CHAPTER III
MATERIALS AND METHODS
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There are two main approaches for collecting data for the study of physical growth. They are longitudinal and cross-sectional. Longitudinal study is based on measurement of a child or a specific group of children at certain intervals of time over any number of years. This method yields detail information on individual variation in growth as well as growth trend of a population. It has, however, certain drawbacks. It is time consuming, and also it has the difficulty of not getting the same child or group of children under the study in every time interval. There is a modification of this method, known as mixed longitudinal in which the children of a particular age are measured at different periods. But, in the case of non-availability of some children in the next measurement, they will be replaced by new children of the same age. The most widely used method of growth study is cross-sectional method. In this method each child is measured once only. The children of one age group are pooled together and then the average values are obtained. The children of one age group say 10 years of age will be different from that of a age group 11 or 12 or so. Such studies are quicker, cheaper and less laborious. Within a short time children of many age groups can be covered for investigation. Analyses of such data provide valuable information more
particularly on distance curve as well as velocity curves of growth. That is why the present study is based on cross-sectional method of growth study.

The Data:

Altogether 682 subjects were taken for the study of different age groups ranging from 10 to 20 years of age of which 348 were boys and 334 girls. Age group was made at one year interval which means age group 10 includes those subjects from 9 years 6 months to 10 years 5 months and 29 days, age group 11 includes subjects from 10 years 6 month upto 11 years 5 months 29 days and so on until age group 20 which includes 19 years 6 months upto 20 years 5 months 29 days (Sen 1994). The age of each subject was recorded as per information given by the subject itself or by the parents and cross checked through Church registrars.

The data on occupation of parents of the subjects which were randomly selected were collected and broadly classified into:

1. Skilled labour : Carpenter, Tailor, Driver, Motor mechanic, Blacksmith, Electrician, Mason, Mohori etc.

2. Lower profession : Peon, Grade IV, Constable, School chowkidar, Post master, Postman, Sweeper, Hospital attendant, Fireman, Pensioner etc.

3. Middle profession : Medical representative, Clerk, School Teacher, Social worker, Pastor, Traditional Medical Practitioner (Lumbo) BTWT, Catichist Bapter, Theologist etc.

4. Higher profession : Doctor, Veterinary Doctor etc.
5. Business : Shopkeeper, Contractor, Tea stall etc.

6. Cultivator

Among the boys 3.16% were from skilled worker family, 5.46% from lower profession; 18.16% from middle profession, 1.20% from higher profession, 2.70% from Business and 71.84% from cultivator family. Among the girls 4.49% were from skilled workers family, 7.78% from lower profession, 18.26% from middle profession, 1.20% from higher profession, 2.70% from Business profession and 65.57% from cultivator family. From this we can conclude that majority of subjects were from Lower Income Family.

The following measurements are taken into consideration for the purpose of the study.

1. Stature
2. Height Tragus
3. Height Tibiale
4. Head Height
5. Sitting height vertex
6. Maximum head length
7. Maximum head breadth
8. Bizygomatic breadth
9. Bigonal breadth
10. Total facial height
11. Upper facial height
12. Nasal height
13. Nasal breadth
14. Biacromial breadth
15. Bicristal breadth
16. Horizontal circumference of head
17. Wrist girth
18. Arm girth
19. Chest girth
20. Waist girth
21. Hip girth
22. Calf girth
23. Total Arm girth
24. Chest depth
25. Chest width
26. Humerus width
27. Femur width
28. Weight
29. Triceps skinfold
30. Subscapular skinfold
31. Suprailliac skinfold
32. Supraspinal skinfold
33. Anterior thigh skinfold
34. Calf skinfold
35. Contour tracing of foot
All the body measurements were taken according to the methods prescribed by Martin (1928). But the skinfold measurements were taken by Heath and Carter method. The weight was taken with a portable weighing machine. And all the measurements were taken by the researcher herself.

1. **Height Vertex (Stature)**: The vertical distance from the plane where the subject stands to the vertex was taken by an anthropometer in the mid sagittal plane of the subject.

2. **Height Tragus**: The vertical distance from the plane where the subject stands to the trigon was taken by an anthropometer (in the right side of the subject).

3. **Height Tibiale**: The vertical distance from the plane where the subject stands to the tibiale was taken by an anthropometer (in the right side of the subject).

4. **Head height**: Head height is obtained by subtracting the distance of height tragus from the height vertex.

5. **Sitting height vertex**: The vertical distance from the plane where the subject sits to the vertex with the vertical column stretched to its maximum was noted by an anthropometer.

6. **Maximum head length**: The straight distance between glabella and opisthocranion was taken by a spreading caliper with blunt ends.

7. **Maximum head breadth**: The distance between the two eurya was noted by a spreading caliper with blunt ends.

8. **Bzygomatic breadth**: It measures the straight distance between the two zygia, the most lateral points on the zygomatic arch by a spreading caliper with blunt ends.
9. **Bi-gonial breadth**: It measures the straight distance between the two gonia by spreading caliper.

10. **Total facial height**: The straight distance between nasion and gnathion was measured by a sliding caliper.

11. **Upper facial height**: The straight distance between nasion and prosthion was measured by a sliding caliper.

12. **Nasal height**: It measures the straight distance between nasion and subpoeanas by a sliding caliper.

13. **Nasal breadth**: It measures the straight distance between the two alaria by sliding caliper with flat arm.

14. **Biacromial breadth**: The straight distance between the two acromion points was taken by the first segment of the anthropometric rod which is known as Rod compass.

15. **Bicristal breadth**: The distance between the two illiocristalis, the most laterally placed points on the iliac crest when the subject is standing in the natural position was taken by a pelvimeter (large spreading caliper).

16. **Horizontal circumference of head**: It measures the maximum circumference of the head taken horizontally by a tape.

17. **Wrist girth**: The least circumference of the forearm almost proximate to the styloid process was taken by a flexible tape.

18. **Arm girth**: The maximum circumference of the upper arm where the biceps muscles and are the most developed one, and it was taken by a tape.
19. **Chest girth**: The value obtained was the average measurements taken during inspiration and expiration. The measurements were taken at the level of mesosternal passing over the lower scapular angles by a tape.

20. **Waist girth**: The circumference of the abdomen at the most lateral contour of the body ribs and intestine was taken by tape.

21. **Hip girth**: The circumference of the hips at their widest portion was taken by tape.

22. **Calf girth**: It measures the circumference of the calf where calf muscles are most developed by a flexible tape which was held vertical to the axis of the lower extremities.

23. **Total Arm length**: It measures the straight distance between acromion and dactylion when the arm is hanging downwards by the first two segments of Anthropometer rod.

24. **Chest depth**: It measures the straight distance of mesosternale to the horizontally placed point in the vertebral column when the subject was standing erect in normal breathing by spreading caliper.

25. **Chest width**: The measurements was taken by Rod-compass at the most laterally placed points of the ribs at the height of mesosternal when the subject was standing erect in normal breathing.

26. **Humerus width**: It is the straight distance between the two humeralia (hm - hl). The measurements are taken by sliding caliper from the back. The subject's elbow is bent to a right angle and the width across the outermost parts of the lower end of the humerus is taken.
27. **Femur width**: It is measured by sliding caliper and is straight distance between medial and lateral epicondyles i.e the most medial and lateral points of femoral condyles.

28. **Weight**: Body weight was taken by a standard portable weighing machine with minimum clothing of the subject.

In the present study, six skinfolds i.e. Triceps, Subscapular, Suprailic, Supraspinale (Umbilical), Anterior thigh skinfold and Calf skinfold are taken to unveil the skinfold profiles of the boys and girls by age group.

**Triceps**: It is obtained at the level of mid-upper arm circumference, i.e. mid-way between the acromion and the olecranon. It is important that the skinfold is picked up both at a mid-point on the vertical axis of the upper arm and a mid-point between the lateral and medial surfaces of the arm. The thumb and the middle finger are moved along the vertical axis of the upper arm until they are at a level about 1.0 cm above the marked mid-point. The skinfold is then lifted away from the underlying muscle fascia. With a sweeping motion of the fingers to the point at which the observer is gripping the neck of the fold between middle finger and thumb. The skinfold caliper, which is held in the right hand with dial upwards, is then applied to the neck of the fold immediately below the middle finger and thumb. The skinfold caliper, which is held in the right hand with dial upwards, is then applied to the neck of the fold immediately below the middle finger and thumb at the level marked. The observer maintains his grip at the fold and releases the trigger of the skinfold caliper to allow the caliper to exert its complete
pressure (i.e. 10 gm/mm²) on the skinfold. The reading is recorded, few seconds after the complete pressure is exerted, to the, last completed 0.1 mm count.

**Subscapular:** It is obtained just below the inferior angle of the scapula. The subject stands with his back facing the observer and his shoulders released relaxed and arms having loosely at his sides. The skinfold is picked up by a sweeping motion of the index finger and thumb, as in case of triceps skinfold. The caliper is applied to the neck of the fold just below the finger for reaching the skinfold thickness.

**Suprailiac:** It is obtained at a level which is 1.0 cm above and 2.0 cm medial to the anterior superior iliac spine. The skinfold is lifted in the manner as that of triceps and the caliper is applied just below the fingers for recording the skinfold thickness.

**Supraspinale (Umbilical):** It measures on the abdomen 5 cm lateral to the mid point of the amблиcus on the left side. For this measurement the subject has to relax the abdominal wall musculature as much as possible and to breathe normally. The subject has to stand erect with body weight distributed evenly on both feet. In the obese, it may not be possible to take this measurement.

**Anterior thigh skinfold:** This skinfold is picked up vertically above a point marked mid-way between the mid-inguinal point and the proximal border of the patella when the knee is flexed at right angles.
**Calf skinfold**: This skinfold is picked up vertically at the level of the maximum calf circumference on the medial side of the calf (when the knee is flexed at right angle).

**Foot contour**: Contour tracing of the feet of the individuals have been taken on papers using suitable sharpened pencils. Landmarks for feet measurements were plotted while tracing the contour. Length of foot is the distance between ptomain and acropodion which was measured between the plotted points of metatarsale medial to metatarsale laterals. Hallux divergent angle is drawn by joining the acropodion point with the ptomain points on the big toe and second toe.

**Foot type**: Among the population the type of foot was ascertained basing on the location of ptomain. If it is located on the big toe or when the big toe is longer than the second toe, the type is assigned as ‘T’ (Tibia) following the classification of Menami, after his study among the Japanese. If the second toe is longer than the first, it is called ‘F’ type (Fibular). Some feet have equal length of the first and second toe. Such type is called ‘O’ (Transitional). Some individuals possess the same type in both feet, while the two feet of some individuals are of different types. Those who have the same type are termed ‘Homo’ type which are again divisible into 3 sub-classes, viz ‘TT’, ‘FF’ and ‘OO’. “Hetero” type which mean difference in the types of two feet and it may be six variations viz, TF, FT, TO, OT, FO, OF depending on the side of occurrence.
Somatotyping:

Somatotyping is a method of describing human morphology in shape but not the size and is expressed by a 3 number rating and this is a short hand description of relative body shape and apparent compositions. Somatotype ratings are calculated from the anthropometric method. There are three components of somatotyping.

1. Endomorphy: Endomorphy implies a trend towards the predominance of soft roundedness throughout the different regions of the body and particularly a massiveness of the digestive viscera.

   \[
   \text{Endomorphy} = 0.1451 (x) - 0.00068 (x^2) + 0.000014 (x^3) - 0.7182.
   \]
   
   where \( x \) is the sum of triceps, subscapular and suprailiac skinfolds in millimeter, adjusted for height i.e \( x = \text{sum of three skinfolds X (170.18 / height in centimeter)} \).

2. Mesomorphy: Mesomorphy is the accentuated development of certain body structure derived from the embryonic mesoderm, particularly bone, muscle and connective tissue.

   \[
   \text{Mesomorphy} = 0.858 \text{bi-epi condylar width of humerus} + 0.601 X (\text{Upper arm girth - triceps skinfold}) + 0.616 X (\text{Calf girth - Calf skinfold}) - \text{height X 0.131}
   \]

   It is to be noted that both triceps and calf skinfold thickness are measured in millimeter scale, but at the time of substraction this unit is to be converted into centimeter scale.
3. Ectomorphy: Ectomorphy mean predominance of surface area relative to
bulk of the brain and central nervous system relative to mass. When ectomorphy
is in the ascendancy, the body build type is linear and fragile.

Ectomorphy = HWR X 0.732 - 28.58.

where HWR or Height Weight Ratio = Height / √Weight

If HWR < 40.75 but > 38.25, then Ectomorphy = HWR X 0.463 -
17.63.

If HWR ≤ 38.25 then a rating of 0.1 is assigned to the ectomorphic rating.

Further sub-division of distribution of population are categorised into:

Balanced Endomorphy: The first component is dominant and the second
and third components are equal (or do not differ by more than one-half unit).

Mesomorphic - Endomorph: Endomorphy is dominant and the second is
greater than the third.

Mesomorph - Endomorph: The first and second components are equal
(or do not differ by more than one half unit) and the third component is smaller.

Endomorphic - Mesomorph: The second is dominant and the first
component is greater than the third component.

Balanced - Mesomorph: The second component is dominant and the first
and third components are less and equal (or do not differ by more than one-half
unit).

Ectomorphic - Mesomorph: The second component is dominant and the
third component is greater than the first component.

Mesomorph - Ectomorph: The second and third components are equal
(or do not differ by more than one-half unit) and the first component is lower.
Mesomorphic - Ectomorph: The third component is dominant and the second component is greater than the first component.

Balanced - Ectomorph: The third component is dominant and the first and second components are equal and lower (or do not differ by more than one-half unit).

Endomorphic - Ectomorph: The third component is dominant and the first component is greater than the second component.

Endomorphic - Ectomorph: The first and second components are equal (or do not differ by more than one-half unit) and the second component is lower.

Ectomorphic - Endomorphic: The first component is dominant and the third component is greater than second component.

Central: No component differs by more than one unit for the other two, and consists of ratings of third and fourth.

**Somatometric Indices:**

Calculated Somatometric indices for a series of age groups in the growing period can also indicate whether the growth of one characteristic compared to another is faster or slower. The following indices were calculated in respect of the present study.

1. Ponderial Index = \( \frac{1000 \times \sqrt{\text{Weight}}}{\text{Height} \times \text{Vertex}} \)

2. Cephalic Index = \( \frac{\text{Maximum Head Breadth}}{\text{Maximum Head Length}} \times 100 \)
3. Morphological Facial height Index = \( \frac{\text{Morphological facial height}}{\text{Bizygomatic breadth}} \times 100 \)

4. Nasal Index = \( \frac{\text{Nasal breadth}}{\text{Nasal height}} \times 100 \)

5. Jugo-Mandibular Index = \( \frac{\text{Bigonial breadth}}{\text{Bizygomatic breadth}} \times 100 \)

6. Relative Sitting height Index = \( \frac{\text{Sitting height Vertex}}{\text{Height Vertex}} \times 100 \)

7. Relative Skelic Index = \( \frac{\text{Height Vertex} - \text{Sitting height Vertex}}{\text{Sitting height Vertex}} \times 100 \)
   (Proposed by Manouvnier)

8. Relative Bi-acromial Index = \( \frac{\text{Biacromial breadth}}{\text{height Vertex}} \times 100 \)

9. Relative Chest girth index = \( \frac{\text{Chest girth}}{\text{Height Vertex}} \times 100 \)

10. Stature Footlength index = \( \left( \frac{\text{Foot length}}{\text{Stature}} \right) \times 100 \)

11. Stature Footbreadth index = \( \left( \frac{\text{Foot breadth}}{\text{Stature}} \right) \times 100 \)

12. Footlength and Breadth index = \( \left( \frac{\text{Foot breadth}}{\text{Foot length}} \right) \times 100 \)
Besides these indices, an attempt has been made to find out relationship between different body segments in respect of growth.

Certain other observations:

While collecting somatometric data, development of secondary sex character among the girls such as appearance of age at menarche was also recorded from all the girls in order to assess the influence of puberty on physical growth. Proper care was taken to obtain the correct age of each of the girls under study. Most of the Poumai girls could tell the exact date of menarche because the event occurred recently as well as they are school going students and some of the data were obtained by recall method. According to Damon and Bajema (1974), recalled age at menarche is accurate enough for anthropological and epidemiological purposes involving group comparisons. The age at menarche is calculated by subtracting the date of birth from the date of menarche.

Analysis of Data:

At first, all the calculations were done by a "CASIO - fx - 1000" electronic calculator. But later on it was rechecked by computer several times. For each trait, a distance curve, a velocity curve and a histogram have been drawn. The distance curve drawn was based on the mean values of different age groups, taking age groups as abscissa and absolute growth as ordinate. If the mean value of the somatometric characteristic decreased at the next higher age group with the result that absolute growth between the two age groups was negative, that
negative growth was shown by drawing the curve below the abscissa. The histogram was drawn taking age groups as abscissa and growth gradients as ordinate.

Besides, an attempt has been made to find out relationship between different body segments in respect of growth. Necessary calculations in this connection have been done following the standard statistical methods described under “Statistical consideration“.

Statistical Consideration:

To analyse and interpret the data accurately, the following statistical measures are considered.

Mean ($\bar{X}$):

Mean is the central value of distribution. It is calculated by the following formula.

$$\text{Mean} = \bar{X} = X + \frac{\sum fdx}{n} \times i$$

Where, $X =$ Assumed mean

$$\sum fdx = \text{The summation of the product of the frequency and step deviation}$$

$N =$ Total number of observations

$i =$ Class interval
Standard Deviation (S.D):

\[ S.D = \sqrt{\frac{\sum_{i} f dx^2}{n} - \left(\frac{\sum_{i} f dx}{n}\right)^2} \times i } \]

Where, \( f = \) Class frequency
\( d = \) Deviation from the assumed mean measured in classes
\( n = \) Total number of observations
\( i = \) Class interval

Co-efficient of Variation (C.V):

It is the standard deviation expressed as a percentage ratio of mean. It is calculated as follows:

\[ C.V = \frac{\sigma}{\bar{x}} \times 100 \]

where, \( \sigma \) stands for standard deviation and \( \bar{x} \) stands for mean

Standard Error (S.E):

Statistics computed from samples are always subject to sampling error. To get an indication of the usual magnitude of the sampling errors the standard errors were calculated.

Standard Error (S.E) for Mean:

It is calculated by the formula: \( S.E \) for \( \bar{x} = \frac{\sigma}{\sqrt{N}} \).
Standard Error for Standard Deviation:

It is calculated by the formula: 
\[ \text{S.E for } \sigma = \frac{\sigma}{\sqrt{2N}} \]

Standard Error for Coefficient of Variation:

It is calculated by the following formula: 
\[ \text{S.E for CV} = \frac{CV}{\sqrt{2N}} \]

Absolute Growth:

Absolute growth of a character (difference of mean) is calculated by subtracting the mean of the lower age group from that of the next higher age group.

\( (\bar{x}_2 - \bar{x}_1) \) where, \( \bar{x}_1 \) stands for the mean value of the lower age group, and \( \bar{x}_2 \) stands for the mean value of next higher age group.

Growth percent per annum:

It is calculated by using the formula: 
\[ \frac{\bar{x}_3 - \bar{x}_1}{\bar{x}_1} \times 100 \]

Growth Gradients:

It is calculated to indicate the level of maturity of a variable at any given age, as compared to its mature size. For the present study, the last age group (20) stands as the level of maturity for calculating the maturity gradients of various body dimensions. The formula used is:

\[ \text{Growth Gradients} = \frac{\bar{x}_1 \text{ or } \bar{x}_2 \text{ or } \bar{x}_3 \ldots}{\bar{x}_{20}} \times 100 \]

where, \( \bar{x}_1 \) stands for mean of the first age group.

\( \bar{x}_{20} \) stands for mean of the last age group.
Correlation:

To find out the correlation between two variables the co-efficient of correlation \( r \) is calculated by using the following formula:

\[
\text{Co-efficient of correlation} \ (r) = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{(N \sum X^2 - (\sum X)^2)(N \sum Y^2 - (\sum Y)^2)}}
\]

where, \( N \sum XY \) is the product of number of frequency with the sum of the product of all the corresponding individual X and Y observations.

\( \sum X \) is the sum of all the individual observations of X series.

\( \sum Y \) is the sum of all the individual observations of Y series.

\( \sum X^2 \) is the sum of the squares of all the individual observations of X series.

\( (\sum X)^2 \) is the square of the sum of all the individual observations of X series.

\( \sum Y^2 \) is the sum of the square of all the individual observations of Y series.

\( (\sum Y)^2 \) is the square of the sum of all the individual observations of Y series.

Probable Error (P.E) of Correlation:

\[
P.E \text{ of } \ r \ = 0.6745 \times \frac{1 - (r)^2}{\sqrt{N}} \quad \text{where, 0.6745 is the constant value of P.E}
\]
Regression:

To study the dimensional proportions of the various pairs of body segments, the linear regression equation of the character Y on X is calculated by using the following formula:

\[ Y = a + bx \] (1)

In the above equation a and b are constants which are called parameters of the line where ‘a’ determines the level of the fitted line (as intercept on the Y-axis) and ‘b’ determines the slope of the line.

Slope \(b_{yx}\) = \[
\frac{\sum XY - (\sum X)(\sum Y)}{N} / 
\frac{\sum X - (\sum X)^2}{N}
\]

Intercept \(a_{yx}\) = \[
\frac{\sum Y}{N} - \frac{b_{yx}}{Y} \sum X
\]

where, \(\sum XY\) the sum of the product of XY for each X and Y observations.

\(\sum X\) the sum of all the observations of X series.

\(\sum Y\) the sum of all the observations of Y series.

\(\sum X^2\) the sum of the squares of all the observations of X series.

\(\left(\sum X\right)^2\) the squares of the sum of all the observations of X series.

\(N\) total number of frequencies.
**Test of Significance:**

To test the significance of the value of co-efficient of correlation \( r \), the value of \( t \) is calculated using the formula:

\[
 t = \sqrt{n-2} \times \frac{r}{1-r^2}
\]

To test the significance of the value for comparison between two sexes or population

\[
 t = \frac{x_1 - x_2}{\sqrt{S.E \cdot x_1^2 + S.E \cdot x_2^2}}
\]

where, \( x_1 \) mean value of first individual.

\( x_2 \) mean value of second individual.

S.E of \( x_1 \) = S.E of the first individual.

S.E of \( x_2 \) = S.E of the second individual.