CHAPTER II

REVIEW OF THE RELATED LITERATURE

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CHAPTER II

REVIEW OF THE RELATED LITERATURE

2.0 Introduction

Child growth is an area of study which draws upon many disciplines such as biology, Physiology, Pediatrics, Sociology, Psychology, Home Science, Education and Anthropology in an attempt to understand children. It represents a body of knowledge gleaned from many sources and includes every area of development i.e. physical, mental, emotional and social.

It was in the latter part of the nineteenth century and the beginning of the twentieth century that the first truly scientific investigations of children were carried out. G. Stanley Hall (1844-1941) in America and Alfred Binet (1857-1911) in France were two of the pioneers who stimulated the growth of a science of child development. Today in the second half of the twentieth century, those interested in child development and others are making particular efforts to state theories which seem appropriate in terms of current points of view and knowledge. They are trying to pull from various sources general principles about human beings, their growth, development and behaviour and are attempting to assemble from these sources some overall statements which make sense in the light of present information.
The student of child development must concern himself with the methods used to discover individual differences that exist among children and the changes that occur with age. Much can be learned about children through scientific investigation. As there are many economic and social changes occurring it is vital to learn now to insure optimal development of all potentialities possessed by everyone. Investigators of child development have used a variety of techniques to find out facts about children.

Gardner (1964) has classified the ways in which Scholars and Scientists have viewed the child in the 20th century:

1. the behaviourist approach of Pavlov, Watson and followers,
2. the normative descriptive approach,
3. the psycho-analytic approach initiated by Sigmund Freud.

The normative-descriptive approach has yielded behaviour descriptions for each age level, or "age norms". These norms provide useful reference points by which growth and behaviour of a child can be described and understood more clearly. The contribution of Arnold Gesell and his co-workers in this respect is the most noteworthy (Gesell and Ilg - 1949).
2.1 General Characteristics of Growth

Growth is rhythmic, not regular. A child does not grow a given number of pounds annually or a given number of inches in height. Growth comes, on the contrary, in cycles or waves the 'periods', or 'phases' of growth (Scammon, 1942; Krogman, 1948; Thompson, 1954). This growth is not random or haphazard. As Krogman (1943) has pointed out, "The child grows in obedience to certain biological laws inherent in his phylogenetic history. This means that man has a growth pattern which is at once generalized - his phylogeny and specialized - his ontogony. Research has enabled us to analyse this two fold pattern and to ascertain the part of it, that is uniquely human. In fine, we have a pretty good idea of what constitutes normal human growth."

Studies of the growth cycles have revealed that there are four distinct periods, two characterized by slow growth and two by rapid growth. From birth to two years, there is rapid growth. This is followed by a period of slow growth up to the time of puberty or sexual maturing, beginning usually between the eight and eleventh years. From then until fifteen or sixteen years, there is rapid growth, and is followed by a period of fairly abrupt tapering off of growth to the time of maturity (Meredith, 1935; Scammon, 1942, Krogman, 1948; Thomson 1954). Because growth is an energy consuming process, it is important that the work burden of
the child be adjusted, whenever possible, to meet the demands of growth (Krogman, 1948).

There are variation in the normal pattern of growth cycles. But as Krogman (1948) has stressed with few exceptions, the variation follows as orderly progress; there is a range which we have learned to except. Growth is not a narrow path; it is, rather a broad highway. We do not so much stray from the path of growth as we meander along the highway of growth. Variation is in and of itself an unequal factor, for some children are more variable than others, and variability, in general increases with age. The excessive variability of some children may be explained in part by their hereditary background, and in part by their food and health habits, as well as their health vicissitudes. As a rule a markedly erratic growth progress in a child is a signal for more intensive investigation, for health problems seem to be correlated with extreme deviates. A growth item, i.e. length of a limb segment, which is less variable than, say, weight, will be more significant in its deviation.

A number of factors have been reported to influence the amount of variability that accompanies the growth pattern. Family and ethnic background influence the rates of growth for different children. Similar growth patterns within families in height, bone development, age of sexual
maturing, and eruption and decaying of teeth have been reported (Gould and Gould 1932; Boas, 1935; Reynolds, 1943; Klein, 1946, Krogman 1948; Thompson, 1954; Breckenridge and Vincent 1955). There are sex differences in growth with boys growing faster than girls at certain ages and girls faster than boys at other ages. Variability within the sex group is usually greater for boys than for girls (Norval et al., 1951). For both boys and girls, however, variability in growth rate increases with age (Krogman, 1948).

Body size influences the rate of growth and is responsible for some of the variations that occur. A small child grows over a longer period of time than a large child who has a greater period of initial growth (Muhsam, 1947; Krogman, 1943; Norval et al., 1951). Body type likewise influences variations in growth patterns. Ectomorphs, for example grow in height over a longer period of time than do mesomorphs, while mesomorphs grow faster at each age level, especially in weight (Dupertuis and Michael, 1953). Emotional tension may seriously curtail growth rate, though it has a greater effect on weight than on height (Widlowson, 1951).

Season of the year is responsible for some variation in growth rates, just as there are variations from one year to another. July to middle December is the season most
favourable for increase in weight, with the most rapid gains from September to December. At this time, the average gain is four times that from February to June. The least growth comes from the beginning of May to early July. Growth in height, on the other hand, follows an entirely different cycle. The greatest increase comes from April to the middle of August, paralleling the slow period of increase in weight while the least increase comes from August to the end of November, the period of greatest increase in weight (Marshall, 1937; Reynolds and Sontay, 1944; Krogman, 1948; Dale, 1950; Thompson, 1954). Because seasonal variations are most marked in weight, it suggests that this may be merely a seasonal difference in water content of the body rather than a true growth trend (Thompson, 1954). Or it may reflect differences in time of day when the weighing is done (Krogman, 1948).

2.3 Growth Cycles for Different Organs

The human body does not grow as a whole, nor does it grow in all directions at once, (Thompson, 1954). Each organ and each part of the body follows its own laws of development. The different parts of the body have their own individual periods of rapid growth, and each reaches its mature size at its own individual time. However, as Merry and Merry (1950) have stressed, "All phases of growth are continuous and take place concurrently. For example, the
individual skeleton does not grow on one particular day, while the rest of his structure lies dormant, nor does his nervous system develop at one time and his muscles at another, but all are developing at the same time, each in its own way and at its own rate."

Studies of growth curves for height and weight have shown that they converge until about six years, run parallel until ten years, and then diverge. Height is gained as a constantly decelerating rate, while weight is gained at a constantly accelerating rate. As Krogman, (1948) has expressed it "we get taller, faster, heavier slower". The lower part of the face grows more rapidly than the upper especially from ages five through eight years (Allen, 1948). In muscular growth it has been found that increase in breadth of the muscle in the calf of the leg comes with increasing age. Growth occurs at a rapidly decelerating rate in the second year, at a slowly decelerating rate to the onset of puberty, then at an accelerating rate during puberty, and at a decelerating rate thereafter until growth ceases (Lombard, 1950).

A realistic picture of the change in body proportions that occur between birth and maturity can be obtained by considering the amount of growth which each major segment of the body normally undergoes (Gardner, 1964).
At birth the head comprises one fourth of the total body length, whereas in an adult the head is about one eighth of the total length. The proportion of legs to total length changes from approximately one third at birth to one half at adulthood. The difference in the rate of growth of the different segments of the body during the development period is as follows:

The head doubles its length.
The trunk triples itself.
The arms increase about four times.
The legs increase about five times.

It has been noted by scientists that the rate of development is not constant and different parts have their own individual patterns and sequences of development. In measurement of the same child, taken at different periods in his life, it is seen that he is growing rapidly at some times and very slowly at others (Hurlock, 1950).

During the first year stem length and total length increase at approximately the same rate. After the first year legs begin to grow more rapidly than the combined head and trunk. By two years the legs are about 34 per cent of total length, and by five years about 44 per cent.* By two years a child's legs have doubled their length; by five

* Calculated from data by Meredith and Knott.
years they have almost tripled their length. In the first two years there is a more rapid increase than that between two and five years. Stem length is less than doubled by five years of age. About half of the increase during infancy and pre-school years occurs before eighteen months. Thus, both growth in stem length and in leg length indicate a rapid but decelerating rate in these early years.

2.3.1 Qualitative aspects of Physical Growth

(a) Weight

The components of weight vary in their proportion to total weight with age and between children of the same age. For example, at birth about 25 per cent of the total weight can be attributed to muscle, 16 per cent to the vital organs and 15 per cent to the central nervous system, whereas at maturity muscles, viscera and the central nervous system will represent approximately 43 per cent, 11 per cent and 3 per cent respectively. Two children may weigh the same, yet one may have relatively large muscles and the other relatively more fat.

Early matured ones have more fat than late matured ones. During childhood and adolescence boys are consistently larger in muscles and bone while girls in fat. It would seem that increase in weight during adolescence means relatively more increase in muscle for boys and fat for girls.
During early life, growth in weight is characterized by a rapid but decelerating rate for the first two years, slow deceleration in rate for the remainder of the preschool period. Thus an infant doubles his weight by five months, triples it in the first year, and quadruples it by the end of two and one half years.

The gain in weight from two to five is less than the amount gained in the first year of life.

By two years of age a child is approximately one fifth as heavy as he will be at eighteen; by five years he has achieved approximately one third of his weight at eighteen. Girls are slightly advanced over boys in their progress toward attaining mature weight (Stuart, H.C., 1959).

There is a wide variability in weight among small children of the same age. Children who are heavier at birth tend to remain heavier throughout infancy and early childhood. One study (Tanner et al., 1956) reports that about 25 per cent of the variability in children at three years of age can be attributed to birth weight. Boys have a slight tendency to be heavier than girls, and also there are some differences at the same age for the same sex. According to Stuart, 80 per cent of boys at two years, weigh between 24.7 and 31.9 pounds; at five years 80 per
cent weigh between 35.5 and 46.7 pounds. These wide individual differences are also true of girls.

The factor contributing to individual differences in weight is family-line heredity. Which includes race, emotions and environment. The environmental factors, especially those related directly to nutrition, have a particularly strong influence on weight, as indicated by studies of height and weight of children in time of war.

In addition to differences in weight between children fluctuations in growth in weight occur from time to time in an individual. The curve for growth in weight is not as smooth as that for growth in height. This can be expected since weight, which represents body bulk, including muscle, bone, the various organs, fat and water, is fairly easily affected by environment and the health vicissitudes of a child.

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* The resemblance in the early years between parents and children is less for weight than for height. Bayley found correlations between parent and son to be rather low with a tendency to increase with age. The father-daughter correlations indicated some relationship by five years but never reached statistical significance. However, the daughter-mother correlations showed strongly increasing similarities which were significant by six years of age.

** The instability of the pattern of growth in weight has been indicated in the Berkeley study in which correlations with adult weight were found to be .44 for boys and .59 for girls at three years and .44 and .68 respectively at five years of age.
The weight of the child at every age is dependent to a certain extent upon his body build. To discover the "Normal weight" for a child, it has been suggested that the most accurate indicator is to use calf width and height (Massler and Suher, 1951).

Many children are obese in that they are proportionally too great for their height; very rarely this is due to glandular condition. On the contrary, it generally stems from psychological factors of an unfavourable sort, such as overdependency, feelings of rejection and feelings of inadequacy (Bruch, 1939, 1940, 1941, 1943; Bruch and Touraine, 1940).

Bad family eating habits and constitutional factors are likewise responsible for obesity (Tolstrap, 1953). Among older children and pubescents, appetite increases and habits of overeating may develop (Wolff and Bayer, 1952). While most obese children derive their overweight from fat, others are too heavy because of their bone and muscle development (Reynolds and Asakawa, 1948).

Birth order has little influence on variation in body size. There is, however greater correlation in height than in weight measurements for brothers (Howells, 1948). Sex differences in favour of boys are present from birth.
until eleven or twelve years in both height and weight. The girls are slightly larger than boys until the fifteenth year, after which boys again surpass girls (Simmons, 1944, Krogman, 1948; Thompson, 1954). Variations due to racial stock have been reported for children of all ages. While Negro babies during the first year of life do not differ in size significantly from white babies of comparable economic levels (Bakwin and Patrick, 1944; Scott et al., 1950), differences become greater with age as the Negro child typically is of a more slender build than the white child (Royster, 1936). Children of Finnish ancestry are larger than those of Italian ancestry at all ages (Mutheny and Meredith, 1947), as is true of those of Mexican ancestry (Meredith and Goldsteen, 1952). Children from Okinawa are smaller in both height and weight than are children from France, South Africa or the American Indians (Meredith, 1948).

Size varies with level of intelligence; children of high level of intelligence are taller and heavier for their ages than are children of lower levels of intelligence (Hollingworth, 1926; Katx, 1940; Thompson, 1954).

Variations in size according to the socio-economic status of the family are marked, especially in weight. These differences are due to differences in diet, during the early years of life, (Bowler, 1932; Meredith, 1941;
Hopkins, 1947; Meredith and Meredith, 1950; Greenbery and Bryan, 1951). Children whose fathers belong to the professional or managerial class are larger in every body measurement than children of skilled or semiskilled workers. These differences become greater as the children grow older (Amer and Flory, 1944; Meredith, 1951).

The I.C.M.R. (1972) undertook the cross-sectional study on different aspects of growth and development of Indian Children from birth to 21 years of age on a countrywide basis in 1957. Experts in the field of anthropology, statistics, nutrition and pediatrics participated in the projects and collected and processed the much needed information on growth norms and developmental standards of Indian Children. The findings were published in 1972.

According to I.C.M.R. (1972) conclusions, the mean weight of children from 1 to 18 years increased with age, the range being 8.4 kg. to 47.4 kg. for boys and 7.8 kg. to 42.4 kg. for girls. The initial sex difference of 0.6 kg. at age one year was halved by the age of five years and this difference was maintained till the age of nine years. Thereafter, the girls began to overtake boys at age of ten years and continued to be heavier than them until fourteen years of age, the maximum sex difference in the mean values being 1 kg. After the age of 15 years, the boys gave an
indication of faster increase in weight than the girls as judged by the mean values. Between 15 & 18 years the mean values for boys increased by about 7.8 kg, whereas for girls it was only about 3.6 kg.

A total increase of 39.0 kg. in mean weights between ages of 1 and 18 years in boys and 34.6 kg. in girls was observed. The variability of the mean weight increased steadily with age of 15 years for both the sexes and then decreased.

Someswara Rao, Taskar and Ramanathan (1954) made a health survey of 2015 children in the Nilgiris. The children were from homogenous racial stock and came from poor and lower middle class families. The ages of the children ranged from 2 to 19 years. The findings of the study regarding the children of weight of the two to six years of age showed that boys were heavier than girls.

Ila Devi (1958) made a study of the weight of boys and girls from five to seventeen years of age. The subjects were pupils from various schools in Delhi. At each level twenty five girls and twenty five boys, were randomly sampled. Her findings at age level of 5 and 6 years showed that boys were heavier than girls. Medical examinations of school children of middle and higher class were made in Bombay by Athavale. Athavale, (1959) did not give separate
measurements for boys and girls. However he pointed out that the maximum weights of these children corresponded to about the 75th percentile of the American male child, and the minimum weights in the age group three to nine years corresponded to the third percentile weight of the American children two to three years younger.

Measurements of weight in the Chetan Balwadi, Baroda were compiled by R.C. Smart in 1960. These measurements as well as those made by Athavale and Ila Devi were higher than those for the Nilgiri children. The samples used in these studies were too small to permit scientific generalization. However, perhaps the Nilgiri sample contained children of more poorer class than the samples in the other studies, might account for their lower standing in physical measurements.

Boys grow in weight from a range of 6.3 to 9.1 pounds at birth to a range of 120 to 169 pounds at eighteen years. Girls show from a range of 6.2 to 8.6 pounds at birth to arrange of 103.5 to 144.5 pounds at eighteen years. (Staurn and Meredith norms).

(b) Height

At birth a baby is generally 19 to 21 inches long. Boys tend to be slightly longer than girls and the first
born tends to be a little shorter than later babies in the family. According to Stuart's norms. *80 per cent of newborn boys range from 18.9 inches to 21 inches, girls range from 18.8 inches to 20.4 inches.

Growth in length in infancy and early childhood is characterized by a rapid but decelerating rate from birth to two years of age and by a slowly decelerating rate for the pre-school years. By three months a baby will have gained 20 per cent of his birth length; by one year, 50 per cent; and by two years, 75 per cent. At about four years he will have doubled his birth length. The slowing-down of growth in length in the pre-school years is dramatically indicated by the fact that a baby in the first year of life gains about an inch and a quarter more than he will gain between the ages of two and five years (Stuart's norms).

With this early rapid growth it is not surprising to note that a large percentage of adult height is achieved in the first few years. Half of adult height is usually attained by girls between one and a half and two and a half years, and by boys between two and two and a half years.

* These norms are based on measurements of a group of healthy white children of north European ancestry living in or near Boston, for the most part of lower economic status but all under regular health supervision.
Sixty per cent is achieved by girls at three and a half years and by boys at four and one half years. Thus girls progress toward mature height faster than boys.

Individual children vary considerably in height. Sex differences have been mentioned above. The early superiority of boys become negligible for four and five-year olds. According to Stuart's norms 80 per cent of two-year-old boys will measure between 33.1 and 35.9 inches; 80 per cent of five-year-old boys will measure between 40.8 and 45.2 inches. Similar differences can be expected of girls. Children of widely differing backgrounds will show even greater variability.

The pattern of growth in height for individual children is somewhat stable, as indicated by the Berkeley Growth Study. During the first year, the children's height correlated close to .5 and .6 with their stature as adults. This correlation increased to .63 and .65 for boys and girls respectively at three years of age, and to .86 and .82 respectively at five years of age.* However, the pattern of growth in height may vary from child to child; some may be fast growers from the start; others

* Tanner et al., also in correlating early stature with adult stature found the correlation at two years to be .79 and .74 for boys and girls respectively and at five years to be .77 and .81 respectively.
may be slow growers. Children in the early years may not resemble their parents in tallness or shortness but become similar to them as they grow older. Bayley gives an example of one child who resembled his parents in stature from an early age while still in the pre-school period. Another was consistently tall for his age until sixteen years of age when he stopped growing and became an adult of average height. Bayley found that most children tended to become more like their parents in stature as they grew older.

Correlations between the adult height of the parents and that of the children increased and became significant before they had passed beyond the pre-school years. Thus, this studies indicate, not only are there differences in growth patterns, but also that a genetic factor is involved in determining the stature of an individual.

Young children in a superior environment generally are taller than children of comparable age, who live in less favourable circumstances. Japanese children are shorter than American white children. Negro children also tend to be shorter than white children. These differences, however, cannot be attributed solely to race. Japanese children born and reared in America have been found to be taller than those born and reared in Japan. A study of the growth in height of Negro infants from families in the
lower middle class has shown that the growth curves of Negro and White infants from comparable economic levels are similar. Growth in height of an individual child is, therefore, dependent on the interaction of his heredity and his environment. Heredity sets the potential for growth in height; health and environment determine the degree to which that potential is achieved.

According to I.C.M.R. findings, (1972) the height increases with the age of the child. The ranges of means of height were 73.9 cms to 163.1 cms and for boys and 72.5 cms to 151.7 cms for girls. The boys were taller than girls at all ages say at 10, 11 and 12 years. Between 1 through 9 years sex differences in the mean values lay between one cm and two cms. At nine years of age, it started decreasing until the girls overtook the boys at eleven years. After the age of twelve years, the increase in the mean values for boys was rapid than that for girls, and as a result at age eighteen years the sex difference in the mean values was 11.4 cms. The sex difference was statistically significant after the age of fifteen years. Both for boys and girls, the variability of the means increased steadily until the age of twelve years, and thereafter there was a steady decrease for girls, the trend for boys being irregular. For boys the values of S.D. were higher than those for girls after the age of twelve years.
Growth in height generally ceases somewhere between sixteen years and the early twenties.* Studies demonstrate that children of the same chronologic age who are further advanced toward sexual maturity are taller than those who are mature more slowly. In one study among fourteen year old boys the postpubescents were 4.6 inches taller than the pre-pubescents; in another study the average twelve year old girl who menstruated before her thirteenth birthday was 4.34 inches taller than the average twelve year old girl who did not menstruate until she was at least fourteen years old.

The initiation of the period of rapid growth in height generally occurs sometimes between two and one-half to three and one-half years before menarche and the year of most rapid growth sometime within the two years preceding menarche. For example, according to Shuttleworth girls who menstruated for the first time at eleven years had their year of most rapid growth in the preceding year between their tenth and eleventh birth days. Those who menstruated for the first time at fifteen years, however, has their most intensive growth between twelve and a half and thirteen and a half years. Boys according to Stolz and

* Brush Foundation figures give fifteen to twenty years for boys and fourteen to eighteen years for girls. These Cleveland children can be considered above average economically and socially.
Stolz have their greatest gains concurrently with increase in the size of the genitalia.

Boys grow in height from a range of 18.6 to 21 inches at birth to a range of 65.5 to 71.8 inches at eighteen years. Girls grow from a range of 18.8 to 20.4 inches at birth to a range of 61.5 to 66.7 inches at eighteen years (Stuart and Meredith).

Progress also can be expressed in terms of the percentage of achievement. At birth the percentage of mature height is 30.9 for girls and 26.5 for boys at five years, 66.2 and 61.8, at twelve years, 92.9 and 84.2 at fifteen years, 99.1 and 96.1 for girls and boys respectively. Mature height is reached at seventeen years for girls and eighteen and one-half years for boys.

(c) **Head Circumference**

According to I.C.M.R. findings, (1972) the head circumference was found to increase steadily upto the age of 18 and 17 years for boys and girls respectively, being 44.4 cm upto 53.5 cm for boys and 43.6 cm upto 52.5 cm for girls. The boys had a large mean circumference relative to the girls, except during the ages 13 and 14 years when girls caught up with the boys. The sex difference in children aged 3 and 4 years was about 1 cm which was
statistically significant. The maximum increase in the mean values occurred between 1 and 5 years for both sexes.

Prasad, (1964) quotes Westropp and Barber's longitudinal study of head size in 331 boys and 333 girls of Oxford Child Health Survey in 1944-45. The mean value of head circumference of boys was a fraction larger than mean value for girls.

The head of a child at birth measures 12 to 14 inches in circumference, the circumference being slightly larger in boys than in girls. By one year the head has increased about 33 per cent; by five years, when it closely approximates its adult size, it has increased 48 per cent.

The surface area of the head decreases from 21 per cent of the total surface area of the baby at birth to 13 per cent at five years, 10 per cent at twelve years and 8 per cent at eighteen years (Boyd, 1935). At ten years, the head is 95 per cent of its adult size and at fifteen years, 98 per cent (Devenport, 1940).

(d) Chest Circumference

According to I.C.M.R. findings, (1972) the chest circumference increased steadily with age upto 10 years and thereafter the mean values increased steadily. The range
was 43.3 cm. to 75.5 cm. for boys and 42.3 cm. to 73.8 cm. for girls. During the pubertal period 11 to 15 years girls overtook the boys. The maximum sex difference during pubertal period was 2.4 cm. at the age of 14 years. For all the ages, the sex difference was not statistically significant.

The variability of mean values increased with age. These values were more consistent for girls than for boys as judged by the co-efficients of variation.

Chest circumference of boys and girls were not found to be significantly influence by the socio-economic status.

It was also observed that the mean values of chest circumference of children belonging to urban areas were higher than those of children from rural areas, and girls were also higher than boys for a particular period (11 to 14 years).

From I.C.M.R. findings, (1972) it was observed that the ratio of the chest circumference to the head circumference was less than unity up to the age of two years and 6 months and two years and 9 months beyond which the chest circumference overtook the head circumference. Among American children the chest circumference overtook the head circumference by about the age of one year (Watson and Lowrey, 1962).
(e) Sitting height

According to I.C.M.R. findings, (1972) the mean sitting height increases with the age of child. The boys were taller than girls at all ages except 11, 12 and 13 years and equal at eleven and fourteen years. The sex difference was around 1 cm. up to the age of 9 years, and vanished at ages 11 and 14 years.

Mean and standard deviations for sitting height of children from 9 to 14 years by sex and stated age with actual number of children measured.

2.4 Factors Influencing the Physical Growth

(a) Residence (Urban/Rural)
(b) Socio-economic status
(c) Race
(d) State and countries
(e) Nutrition
(f) Food habits
(g) Endocrines
(h) Thyroid glands
(i) Adrenal glands
(j) Sex glands
(k) Pituitary glands
(l) Heredity and environment
(m) Sex of the child
Factors influencing the physical growth

(a) Residence (Urban/Rural) and its influence on physical growth

It is generally believed that the place of residence of children exerts some influence on growth, but reports on this aspect in literature are few. It was observed from I.C.M.R. data, (1972) that the mean values of height and weight of children belonging to urban areas were higher than those of children from rural areas during the growth period. However, the differences were not statistically significant. The same trend was seen in other anthropometric measurements as well.

It has been also shown from Indian data that the urban girls attain age at menarche earlier than the rural girls (Shantha Madhavan, 1905). It was interesting to find that puberty signs appeared more or less at the same mean ages for both urban and rural boys, whereas urban girls attained
puberty signs earlier than those from the rural areas as judged by the mean ages. The mean ages for boys ranged from 14.00 to 17.42 years and 13.42 to 16.63 years for urban and rural areas respectively. For girls, the corresponding ranges were 11.73 to 13.39 years and 12.07 to 14.04 years.

Bad housing is a symptom of low economic status and usually does not exist alone. It is frequently accompanied by inadequate food, insufficient medical care and crowding. This gives poor chances of good development for children.

(b) Socio-economic status and its influence on physical growth

Socio-economic status plays a dominant role in the growth and physical development of children. Children from different socio-economic classes with the same community differ in their average body size at all stages, even at birth those of upper socio-economic class always having the highest. The influence of socio-economic factors is manifested in the nutrition and the entire environment which the children are compelled to adopt. Children from better socio-economic classes would naturally have better nutrition and better environment (Wilson et al. 1937; Wilson and Mitra, 1938; Mitra, 1940; Varkki et al. 1955).

Socio-economic status determines to a large degree the paucity or abundance of those conditions which are
conducive to healthful living. Many studies in the past have pointed to the fact that material well-being affects physical development. Investigators have accumulated evidence by comparing private and public school children, by grouping children according to the family income, according to the occupation of the parents, or the type of neighborhood in which they live. Meredith (1951) has summarized the evidence presented in American Studies for boys seven to ten years old. Karpinos (1956) found differences in height and weight between selective service registrants of differing socio-economic status. Hummond, (1957) reported similar differences among English children. Using several studies, Meredith, (1951) concluded that white boys of the professional and major managerial classes, are taller and heavier than those of the unskilled and semi-skilled classes. The difference between the two classes averaged one inch in height and three pounds in weight. As Meredith, (1951) states, the explanation of differences in height and weight between different socio-economic groups is not known, but diet, housing conditions, health practices, occupational demands and selective mating are possible contributing factors, sexual maturing as indicated by menarche occurs earlier in better than in poorer socio-economic levels.

Height and weight of children were found to be significantly influenced by the socio-economic status of the
children. In both sexes they were seen to be highest in the case of children belonging to the highest socio-economic status and lowest in case of those belonging to the lowest socio-economic status. Similar trend was seen in the mean values of other anthropometric measurements.

While discussing the environmental trend among the American Negroes, Michelson, (1945) states that the greater incidence of tuberculosis and syphilis, higher mortality rate and more illness among the Negroes than the Whites can be associated with factors which go to make up the Negroes' poor socio-economic status.

Hardy et al., (1938) in a study of the health records of 6438 children, representing widely different income levels and various types of community areas in Chicago, found an association of low income with poor physical conditions. More dental care as judged by the physician was needed in the lower income class. The physician considered the children from the lower economic level less robust than those from the other groups. Ratings indicative of excellent health, were three times as frequent at the economically independent level as at the relief level. Underweight, as judged by a comparison with Baldwin-Woods standards was noted more frequently in the low income class.
There is a definite relationship between low incomes and subcritical malnutrition. Roberts gives poverty as one of the underlying causes of malnutrition and cites evidence to prove that when families have inadequate income, they are unable to give their children proper food. A study of urban grade school children in Pennsylvania revealed better general physical ratings, better bone development and better reserves of vitamin A in the upper income group, though it found no differences in weight status, dental scores, or in hemoglobin. Another study of high school students in New York city found indications of vitamin -A, C and riboflavin deficiencies more frequently in lower than in higher income levels.

It can be realized of course, that the poor physical condition of low income children springs from more than the actual food, shelter and medical care. The poor physical condition of children in low income families may, therefore, be due to a complex of hereditary, nutritional and social factors.

(c) Race and its influence on physical growth

Racial differences in body proportions as well as rate of growth have long been observed. North and South European stock (Scandinavian and Italian example) may differ as much as four years in rate of maturation, with the latter more accelerated. Members of the yellow race tend toward shortness
of structure and Italians tend to be shorter than Anglo-Saxons (Shuttleworth, 1934). Comparisons of White and Negro babies during the first years of life revealed that the developmental level achieved by the Negro babies was about 80 per cent that of the White babies (McGraw, 1931). In comparing children of various races in Hawaii, it was found that children of North European stock had the greatest stature at each age, followed in order by Hawaiian, South European, Chinese and Japanese (Shuttleworth, 1949).

Some of these early studies of race and growth were naive in ignoring socio-economic status. However, even taking this into account, differences still exist, but not to as great an extent. In one recent extensive medical research project, nearly 900 matched pairs of American born and native born children of Japanese parents were studied. The American born (California) children were found to be taller, heavier and more advanced in development than had been supposed. At every age included in the study (six to nineteen years) the American-born Japanese boys exceeded in average stature, the boys of Japan by an amount greater than the increase which has taken place in the average stature of the boys of Japan since the beginning of the present country. The difference among females was similar to that of the males.

Thus it is apparent that in evaluation of a child's growth, one must consider the child in relation to his racial
and ethnic group but it must not be overlooked the effect of his particular home environment.

(d) State and Countries and their influence on physical growth

From the I.C.M.R. data, (1972) the mean values of standing height and weight of children belonging to different states were found to be significantly different from another. The growth pattern varied from state to state throughout the age range. The children from Panjab and Delhi were taller and heavier than children from other states.

It was also found that Indian children were shorter and lighter than their counterparts, in the United States (Waston and Lowrey, 1962) and in Britain (Provis and Cellis, 1955). The difference in the growth was more pronounced after 13 years of age in both sexes. Indian children who belonged to the highest socio-economic status displayed growth pattern similar to that of the British children. This might implicate the influence of better nutrition and better standard of living enjoyed by children who belonged to this highest socio-economic status than those from the other classes.

American girls were taller between ages eleven and thirteen and heavier between seven and fourteen years than the boys. For the rest of the age range the situation was reversed.
In case of British children the mean values of height and weight of girls were higher than those of boys between the ages eleven and thirteen years and eleven and fourteen years respectively. Among Indian girls, mean heights and weights were relatively greater at eleven and twelve years and between ten and fourteen years respectively.

The co-efficients of variation of height of Indian boys aged five years and seventeen years were 7.9 per cent and 6.5 per cent respectively. The corresponding values for girls were 7.2 per cent and 5.0 per cent. The co-efficients of variations of weight of Indian boys aged five years and seventeen years were 15.4 and 19.8 per cent respectively, the corresponding values for girls being 16.0 per cent and 15.9 per cent. These values were higher than the corresponding values of American and British boys and girls.

(e) Nutrition and its influence on physical growth

It is an accepted fact that food affects health and growth; that nutrition can be a limiting factor in growth and development. Under-nutrition and mal-nutrition are found all around the world, but they are more prevalent in some areas than in others. Under-nutrition is a condition due to inadequate food in which the deficiency is quantitative rather than qualitative i.e., a deficiency of calories with the nutrients fairly well balanced. Such was the condition in
much of Europe during and directly following World War II, described in studies of undernutrition, Wuppertal, 1946-1949. In the United States, whose economy is such that sufficient food is available to almost everyone, malnutrition, is not so much a problem of groups of individuals. There is even the problem of overnutrition's leading to obesity. In technologically underdeveloped areas with low per capita supply of food in general and certain kinds of nutrients in particular and limited purchasing power, evidence of the relation of nutrition to health and growth can be observed.

In the United States, Spies and his co-workers (1949) have compared the growth of children with and without nutritive failure. These children were of the same ethnic stock and lived in the same geographical area. The children with nutritive failure at three years of age showed a substantial lag in height and weight. This weight lag increased progressively in boys and girls to fifteen years and nine months. The height lag increased progressively for boys, in girls it remained fairly constant. Average difference in height throughout the age range was 2.42 inches for boys and 1.77 inches for girls. Range extended from mean of 1.11 inches at twelve years to 5.61 inches at fourteen years for boys, and from seven years, three months to 3.60 inches at thirteen years, three months for girls. The speed of growth as determined by the Wetzel Grid, (1948) was slower for those with nutritive failure than for those without nutritive
failure. Children with nutritive failure also had a disturbed pattern of skeletal development.

On the other hand, children of today in countries with higher standards of living are generally taller and heavier than children of former generations and are maturing earlier. Nutrition is thought to be one of the factors associated with this increase.

There are vast differences in the food eaten in families. Income, availability of foods, family size, management and food habits are some factors contributing to these differences. Studies of differential growth in the different socio-economic levels point to nutrition as a contributing factor.

Growth of children in weight and to a lesser degree in height has been shown to be affected during war time by restrictions in food intake, caused by scarcity of food.* The extent of the growth deficit is related to the severity of the undernutrition or malnutrition. Evidence comes from observations during World War II in France, Belgium, Greece and Holland. In Holland, in 1945, for example, most children over one year of age lost weight, and toward the end of the

famine period they ceased growing in height. In Greece 55 per cent of the three to eight year olds were underweight for height in 1942 and 1943 and 64 per cent in 1944. In a French study of children from six to twenty year of age the thirteen year old girls were the most vulnerable. Children who continue to grow up with inadequate food will not have the opportunity for rehabilitations and thereby will be unable to achieve their potential for growth.

Studies have shown that improvement of inadequate diets can improve the health and growth of children. Spies and his co-workers, (1949) have demonstrated that milk added as a supplement to inadequate diets of malnourished children will improve their growth. Children of four to fifteen years of age during a twenty month period of supplementation averaged an increased monthly gain of 3.6 per cent in height and 29 per cent in weight. When the milk was withdrawn for the following twelve months, the improvement ceased.

A second study (Spies, T.D., et al., 1953) was made of the skeleted maturation of 82 children, half of whom received a dietary supplement of dried milk equivalent in protein value to three quarts of milk per week for forty months, after which the supplement was increased to twelve quarts of milk per week for six months. The other
half of the children served as controls. During the forty months little difference in progress in bone maturation was found between the two groups. However, when 19 of the experimental group were given twelve quarts of milk a week, they increased their rate of bone maturation by 80 per cent over that of the former period and far surpassed the other children who had no milk or only three quarts.

In India, a group of children between four and fifteen years of age is an orphanage, were given 2 ounces of the multi purpose food daily for 5 months in addition to their regular diet. Those receiving the multipurpose food made significantly greater gains in height, weight and hemoglobin levels than did a group who served as controls.

In Nigeria the limiting factor in the growth of the Munshi Children was found to be iodine. After four years of feeding iodine, children were on the average, about 4 inches taller than their parents.

Pett, (1953) in a Canadian orphanage was able to demonstrate improved weight, a decline in respiratory infections, enlarged or infected tonsils and various mild illnesses, and unmeasurable benefits such as liveliness, better work in school and more energy for recreation when the milk intake was increased from 8 to 24 ounces per child daily.
The amount of energy needed in terms of calories varies from individual to individual and is dependent upon a number of variables. The fast-growing child will need more calories than the slow-growing child. During the periods of his life when the impetus to grow is most intense, infancy and early adolescence, the amount of energy required for growth will be greatest. Johnston (1944) shows that the caloric requirement of the adolescent girl parallels her rate of growth.

The vitamins, as regulators of body processes, have a vital role to play in keeping children well and furthering their development. The vitamins now recognized as contributing to the health and growth of children and youth. Proteins make up a part of all body cells and participate in nearly all life processes; therefore, they are necessary for growth. A study in France during World War II indicated that a deficiency of animal protein was a determining factor in the incidence of tuberculosis.

Carbohydrates and fats, as the chief sources of energy, are necessary for growth, in that they furnish energy for the growth process. Inadequate energy-yielding substances will slow down the rate of growth.

In the past, the most important influence on the growth of adolescents was nutrition and there is a
plethora of data available which records a progressive increase in the heights and weights of school children and the association of these parameters with the trend towards earlier puberty and greater fertility in many countries of the World (Tanner, 1962; Takahashi, 1968; Van Weiringen, 1972; Masse and Marti-Henneberg, 1975; Frisch, 1978).

Secular anthropometric measurements of children are good indicators of the state of health and nutrition of a population whose ethnic, demographic and socio-economic characteristics are known precisely.

The very early study by the British Association (1884) showed marked differences between the heights of boys drawn from different social classes. Over fifty years later, Boyd Orr, (1936) observed that the average height of 14 years old boys in the lower socio-economic level was 8 cm. below that of the artisan boys of the same age, and 15 cm. below that of boys of professional class. From 1883 to 1936 the average height for the upper and middle classes rose significantly, but there was little change in the height of children from the lower class.

Scott, (1961) reported a consistent pattern of lower heights and lesser weights as family size increases. The report showed that intelligence and physique tended to decrease as family size increased.
Cook et al., (1973) have confirmed that children from the lower socio-economic levels and larger families have poorer stature which could be related to a decreased intake of most nutrients except for carbohydrate, particularly sugar.

Miller et al., (1972) carried out one of the few longitudinal studies of human growth from birth to adult life. In 1968, they traced and measured 201 males and 240 females who were born in 1947 and who had been observed in the course of their thousand families in Newcastle upon Tyne study. They showed that a social gradient existed and there was a significant degree of correlation between birth weights, early growth, and subsequent adult size, which suggested that the effects of early growth retardation be irreversible. The need to ensure that children enter adolescence without any nutritional handicap acquired during early life is, therefore, of the utmost importance.

Schraer and Newman, (1958) reported that in Peru, a diet largely deficient in calcium, fat, proteins, vitamins, and energy produced a significant slowing of the rate of growth at about 10-15 years, delayed the adolescent growth spurt and resulted in a final small adult stature.

Today, the link between socio-economic level and size of child cannot be explained wholly in terms of nutrition.
or other environmental influences, heredity and ethnic background are playing an increasingly important role.

Gram and Wagner (1969) observed in their studies that the gain in skeletal weight due to calcium is most rapid during the adolescent growth spurt. Average linear growth during this period may be as much as 0.25 mm/day and the skeleton may gain 1.2 g of dry weight per day. About 45% of the adult skeletal mass is formed during adolescence, continue well beyond the adolescence period.

All of the calcium for the growth of the skeleton must be derived from the diet, and in the normal human adult about 1200 g of calcium are found in the bones. Girls enter adolescence with a skeleton weight of approximately 1500 g, and finally achieve a skeleton weight of about 3000 g. Boys enter adolescence with about 2300 g of skeleton indicating the larger bone diameter and thicker cartex, and finally attain some 4300 g of dry skeletal weight. The largest gains are made in early adolescence, about 10.14 years old in girls and 12-16 years in boys. After 18 years of age, new bone formation is markedly reduced in both sexes (Garm and Wagner, 1969).

(f) Food habits and their influence on physical growth

Dietary habits which affect food preferences, energy consumption and nutrient intakes are generally developed in early childhood and particularly during adolescence.
Although the home and school environment play a major role in determining a child's attitude to and consumption of individual foods.

Schorr et al., (1972) studied some of the factors which affect teenage food habits, including food preferences, nutritive intakes and the relations between food consumption practices and several life-style characteristics in 118 adolescents in the U.S.A. The complexity of an adolescents diet was found to increase significantly with the father's and mother's occupational level, the extent of the teenager's social participation, and whether or not the adolescent had a job. Diet complexity was related to neither age, sex, and family size, nor interestingly enough, to the number of available nutrition information Channels.

The period of the most rapid accumulation of fat are in the first year of life and during early adolescence. These changes are apparent from the analysis of fat fold data (Garn and Clark, 1976) and from calculations of changes in fat and LBM (Lugdale, 1975). There are sharp sex-related differences in the amount, thickness, and time of deposition of adipose tissue.
Gran and Clark (1976) reported that, in general, the male is the leaner of the two sexes with boys tending to show a decrease in fatness from age 3 to 8 and an initial adolescent gain in fat followed by a latter adolescent loss in fatness. On the other hand, girls show a gradual prepubertal gain in fat followed by a substantial increase during the adolescent years, so that by the end of adolescence the female has about twice as much fat as the male.

Stunkard et al. (1972) reported that obesity is far more prevalent in adolescents in the lower socio-economic classes and strikingly so in the case of girls. However, Garn and Clark (1976) showed that there is a greater prevalence of obesity in the higher income groups in males at all ages, especially during adolescence. For adolescent girls and women at all ages, there is a remarkable income related reversal of fatness. Before puberty, poorer girls are leaner but from late adolescence in the poorer girls and women become fatter, whilst the girls and women of higher incomes become leaner. These socio-economic differences in prevalence of obesity persist into adulthood (Garn et al., 1977).

Many obese children have a strong family history of obesity. Garn and Clark (1976) provided new basic family line information on the genesis of obesity to test the
genetic hypothesis. The authors demonstrated that parental fatness had a clear influence on the fatness level of the offspring. The level of fatness of the child rises progressively with the level of fatness of the parental mating combination.

(g) Endocrines and their influence on physical growth

The endocrines are intrinsic regulators of development. They affect health and development through the secretion of complicated chemical substances, called hormones. Differences in the amount of hormone secreted and differences in the response to these substances produce diverse patterns of bodily function and development. In the case of the pituitary, too little growth hormone may produce dwarfism; too much may result in gigantism; a normal level of secretion will make for normal growth.

(h) Thyroid and its influence on physical growth

The thyroid gland secretes a hormone which regulates the rate of oxidation in the body. The activity of the thyroid influences the rate of growth, the development of the bones, the nervous system, circulation and muscles. A decrease in the thyroid function, results in a decrease of tissue activity. In most cases intelligence is seriously retarded and attention is dulled. Movements
are slow and awkward. Johnston (1944) stated that some decrease in the thyroid function, delayed in growth and development, mental retardation, fatigue and menstrual disorders.

(i) **Adrenal glands and its influence on physical growth**

The hormones secreted by adrenal glands are responsible for the accelerated growth and muscular development in boys and girls during adolescence period. Without a sufficient amount of these, girls fail to develop pubic and axillary hair.

(j) **Sex glands and their influence on physical growth**

The presence of a sufficient quantity of these sex hormones is necessary to stop growth in height at the proper time. If the testes and ovaries mature early and produce their secretions too soon. Growth is prematurely arrested and the child is abnormally short at maturity, although shortness is not always due to an endocrine disturbance. Excessive secretion in early childhood produces precocious puberty. If, however, adequate production, of the sex hormones is unduly delayed, growth especially that of the arms and legs, continues longer than would be expected, and the individual becomes quite tall with disproportionately long arms and legs.
(k) **Pituitary gland and its influence on physical growth**

The hormones produced by the pituitary gland regulate body growth. If there is an excess of this hormone during the growing years, an individual may become a giant, attaining a height of as much as 8 or 9 feet. Ordinarily growth in these bones ceases during adolescence but in giants, these bones continue to grow for a longer time. A deficiency in the secretion of this growth hormone suppresses growth. The extreme of such a condition is one type of dwarfism.

Normal growth and development depend upon the reciprocal and properly timed action of the various hormones.

(1) **Heredity and environment and their influence on physical growth**

The mechanisms of heredity serve in much the same way as the programme of a modern electronic computer. Just as the programme tells the computer what to do with the information fed into it, so the genes "tell" the organism how to use materials of the environment to grow and develop and how to maintain a proper balance of internal conditions.

Individual differences are due to environment when individuals having the same heredity are subjected to
different environments. But individuals of differing heredity are not made alike by exposure to the same environment. They can be made alike (in some aspects) by unequal environmental pressures compensating for their unequal heredities. For the most part, individual differences are the result of heredity and environment combined.

There are three important points on heredity:

(1) The child's heredity is derived from both his parents.

(2) It is fixed and determined at the moment of fertilization on conception, no additional heredity can get into him later, even from the mother who carries him and provides his nourishment for the next nine months.

(3) His heredity pervades his entire organism, being present in every one of his cells.

Genes are not changed by alterations in the body cells of the parents. The fact that a father has several college degrees in himself does not affect the inherited mental capacity of his children. A mother who has been crippled by infantile paralysis will not necessarily produce crippled children. Becoming proficient in playing a musical instrument will not assure a parent that he will have a
child with exceptional ability in music. One does not pass on an acquired appreciation of the beauties or nature or art through the germ cells.

The characteristics which are accepted as due almost exclusively to heredity are color of eyes and hair, blood types, form features, structure of body and many physical peculiarities.

(m) Influence of the Sex of the child on the physical growth

The disparity in relative physical maturity between the sexes is present from birth onward. Since differences in rate are greater within each sex than between sexes, we are likely to pay little attention to them in a group of children in the lower grades in school. By the time fifth or sixth grade is reached, however, some of the girls begin forging ahead in growth and by junior high school age the differences, as noted above, are striking. The teacher of this age group is likely to have in the same class many girls who have reached the menarche, whose breast and general bodily development identifies them as budding young women, together with a majority of boys who are still children physiologically. In seventh or eighth grade class one might expect to find seven out of ten girls as compared to three out of ten boys already in the puberal cycle. But
this also means that at least three of the ten boys will be more advanced than a similar number of girls (Ahrens et al., 1941). The girls on the average are likely to be a little taller than the boys between the ages of eleven and thirteen. Since development is global and involves much more than height and weight, puberty brings with it changes in hormones balance that elicit new motives interests, and general patterns of behaviour.

Hansman, (1970) has reported the results of a long term longitudinal study of healthy white children belonging to the middle and upper middle socio-economic groups, he reports that from birth to two years, the boys are larger on the average than girls (considering height and weight). The sexes are nearly equal in size during the childhood years. Datta Banik et al., (1967) reported that mean birth weight was higher in male than female infants.

The same sex differences as described for height are demonstrated in sitting height; there is very little difference between sexes prior to the adolescent years.

In all the Indian studies on the pre-school children, the boys have the upper edge in all the dimensions of the physical size studied. (Currentbhoy, 1963, I.C.M.R., 1972; Proffenberger and Verma, 1963) studied the health problems
and sex differences of a sample of urban pre-school children. They hypothesized that the greater number of illnesses found among boys than among girls may be a functional value placed upon the sexes in Indian society. This differential value could be responsible for sex differences seen during the early childhood in other aspect of physical development.

Sex differences in the pattern of growth emerge with the adolescent spurt. Boys and girls generally gain about the same yearly in height between four and ten years and in weight between five and eleven years. Girls, then, have a temporary superiority over boys. They pass through this period and reach mature height about two years before boys.

(n) Influence of family size and birth order on physical growth

It is obvious that larger the family size, lower the per capita income of the family and greater probability of malnutrition. Tanner. (1970) states that height and weight very inversely as the number of siblings in the family but adds that the difference disappears when adult size is reached.

Pachauri, (1970) has discussed the socio-economic factors in relation to birth weight. Higher birth weight
was observed in single families and there was +ve correlation between birth weight and per capita income.

According to Datta Banik et al., (1967) birth weight increases up to the third parity in male children and up to the fourth in the female children. Again according to the same researches, there is a tendency for the birth weight to increase with the mother's age up to 30 years. Arora et al., (1963) observed the tendency for the birth weight of the infant. They also found that the dietary status of the mother during pregnancy influenced the birth weight of the infant.

Earlier Paul and Athawala, (1957) in their study on healthy new borns in Delhi had observed that younger mother's had lighter babies up to 35 years and that birth weight increased with parity. Babies of obese mothers tend to be heavier than those of mothers of standard weight. The first born is a little lighter than later babies in the family. Babies under 5 1/2 pounds are considered premature or immature. According to Stuarts norms 80 per cent of the new born males range from 6.3 to 9.1 pounds, girls range from 6.2 to 8.5 pounds.

(0) Home and school and their influence on physical growth

Home is the important factor, which plays an important
role in the physical growth of a child. Each family presents a unique environment for a child on the basis of contributions from the past. With its background a family sets an environment for the child depending upon its financial status and educational level, its cultural interests, standards and values.

Home is a place where the child's physical and psychological needs are met.

The school has to provide all of its children with the opportunity to utilize whatever capacity they have and to make it possible for them to benefit as much as they can from the school experience. The school needs to acknowledge and provide for individual differences in ability and pace of development.

The schools should be planned in such a way that they provide for a variety of educational experiences in a healthful environment where space, light, heat, ventilation, toilet facilities and place for physical and sports activities, are provided in a manner which allows for safety, health and comfort of pupils.

The site for the school, the plan of the building and the equipment and materials to be used should be considered in relation to the development and needs of the
particular children who will spend so many hours of their day in school. Increasing emphasis is being given to provision for the safety, health and comfort of pupils and teachers.

Proper placing of seats in relation to lighting in the room is necessary to prevent eye strain and its accompanying fatigue. Movable desks and chairs have an advantage over the stationery kind in that they can be moved about at the convenience of the pupils and teachers. The size and construction of chairs and desks must be considered in relation to the size and body proportion of the children using them. Seats which too small or too large lead to bad postural habits and all the attending physical and psychological difficulties. Because children vary so in their size and build, adjustable desks and chairs are almost a necessity.

(p) Illness and its influence on physical growth

Earlier studies (Harøy, M.C., 1938) give evidence of no significant differences in the growth in size of children who had frequent illnesses and those who had been relatively free from illness. One recent study of pre-school children showed a small but definite decrease in the rate of growth in height but not in skeletal maturation during years in which illness was recorded.
(c) Emotion and its influence on physical growth

The well-being of the child physically is a primary factor in the quality of his physical growth, so is his well-being emotionally a primary factor in his mental and personality development. As we have already seen, however, the relationship is not only one of physical factors upon physical growth and of emotional factors upon psychologic growth. There is also a cross relationship, physical factors influence psychologic growth, and emotional factors influence physical growth.

(r) Other factors related to Nutrition

To provide children with the food they need for health and growth is not enough. The food must be broken down by digestion into substances which the body can absorb; those substances, such as glucose, fatty acids, amino acids, minerals and vitamins, must pass through the walls of the digestive track into the blood stream, be carried to the various parts of the body, transmitted to the body cells where they are assimilated and converted into body tissues. The efficiency with which the body performs these processes is not perfect and that efficiency varies from time to time within the individual and varies from individual to individual.
Everyone knows of children who, inspite of consuming large quantities of food, remain thin, while other children gain weight on a much smaller intake. It is, therefore valuable to know some of the factors which influence the assimilation and utilization of food. Balance of nutrients is essential. overemphasis on one element may interfere with another, such as in the case of calcium and phosphorus. Further, the conditions under which the food is eaten influence the use the body can make of it.

The elimination of waste products is necessary for the well-being of the whole body. These waste products consist of substances which result from metabolic processes and substances in the digestive track which have not been absorbed.

(i) Rest and Activity

Activity and rest are important because of their relation to nutrition and growth. Muscular activity is important in that it improves circulation and respiration, stimulates appetite aids digestion, improves muscle tone, thereby fostering good posture and normal elimination, and increases endurance, strength and accuracy. The amount and kind of activity for the child should be considered in respect to his constitutional strengths and weaknesses, his general physical health, and his stage of development.
The balance of rest and activity differs for different children. Some require more rest than others, as for examples, the child who has been ill. His muscles have lost some of their tone and are, therefore more easily fatigued. Such a child needs more frequent and longer rest periods until he has attained his normal vigor once more. Children who are malnourished need additional rest. Some children require more mental and emotional rest and greater physical activity. For children who have been sitting for hours in a classroom, outdoor play is more restful than sitting for hours in a corner reading a book.

To plan a child's regimen so as to allow for a balance of activity and rest, it is necessary to know the child, his health history and growth, and his home and school environments with the demands they place upon him.

(ii) Sleep

Sleep is the most complete and satisfactory of all the forms of rest. It rests not only the voluntry muscles and the eyes but there is also a depression of other tissues and organ activities. The circulation and respiration are slowed. That less energy is expended is indicated by a lower metabolic rate. More energy, therefore, is available for growth.
From the studies it is evident that a light meal, quiet, relaxing time before going to bed, freedom from emotional stress or strain or excitement are conducive to quiet rest.

Children in their periods of rapid growth may well need more sleep than at other times. Adolescence may be one of these periods. Sometimes these children are accused of being lazy because they sleep late in the morning, while, in reality, this is an expression of a physiological need. An adolescent needs long hours of sleep.

Children who are fatigued need a well-balanced programme of rest and play, in which there are long periods of relaxation and short periods of activity. As capacity for activity increases, the length of the activity periods may be increased. Exercise is important in improving the tone of the muscles and other tissues. The chronically tired child should have a thorough physical examination, increased rest, a good diet, with emphasis on the "protective" foods, and a satisfactory emotional climate in the home.

2.5 Method of Studying Physical Growth

(a) Sources of Data

It is a principle of scientific method that research data should be amassed using the most parsimonious medium
for attaining the needed degree of exactitude. This is a basic reason for data obtained directly on the living or the nonliving child. If it were an investigator's purpose to describe variability of head width for children of a given age, measuring the subjects' heads directly would be more economical and for most purposes no less valid, than obtaining roentgenograms of the head and measuring them (Potter and Meredith, 1948).

Indirect sources supply the only data sufficiently valid for the study of certain problems, e.g. determining the extent to which rate of change in width of the lower face during childhood shows oscillation and individual variation (Newman and Meredith, 1956). With respect to other problems, indirect source materials constitute the sole avenue of investigation available. An example is the study of childhood differences in increase of muscle tissue in selected body regions (Stuart, Hill and Shaw, 1940; Maresh, 1948).

(b) The living child

Human anatomic ontogenesis takes place in individuals who live and move and acquire standards of modesty. Respiratory and digestive functions, postural changes, and reluctance to submit some parts of the body for examination all give rise to methodologic problems in using the living child as a source of research data.
Problems pertaining to the child's willingness to co-operate usually can be resolved by taking sufficient time to develop rapport, remaining sensitive during examinations to cues from the child and exercising professional tact in the collection of data. Some of the problems that arise from involuntary physiologic functioning can be only partly surmounted. In determining the body weight, for instance, it is considerably more feasible to remove or standardize the extraneous material carried as clothing (Clark, 1930; Sumner and Whilacre, 1931) than to remove or standardize the extraneous material carried as urine and faces.

Townsend, (1887) reported (1) weighing the contents of the bladder and bowels of a still born infant and (2) weighing four live infants immediately following birth and again after washing. He estimated that the extraneous urine meconium, and vernix case added 0.1 kilogram to the weight of the neonatal organism. Griffith, (1899) listed as factors that may spuriously influence weekly weight gains in infancy the time and quantity of feeding, the emptying of the bladder and bowels, the amount of exercise and respiration, and the metabolic changes going on during sleep.

Three pre-school children were weighed by Palmer, (1930) at approximate hourly intervals during the day for periods of three to five days. He found that children
typically gain in weight during the day, attain a maximum weight during the day, attain a maximum weight after evening meal, lose weight during the night, and reach a minimum weight in the morning after discharge of the accumulated excreta.

Diurnal fluctuations varied for different children and for the same child on different days. Summer and Whitaire, (1931) weighed 58 elementary school children and then reweighed them following the request that they urinate. After urination, 50 per cent were 0.1 kilogram or more lighter and 17 per cent were 0.2 to 0.5 kilogram lighter. During a six month period Curtiss, (1898) obtained nude weights for three young adults just before they retired at night and as soon as they arose in the morning. There was no food intake and no urination or defecation between the two weighings. Average loss during the night was 0.4 kilogram, with variation in loss extending from 0.2 to 0.7 kilogram.

Mckay and Patton, (1935), in a study on food habits and physical development of pre-school children, obtained nude weights at monthly intervals always having the child empty his bladder and always weighing at the same hour of the day. Clayton, (1944), in a study on food habits and physical conditions of elementary school children, requested
each subject to urinate before being weighed, determined weight with the subject wearing only a one piece gown, and subtracted the weight of the gown.

Beyond the methodologic difficulties of obtaining the weight of a living organism lies the biologic perspective of body weight as a gross over-all measure that aggregates varying tissue representations in slender, muscular, and obese children of a given age (Stuart, Hill and Shaw, 1940) and disregards change in tissue proportions with age (Reynolds, 1948).

In the phraseology of Scammon, (1929), a weight increase of 1.0 kilogram in an infant represents a gain in brain substance and viscera, together with some enlargement of other parts of the body; in an adolescent, it is primarily an increase in bone and muscle; whereas in the middle-aged it is often an accumulation of adipose tissue.

Next to body weight, the structural trait most frequently studied on the living child is stature. Stature is the projected (straight line) distance from the top of the head to the plantar surfaces of the feet. It is common to refer to stature in the erect orientation as standing height, or body height.

Early studies of individual children by Bradford, (1883), Shinn, (1893) and Hell (1896) found stature
"horizontal" to exceed stature "vertical" by 1.1 centimeter in a girl aged 1 year, 1.5 centimeter in a boy aged 1.5 years, 1.8 cms. in child aged 3.5 years, and 2.3 cms. in an adolescent aged 15 years. Studies of the same problems on large samples of children have been made by Wilson et al., (1930), Palmer, (1932), and Vickers and Stuart, (1943). The Vickers Stuart investigation, based on more than 2000 children between the ages of 2 and 10 years, shows that on the average stature erect is 1.5 centimeter less than stature supine. The Palmer report, covering the postnatal period of 18 months to 20 years and utilizing over 1000 subjects, includes tables of erect and supine equivalents for each centimeter of stature from 80 to 180 centimeters.

From measurement of a young adult, it was discovered prior to 1730 that stature is greatest following recumbent sleep and decreases after arising and with prolonged exertion (Scammon, 1927). About a century later, Malling Hunson, (1836) studied a group of 70 boys and confirmed diurnal stature variation for the school-age segment of the human life cycle. Investigations on pre-school children have been made in the present century. Taken collectively, the accumulated studies support the generalization that at all ages beyond 2 years ambulant human beings typically are 2.0 centimeters taller when they assume the erect position in the morning than when they return to the recumbent position at night (Redfield and Meredith, 1938).
Another group of kinesiological and physiological problems is faced in using the living child as a direct source for measures of shoulder breadth and girth of the trunk and limbs. Maximum girth of the leg in the calf region is not the same (1) as a child stands with his weight distributed equally in both lower limbs and (2) as he sits with his legs hanging over the edge of a table. Girth of the upper limb midway between the shoulder and the elbow is not the same (1) when a child's arm is raised and his bicept muscle contracted and (2) when the arm hangs at his side in a relaxed state. The human shoulder girdle is highly mobile and not readily placed in the same position on successive occasions. Girth of the thorax alters with inspiration and expiration, elevation of the shoulders, tipping of the head, and orientation of the trunk to the force of gravity. Girth of the abdomen varies with time and quantity of food intake, especially in infancy, and is difficult to bring under control, since children are able to produce marked fluctuation by voluntary contraction of abdominal muscles.

Far more data for studying anatomic ontogenesis have been obtained from direct measurement of the living child than from any other source. This is shown readily by reference to research bibliographies, reviews, and syntheses, Krogman, (1941) in displaying the extent to which body size and form are related to racial, geographic, socio-economic
dietary, and other variables, assembled more than 1000 tables based on direct study of children. A Children's Bureau, (1927) publication lists over 500 studies on age changes in body weight. More than 60 investigations employing data obtained directly on children, are colligated in a review of North American research for the period 1850-1900 (Meredith, 1936). There are syntheses of direct measurement research drawing from 130 studies on growth in stature during infancy (Meredith, 1943), 70 studies on the association between body size and birth order (Meredith, 1950) and 30 to 50 studies each on the development of head width (Meredith, 1946), face width (Meredith, 1954), upper limb length (Meredith, 1947) and foot length (Meredith, 1944). Multitrait investigations, each extending from early childhood to early adulthood and utilizing direct measurement data, have been reported by Herskovits, (1930), Gray and Ayres, (1931), Meredith, (1935), Boynton, (1936), Goldstein, (1936), O'Kriek et al., (1941) and Simmons, (1944).

Roentgenograms (Radiographs):

With the discovery of the x-ray by Wilhelm Roentgen in 1895, many facets of anatomic ontogenesis previously accessible to study only by the cross-sectional approach (using difference cadavers for each stage) were opened to study by the longitudinal approach. Roentgenograms could be made depicting the same child at successive stages with respect to ossification of the skeleton (Pyle and Sontag,
1943), Calcification of the dentition (Gleiser and Hunt, 1955), thickness of the skeletal musculature (Reynolds, 1944), and shape of the viscera (Lincoln and Spillman, 1928).

The roentgenogram has become the most broadly used of the several indirect sources of research data on human structural development. Seriate or time series, radiographs have been accumulated for all regions of the body (Stuart, 1939). Beginning with Pryor's publication (1905), reported investigations on child growth have utilized radiographs of the head (Young, 1951), face (Woods, 1950) thorax (Maresh 1948), abdomen (Bakwin and Bakwin, 1935), pelvis (Reynolds 1947), arm and forearm (Maresh, 1955), wrist and hand (Baldwin, Busby, and Garside, 1928). Knee (Pyle and Hoerr, 1955), leg (Stuart and Dwinell, 1942) and foot (Wallis, 1931).

One easily underestimates the technical aspects of obtaining roentgenograms suitable for research purpose and adequately interpreting them at datum sources. A radiographic film, once exposed and developed, is a permanent record, a fixed exhibit pertaining to some part of the child's body. This tangibility should not be confused with anatomic validity. In order to study developmental changes in the form of a structure, the consecutive roentgenograms must be secured with the structure in a similar position on each occasion. For studying developmental changes in the size of a structure, there must be standardized positioning.
and also adjustment of the radiographically obtained measures to "life-size" measures. For investigating developmental changes in tissue density, it is necessary to hold the degree of x-ray penetration in good control with a densimeter (Garn and Shamir, 1958). In short, the extent to which data derived from radiographs are valid depends upon the purpose(s) for which they are used and numerous methodologic considerations.

(c) Tools of Measurements

A measurement is a datum obtained by means of an instrument or apparatus having a scale graduated in equal intervals. Nearly all of the instruments used in the study of anatomic ontogenesis have scales that begin at an absolute zero point and are graduated in units of the metric system.

Instruments of many kinds and varieties are available for measuring body structures. These include slide-type and spread-type calipers for measuring diameters (Steggerda, 1949), metric types for measuring girths (McCloy 1936), planimeters for measuring areas (Baldwin, Busby, and Garside, 1928), platform-type scales for measuring weights (Goldstein, 1937), scaled tanks for measuring volumes (Tilton, 1930), and variously named instruments for measuring angles (Schultz, 1929; Salzmann, 1945).
The development of anthropometric precision instruments has occurred largely in the period since 1830 platform type weighing scales were produced first in 1831 (Goldstein, 1937), and spread-type calipers a few years later (Woodbary, 1952). Between 1850 and 1870 a number of metrically scaled boards, rods, and calipers were designed for anthropological research on skeletal material and living adults; Paul Broca was a leading contributor to this improvement of the equipment armamentarium (Hrdlicka, 1920). The development of instruments especially adopted for measuring fetuses and young children began shortly before the end of the nineteenth century (Chapin, 1894) but received scant attention prior to 1920. In the period 1920-1940 a variety of these instruments was described by Schultz, (1920), Baldwin, (1921), Thompson, (1929), Wilson et al., (1930), Garey, (1936), Cates and Goodwin, (1936), Stuart, (1939) and Knott, (1941).

The design and production of improved measurement tools continues. During the last decade Tanner and Weiner (1949) have described spread calipers with a scale x 5 enlargement; Woodbury, (1952) and Tanner and Whitehouse, (1955) have described dial-type spread calipers; Tanner and Whitehouse, (1957) have described counter-type slide calipers, and Karpovich, (1951) has described a modified tape for measuring trunk girths.
Research pertaining to the selection of instruments has been reported by Whitacre, (1934) and Gray, (1935). Two laboratory instruments commonly used in measuring stature are the fixed vertical rod and the fixed vertical board. Whitacre measured 400 children by each method in succession and 25 children by each method on two different days. All positioning was the same except that when the rod was used the child "Stood Free" and when the board was used his heels, buttocks, and shoulders were in contact with it. Compared with the measures by rod, the measures by board were systematically larger and considerably more reliable. This study illustrates the principle that one way to increase reliability is by controlling the posture of each body segment included in a dimension.

Not infrequently bilateral structures are of unequal size. One shoulder may be higher than the other, one arm thinner than the other, one hand broader than the other, one leg shorter than the other, one foot longer than the other (Davenport, Steggerda and Drager, 1934). Studies of corresponding have shown both individual and group differences (Morton, 1886; Bjelke-Peterson, 1902; Van Dusen, 1939). Consequently, it is necessary to identify the side on which a measurement is taken. The Geneva agreement recommends that whenever plans are made to collect data on one side only the left side should be measured.
In applying calipers and tapes to non-rigid structures the anthropometrist is confronted with the task of controlling the degree to which tissues are compressed. Hall, (1895), in an early description of methods of measuring girths of the trunk and limbs on school boys, emphasized that special effort must be made to avoid the introduction of error caused by variation in the amount of tension applied to the tape. Steggerda, (1942), in a comparative investigation of the measurement techniques being used at ten laboratories, found wide deviation in the pressure exerted in measuring width of shoulders, width of hips, and other diameters of the body stem.

Knott, (1941), in a major monograph on measurement of the child, (1) reviewed reliability studies made prior to 1940 on fetuses, infants, and older children and (2) investigated reliability for 35 external body measurements on children 3 to 6 years of age. Other reports on the reliability of measurements taken on the living child were made by Goodman (1942), O'Brien, Girshick and Hunt (1941), Newcomer and Meredith (1951), Stolz and Stolz (1951), and Edwards et al., (1955). Collectively, these studies are based on samples of children at different ages from birth to early adulthood, and encompass numerous lengths, widths, girths, and measures of thickness. They show that many traits of body size can be measured by competent
anthropometrists with high dependability, e.g. paired series of independent measures on children homogeneous in age, sex, race, region and secular period yield reliability coefficients above .95 for about 50 per cent of the dimensions studied and above .90 for over 80 per cent of the dimensions studied.

Reliability investigations were reported by Bjork (1947) for measurements on roentgenograms, by Tanner and Weiner (1949) for measurements on photographs, and by Boyd (1935) and Meredith and Hopp (1956) for measurements on casts. Potter and Meredith (1948) compared reliabilities for measurements taken on the roentgenogram and the living subject; Geoghegun (1955) compared reliabilities for measurements taken on the photograph and the living subject. Among other findings, these studies report standard errors of measurements below 0.10 centimetre for several facial diameters obtained from roentgenograms and below 0.02 centimetre for some dental diameters obtained from casts.

2.6 Sampling and Location of Areas

(a) Size of Sample

The size of sample necessary to secure significant results for a particular problem presents a real difficulty. In the 1930's it was assumed that more the cases used more significant were the results. Although this principle is
still sound, provided the sample is adequate in character, most scientific workers are under practical limitations of time, money and availability of subjects. If then becomes desirable to so design and arrange a study that the results will be significant, without undertaking a great amount of unnecessary experimentation. From modern discussions, it is clear that a small sample selected in accordance with criteria rigidly laid down in advance gives more significant and meaningful results than does a larger sample, the characteristics of which are unknown. The better public opinion polls and the sampling techniques used in modern industry are based on this principle. But some students assume that small samples have some peculiar virtue of their own and interpret Fisher's work as supporting that position. But Fisher is quite clear that a large sample is to be preferred to a small sample.

The size of the sample also varies with the type of problems under investigation. For instance, reaction time can be determined with great accuracy on a small number of cases, whereas measures of more complex processes need a larger number of cases. Further, the size of the sample depends upon the number relations involved. Where two variables are studied and extraneous factors are rigorously controlled by the experimental set-up, a smaller sample is necessary than when the weight and pattern of many factors
contributing to a complex area of behaviour are to be studied without rigorous experimental controls. Precision depends also upon the reliability and validity of the measuring instrument.

Implicit in any discussion of sampling is the problem of statistical significance. Since, the purpose of research is to generalize from a sample to a population, the question whether the results obtained from a given sample arise by chance or are the outcome of the conditions being studied is pertinent. In modern treatments, the null hypothesis is assumed namely, that whatever appears in any particular sample is the outcome of chance. It becomes the obligation of the investigation to prove that his results are not likely to be chance outcomes but are the results of the introduced condition he is studying. He does this showing the degree of confidence that can be placed in the differences obtained, or the likelihood that they would not occur by chance alone.

Sampling problem first arose in connection with normative studies, since the value of a standard is clearly a function of the function. Height-weight tables and intelligence test scales are standards against which thousands of individual children will be checked for diagnostic, and practical purposes. If the standards are inaccurate or inadequate, the usefulness of the instrument is substantially reduced.
Generally the following methods are used for selecting a sample:

i. Stratified Sampling

ii. Combination of Control

iii. Cross-sectional and Longitudinal Method

Stratified Sampling

To meet the problems imposed by the different selection of human beings by their social environments, various techniques have been evolved for drawing stratified samples from the total population. For example, since the child population of the state varies, an investigator might draw a sample from each state that was proportionate to the total child population of the state. Stratified sampling assumes that the total population can be divided into classes in accordance with known and measurable characteristics. Within these classes, the size of the sample selected is proportionate to the size of the class in the total population. Stratified sampling has been given great impetus by the development of public opinion polls in which such sampling is critical.

In the selection of stratified samples of children, the following breakdowns are commonly used:
(a) Age

In many earlier studies the numbers of cases at different age levels varied. In modern studies the problems of age sampling is solved by using the same number of children at each age level, say 100 at 2 years, 100 at 3 years and so on selecting a constant number of children at each age level not only improves sampling, it also simplifies calculations and the determination of various statistical constants.

(b) Sex

Some of the earliest studies on children, even those on physical growth, made no distinction between the sexes. But now, since it has become clear that some developmental phenomena differ in the sexes, the practice of reporting results on boys and girls separately is almost universal. The common practice is to use equal number of boys and girls. The age sample of 100 children described above would, with sex stratification, consists of 50 boys and 50 girls at each age level.

(c) Location or Area

In the early standardization of intelligence tests, particular effort was made to secure children from
different areas and parts of the country on the assumption that there was great variation with geographical location. In the past educational standards, the enforcement of school attendance and the content of the curriculum varied widely. But as conditions improved in background areas and as modern means of mass communication developed, these differences have disappeared.

One difference in location is, of some importance, that of rural or urban residence. Baldwin, Hillanone and Audley (1930) found significant differences in intelligence test scores and the studies of the College Entrance Examination Board have revealed some differences in verbal and problem-solving ability, the former in favour of rural adolescents. With improved means of transportation, the consolidation and equalization of school and the widespread extension of the radio, many of these differences have disappeared. A surprisingly large proportion of all the studies on children that were available in the literature have been done on the city children because they were more readily available.

Human societies is divided into strata based on income, educational level, cultural background and a variety of related factors. Because these strata differed markedly in the facilities and opportunities afforded children, a significant sampling problem arises. Various proposals had been made for its solution. The most common
involved selection either in terms of a single factor, such as paternal occupation or income, level, or in terms of a series of questions covering occupation, income, possessions etc., as in the Sims' scale (1936); or in terms of cultural level, as in the studies of Warner et al., (1949).

Paternal occupation is one of the few cultural facts for which universal figures are available. One of the most widely used socio-economic devices is the Minnesota scale of paternal occupations, which divides adult males into seven classifications according to their occupations.

(ii) Combination of controls in sampling

In most investigators in which sampling is controlled, a number of controls are used simultaneously. The most common are age and sex. School grade is frequently used. Urban and rural residence are less often added. Either mental age or sex is sometimes used as a control. The selection of controls depends upon the nature of the study and the size and location of the population available for study. In general, the deliberate control of sampling through laying out criteria in advance is the ideal.

(iii) Cross-sectional and longitudinal method

Cross-sections give approximations rather than accurate representations of the developmental process. For
example, because children grow at different rates and reach similar development levels at different times, a cross-section study places together at the thirteen year age level, many girls well past puberty and many girls months away from puberty.

Longitudinal studies measure the same children at successive periods. While means and standard deviations can be obtained at each age level, as in the cross-section study, the longitudinal study in addition, permits:

1. an analysis of the development and growth of each individual child,
2. a study of growth increments, both for the individual and the group,
3. an analysis, in detail of the inter-relations between, growth processes, both maturational and experiential, because all data have been obtained on the same children.

But, it too has some disadvantages. No matter how carefully a sample is selected at the beginning, whatever limits the original sample, which is drawn but once, will affect all subsequent data. In some studies, families of stable position in the community, such as home owners, are used; in others, communities known to have little mobility are used. But this may mean a sample that is not typical from the beginning. Casualties because of death, illness,
families moving away and changes in the cooperation of children and parents with investigator will further distort the sampling at later ages. The investigator should discarded data for the incomplete cases, since their use will not only destroy the advantages gained by the longitudinal method but may also actually distort the results (Anderson and Cohen, 1939).

With longitudinal data, other problems appear, since a cross-section method lumps all individuals of a particular age level together, irrespective of development level, treating longitudinal data as though they were cross-sectional data. This gives no advantage. Shuttleworth, (1939) superimposed the periods of maximal rate of physical growth for early and late maturity groups, irrespective of chronological age and made an analysis by plotting curves. Basic similarities in the growth pattern that were not apparent before this treatment were revealed. Markey's (1928) individual curves for vocabulary growth from the baby biographies differ noticeable from the usual growth curves worked out by cross-section methods. Some evidence is available to the effect that the course of animal learning is predictable when equations are plotted for individuals, and not for groups. This suggests that some of the statistical methods centering in measures of status, i.e. mean, standard deviation, correlation coefficients etc.,
which are appropriate for cross-section studies have limited use in longitudinal data, for which treatments concerned with progression, rates increments, and velocity are more appropriate. Courtis (1950), who applied the Gompertz curve to cross-section data obtained over a range of ages, feels that even for such data statistical methods for studying growth and prediction can be much improved. Honzik (1936) and Anderson (1939) found that measures of intelligence vary in predicting terminal status as measures are separated in time and as the functions measured overlap.

A method of treating longitudinal data in terms of increments that result in good curves of the growth process involves selecting point at which the maximum number of cases is available, calculating the mean of the measures at this point, then calculating the mean of the increments (or decrements) to the next level, adding (or subtracting) this mean to the mean at the base level, then calculating the mean of the increment (or decrement) to the next level, and adding (or subtracting it to the base level mean plus the mean of the previous increment, and so on. Standard deviations can also be combined by appropriate formulae. The use of increments eliminates the variance of the individuals in the base at different age levels, (Shuttleworth, 1934).
A summary of some of the interpretations of longitudinal data is found in Olson (1949), who developed a method of representing developmental level in what he calls organismic age. This is obtained by combining various measures of development which have been scaled in age terms, such as method age, dental age, carpal age, weight age, grip age and reading age. Thus, when such measures are available for a given child, inadequacies of development can be spotted. This assumes, however, that development in its various phases should be uniform and parallel, which may or may not be true. The combination of various dissimilar measures with differing reliabilities into a single scale with equal weights is open to question.

The design of longitudinal studies is simple, unless a control group runs parallel to the longitudinal group. Many more cases must be studied at the beginning in order to allow for selective elimination. Once the children are selected, emphasis is given to the measures to be used and their arrangement in time. Precision is increased by using fixed intervals for testing. Often these come near the child's birth day. In planning, particular care must be taken to anticipate the early data that will be needed for interpretation of later data. Early records should be extra-ordinarily complete (Macfarlane, 1938) as, once a study is well under way, it is almost impossible to make up deficiencies.
Included under the longitudinal genetic approach are a number of methods for studying children. The classical baby biography described the development of a single child. Detailed studies of the successive drawings of the same children over a long span of years have been made (Goodenough and Harris, 1950). Descriptive accounts of the development of peculiar or abnormal children are available. More recently extensive and well planned programmes follow the same children for long terms of years and use many methods of measuring and observing the children. With the development of cumulative record systems in schools and clinics, a type of record-keeping is being practised which should give us many of the advantages of the longitudinal studies in the future studies.

2.7 Conclusion

The studies and results discussed so far reveal that an intensive work has been done, in the area of physical growth and development, in the Western Countries. In India, of course, a few studies have been conducted out of which that by I.C.M.R. is the most comprehensive one. But, most of the studies pertaining to child growth and development cover either fetus, infants, or early childhood stages of development. There are, of course, a few studies related to adolescents. It is obvious from all these that the late
childhood stage of development has by and large, been left untouched somehow. No doubt, the stage of infancy is the most crucial stage of the development but that does not mean that the late childhood stage has no importance at all. In the life-span of human beings all the stages of development have their own importance during the period of that particular stage. Later childhood is also known, generally as a stage of pseudo-maturity stage. In foreign studies, it has been mentioned that the growth rate is almost nil at this stage and hence it has been labelled as plateau of physical growth. But a question may arise here. Is it true for Indian boys and girls? India comparatively is a country with warm weather prevailing for most part of the year. In India naturally boys and girls would enter the stage of puberty—earlier than the western boys and girls. The rate of growth of Indian children may not be at par with the rate of growth of western children due to many other differences in socio-economic conditions. All these emphasize the acute need of studying the Indian children in Indian climatic and social conditions.