Chapter II

Material and Methods
MATERIAL

The present study is based on a cross-sectional sample of 854 children (458 boys and 396 girls) of rural Kashmiri Muslim population (Table 1). The subjects ranging in age from 5 to 10 years were selected randomly from various schools and homes in villages Ledhu (Pulwama district), Khonmoh and Balahama (Srinagar district). The field work was conducted during the year 1989-90. In all, 15 anthropometric measurements have been taken on the children besides detailed information on the prevalence of nutritional deficiency signs. Every effort has been made to include, for the present study, only those children who were apparently physically and mentally normal.

Geography

The J&K State is the northern-most state of India. It is bordered on the north by China, on the east by Tibet, on the west by Pakistan and in the south by the states of Himachal Pradesh and Punjab, of the Indian Union. Ladakh, the northern part of the state, is thinly populated by people of Mongoloid origin. Jammu, the south-western section of the state is inhabited predominantly by Dogra (Hindu) population. The Valley of Kashmir, lying about 1,505m above sea level, is enclosed between the Pir Panjal, an offshoot of the Himalaya and the main Himalayan range. It is about 135km long and 40km wide. The Jhelum river drains the valley from south to north. The climate is continental with severe winters and mild summers.
Map of the Jammu & Kashmir state indicating the area of study.
TABLE 1: Distribution of boys and girls according to age

<table>
<thead>
<tr>
<th>AGE IN YEARS</th>
<th>NUMBER OF MALES (M)</th>
<th>NUMBER OF FEMALES (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>58</td>
<td>52</td>
</tr>
<tr>
<td>6</td>
<td>74</td>
<td>60</td>
</tr>
<tr>
<td>7</td>
<td>90</td>
<td>71</td>
</tr>
<tr>
<td>8</td>
<td>92</td>
<td>79</td>
</tr>
<tr>
<td>9</td>
<td>79</td>
<td>68</td>
</tr>
<tr>
<td>10</td>
<td>65</td>
<td>66</td>
</tr>
<tr>
<td>TOTAL</td>
<td>M = 458</td>
<td>F = 396</td>
</tr>
</tbody>
</table>

M + F = 854
According to the 1981 Census the relevant information about the villages studied are:

<table>
<thead>
<tr>
<th>Village</th>
<th>District</th>
<th>No. of occupied Residential Households</th>
<th>Total Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>KHONMOH</td>
<td>Srinagar</td>
<td>504</td>
<td>5,067</td>
</tr>
<tr>
<td>BALAHAMA</td>
<td>Srinagar</td>
<td>238</td>
<td>2,101</td>
</tr>
<tr>
<td>LEDHU</td>
<td>Pulwama</td>
<td>369</td>
<td>2,820</td>
</tr>
</tbody>
</table>

**People**

The present study is based on children derived from the majority community - the Muslims, living in the above cited villages of southern part of the Kashmir Valley. They are tall, fair, sharp-featured people. Both men and women wear a long loose robe, locally called the *pheran*. The villages localities or the *mohallas* are generally categorised and named according to the type of occupation persons living there, follow, e.g., *goori-mohalla* (after the term *goor* meaning milkman) is mainly inhabited by those who sell milk for their livelihood. Similarly, there are the carpenters, the artisans or the workers in the stone-quarries, after whom various localities/mohallas are termed. Observations revealed that the economy is mostly agriculture based.

A Primary Health Centre (PHC) serves the people and villages within a radius of about 10km. Ayurvedic dispensaries are also functional in some areas. However, the people prefer
the hakims* and peers** for minor ailments and allopathic treatment for major ailments. From the medical records available at the PHC, it was found that the following ailments were widespread in these regions: Upper respiratory-tract infection was the highest followed by urinary-tract infection and gastroenteritis. Low-backache and dysentery were other major ailments reported. Worm infestation (mostly hook-worms) was also fairly widespread. The people under study were not much educated, especially the women.

The staple diet of these people is rice. The cooking medium is mustard oil, and people usually eat all seasonal vegetables, especially the saag, locally called haakh (Brassica oleracea), is a vegetable consumed by all; other vegetables are spinach, turnip, lotus-stem, potato, etc. Mutton, fish and fowl considered delicacies, are also favoured and cooked on all important occasions. Muslims generally use garlic to add flavour to their cooking.

Tea is consumed in abundance both by children as well as adults. There are two types of tea - the Kashmiri kahawa and a salty tea (sheeri-chaai) taken with cream which is a favourite. Fruits like apple, pear, cherry, apricot, mulberry, strawberries, etc. and nuts and almonds are grown in Kashmir. These are occasionally consumed but usually are sold outside the state.

*Indigenous medical man
** Religious preacher/Sooften
Smoking is widely prevalent among elders as well as children. Smoking of hukkah is preferred by elders; chewing of tobacco is also widespread.

**METHODS**

**Age recording**

The date of birth of each subject was recorded from the school register and cross-checked from the parents and teachers. The age was calculated from the date of birth to the date of examination, using the 'decimal age calendar'. All doubtful cases were excluded. Age-groups have been based on the nearest birthday, for example, age 6 years includes all children above 5.500 years and below 6.499 years (Table 2).

**Anthropometric measurements**

Anthropometric measurements are usefully applied to study physical growth in terms of body size and body form. Linear, circumferential and skinfold measurements have been taken on each subject following the standard methods described by Weiner and Lourie (1969).

1. **Weight (kg)**

   Technique: Weight was taken with a portable weighing machine graduated in kilogramme with the subject in minimum clothing.

   *Instrument*: Weighing machine.
<table>
<thead>
<tr>
<th>AGE GR.</th>
<th>SEX</th>
<th>NO.</th>
<th>MEAN</th>
<th>SEM</th>
<th>SD</th>
<th>SESD</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>M</td>
<td>58</td>
<td>61.56</td>
<td>0.02</td>
<td>0.18</td>
<td>0.02</td>
</tr>
<tr>
<td>(4.50-5.499)</td>
<td>F</td>
<td>52</td>
<td>61.20</td>
<td>0.03</td>
<td>0.19</td>
<td>0.02</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>74</td>
<td>74.64</td>
<td>0.18</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>(5.50-6.499)</td>
<td>F</td>
<td>60</td>
<td>73.44</td>
<td>0.03</td>
<td>0.22</td>
<td>0.02</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>90</td>
<td>84.96</td>
<td>0.03</td>
<td>0.27</td>
<td>0.02</td>
</tr>
<tr>
<td>(6.50-7.499)</td>
<td>F</td>
<td>71</td>
<td>84.24</td>
<td>0.03</td>
<td>0.29</td>
<td>0.02</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>92</td>
<td>95.64</td>
<td>0.03</td>
<td>0.29</td>
<td>0.02</td>
</tr>
<tr>
<td>(7.50-8.499)</td>
<td>F</td>
<td>79</td>
<td>95.28</td>
<td>0.04</td>
<td>0.32</td>
<td>0.03</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>79</td>
<td>108.00</td>
<td>0.03</td>
<td>0.29</td>
<td>0.02</td>
</tr>
<tr>
<td>(8.50-9.499)</td>
<td>F</td>
<td>68</td>
<td>108.24</td>
<td>0.03</td>
<td>0.29</td>
<td>0.02</td>
</tr>
<tr>
<td>10</td>
<td>M</td>
<td>65</td>
<td>120.72</td>
<td>0.03</td>
<td>0.22</td>
<td>0.02</td>
</tr>
<tr>
<td>(9.50-10.499)</td>
<td>F</td>
<td>66</td>
<td>120.84</td>
<td>0.03</td>
<td>0.26</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**TABLE 2: Age (months) of boys and girls**
Linear body measurements

2. Height (cm)
   
   Technique: The measurement is taken with the subject standing on a horizontal platform with his heels together, stretching upwards to the fullest extent, against a vertical wall. The head is kept in the Frankfurt Horizontal (FH) plane. The anthropometer is held vertically in front of the subject in mid-sagittal plane and the horizontal movable arm is brought in contact with the subject’s head and the measurement recorded.
   
   Instrument: Anthropometer

3. Sitting-height (cm)
   
   Technique: The subject is directed to stretch up straight his back as he sits on a plane surface, with his thighs resting completely on the table top and legs hanging freely. The head is held high in the FH plane, and the anthropometer held vertically, in contact with the back at the sacral and inter-scapular regions. The movable arm of the anthropometer is then brought in contact with the vertex and the measurement recorded.
   
   Instrument: Anthropometer.

4. Lower-extremity length (cm)
   
   Technique: It is derived by subtracting sitting-height from the height vertex.

5. Bi-iliocristal diameter (cm)
   
   Technique: The measurement is taken with the subject
standing with his heels together. The anthropometer arms are brought in contact with the iliac crest, at the place which gives the maximum diameter. Strong pressure is applied to the anthropometer blades to push aside any fat covering the bone.

*Instrument*: Anthropometer.

6. **Humerus bi-condylar breadth (cm)**

*Technique*: The subject’s elbow is bent to a right angle and the width across the bony prominences of the distal epicondyles of the humerus is recorded.

*Instrument*: Sliding callipers.

7. **Femur bi-condylar breadth (cm)**

*Technique*: This measurement is recorded as the width across the bony prominences of the distal epicondyles of the femur, when the subject sits on a table with his knees bent at right angles. Slight pressure is exerted to compress the tissues.

*Instrument*: Sliding callipers.

**Circumferential measurements**

8. **Upper-arm circumference (cm)**

*Technique*: The subject’s arm hanging relaxed, the measurement is taken with a steel tape in a plane at right angles to the long axis of the humerus, and at a level halfway between the acromion process and ulnar olecranon.
The tape is held in contact with the skin but not pressing the tissues inwards.

*Instrument*: Steel tape.

9. Chest circumference (cm)

*Technique*: It is measured at the marked union of the third and fourth sternebrae, at right angles to the axis of the body. The tape is held taut, so as to bring it into firm contact with the perimeter of the thorax, and passing the level of nipples in front and below the inferior angles of the scapulae behind. The measurement is recorded as the median value during normal respiration.

*Instrument*: Steel tape.

10. Calf circumference (cm)

*Technique*: The maximum circumference of the calf was recorded by passing the tape around the leg, over the calf muscle, in the horizontal direction so that it is in firm contact with the skin.

*Instrument*: Steel tape.

**Subcutaneous fat measurement**

All skinfolds were measured by pinching up a fold of skin and subcutaneous tissue between thumb and forefinger. The measurements were made on the left side of the subject with a skinfold calliper which exerts a constant pressure of 10 gm/mm² on the jaw surfaces. The two jaws were
applied to the tip of the fold and the reading recorded just after releasing the pressure of the callipers.

Instrument: Harpenden skinfold callipers.

11. Biceps skinfold (mm)
   Technique: The skinfold is measured on the anterior mid upper-arm about 1 cm above the level marked on the skin for upper-arm circumference.

12. Triceps skinfold (mm)
   Technique: The skinfold is picked up on the posterior aspect of the upper arm, over the triceps muscle directly in line with point of the elbow or olecranon process.

13. Sub-scapular skinfold (mm)
   Technique: The skinfold is picked up immediately below and just lateral to the inferior angle of the left scapula pointing slightly downwards and outwards.

14. Supra-iliac skinfold (mm)
   Technique: The skinfold is lifted at a point in the mid-axillary line just above and medial to the anterior superior iliac spine. The line of fold is approximately 45° to the mid-axillary line.

15. Calf skinfold (mm)
   Technique: The skinfold is picked up at the level of maximum circumference of the calf, on the medial aspect of the leg.
In addition to the above measurements, below mentioned observations regarding nutritional deficiency signs were observed following Jelliffe’s (1966) simple schedule:

<table>
<thead>
<tr>
<th>HAIR</th>
<th>EYES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispigmentation</td>
<td>Bitot’s spots</td>
</tr>
<tr>
<td>Easy pluckability</td>
<td>Conjunctival Xerosis</td>
</tr>
<tr>
<td>Sparseness</td>
<td>Pale Conjunctiva</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MOUTH</th>
<th>TONGUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angular stomatitis</td>
<td>Oedema of tongue</td>
</tr>
<tr>
<td>Cheilosis</td>
<td>Magenta tongue</td>
</tr>
<tr>
<td>Swollen bleeding gums</td>
<td>Atrophic papillae</td>
</tr>
<tr>
<td></td>
<td>Glossitis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SKIN</th>
<th>SKELETON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oedema (Bilateral)</td>
<td>Knock knees</td>
</tr>
<tr>
<td>Follicular hyperkeratosis</td>
<td>Bow legs</td>
</tr>
<tr>
<td>(type 1)</td>
<td>Epiphyseal enlargement</td>
</tr>
<tr>
<td>Pellagrous dermatosis</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THYROID GLAND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goitre</td>
</tr>
</tbody>
</table>
Clinical Observations

This method is based on the examination of changes believed to be related to inadequate nutrition. These changes can be seen or felt in superficial epithelial tissues, especially skin, eyes, hair and buccal mucosa, in organs near the surface of the body, such as parotid and thyroid glands.

These various changes and symptoms are more prevalent in areas where malnutrition is widespread. Various signs taken into consideration for the study were:

1. HAIR

a) Dispigmentation
The hair shows a distinct lightening of its normal colour, most usually distally. The sign is a common feature of some forms of protein-calorie malnutrition in young children and is due to disturbances in melanogenesis.

b) Easy pluckability
In this sign, a small clump or tuft of hair can be easily pulled out with moderate force and without pain. It is usually accompanied by other hair changes, such as dispigmentation and sparseness, and occurs in Kwashiorkor
and other forms of protein-calorie malnutrition in early childhood.

c) Sparseness
The hair may become thin and sparse, that is, covering the scalp less abundantly and completely, and with wider gaps between hairs.

2. EYES

a) Bitot’s Spots
These are an extreme form of thickening of the epithelium of the bulbar conjunctiva. These are usually well demarcated, superficial, dry, greyish, silvery or chalky-white foamy plaques often triangular or irregularly circular in shape, more often confined to the region, lateral to the cornea and rarely overlying it. They are usually bi-lateral.

b) Conjunctival xerosis
Conjunctival xerosis has been described as a sign of Vitamin-A deficiency; the condition is the thickening of the outer layer of the front eye ball.

This condition is usually characterised by dryness, thickening, pigmentation and lack of lustre and transparency of bulbar conjunctiva of the exposed part of the eye ball. A few seconds exposure, by drawing back the lids, aids in its identification.
c) Pale conjunctiva

When the conjunctiva is pale in colour than the usual white colour, it is put down to iron deficiency in the diet.

3. MOUTH

a) Angular stomatitis

This develops as fissures or cracks radiating from the angles or corners of the mouth. The fissures may be shallow or deep, confined to a small area of the angles of the mouth. Milder lesions are discerned more easily with the mouth half-open. The sign was taken as positive only if both angles of the mouth were involved. This condition is attributed to riboflavin deficiency. Niacin and pyridoxine deficiency may also be involved.

b) Cheilosis

The lesion is characterised by vertical fissuring, later complicated by redness, swelling and ulceration of lips other than angles. The centre of the lower lip is most commonly affected. It is put down as caused by riboflavin deficiency.

c) Swollen bleeding gums

Red spongy swelling of the inter-dental papillae and/or the gum margins, which usually bleed easily on slight pressure. This is due to Vitamin-C deficiency.
4. **TONGUE**

a) **Oedema of tongue**
   This can be detected by the indentations made by pressure of teeth along the edges of the tongue. The papillae are usually prominent. This condition is associated with deficiency of riboflavin and niacin.

b) **Magenta tongue**
   The tongue is purplish red in colour; numerous morphological changes may co-exist.

c) **Atrophic papillae**
   The filiform papillae are absent giving the tongue an extremely smooth appearance. The distribution may be central or marginal. It may be painful. This condition may be due to lack of niacin.

d) **Scarlet and raw tongue (Glossitis)**
   The tongue is bright red in colour, usually of normal size or slightly atrophic, denuded due to desquamation and very painful. It is usually due to niacin deficiency that this condition appears.

5. **SKIN**

a) **Oedema (bilateral)**
   It is recorded only if present bilaterally. The sign is taken as positive if there is a visible and palpable pit that persists after the pressure is removed. Usually
first apparent over the ankles and feet, it may extend to other areas of the extremities. Oedema is normally a sign of Kwashiorkor.

b) **Follicular hyperkeratosis (Type 1)**

In early literature on the subject, the condition was termed 'phrynoderma'. In it the lesion consists of hyperkeratosis surrounding the mouths of hair follicles and forming plaques that resemble spines. This is associated with Vitamin-A deficiency.

c) **Pellagrous dermatosis**

Typical pellagrous skin lesions are symmetrical, clearly demarcated, hyperpigmented areas with or without exfoliation. The lesions are common, in parts of the body exposed to sunlight, including the cheek and the forearms. This condition is due to niacin deficiency.

6. **SKELETON**

a) **Knock-knees and bow-legs**

Once a child with rickets begins to stand, walk and become active, he develops new deformities due to the soft or weak character of the bones. The commonest of these is bow-legs, and less frequently knock-knees.

b) **Epiphyseal enlargement**

Enlargement of the epiphyseal ends of long bones, particularly affecting the radius and ulna at the level of
the wrist and tibia and fibula at the level of the ankle.
In the assessment of this sign, allowance was made for the
degree of subcutaneous fat present.

7. GOITRE

Thyroid gland is visibly or palpably enlarged. The
enlargement may be diffuse or nodular. Inspection and
palpation, while the subject swallows, was helpful in
diagnosis.

Grade I
Persons with palpable goitre. The thyroid is probably enlarged
four to five times, although not visible with the head in
normal position. In most cases it was readily visible with the
head thrown back and the neck fully extended. Palpation was
carried out by the examiner, sitting or standing, facing the
subject, and placing his thumb gently on either side of the
thyroid area.

Grade II
Persons with visible goitre. Goitre in this category can be
recognised easily with the head in a normal position; they are
smaller than goitres in grade III.

Grade III
Persons with very large goitre. Goitre can be recognised from
a distance. They are grossly disfiguring. Iodine deficiency
causes the enlargement of the thyroid.
The nutritional deficiency signs were broadly classified as indicating Vitamin-A deficiency, Vitamin-B deficiency, Vitamin-C deficiency, Vitamin-D deficiency and Iron deficiency. The signs suggestive of Vitamin-A deficiency are: Bitot's spots, Conjunctival xerosis and Follicular hyperkeratosis (type 1). Vitamin-B deficiency signs are: Angular stomatitis, Cheilosis, Atrophic lingual papillae and Pellagrous dermatosis. Vitamin-C deficiency signs are: Spongy and bleeding gums, and Epiphyseal enlargement (painful). Vitamin-D deficiency signs are: Bow legs, Knock-knees and Epiphyseal enlargement (painless). Iron deficiency is suggested by Pale conjunctiva.

Incidence of Malnutrition

Various methods are in use for evaluating the growth and nutritional status of children and adults. The usual consensus is to use the 50th percentile of a given standard with the various corresponding measurements.

In the present work, Gomez's classification (weight-deficit) and Waterlow's classification (height-deficit) have been used to classify the boys and girls into different grades of malnutrition.

(i) **Gomez's classification** (Gomez et al. 1956)

This classification takes into consideration that the malnourished child does not have the weight expected for his age. Using NCHS Standards, four categories of nutritional status can be derived:
Normal : More than 90% median weight for age.

Grade I Malnutrition : 76% - 90% median weight for age.
   (Marginal)

Grade II Malnutrition : 61% - 75% median weight for age.
   (Moderate)

Grade III Malnutrition : Less than 60% median weight for age.
   (Severe)

(ii) Waterlow's classification (Waterlow et al. 1977)

In this classification, people suffering from malnutrition do not have height expected for their age. Four categories of nutritional status can be derived using the NCHS Standards:

Normal : More than 95% expected height for age.

Grade I Malnutrition : 91-95% expected height for age.

Grade II Malnutrition : 85-90% expected height for age.

Grade III Malnutrition : Less than 85% expected height for age.

Indices

In order to study the changes that take place during growth of the total body in relation to its component parts, the following anthropometric ratios have been computed from the basic anthropometric measurements:

1. **Ponderal Index (PI)** = \( \frac{\text{Height (in)}}{\text{Weight}^{1/3} \text{(lbs)}} \)

2. **Body Mass Index (BMI)** = \( \frac{\text{Weight (kg)}}{(\text{Height})^2 \text{(m)}} \)
3. Relative sitting-height = \( \frac{\text{Sitting-height (cm)}}{\text{Height (cm)}} \times 100 \)

4. Relative Upper-arm circumference = \( \frac{\text{Upper-arm circumference (cm)}}{\text{Height (cm)}} \times 100 \)

5. Relative Calf circumference = \( \frac{\text{Calf circumference (cm)}}{\text{Height (cm)}} \times 100 \)

6. \( \frac{\text{Biceps:}}{\text{Triceps}} = \frac{\text{Biceps skinfold (log-transform)}}{\text{Triceps skinfold (log-transform)}} \times 100 \)

7. Inter-bi-condylar = \( \frac{\text{Humerus bi-condylar (cm)}}{\text{Femur bi-condylar (cm)}} \times 100 \)

\[ D_1 = \frac{C_1}{\pi} - S_1 \]

\[ D_2 = \frac{C_2}{\pi} - S_2 \]

Where,

- \( C_1 = \) Upper-arm circumference, cm;
- \( C_2 = \) Calf circumference, cm;
- \( S_1 = \) Triceps skinfold, mm;
STATISTICAL CONSIDERATIONS

In order to understand the complex phenomenon of growth, certain statistical techniques have been used in the present study. A brief description of these statistical methods is given in this section.

Measures of central tendency

1. Arithmetic Mean

The most widely used measure of central tendency is the arithmetic mean which gives the average value of the whole range of the data. This is given by the formula:

\[ \bar{x} = \frac{\sum x}{n} \]

where,
\[ \bar{x} = \text{the arithmetic mean}, \]
\[ n = \text{total number of variables}, \]
\[ \sum x = \text{sum of all recorded variables}. \]

2. Standard Deviation (SD)

It gives the dispersion around the mean and is given by the formula:
3. Coefficient of Variation (CV)

When the standard deviation is expressed as a percentage of mean, it is called coefficient of variation. It measures the degree or percent of variability in the character relative to the average of the group. It also helps in comparing variability between two variables having different units, and is given as:

\[
CV = \frac{SD}{\bar{x}} \times 100
\]

where,

- \( CV \) = Coefficient of Variation,
- \( SD \) = Standard Deviation
- \( \bar{x} \) = Arithmetic mean.

Statistics computed from samples are inevitably subject to sampling error, hence the results derived from the sample and
the entire population may not be the same. In order to
visualise the magnitude of error due to sampling, Standard
Error of Mean and Standard deviation are calculated.

a) Standard Error of Mean (SEM), is given by the
formula:

$$SEM = \frac{SD}{(n-1)^{1/2}}$$

where,
SEM = Standard Error of Mean,
SD = Standard Deviation, and
n = size of sample.

b) Standard Error of Standard Deviation (SESD) is
calculated using the formula:

$$SESD = \frac{SD}{(2n-1)^{1/2}}$$

where,
SESD = Standard Error of Standard
Deviation,
SD = Standard Deviation and
n = size of the sample.

Coefficient of Correlation

A correlation coefficient (r) is an index that measures
the strength of a relationship between two variables in a given
set of data. The possible values of the correlation coefficients range from +1 to -1 for complete positive and negative correlation. The significance of $r$ is considered following the tables given by Fischer and Yates (1957).

The correlation coefficient ($r$), is given by the following formula:

$$ r = \frac{\sum [(x-\bar{x})(y-\bar{y})]}{\sqrt{\sum (x-\bar{x})^2} \sqrt{\sum (y-\bar{y})^2}} $$

where, $r$ is the coefficient of correlation, and $x$ and $y$ represent two sets of data with respective means $\bar{x}$ and $\bar{y}$.

Partial Correlation Coefficient

For calculating the average total correlation coefficient among various measures, all the age-groups were combined. In doing so, the covariation among these measures brought about by age was completely ignored. By adjusting via Partial Correlation for the covariation attributable to age, a clearer picture of relationship can be obtained (i.e., age was partialled out). The partial correlation between $y$ and $x_1$, holding $x_2$ (here age, in months) fixed, is given by:

$$ r_{y12} = \frac{r_{y1} - r_{y2} r_{12}}{\sqrt{(1-r_{y1}^2)(1-r_{12}^2)}} $$

where, $r_{y1}$, $r_{y2}$ and $r_{12}$ are the simple correlation coefficients between $y$ and $x_1$, $y$ and $x_2$ and between $x_1$ and $x_2$, respectively.
Regression

Regression serves primarily as a predictive function (Simpson et al., 1960), because a unit change on the x-axis represents a change of b-units on the y-axis.

The simple regression equation is given by:

\[ y = a + bx \]

where, x and y are variables, and a and b are constants.

Regression Coefficient (b) is given by:

\[
 b = \frac{\Sigma (x-\bar{x})(y-\bar{y})}{\Sigma (x-\bar{x})^2}
\]

where, \( \bar{x} \) and \( \bar{y} \) are sample means.

An alternate formula, usually used in computational work, and used in this study, is:

\[
 b = \frac{\Sigma xy - \frac{(\Sigma x)(\Sigma y)}{n}}{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}
\]

and

\[ a = y - bx \]
Percentiles

The percentile method of expressing position of the individual within a group is important. Taking the mean as the 50th percentile, other percentiles, namely, 3rd, 10th, 25th, 75th, 90th and 97th, have been calculated for some selected measurements using the formula given by Tanner et al. (1966). To minimise the effect of age-grouping on the variance of the population measurement, the correction suggested by Healy (1962) was applied to the standard deviation, so that.

\[
\text{corrected SD} = \sqrt{\left[\frac{(SD)^2 - (\text{velocity})^2}{12}\right]}
\]

The formulae given by Tanner et al. (1966), after applying the corrections, and as used in the present sample, are:

- 3rd and 97th percentile = \(\bar{x} + 1.881 \times \text{corrected SD}\)
- 10th and 90th percentile = \(\bar{x} + 1.282 \times \text{corrected SD}\)
- 25th and 75th percentile = \(\bar{x} + 0.675 \times \text{corrected SD}\)

where, \(\bar{x}\) is the mean and SD the standard deviation.

**t-test**

The t-test gives the difference between the two means, \(\bar{x}_1\) and \(\bar{x}_2\), of two independent samples of size \(n_1\) and \(n_2\) and SD
S₁ and S₂. The main purpose of this is to test the hypothesis that the studied samples come from the same normal population i.e., \( \bar{x}_1 - \bar{x}_2 = 0 \). It is calculated by using the formula:

\[
t = \frac{\bar{x}_1 - \bar{x}_2}{s} \times \sqrt{\frac{n_1 n_2}{n_1 + n_2}}
\]

and

\[
s = \sqrt{\frac{s_1^2 n_1 + s_2^2 n_2}{n_1 + n_2 - 2}}
\]

where,
\( \bar{x}_1 \) = mean of first sample with SD = S₁,
\( \bar{x}_2 \) = mean of second sample with SD = S₂,
\( n_1 \) = size of the first sample,
\( n_2 \) = size of the second sample, and
S = combined SD.