MATERIAL AND METHODS

MATERIAL

The present study is based on a cross-sectional sample of 610 Rajput females of Kulu Valley in Himachal Pradesh ranging in age from 6 to 17 years. The subjects were selected from various schools at Bajaura, Bhuntar, Jaree, Kais, Mohal, Raison, Katrain, Larji, Banjar, Jibhi, Goshani and Kalwari, all in Kulu District. The field work was conducted during the year 1976. In all, 21 anthropometric measurements have been taken on each individual. This anthropometric data on each subject includes ten linear, six circumferential and five skinfold measurements. Besides basic anthropometric data, additional data on secondary sexual characters and onset of menarche have also been collected. All the subjects were examined by the author herself. Information regarding the general health of the subjects was obtained from their respective parents and teachers. Care was taken to exclude all those individuals who were related and were found to be either mentally/physically handicapped or had suffered from any ailment during the last six months. Thus, the present sample includes only the healthy, apparently normal and unrelated individuals.
LAND AND PEOPLE

Kulu region forms a homogeneous tract between the North latitudes of 30°20' and 32°26' and the meridians of 76°59' and 77°50' East. It connects the immense glacier-crowned ranges, bordering on Lahaul and Spiti with the foothills which extend in parallel waves. The barrier separating Kulu from Lahaul has a mean elevation of about 13,000 feet, with two passes—the Moktang (13,000 feet) and the Manda (14,000 feet) (Gazetteer District Kangra, 1917).

The main river valley is only eighty kilometers long and less than two kilometers at its broadest. Running from north to south, the valley follows the river Beas from its source to the point near Larji, where its course suddenly turns west and enters the Mandi district through a deep gorge.

The mountain system is comprised of long high ridges with sharp crests and steep sides. The main ranges are continuations of the surrounding Himalayas, the northern range being a part of the Pir Panjal Range.

Kulu valley remains covered with snow becoming very cold during winter (maximum temperature 56.7°F and minimum temperature 38°F). Summers are usually pleasant (maximum temperature 92.7°F and minimum temperature 62.4°F) although it is slightly cold at high altitudes. The annual rainfall for proper Kulu works out to be 110 cms. (Census of Kangra District, 1961).
The population of Kulu Valley is 1,92,171 (Directory & Year Book, 1976). About 96% population lives in the villages. The villages are found wherever an area of cultivable land exists sufficient to support a few families. The houses are generally two storeyed and roofed with slates. The lower storey is used for cattle and the upper storey or storeys as the general living place of the family.

Over 90% people are Hindus by faith and in their day-to-day life they are devoted to traditional Gods. Almost every village has its own deity who is worshipped for good harvest, timely rains and in times of trouble.

The general socio-economic status of people is low. About 93% of the population lives on agriculture. Female labour force participation is high in agriculture. The subsidiary occupations of major part of the population include spinning and weaving of wool, carrying loads, work in forests and in road-construction, and bee-keeping. Principal communities are Rajputs, Brahmans and Kolis. Among these Rajputs are predominant.

Rajputs

They are considered to be the descendants of vazirs and retainers of Kulu Rajas and are highly respected. Below these
in social hierarchy are the cultivating classes, kanets and giraths followed by artisans and menials. Kanets are cultivating classes of the eastern Himachal Pradesh who are found as far west as Kulu and the eastern portion of Kangra District (Gazetteer District Kangra, 1917). Hill Rajputs are people of remote ancestry, and majority of them are too proud to cultivate with their own hands. They employ kanets as husbandmen. Kanets regard themselves as the children of women of hills by Rajputs who came up from the plains. They have a long history of contact and intermixture with hill Rajputs. The intermingling between the two is so profuse and widespread that it is now exceedingly difficult to draw a line between the two and regard them as separate entities.

**METHODS**

**AGE RECORDING**

The date of birth of each subject was recorded from the school register and was cross-checked from the parents and teachers. Also, dental status of each child was recorded to help in assessing the age. All doubtful cases have been excluded from the present study since correct assessment of age is the most important prerequisite of a growth study.

The ages were calculated from the dates of birth to the dates of examination using 'Decimal age calendar' (Tanner
<table>
<thead>
<tr>
<th>Age in yrs</th>
<th>No.</th>
<th>Mean</th>
<th>S. E.</th>
<th>S.E. of Mean</th>
<th>Co.V.</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>51</td>
<td>6.086</td>
<td>0.039</td>
<td>0.275</td>
<td>4.437</td>
<td>6.6 - 6.7</td>
</tr>
<tr>
<td>7</td>
<td>53</td>
<td>7.057</td>
<td>0.038</td>
<td>0.253</td>
<td>4.094</td>
<td>6.6 - 7.6</td>
</tr>
<tr>
<td>8</td>
<td>52</td>
<td>8.031</td>
<td>0.040</td>
<td>0.293</td>
<td>3.648</td>
<td>7.6 - 8.1</td>
</tr>
<tr>
<td>9</td>
<td>54</td>
<td>9.109</td>
<td>0.042</td>
<td>0.312</td>
<td>3.425</td>
<td>9.0 - 9.2</td>
</tr>
<tr>
<td>10</td>
<td>52</td>
<td>10.063</td>
<td>0.036</td>
<td>0.251</td>
<td>2.892</td>
<td>9.9 - 10.1</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>11.087</td>
<td>0.035</td>
<td>0.255</td>
<td>2.299</td>
<td>11.0 - 11.1</td>
</tr>
<tr>
<td>12</td>
<td>52</td>
<td>12.041</td>
<td>0.034</td>
<td>0.246</td>
<td>2.043</td>
<td>11.9 - 12.1</td>
</tr>
<tr>
<td>13</td>
<td>57</td>
<td>13.094</td>
<td>0.037</td>
<td>0.284</td>
<td>2.168</td>
<td>13.0 - 13.1</td>
</tr>
<tr>
<td>14</td>
<td>49</td>
<td>14.945</td>
<td>0.039</td>
<td>0.273</td>
<td>1.957</td>
<td>13.8 - 14.0</td>
</tr>
<tr>
<td>15</td>
<td>50</td>
<td>14.966</td>
<td>0.043</td>
<td>0.309</td>
<td>2.057</td>
<td>14.8 - 15.0</td>
</tr>
<tr>
<td>16</td>
<td>47</td>
<td>16.038</td>
<td>0.040</td>
<td>0.275</td>
<td>1.714</td>
<td>15.9 - 16.1</td>
</tr>
<tr>
<td>17</td>
<td>42</td>
<td>17.155</td>
<td>0.044</td>
<td>0.288</td>
<td>1.678</td>
<td>17.0 - 17.2</td>
</tr>
</tbody>
</table>
At et al., 1966). The data have been divided into 12 yearly groups. In each age group are included all girls not more than 6 months older or 6 months younger than the age assigned to the group. Thus age group 6 included all girls above 5.500 years and below 6.499 years, as illustrated below:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.500 - 6.499</td>
<td>6 years</td>
</tr>
<tr>
<td>6.500 - 7.499</td>
<td>7 years</td>
</tr>
<tr>
<td>8.500 - 9.499</td>
<td>8 years</td>
</tr>
</tbody>
</table>

An attempt was made to apply linear interpolation (Sharma, 1972) with respect to few parameters but interpolated values did not exhibit appreciable differences between the sample and instantaneous means. Therefore, no change has been effected in the mean values computed for the sample, and the results are presented for each age group as shown above.

**Anthropometric Measurements**

Anthropometric measurements constitute the basis of the subject of physical growth and development and are substantially applied to study physical growth in terms of body size and body form. Twenty-one linear, circumferential and skinfold measurements have been taken on each subject after the methods described in Weiner & Lourie (1969). The anthropometric
measures taken were:

**Linear Body Measurements**

1. Height (Kg.)
2. Stature (cm.)
3. Sitting height (cm.)
4. Trunk height (cm.)
5. Total upper extremity length (cm.)
6. Total lower extremity length (cm.)
7. Bicromial breadth (cm.)
8. Bicristal breadth (cm.)
9. Chest breadth (cm.)
10. Chest depth (cm.)

**Circumferential Measurements**

11. Chest circumference (cm.)
12. Hip circumference (cm.)
13. Abdomen circumference (cm.)
14. Upper arm circumference (cm.)
15. Thigh circumference (cm.)
16. Calf circumference (cm.)

**Subcutaneous Fat Measurements**

17. Biceps skinfold (mm.)
18. Triceps skinfold (mm.)
19. Sub-scapular skinfold (mm.)
20. Mid-axillary skinfold (mm.)
21. Calf skinfold (mm.)

In addition to the above measurements, observations regarding secondary sexual characters were made. Below mentioned three characters were considered following the methods given in Weiner & Lourie (1969):

**Secondary Sexual Characters**

1. Stages of breast development.
2. Stages of pubic and axial hair development.

A detailed description of the landmarks and techniques applied is given in Appendix.

**Indices**

An objective approach to the study of body build is through anthropometric ratios. In order to study the changes that take place during the progression of the total body in relation to its component parts as growth and development occurs, anthropometric ratios have been computed from the basic anthropometric measurements. The anthropometric ratios taken were:

1. Rohrer's Index \[ = \frac{\text{Weight}}{\text{Stature}^3} \times 100 \]
2. Ponderal Index \[ = \frac{\text{Stature}}{(\text{weight})^{1/3}} \]
<table>
<thead>
<tr>
<th></th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Relative sitting height = ( \frac{\text{Sitting height}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>4</td>
<td>Relative upper extremity = ( \frac{\text{Upper extremity length}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>5</td>
<td>Relative lower extremity = ( \frac{\text{Lower extremity length}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>6</td>
<td>Relative bicromial breadth = ( \frac{\text{Bicromial breadth}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>7</td>
<td>Relative bicristal breadth = ( \frac{\text{Bicristal breadth}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>8</td>
<td>Relative upper arm circumference = ( \frac{\text{Upper arm circumference}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>9</td>
<td>Relative chest circumference = ( \frac{\text{Chest circumference}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>10</td>
<td>Relative hip circumference = ( \frac{\text{Hip circumference}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>11</td>
<td>Relative thigh circumference = ( \frac{\text{Thigh circumference}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>12</td>
<td>Relative calf circumference = ( \frac{\text{Calf circumference}}{\text{Stature}} \times 100 )</td>
</tr>
<tr>
<td>13</td>
<td>Sitting height : Bicromial breadth index = ( \frac{\text{Bicromial breadth}}{\text{Sitting height}} \times 100 )</td>
</tr>
<tr>
<td>14</td>
<td>Sitting height : Upper extremity index = ( \frac{\text{Upper extremity length}}{\text{Sitting height}} \times 100 )</td>
</tr>
<tr>
<td>15</td>
<td>Sitting height : Lower extremity index = ( \frac{\text{Lower extremity length}}{\text{Sitting height}} \times 100 )</td>
</tr>
<tr>
<td>16</td>
<td>Inter-membral index = ( \frac{\text{Upper extremity length}}{\text{Lower extremity length}} \times 100 )</td>
</tr>
</tbody>
</table>
17. Acromio-iliac index = Bicristal breadth
               Biacromial breadth x 100

18. Thigh circumference: Calf
    circumference index = Calf circumference
               Thigh circumference x 100

               Triceps skinfold x 100

**Upper arm diameter**
\[
D = \frac{C}{\pi} - s_1
\]
\[
C = \text{Upper arm circumference}
\]
\[
s_1 = \text{Triceps skinfold}
\]
\[
\pi = 3.14159
\]

**Calf diameter**
\[
D = \frac{C}{\pi} - s_2
\]
\[
C = \text{Calf circumference}
\]
\[
s_2 = \text{Calf skinfold}
\]
\[
\pi = 3.14159
\]

**Statistical Considerations**

Statistical methods constitute the basis of an important part of the subject of growth and development. According to Edmund Churchill (1966) "Human growth is a process of change that has to be observed and followed by means of multiplicity of measurements. It is a process to be summarized, evaluated and understood through careful and resourceful interpretation and analysis of the data created by these measurements". In order to understand the complex phenomenon of growth certain
statistical techniques have been made use of in the present
study. A brief description of these statistical operations is
given in this section.

MEASURES OF CENTRAL TENDENCY

Most popular and widely used measure of central tendency
is the arithmetic mean which measures the location of the sample.
Its value is obtained by adding together all the individual
values and then dividing the resulting sum by the number of
values in the sample. Thus,

\[ \bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \]

\( x_i \) are the individual values for \( i = 1, 2, \ldots, n \); \( n \)
is the sample size.

MEASURES OF DISPERSION AND RELATIVE VARIABILITY

Standard deviation measures the absolute dispersion or
variability of a distribution. The greater the amount of
dispersion the greater the standard deviation, for the greater
will be the magnitude of the deviations of the values from
their mean. It is calculated using the formula:

\[ SD = (\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n})^{1/2} \]
where $\bar{x}$ is the sample mean and $n$ the sample size, or

$$SD = \sqrt{\frac{(\bar{x} - \bar{X})^2}{n-1}}$$

when the standard deviation is expressed as a percentage of mean, it is called co-efficient of variation. It is the most commonly used measure of relative variation. Co-efficient of variation 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:

$$CV = \frac{SD}{\bar{x}} \cdot 100$$

Statistics computed from samples are inevitably subject to sampling error. Even if utmost care has been taken in selecting a sample, the results derived from the sample and the entire population may not be the same. The nearness of sample values to the population values is known to vary in degree. In order to estimate the magnitude of sampling error the standard errors have been calculated.

Standard error of mean ($SE_{\bar{X}}$) is given by:

$$SE_{\bar{X}} = SD / (n - 1)^{1/2}$$

where $SD$ is the standard deviation for a distribution and $n$ the
size of the sample.

Standard error of standard deviation (SE_z):

\[ SE_z = SD / (2n-1)^{1/2} \]

CONFIDENCE INTERVAL

'Confidence interval' is a general procedure which helps in setting up from observational data an interval that covers the unknown parameter with a given probability. The specified interval covers the true value and the statement is correct 95 times out of 100. The confidence interval may be written as:

\[ \bar{x} - y\alpha \sqrt{\frac{\sigma}{n}} \leq \mu \leq \bar{x} + y\alpha \sqrt{\frac{\sigma}{n}} \]

where \( y \) is the value of

\[ y = \sqrt{n} \left( \frac{\bar{x} - u}{\sigma} \right) \]

for a given confidence co-efficient \( \alpha \), which can be read from a normal probability integral table. \( \bar{x} \) is the sample mean and \( \mu \) represents the population mean. If \( \alpha = 0.95 \), then \( y\alpha = 1.96 \) no matter what \( n \) is. For example, we find that 95 per cent of sample mean will fall within interval \( \bar{x} \pm 1.96\sigma \times \left( \frac{\bar{x} - u}{\sigma} \right) \), called the standard error of the mean equal to \( \frac{\sigma}{\sqrt{n}} \). Similarly, in repeated sampling if we take the interval extending from a lower limit \( \bar{x} - 1.96\sigma \times \) to an upper limit \( \bar{x} + 1.96\sigma \times \), then
this interval will cover the population mean, \( \mu \) in 95 per cent of the cases.

**RATE OF GROWTH**

Rate of growth or increment per unit time of a variable is calculated by subtracting its mean value at a lower age from that at the next higher age.

Annual velocity = \( x_h - x_{h-1} \)

Percentage rate of growth at a particular age \( h \) has been calculated using the following formula:

\[
\text{% rate} = \left( \frac{x_h - x_{h-1}}{x_{h-1}} \right) \times 100
\]

where \( x_h \) is the mean value at age \( h \), and \( x_{h-1} \) is the corresponding mean value at the preceding age. The expression \( (x_h - x_{h-1}) \) gives the absolute annual increment.

**REGRESSION**

Regression analysis is concerned with the derivation of an appropriate mathematical expression of the functional relationship between variables. When two variables are linearly related to each other the relationship between the 'dependent' variable (\( Y \)) and the 'independent' variable (\( X \)) is expressed by the following equation:

\[ Y = a + b \times X \]
where

\[ Y = \text{dependent variable} \]
\[ x = \text{independent variable} \]
\[ a = \text{estimated Y intercept} \]
\[ b = \text{the estimated slope} \]

'a' unit change on the x axis represents a change of 'b' units on the Y axis. Regression co-efficient (b) is given by:

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

All sums are \(\sum_{i=1}^{n}\), \(x\) and \(Y\) are the sample means. An alternate formula usually used in computational work is:

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

The intercept (a) is calculated by the following formula:

\[ a = \bar{Y} - b \bar{x} \]

or

\[ a = \frac{\sum Y - b \sum x}{n} \]

**Coefficient of Correlation**

Correlation co-efficient (r) summarizes in one figure, not only the degree of correlation (between two or more variables)
but also the direction, i.e., whether correlation is positive or negative. It is found to be more valuable statistics in comparative studies than the regression co-efficient. Correlation co-efficient 'r' between two variables 'X' and 'Y' is given by:

\[ r = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum (X - \bar{X})^2 \sum (Y - \bar{Y})^2}} \]

The value of co-efficient of correlation varies between -1 and +1. When \( r = 0 \), there is no correlation; when \( r = +1 \) there is positive correlation and when \( r = -1 \) there is perfect negative correlation. The closer 'r' is to +1 or -1 the closer the relationship between variables and the closer it is to 0, the less close the relationship. Falkner (1962) cautions against relating causation with correlation. Even a high degree of correlation does not necessarily mean that a relationship of cause and effect exists between the variables.

In the present study, the degree of relationship between two variables, as measured by correlation, is taken as under:

- **r = 0.00 - 0.39** low
- **r = 0.40 - 0.79** moderate
- **r = 0.80 - 1.00** high

(Falkner, 1962)
GROWTH GRADIENT

A growth gradient estimates the level of maturity of a variable at a given developmental stage as compared with its mature value. Maximum value attained by a variable has been taken as maturity level. It is calculated as under:

\[
growth\ gradient = \frac{X^a + X^b + X^c \ldots + X^n}{\lambda} \times 100
\]

where

- \( \lambda \) is the mean value of the variable at maturity level.
- \( X^a, X^b, X^c \ldots X^n \) are the mean values of the same variable at given growth stages.

PERCENTILES

The percentile method of expressing position of the individual within a group is of immense importance for establishing norms and standards for any growth study. In the present study, taking the arithmetic 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).

In a cross-sectional sample it is quite likely that the variance of measurement group may be affected by age grouping. To minimize this effect Healey's (1962) correction has been
applied to the standard deviation, so that

\[ \text{Corrected SD} = \sqrt{\frac{(\bar{x})^2 - (\text{Velocity})^2}{12}} \]

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

- 3rd and 97th percentile = \( \bar{x} \pm 1.361 \) corrected SD
- 10th and 90th percentile = \( \bar{x} \pm 1.292 \) corrected SD
- 25th and 75th percentile = \( \bar{x} \pm 0.675 \) corrected SD

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

't' TEST

Student's 't' test has been applied to ensure valid significance test for differences in dispersion or differences in mean values of body dimensions during adolescence. 't' values were calculated for finding out the 'significance' of difference between the means of a given anthropometric measurement at given age level in girls in whom menarche had occurred and those in whom menarche had not occurred. The below mentioned formula, as applicable to small samples (Blackhouse, 1967), has been used to compute 't' values:

\[ t = \frac{\bar{x}_{U} - \bar{x}_{N}}{\sqrt{\frac{1}{n_{U}} + \frac{1}{n_{N}}}} \]
where,

\[ a_c = \text{mean of a measurement in girls in whom menarche had occurred} \]
\[ b_n = \text{mean of a measurement in girls in whom menarche had not occurred} \]
\[ n_c = \text{number of girls in whom menarche had occurred} \]
\[ n_n = \text{number of girls in whom menarche had not occurred} \]
\[ \bar{S}_c^2 = \text{standard error of the mean which has been calculated as follows:} \]
\[ \bar{S}_c^2 = \frac{n_c^{-2} + n_n^{-2}}{n_c + n_n - 2} \]

where,

\[ s_c = \text{is the standard deviation of a measurement in girls in whom menarche had occurred} \]
\[ s_n = \text{is the standard deviation of a measurement in girls in whom menarche had occurred} \]
\[ \sqrt{\frac{n_c^{-2} + n_n^{-2}}{n_c + n_n - 2}} \]

't' values, thus calculated were looked in the table giving percentage points of the t distribution in Fisher and Yates (1957) for the given number of degrees of freedom (i.e., \( n_1 + n_2 - 2 \)).

For the present study the calculations have been done on IBM 1620 computer.