, body weight, physical development, and general health. It is essential to have adequate nutrition if normal growth and physiological function are to be maintained, whereas insufficient or unbalanced nutrition can have an effect on body size and physical development. It therefore makes sense to use the evaluation of height and weight as a useful method of looking at nutritional differences amongst different population groups. If these anthropometric measurements are combined with information about the residents' setting and the environmental conditions, this can lead to a more comprehensive understanding of the factors related to population health.

The Nabarangpur district in Odisha is a suitable area in which to look at such variations since it contains various communities residing in both rural and urban settings, each with different ecological and socioeconomic features. It may be possible to discover whether the environmental context is linked to differences in anthropometric characteristics by comparing the populations from forested and deforested areas. Moreover, looking at the rural and urban populations separately can give a better understanding of how the residential environment and ecological conditions may interact with physical and nutritional status.

This study therefore intends to look at the relationship between height and weight among the rural and urban populations in the forested and deforested areas of the Nabarangpur district, Odisha. By comparing the height and weight patterns among these different groups, the study hopes to evaluate the variations in anthropometric status and investigate any possible links with physical, environmental, and nutritional conditions. The results could help to improve the understanding of the health of the population and offer useful basic information for future research in the field of anthropology, nutrition, and community health in the area.

1.1 Objectives of the Study

General objective

The aim of the study was to evaluate the anthropometric characteristics and to examine the relationship between height and weight among the rural and urban populations living in both forested and deforested regions of the Nabarangpur district, Odisha.

Specific objectives

To provide a description of the height and weight distribution among the members of the study population. The variation in height and weight should be evaluated by sex and age.

The aim is to use Karl Pearson's coefficient of correlation to determine the relationship between height and weight.

To compare the relationship between height and weight for male and female participants.
To look at the relationship between height and weight among different age groups.

The purpose is to compare the anthropometric characteristics of people in rural areas with those in urban areas.

The aim is to compare the anthropometric characteristics of populations that are classified as living in wooded areas and those in areas that have undergone deforestation.
To find out if the degree of the correlation between height and weight varies depending on the settlement and environmental classification.

2. LITERATURE REVIEW

Anthropometry and human growth

Height and weight are basic anthropometric measurements that are used when assessing physical development; their interpretation, though, is very much dependent on age and sex, especially in childhood since height and weight experience rapid changes with age.

The World Health Organization has prepared growth standards for children aged five and below on the basis of the WHO Multicentre Growth Reference Study; the standards include such indicators as length/height-for-age, weight-for-age, weight-for-height and BMI-for-age.

The World Health Organization has prepared a separate growth reference for children and adolescents between the ages of 5 and 19 years; this reference includes indicators for height-for-age, weight-for-age and BMI-for-age.

Consequently, anthropometric studies which include both children and adults should take into account the biological differences that vary with age rather than regard the whole group as belonging to one age category.

2.1 Height–weight relationship

During human growth height and weight usually show a positive relationship, though the strength of this relationship may vary depending on age, sex and population characteristics. It is therefore useful to use the statistical correlation between these two measurements when describing anthropometric patterns.

The Pearson correlation coefficient is generally used in the case where two continuous variables have an approximately linear relationship and the assumptions of the test are fairly met. Its value lies between -1 and +1, and positive values show that larger values of one variable are associated with larger values of the other.

Caution should be exercised when interpreting correlation, since a strong correlation does not prove that there is causation, and a correlation found in a population including individuals over a very wide age range may in part be due to age-related growth.

2.2 Rural and urban anthropometric differences

The socioeconomic conditions of people in rural areas as compared to those in urban areas may vary, together with their occupations, dietary habits, levels of physical activity, access to healthcare and their way of life. These differences could have an effect on anthropometric characteristics.

A study carried out in Odisha has looked at anthropometry and nutritional conditions in rural areas. Palo and others carried out a cross-sectional study on adults who were attending a rural primary health centre in the Khurda district and measured various anthropometric variables such as height, weight, body mass index and the waist-to-hip ratio. The study shows how useful anthropometric measurements are for investigating health-related differences in the populations of Odisha.

2.3 Forest and non-forest habitats

The environment in which people live can affect their standard of living by causing variations in the kinds of work they do, in the amount of food available, in the level of physical activity and in the socioeconomic opportunities and access to services they have.

A study carried out in Odisha by Chakrabarty and Bharati on the Shabar population found differences in body measurements and nutritional condition among people living in urban, rural and forest areas.

This study is based on the general idea of ecological variation in anthropometry but concentrates in particular on certain populations in the Nabarangpur district.

Anthropometric research in Nabarangpur

Nabarangpur is a significant location for population-based anthropometric research due to the large extent of its forest area and the fact that its population is mainly rural. According to the district administration, about 29.91% of the district's geographical area is forest.

This study broadens its geographical scope to include certain blocks and adopts both the environmental and the settlement classifications.

3. Research Questions

Is there a significant statistical relationship between height and weight in the group being studied?
Is the correlation between height and weight stronger for men than it is for women?
Does the relationship between height and weight differ among various age groups?
Is there a significant difference in height and weight between people in rural and those in urban areas?
Is there a significant difference in height and weight between areas with forests and those that have been deforested?
Is the degree of correlation different between the environmental and settlement groups?

Research Hypotheses

Null hypothesis (H0)

Among the participants of the study there is no significant statistical correlation between height and weight.
There are no significant differences in anthropometric characteristics or in the height–weight correlation when the people are classified by sex, age group, environmental category, or type of settlement.

Alternative hypothesis (H1)

There is a significant statistical correlation between height and weight among the participants in the study.
The anthropometric characteristics and/or the correlation between height and weight vary significantly depending on sex, age group, environmental classification and type of settlement.

4. MATERIALS AND METHODOLOGY

4.1 Study Design

This study was set up as a cross-sectional anthropometric one in order to examine variations in height and weight and to find out the relationship between these two anthropometric variables among the rural and urban populations living in both forested and deforested areas of the Nabarangpur district, Odisha; it took into account the different ages, sexes, ecological environments, and types of settlement in order to make a comparative evaluation of the anthropometric features.

The main aim was to evaluate the anthropometric condition of the group of people selected and to look at the correlation between height and weight by using Karl Pearson's coefficient of correlation; the analysis was carried out separately for men and women and then taken into account in relation to the various study areas.

4.2 Study Area

The study took place in the Nabarangpur district of Odisha, India; the following six administrative blocks were chosen for the investigation:
Kosagumuda
Tentulikhunti
Nandahandi
Dabugam

Nabarangpur
Papadahandi

For the purpose of analysis, the blocks were grouped based on their environmental setting and settlement pattern.

The areas which were classified as forested were Kosagumuda, Tentulikhunti, Nandahandi, and Dabugam; those which were classified as deforested were Nabarangpur and Papadahandi.

On the basis of their settlement characteristics, Kosagumuda, Tentulikhunti, and Nandahandi were regarded as rural areas, whereas Nabarangpur, Papadahandi, and Dabugam were considered urban areas.

Table 1. Classification of the selected study blocks

Classification	Blocks included
Forested area	Kosagumuda, Tentulikhunti, Nandahandi, Dabugam
Deforested area	Nabarangpur, Papadahandi
Rural area	Kosagumuda, Tentulikhunti, Nandahandi
Urban area	Nabarangpur, Papadahandi, Dabugam

The classification according to whether the area was forested or deforested and the rural or urban classification were considered as separate analytical dimensions; as a result, a given block might appear in more than one category, for instance Dabugam was listed in both the forested and urban categories. 5

4.3 Study Population

The study involved a total of 960 people, of whom 443 were males and 517 were females. The participants covered a broad age range, stretching from 3 years up to 60 years and over.

The sample was arranged by age and sex in order to look at the differences in anthropometric characteristics during childhood, adolescence, adulthood, and older adulthood, and the same general framework was applied when making comparisons among the six blocks and between the rural and urban populations.

4.4 Anthropometric Parameters

The main anthropometric variables looked at in the present study were standing height and body weight. They were chosen as basic indicators of body size and physical development and were studied in relation to age, sex, place of residence, and environmental background.

The primary variables used for analysis were:

- Height
- Weight
- Age
- Sex
- Environmental category
- Settlement category

The anthropometric data available were sorted separately by males and females and then divided according to age and study block.

4.5 Assessment of Height

The study therefore followed the analytical framework:
Age + Sex + Study Block + Settlement Type + Environmental Setting → Height and Weight → Height–Weight Correlation

4.6 Measurement of Height

For participants who were able to stand on their own, standing height was taken as the height value. The height was measured by having the participant stand up straight on a flat surface without wearing any footwear. The body was kept in an upright position and care was taken to ensure that the head was in the correct position during the measurement.

The participant's height was recorded as the distance measured vertically from the standing surface to the highest point of the head. The measurements were taken in centimetres (cm).

The height measurements were grouped by age group and sex for the purpose of statistical analysis. For each of the six selected blocks, the mean and standard deviation (SD) were calculated for males and females.

4.7 Measurement of Weight

The body weight was measured with the aid of a weighing instrument and noted down in kilograms (kg). When it was possible, the participants were evaluated under standardized conditions, and their footwear was removed if necessary.

The weight measurements that had been recorded were arranged by age, sex, and study block. For the male and female participants within each age group, the mean and standard deviation of weight were calculated separately.

4.8 Age-wise Classification

The study had participants ranging in age from 3 to over 60. These participants were divided into the age groups that were used in the original data collection and in the statistical tables.

It was especially important to carry out an age-wise analysis since height and weight change considerably during childhood and adolescence and may follow different patterns in adulthood and in older age; for this reason, the mean and standard deviation of height and weight were looked at separately for the relevant age groups rather than considering the whole sample as a single homogeneous population.

4.9 Collection and Organization of Anthropometric Data

The anthropometric observations were systematically recorded and subsequently arranged according to:

- Study block
- Age group
- Sex
- Height
- Weight
- Rural/urban classification
- Forested/deforested classification

The data available included the mean and standard deviation values for height and weight among males and females in each of the six blocks. They were used for making descriptive comparisons between the different study groups.

Comparisons were also drawn between rural and urban males and between rural and urban females in order to detect any differences in the anthropometric characteristics linked with the pattern of settlement.

4.10 Rural and Urban Comparison

The blocks that had been selected were split into rural and urban groups.
The rural population consisted of participants from:
Kosagumuda, Tentulikhunti, Nandahandi
The urban population consisted of participants from:
Nabarangpur, Papadahandi, Dabugam
The population in the rural areas and that in the urban areas was compared on the basis of sex and age. For men and women separately, the average height and the average weight were examined in order to detect any differences in anthropometric features between the two types of settlement.
The comparison between the rural and urban areas was therefore made at the level of the general population and also when looking at males and females separately.

4.11 Forested and Deforested Comparison

An environmental comparison was made by dividing the selected blocks into two categories, one consisting of forested areas and the other of deforested areas.
The group that was forested consisted of Kosagumuda, Tentulikhunti, Nandahandi, and Dabugam, while the group that had no forest consisted of Nabarangpur and Papadahandi.
The average and standard deviation of height and weight were looked at according to age and sex within each of these environmental categories. The purpose of this comparison was to find out if the anthropometric features differed between populations residing in different environmental conditions.

4.12 Descriptive Statistical Analysis

The anthropometric features of the study population were summed up using descriptive statistical methods.
For height and weight, the following measures were considered:

- Mean
- Standard deviation (SD)

The average height and average weight were calculated separately for each of the six study blocks, taking age and sex into account. They were then used when making comparisons between males and females, between people in rural and urban areas, and between those in forested and deforested areas.
It was the standard deviation that was employed in order to describe how much the values varied around their respective means.

4.13 Karl Pearson's Coefficient of Correlation

The association between height and weight was investigated using Karl Pearson's coefficient of correlation (r), and the coefficient was calculated separately for men and women in order to assess the strength and direction of the relationship between height and weight.

Karl Pearson's correlation coefficient was calculated using the formula:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[\, n\Sigma x^2 - (\Sigma x)^2 \,][\, n\Sigma y^2 - (\Sigma y)^2 \,]}}$$

where:
r = Karl Pearson's coefficient of correlation
N = number of observations
X = height measurement
Y = weight measurement
The value of r lies between −1 and +1; if it is positive this shows that height and weight tend to increase together while if it is negative there is an inverse relationship; a value near zero means that there is little or no linear association.

The correlation analysis was carried out separately for men and women, and where data were available the association was also looked at in relation to the various study groups.

4.14 Interpretation of Correlation
The Karl Pearson correlation coefficients obtained were used to assess both the direction and the strength of the linear relationship between height and weight; a positive correlation would show that those with greater height tend on average to have greater body weight, while a weak correlation would indicate only a comparatively small linear association between the two measurements.

The correlation coefficients were compared for males and females and, in those cases where they had been calculated, among the various geographical or settlement categories. The interpretation was made on the basis of the actual coefficient values obtained from the dataset and not on any previously assumed ones.

4.15 Comparative Analysis
The methodology allowed the following major comparisons to be undertaken:
● Differences in height and weight between men and women.
The variation in height and weight according to age.
—the anthropometric differences between the six chosen blocks.
—the differences between populations that have forests and those that have no forests.
The differences between people in rural areas and those in urban areas.
● Rural and urban differences among males.
● Rural and urban differences among females.
The relationship between height and weight as determined by Karl Pearson's coefficient of correlation.
The purpose of these comparisons was to carry out a multidimensional evaluation of anthropometric variation among the group selected from the Nabarangpur district.

4.16 Presentation of Data

The findings were put together in tables which showed the mean ± SD of height and weight for males and females depending on age and study block; separate tables were prepared for the rural–urban comparisons and for other appropriate group comparisons.

Karl Pearson's correlation coefficient was used in order to show the relationship between height and weight among males and females; furthermore, graphical representations can be employed to illustrate age-related trends in height and weight as well as the relationship between the two anthropometric variables.
Ethical Considerations

Privacy, dignity and the fact that participation was voluntary were all taken into account when the study was carried out. Where appropriate, the participants or their parents/guardians were made aware of the nature and purpose of the anthropometric assessment. Personal information was kept strictly confidential and the observations gathered were used for academic and research purposes.

5. RESULTS

5.1 Overall sample characteristics

A total of 960 participants were included in the study.

Table 2. Sex- wise distribution of participants

Sex	Number	percentage
Male	443	46.15
Female	517	53.85
Total	**960**	**100.00**

The study consisted of 443 male and 517 female participants, with females representing a slightly larger proportion of the total sample.

5.2 Block-wise anthropometric characteristics

Table 3. Block-wise mean height ± SD among males

Block	n (total number)	Mean Height	S.D
Kosagumuda	99	133.22	26.8684
Tentulikhunti	121	136.936	21.302
Nandahandi	31	135.064	34.0355
Dabugam	76	148.786	17.827
Nabarangpur	61	132.972	24.9167
Papadahandi	55	126.851	49.4247

Among the six study blocks there was a noticeable variation in the mean height of males. The highest mean height was found in Dabugam (148.79 ± 17.83), then came Tentulikhunti (136.94 ± 21.30) and after that Nabarangpur (135.06 ± 34.04). Kosagumuda had a mean height of 133.22 ± 26.87 and Nabarangpur a mean height of 132.97 ± 24.92. The lowest mean height was that of Papadahandi (126.85 ± 49.42).

There were also considerable differences in height among the blocks. Papadahandi had the greatest standard deviation (49.42), which shows that there was more variation in the heights of males in this block. On the other hand, Dabugam had the smallest standard deviation (17.83), indicating relatively less variation. The results clearly show that there are differences in the average height of males according to block, Dabugam having the highest average and Papadahandi the lowest.

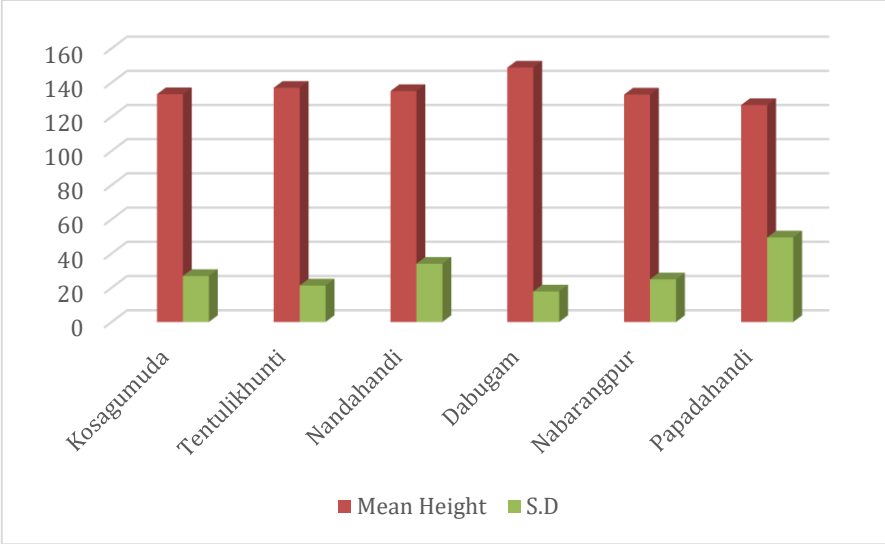

Fig.1. Block-wise height ± SD among males mean

Table 4. Block-wise mean height ± SD among females

Block	n (total number)	Mean Height	S.D
Kosagumuda	100	124.861	26.8684
Tentulikhunti	183	127.646	21.302
Nandahandi	49	126.48	34.0355
Dabugam	45	141.139	17.827
Nabarangpur	78	117.349	24.9167
Papadahandi	62	126.932	49.4247

When the mean height of females was analysed in blocks, there was a large variation among the six study blocks. Dabugam had the highest mean height at 141.14 ± 6.84, then came Tentulikhunti at 127.65 ± 23.14, followed by Papadahandi at 126.93 ± 27.44 and then Nabarangpur at 126.48 ± 27.04. Kosagumuda's mean height was 124.86 ± 25.68, while Nabarangpur had the lowest mean height, which was 117.35 ± 36.56.

The standard deviation shows that there are large differences in height among the blocks. Nabarangpur had the highest degree of variation (SD = 36.56), while Dabugam had the smallest (SD = 6.84), which means that the female height measurements in Dabugam were relatively more consistent. The results as a whole reveal considerable variation in the average height of females according to block, Dabugam having the highest average height and Nabarangpur the lowest.

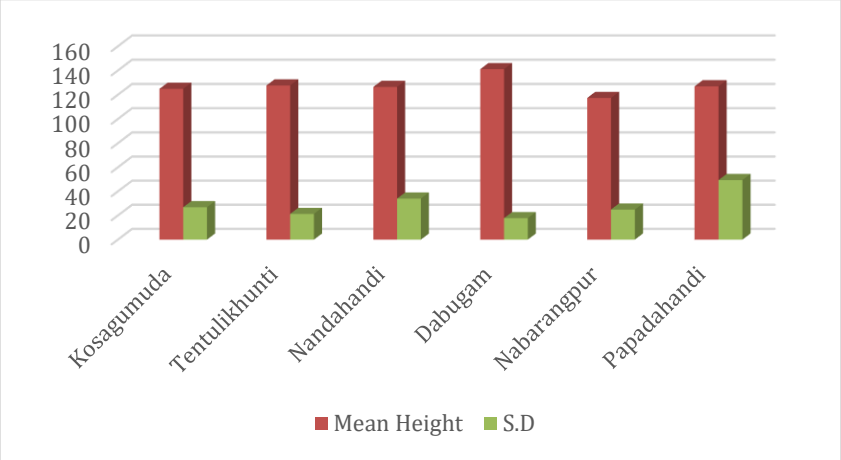

Fig. 2. Block-wise mean height ± SD among females

Table 5. Block-wise mean Weight ± SD among males

Block	n (total number)	Mean weight	S.D
Kosagumuda	99	34.761	16.435
Tentulikhunti	121	37.188	15.1718
Nandahandi	31	35.422	19.5944
Dabugam	76	45.085	12.8357
Nabarangpur	61	41.374	13.1083
Papadahandi	55	35.916	20.1670

The table shows how the average body weight of the male participants is distributed in blocks. The data cover six study blocks, the number of participants in the samples varying from 31 to 121 as indicated in the table. The average body weight varied from 34.76 kg to 45.09 kg.

The greatest average body weight was found in the male participants from Dabugam (45.09 ± 12.84 kg), after which came Nabarangpur (41.34 ± 13.11 kg) and then Tentulikhunti (37.19 ± 15.18 kg). The average body weight in Papadahandi was 35.92 ± 20.17 kg and that in Nandahandi was 35.42 ± 19.59 kg. The lowest average body weight was noted in Kosagumuda (34.76 ± 16.44 kg).

There was a great deal of variation in body weight among the blocks. Papadahandi had the highest standard deviation (20.17 kg), which shows that the body-weight measurements in this group were more spread out. On the other hand, Dabugam had the lowest standard deviation (12.84 kg), indicating that the variation was comparatively smaller.

In general, the results show considerable differences between the blocks in the average body weight of the male participants, Dabugam having the highest average body weight and Kosagumuda the lowest. Moreover, the differences in the SD values indicate that the body weight distribution varied from one study block to another.

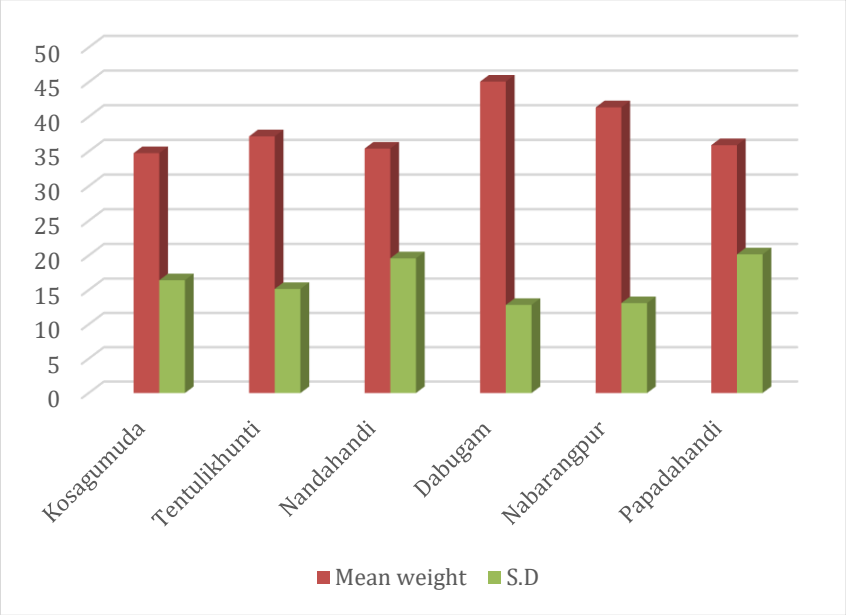

Fig. 3. Block-wise mean Weight ± SD among males

Table. 6. Block-wise mean Weight ± SD among females

Block	n (total number)	Mean Weight	S.D
Kosagumuda	100	33.626	14.638
Tentulikhunti	183	32.414	12.9022
Nandahandi	49	32.242	14.4145
Dabugam	45	40.727	9.4747
Nabarangpur	78	32.750	15.4474
Papadahandi	62	30.291	13.9800

The table shows the mean body weight for the female participants in each block. Across the six study blocks, 517 female participants were included. The mean body weight varied from 30.90 kg to 40.73 kg. The greatest average body weight was found among the women from Dabugam (40.73 ± 9.48 kg; n = 45). Next came Kosagumuda (33.63 ± 14.64 kg; n = 100), then Nabarangpur (32.75 ± 15.45 kg; n = 78), and after that Tentulikhunti (32.41 ± 12.90 kg; n = 183). Nandahandi had an average body weight of 32.24 ± 14.71 kg (n = 49), and the lowest average body weight was noted in Papadahandj (30.90 ± 13.98 kg; n = 62).

The standard deviation varied from 9.48 kg in Dabugam to 15.45 kg in Nabarangpur, showing that the amount of individual difference in body weight varied between the different study blocks. In the case of Dabugam the variation was relatively smaller, while that in Nabarangpur was the highest in terms of dispersion about its mean.

In general, the results show that there was a variation by blocks in the average body weight of the female participants, Dabugam having the highest average body weight and Papadahandi the lowest. The differences in the values of the standard deviation show that the variability in body weight was not the same throughout the six blocks.

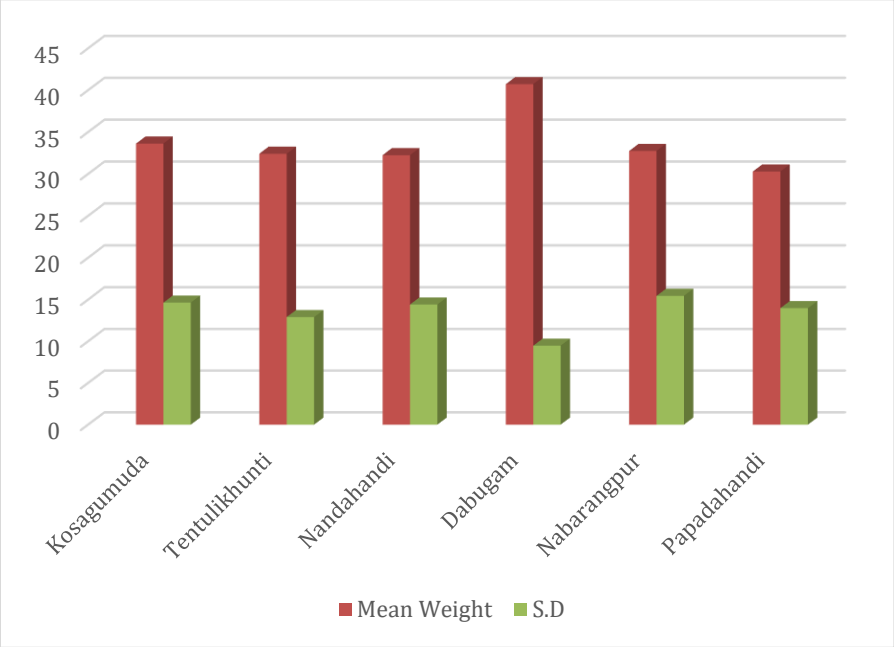

Fig. 4. The block-wise mean Weight ± SD for females

5.3 Environmental classification

Table 7. Distribution of participants according to environmental classification

Environmental category	Blocks included	Male	Female	Total
Forested	Kosagumuda,Tentulikhunti Nandahandi,Dabugam	327	377	704
Deforested	Nabrangpur,Papadahandi	116	140	256

For the two environmental groups the mean ± SD of height and weight should be given.

The study included a total of 960 participants who were divided into two groups according to their environment: those from forested areas and those from deforested areas. The group from the forested areas consisted of people from Kosagumuda, Tentulikhunti, Nandahandi and Dabugam, while the group from the deforested areas consisted of individuals from Nabarangpur and Papadahandi.

704 people took part in the forested area (73.3%), including 327 men (46.4% of those in the forested group) and 377 women (53.6%). By contrast, the deforested area provided 256 participants (26.7%), of whom 116 were men (45.3%) and 140 were women (54.7%).

In the entire study population, 34.1% of the males and 39.3% of the females were classified as forested, while 12.1% of the males and 14.6% of the females were classified as deforested. Female participants therefore made up a slightly higher proportion than males in both types of environmental category.

Most of the participants were from the wooded areas and made up almost three-fourths of the entire sample; the rest of the participants were obtained from the areas where the forest had been cleared.

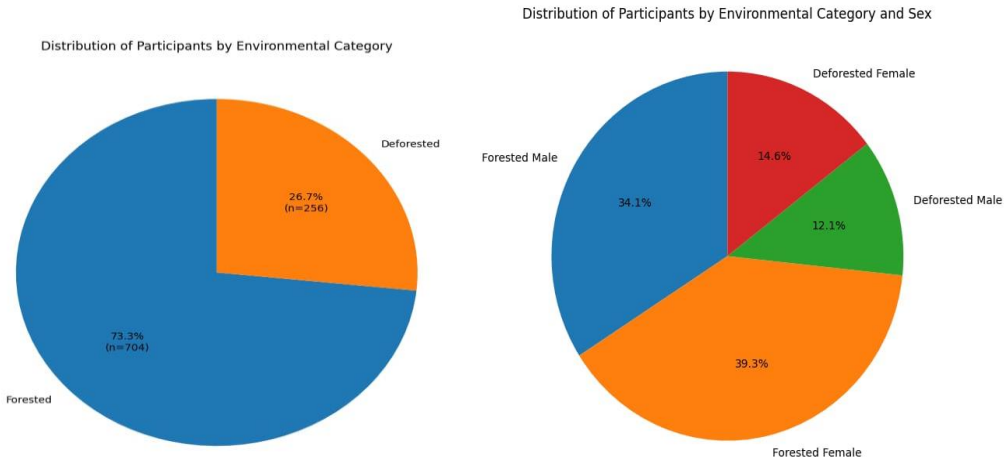

Fig. 5. Distribution of participants according to environmental classification

Table 8. Distribution of participants according to Forested Settlements

MALE					**FEMALE**			
Block	**Mean height**	**S.D**	**Mean weight**	**S.D**	**Mean height**	**S.D**	**Mean weight**	**S.D**
Kosagumuda	133.22	26.8684	34.761	16.435	124.861	26.8684	33.626	14.638
Tentulikhunti	136.936	21.302	37.188	15.1718	127.646	21.302	32.414	12.9022
Nandahandi	135.064	34.0355	35.422	19.5944	126.48	34.0355	32.242	14.4145
Dabugam	148.786	17.827	45.085	12.8357	141.139	17.827	40.727	9.4747
Total	**138.501**	**7.022**	**38.114**	**4.758**	**130.031**	**7.492**	**34.752**	**4.0305**

The anthropometric features of the males and females from the chosen forest settlements were each evaluated at the four different study sites. The average height for males was 138.50 ± 7.02 cm, while that for females was lower at 130.03 ± 7.49 cm. This shows that males were on average about 8.47 cm taller than females.

Male subjects had a higher overall mean body weight (38.14 ± 4.76 kg) than female subjects (34.75 ± 4.03 kg), the difference in average weight being about 3.39 kg. Moderate variability is shown in both height and body weight among the study population as indicated by the standard deviation.

For each individual settlement, the average height of males varied between 133.22 and 148.79 cm, and that of females between 124.86 and 141.14 cm. The average body weight of males was in the range 34.76 to 45.09 kg, as against 32.24 to 40.80 kg for females. The fourth settlement showed the highest average values for both height and body weight among both males and females.

In general, the results show that the men had a higher average height and body weight than the women in the population of the forested settlement. The differences observed serve as evidence of variation in anthropometric characteristics depending on sex and settlement location.

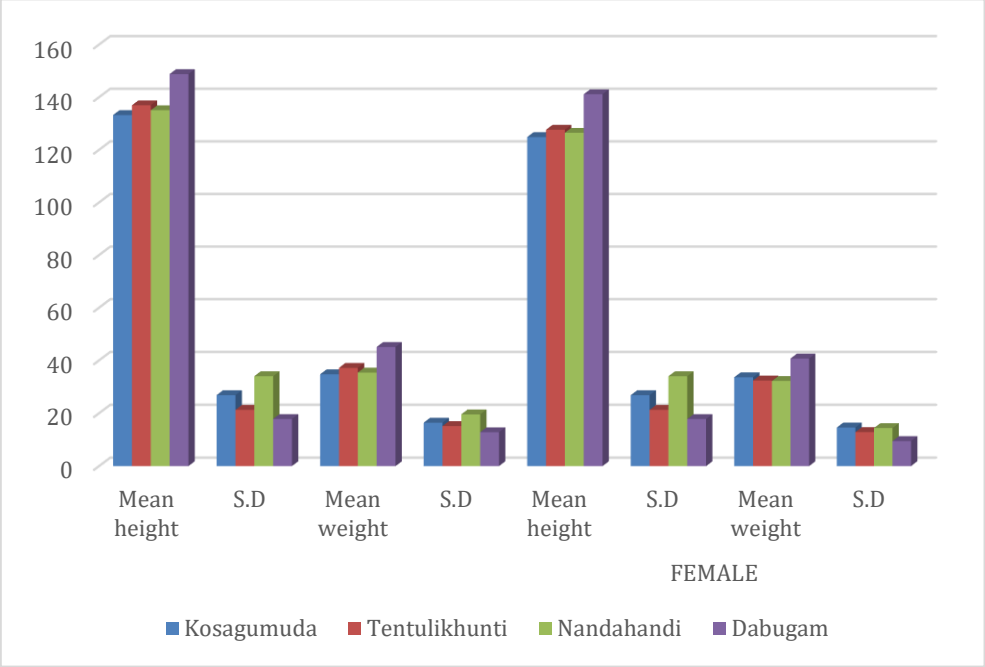

Fig. 6. Distribution of participants according to Forested Settlements

Table 9. Distribution of participants according to Deforested settlements

MALE					**FEMALE**			
Block	**Mean height**	**S.D**	**Mean weight**	**S.D**	**Mean height**	**S.D**	**Mean weight**	**S.D**
Nabarangpur	132.972	24.9167	41.374	13.1083	117.349	24.9167	32.750	15.4474
Papadahandi	126.851	49.4247	35.916	20.1670	126.932	49.4247	30.291	13.9800
Total	**129.911**	**4.3282**	**38.645**	**3.8593**	**122.140**	**6.776**	**31.520**	**1.7387**

The anthropometric measurements of the male and female participants from the deforested areas of the Nabarangpur and Papadahandi blocks were separately analysed. The pooled mean height for the males was 129.94 ± 4.33 cm, and that for the females was 122.14 ± 6.77 cm. The mean height of the males was therefore about 7.80 cm more than that of the females.

The same pattern was seen with regard to body weight. The average body weight of the men was 38.65 ± 3.86 kg, whereas that of the women was 31.52 ± 1.74 kg. The difference between men and women was about 7.12 kg.

The fact that the standard deviation of height is relatively higher for females (6.77 cm) shows that there is more variation in height among the female participants than there is among the male participants (4.33 cm). On the other hand, body weight was more variable among males (3.86 kg) than it was among females (1.74 kg).

In general, the results show that the male participants had a higher average height and body weight than the female participants in the deforested population under study. The fact that these differences exist shows there is a variation of anthropometric characteristics between the sexes.

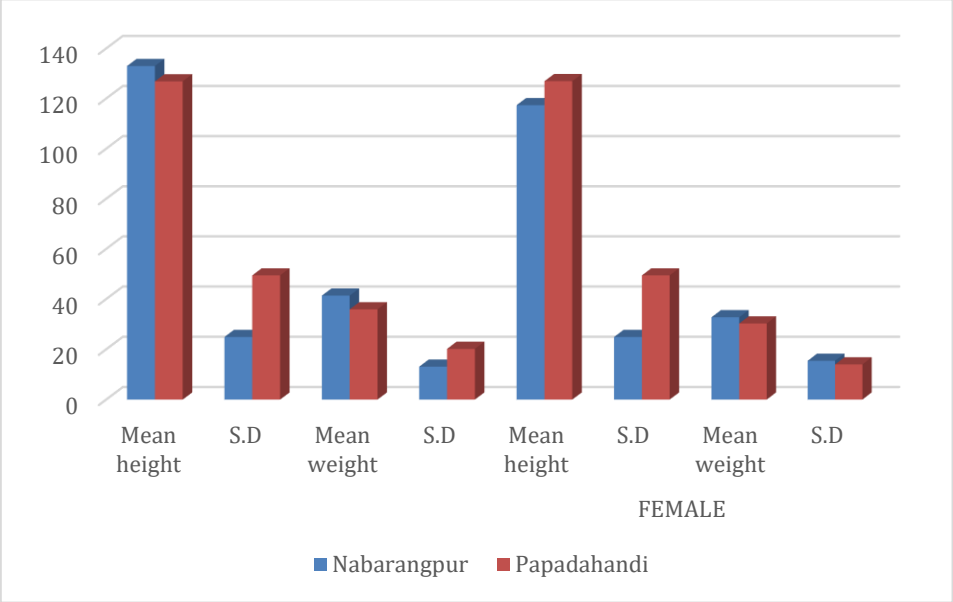

Fig. 7. Distribution of participants according to Deforested Settlements

When the two ecological areas are compared it is found that male height was about 8.59 cm greater in the forested area than in the deforested area, while among women the corresponding difference was about 7.89 cm. On the other hand, the average body weight of males was only slightly higher in the deforested population (38.65 kg) than in the forested population (38.11 kg), whereas the mean body weight of females in the forested area (34.75 kg) was much higher than that of females in the deforested area (31.52 kg).

In general, the descriptive results show that the average height was higher among both males and females in the wooded area, whereas the differences in body weight depended on sex. The standard deviation figures show the variation present in the anthropometric measurements within each population. Yet, these descriptive statistics by themselves do not allow us to determine if the differences found between the populations in the wooded area and those in the deforested area are statistically significant; in order to assess that, an appropriate inferential test would have to be carried out.

Table 10. Distribution of participants according to Rural Area

MALE					**FEMALE**			
Block	**Mean height**	**S.D**	**Mean weight**	**S.D**	**Mean height**	**S.D**	**Mean weight**	**S.D**
Kosagumuda	133.22	26.8684	34.761	16.435	124.861	26.8684	33.626	14.638
Tentulikhunti	136.936	21.302	37.188	15.1718	127.646	21.302	32.414	12.9022
Nandahandi	135.064	34.0355	35.422	19.5944	126.48	34.0355	32.242	14.4145
Total	**135.073**	**1.8580**	**35.790**	**1.2547**	**129.662**	**6.9612**	**32.760**	**0.7543**

Anthropometric measurements were made for the participants from the rural areas of Kosagumuda, Tentulikhunti, and Nandahandi. The results of the pooled analysis indicated that the average height of male participants was 135.07 ± 1.86 cm, while that of the female participants was 129.66 ± 6.96 cm. This means that, on average, males were about 5.41 cm taller than females.

Men had a mean body weight of 35.71 ± 1.25 kg, whereas women had a mean weight of 32.76 ± 0.75 kg; the mean body weight was thus about 2.95 kg greater in males than in females.

The difference in height was much more marked in females than in males, since their standard deviation was higher (6.96 cm) as compared to that of males (1.86 cm). On the other hand, body weight showed only a small amount of variation in both groups, the standard deviation being 1.25 kg for males and 0.75 kg for females.

In general, the results show a difference between the sexes in terms of anthropometric characteristics, the men having higher mean values than the women for both height and body weight in the rural study population.

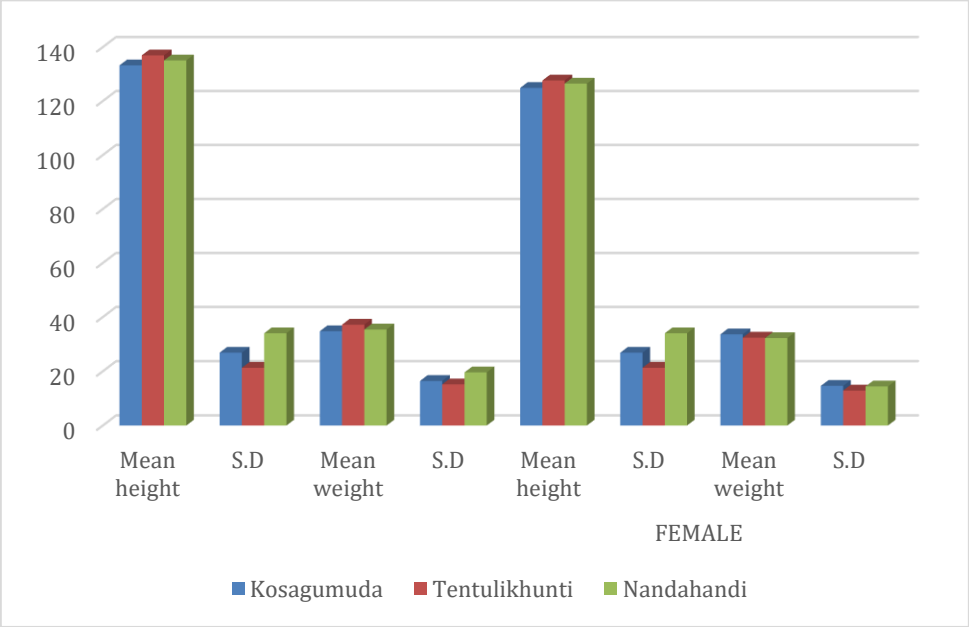

Fig. 8. Distribution of participants according to Rural Area

Table 9. Distribution of according to Urban Area participants

MALE					**FEMALE**			
Block	**Mean height**	**S.D**	**Mean weight**	**S.D**	**Mean height**	**S.D**	**Mean weight**	**S.D**
Nabarangpur	132.972	24.9167	41.374	13.1083	117.349	24.9167	32.750	15.4474
Papadahandi	126.851	49.4247	35.916	20.1670	126.932	49.4247	30.291	13.9800
Dabugam	148.786	17.827	45.085	12.8357	141.139	17.827	40.727	9.4747
Total	**136.203**	**11.3192**	**40.791**	**4.6121**	**128.473**	**11.9696**	**34.589**	**5.4557**

Anthropometric measurements were made for the participants from the urban areas of Nabarangpur, Papadahandi, and Dabugam. The combined results indicated that the average height of the male participants was 136.20 ± 11.32 cm, compared to 128.15 ± 11.10 cm for the female participants. Hence, males had an average height of about 8.06 cm more than that of females.

The same kind of pattern was seen when the body weights were looked at by sex. The mean body weight for males was 40.79 ± 4.61 kg, as against 34.58 ± 5.46 kg for females. Male participants thus had an average body weight of about 6.21 kg more than female participants.

The standard deviation figures show a high degree of individual variation in height for both groups, the variation being slightly greater among men (11.32 cm) than among women (11.10 cm); in the case of body weight, the variability is a bit higher among women (5.46 kg) than among men (4.61 kg).

In general, the results show a distinct difference between the sexes in terms of anthropometric characteristics, male subjects having a higher mean height and body weight than female subjects. It therefore appears that differences associated with sex were present in both of the major anthropometric parameters examined in the study.

In the rural area, men had an average height of 135.07 ± 1.86 cm, whereas women had an average height of 129.66 ± 6.96 cm. The average body weight for men was 35.79 ± 1.25 kg and that for women was 32.76 ± 0.75 kg. Hence, rural men had higher average values for both height and weight than rural women.

In the urban population the average height was 136.20 ± 11.32 cm for men and 128.47 ± 11.97 cm for women, and the average body weight was 40.79 ± 4.61 kg for men and 34.59 ± 5.46 kg for women. Urban males therefore had a higher average height and body weight than urban females.

On comparison of the two residential groups, urban males had a slightly higher average height than rural males (136.20 cm as compared with 135.07 cm) and a much greater average body weight (40.79 kg compared to 35.79 kg). For the females, the rural group had a higher mean height than the urban group (129.66 cm versus 128.47 cm), while urban females had a higher mean body weight (34.59 kg as against 32.76 kg).

The standard deviations show the amount of variation in the anthropometric measurements within each group. Among the urban participants, height had a relatively larger dispersion, especially in females (standard deviation = 11.97 cm) and males (standard deviation = 11.32 cm). With regard to body weight, the highest variability was found among urban females (standard deviation = 5.46 kg), then came urban males (standard deviation = 4.61 kg). The rural participants generally had lower standard deviation values, which means there was comparatively less variation in the measurements recorded.

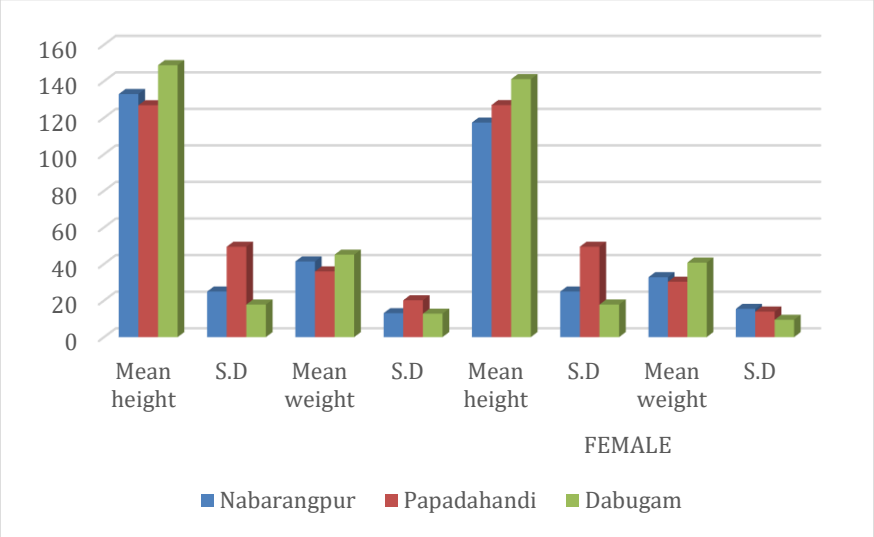

Fig. 9. Distribution of participants according to Urban Area

5.4 Karl Pearson correlation

Table 10. Correlation between height and weight of male

Block	n (total number)	Correlation coefficient (r)	P- value
Kosagumuda	99	0.9912	0.0009918
Tentulikhunti	121	0.9965	0.0002479
Nandahandi	31	0.9701	0.0062
Dabugam	76	0.9970	0.0001992
Nabarangpur	61	0.9984	0.00007355
Papadahandi	55	0.9876	0.001662

The table shows the Karl Pearson correlation between height and weight for male participants in the six blocks. 443 men were included in the analysis. The Pearson correlation coefficients varied from r = 0.9701 to r = 0.9984, which indicates a very strong positive relationship between height and weight in all the blocks.

The highest degree of correlation was found in Nabarangpur (r = 0.9984, p = 0.0000735), then came Dabugam (r = 0.9970, p = 0.0001992) and Tentulikhunti (r = 0.9965, p = 0.0002479). In Kosagumuda a very strong positive correlation was also noted (r = 0.9912, p = 0.0009918). Papadahandi showed a strong positive association (r = 0.9876, p = 0.001662), whereas the lowest correlation was seen in Nandahandi (r = 0.9701, p = 0.0062).

The p-values which were reported all amounted to less than 0.01, this showing that the associations observed were statistically significant at the 1 per cent level. Taken as a whole, the results show a consistent and statistically significant positive association between height and weight among men in all six blocks.

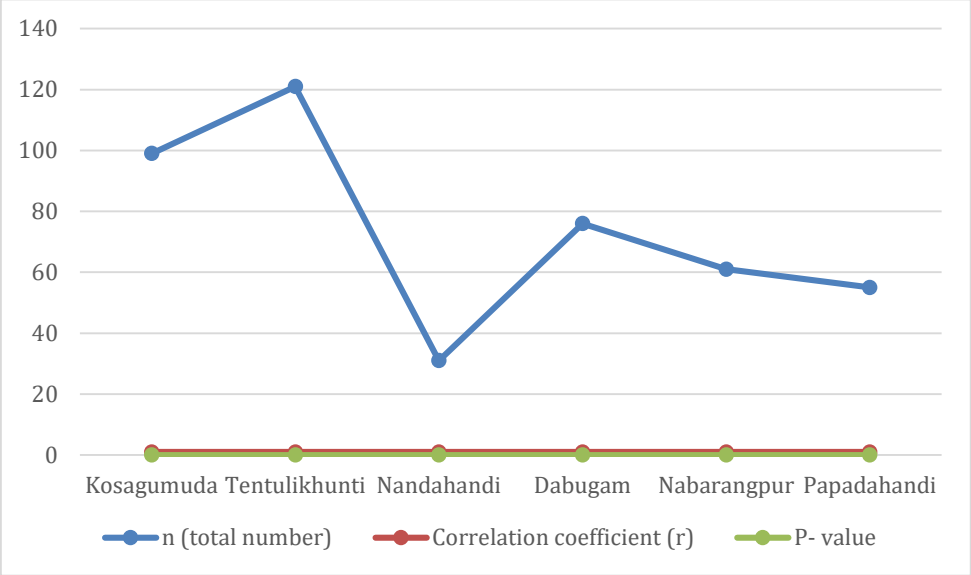

Fig. 10. Correlation between height and weight of male

Table 11. Correlation between height and weight of female

Block	n (total number)	Correlation coefficient (r)	P- value
Kosagumuda	100	0.9873	0.001722
Tentulikhunti	183	0.9988	0.00004877
Nandahandi	49	0.9961	0.0002912
Dabugam	45	0.9987	0.0000549
Nabarangpur	78	0.9999	0.00281
Papadahandi	62	0.9962	0.0002784

A block-by-block analysis showed a very strong positive correlation between height and weight among women in all six blocks. The Pearson correlation coefficient varied from r = 0.9873 to 0.9989, which means that greater height was consistently linked with greater body weight in the group studied.

The strongest correlation was found in Nabarangpur (r = 0.9989), then came Tentulikhunti (r = 0.9988) and after that Dabugan (r = 0.9987). The correlations in Nabarangpur (r = 0.9961) and Papadahandi (r = 0.9962) were also extremely high. The weakest of the correlations, though still very high, was that in Kosagumuda (r = 0.9873). The total number of females included in the table was 517.

The results show a steady and clear linear relationship between height and weight in females regardless of the block, which means that changes in height were closely linked to changes in body weight among the individuals in the study population.

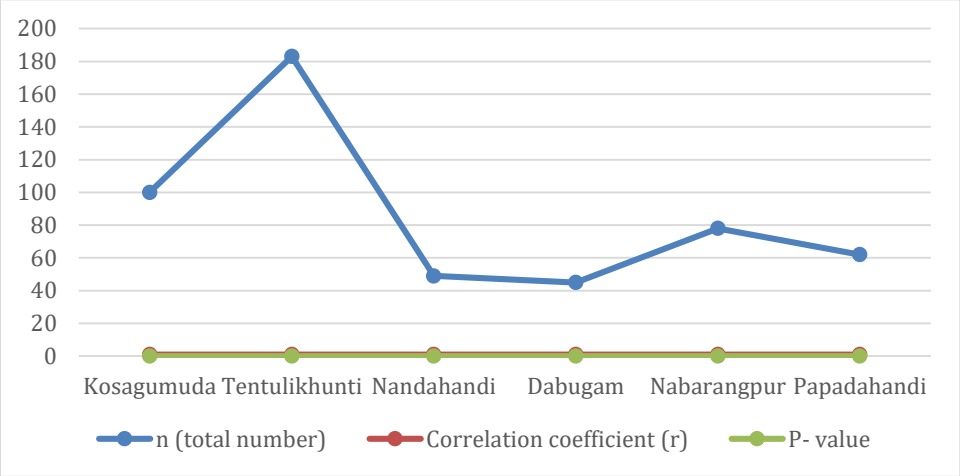

Fig. 11. Correlation between height and weight of female

6. Discussion

This study looked at the differences in anthropometric measurements and the relationship between height and body weight in rural and urban populations who live in both forested and deforested regions of the Nabarangpur district, Odisha. The results show clear variations in the mean anthropometric values depending on sex, place of residence and environmental type, as well as a consistently strong positive association between height and body weight at the block level.

The figures for the participants indicated that 704 out of the 960 participants (73.3%) were from the forested category, while 256 (26.7%) came from the deforested category. In both types of environmental areas, females made up a slightly higher proportion of the sample than males. The fact that more participants came from forested areas is due to the way the blocks were sampled and does not show that there is a difference at the population level between forested and deforested communities.

6.1 Environmental differences in height and weight

There was a noticeable difference in average height between the participants from wooded and cleared areas. In the case of males, the average height in the wooded group was 138.50 ± 7.02 cm as compared to 129.91 ± 4.33 cm in the group from cleared areas. Among the females, those from the wooded areas had an average height of 130.03 ± 7.49 cm, while the height of females from cleared areas was 122.14 ± 6.78 cm. Hence, the individuals in the wooded area had a higher average height for both men and women.

Body weight followed a somewhat different trend. The males in the forested area had a mean weight of 38.11 ± 4.76 kg, whereas those in the deforested area had a slightly higher mean weight of 38.65 ± 3.86 kg. In the case of the females, on the other hand, the mean weight in the forested group was considerably greater (34.75 ± 4.03 kg) than that in the deforested group (31.52 ± 1.74 kg). The results indicate that the classification of the environment was linked to variation in anthropometric characteristics, but the direction and size of the difference were not the same for height and weight.

The anthropometric differences among populations residing in various ecological environments are likely due to the combined effect of nutrition, socioeconomic conditions, physical activity, the living environment and other biological and demographic factors. Research carried out previously in Odisha has also shown that there are differences in body measurements and nutritional features between people who

live in forest, rural and urban areas, although the pattern may vary depending on sex and the particular anthropometric characteristic.

6.2 Rural–urban variation

The comparison between rural and urban areas also showed differences in anthropometric values. Rural males had a mean height of 135.07 ± 1.86 cm and a mean weight of 35.79 ± 1.25 kg, while urban males had corresponding figures of 136.20 ± 11.32 cm and 40.79 ± 4.61 kg. It therefore follows that urban males had a slightly greater mean height and a more marked difference in mean body weight.

For women, the average height in the rural group was 129.66 ± 6.96 cm, as compared to 128.47 ± 11.97 cm in the urban group. On the other hand, urban women had a higher mean body weight (34.59 ± 5.46 kg) than rural women (32.76 ± 0.75 kg). The greater standard deviation found among the urban participants shows that there was more variation in the measurements in this group.

The fact that the urban groups have a higher average body weight is in broad agreement with the relevant literature from India which shows that there are differences in anthropometric and nutritional features between rural and urban populations. Since urbanization is linked to changes in diet, in the kind of work people do, in transportation, in their way of life and in their socioeconomic conditions, all of these factors can affect body composition. A review of anthropometric research carried out in India has also pointed out the different nutritional problems encountered in rural and urban areas. (Khurana et.al, 2024)

It should not be taken as proof that living in an urban area leads to increased body weight. Since residential status is linked to a great many environmental and socioeconomic features, the descriptive data available here are unable to isolate the separate effects of these factors. Similarly, large studies carried out in India have also found that patterns relating to anthropometric measurements and weight differ depending on the degree of urbanisation and other contextual factors. (Patel et.al, 2015)

6.3 Block-wise anthropometric variation

A block-by-block analysis shows a high degree of heterogeneity in the Nabarangpur district. In the case of males, the average body weight differed in the six blocks, the highest average being recorded in Dabugam at 45.085 kg and the lowest in Kosagumuda at 34.761 kg. For females, the highest average weight was found in Dabugam (40.727 kg) and the lowest in Papadahandi (30.2919 kg).

The block-wise height figures also showed differences according to location. For men the highest mean height was found in Dabugam (148.786 cm), the lowest being recorded at Papadahandi (126.851 cm); for women the highest mean height was in Dabugam (141.139 cm) and the lowest in Nabarangpur (117.3496 cm).

The fact that there is variation at the block level shows that considerable anthropometric heterogeneity can exist even within one district. The differences between individual blocks might be due to differences in demographic composition, nutrition, socioeconomic conditions, occupation, level of physical activity and the local environmental conditions. Hence the average figures at district level may mask important local variations.

6.4 Height–weight correlation

A major result of the study was the consistently high positive correlation between height and weight. In the case of males, Pearson's correlation coefficient varied from r = 0.9701 to r = 0.9984 over the six blocks. The most significant association was found in Nabarangpur (r = 0.9984), then in Dabugam (r = 0.9970) and afterwards in Tentulikhunti (r = 0.9965). The weakest correlation recorded, that in Nandahandi (r = 0.9701), still indicated a very strong positive relationship.

This pattern was also seen in the case of females. The correlation coefficients varied from r = 0.9873 to r = 0.9989. The greatest correlation was noted in Nabarangpur (r = 0.9989), whereas the lowest was recorded in Kosagumuda (r = 0.9873). Hence, the association between height and body weight was consistently strong in all six blocks and for both sexes.

All the p-values reported were under the conventional threshold of 0.05, which shows that the positive correlations observed were statistically significant. It thus gives strong evidence of a positive linear relationship between height and weight in the groups of males and females sampled.

Yet the high correlation coefficients should be interpreted with care since a strong correlation does not prove that an increase in height directly leads to an increase in body weight; age, sex, nutritional history, genetics, socioeconomic circumstances and other developmental factors may affect both variables.

6.5 Comparison with previous evidence

The results of this study are in agreement with the general view that anthropometric features vary between populations depending on their habitat and socioeconomic circumstances. A study of the Shabar population in Odisha found that body measurements differed among people living in forest, rural and urban areas and stressed the role of nutritional, socioeconomic and morbidity-related factors in accounting for anthropometric variation. (S Chakrabarty et.al, 2010)

Rural and urban differences in height, weight and body composition have also been recorded in other Indian studies. For instance, a study involving rural and urban Jat women showed that the urban participants had a higher mean height and weight, thus demonstrating that the direction and extent of rural–urban differences can vary from one population and demographic group to another. (Kaur et. al, 2011)
This study applies the kind of anthropometric assessment previously used to the Nabarangpur district, allowing for a simultaneous consideration of whether individuals reside in rural or urban areas and whether they live in forested or deforested areas. In this way it offers a more local point of view than do studies which rely only on comparisons at the national or state level.

6.6 Implications of the findings

The fact that there are differences has important consequences for nutritional and public-health evaluations. Since the urban groups have a mean body weight that is relatively higher and there are differences between the populations in forested areas and those in deforested areas, anthropometric assessments should take into account the environmental and residential circumstances of the population under study. On the other hand, the large variation from block to block shows that remedies which are based merely on district-wide averages might fail to take local differences into consideration.

The fact that there are strong height–weight relationships in all the blocks also shows that these two simple anthropometric measurements are useful for describing the characteristics of a population. Yet height and weight by themselves are not sufficient to properly distinguish between undernutrition, normal nutritional status and excess adiposity. To obtain a more complete understanding of nutritional status, it is necessary to use additional measures such as BMI, waist circumference, MUAC or other body-composition indicators, along with age-specific assessment.

Overall interpretation

When the findings are considered as a whole, it becomes clear that the anthropometric characteristics in the Nabarangpur district differ by sex, residential setting, and environmental category. People living in forested areas had a higher average height than those in deforested areas, whereas urban participants generally had a higher average body weight than their rural peers. The results at the block level also showed considerable local variation. Most significantly, there was an extremely strong and statistically significant positive relationship between height and weight in both men and women across all six blocks.

7. Strengths of the Study

The study features a sample size which is relatively large consisting of 962 participants.
There are individuals of both the male and female sex.
The age group includes children through to older adulthood.
The study includes a number of blocks in the Nabarangpur district.
The text looks at both the characteristics of settlement and the various environmental classifications.
Height and weight are objective measurements of anthropometric data.
Pearson's correlation gives a quantitative measure of the relationship between height and weight.
A comparison of the correlation coefficients offers a more thorough analysis than simply reporting the individual correlations.

8. Conclusion

This study shows a clear association between the anthropometric features and the environmental and settlement circumstances of the population examined in the Nabarangpur district of Odisha. Of the 962 participants, 445 of whom were males and 517 females, measurable differences were found in the average height and weight among those living in forested, deforested, rural and urban areas.

People from the wooded area generally had higher average heights and weights than those from the area where the forest had been cleared. In the case of men, the group from the wooded area had a mean height of about 138.50 cm and a mean weight of 38.11 kg, while the corresponding figures for the group from the deforested area were about 129.91 cm and 38.65 kg.

For women, the forest group had a mean height of around 130.03 cm and a weight of 34.75 kg, as against approximately 122.14 cm and 31.52 kg for the deforested group. Furthermore, the rural–urban comparisons showed differences in the mean anthropometric measurements.

The results obtained in a block-by-block analysis showed great variations among the six study blocks, indicating that the anthropometric status is not the same throughout the district. Dabugam had a relatively higher mean height for both males and females, whereas Paprahandi and Nabarangpur had comparatively lower values in a number of the measurements. These differences could be due to the combined effect of

environmental conditions, the characteristics of the settlements, socioeconomic conditions, nutrition and other local factors.

A highly consistent result was the very strong positive correlation between height and weight. In each of the six blocks the Pearson correlation coefficients were near 1.00 for both males and females, the associated p-values being statistically significant. This shows that in the group under study greater height was closely linked to greater body weight.

In general, the findings indicate that the environmental setting and where people live are linked to differences in anthropometric characteristics, and at the same time height and weight remain closely related throughout the study population. The results offer useful basic anthropometric data for understanding variations in the population of the Nabarangpur district and could be of value to future research looking into the roles of nutrition, socioeconomic conditions, lifestyle and environmental change in human growth and development.

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