CHAPTER-1
INTRODUCTION

In this World every living organism tries to achieve complete stable form of maturity via a beautifully organized process of growth and Development.

Human beings like other animals start life in a single fertilized ovum, in mother’s womb, develop into infants and then meet the large world of adulthood through an organized and channelized phenomenon of growth.

Growth and development in humans occur over a lifetime. At every stage of life, there are physical and psychological changes in the human body. Although every person experiences growth and development uniquely, the patterns are almost similar for all humans. Different tissues and different regions of the body mature at different rates, and the growth and development of a child consist of a highly complex series of changes. It is like the weaving of a cloth whose pattern never repeats itself. The underlying threads, each coming off its reel at its own rhythm, interact with one another continuously, in a manner always highly regulated and controlled.

Growth, development and maturation, the three concepts are more often used together and sometimes considered as synonymous. But it is important to realize that growth, development and maturity are essentially three different concepts. Growth implies changes in size and shape only, development means the integrated functioning of the body, emotional makeup and motor behavior etc, while maturity means maturation of various biological systems towards the adult status and each of these terms has been discussed in detail as under. (Kaur, 2007)

1.1 GROWTH

In layman’s language, growth of a human being is the increase in size and shape of the body. It starts in mother’s womb as a zygote
and continues at the age of approximately 18 years after birth. In case of males, it takes twenty years for completion from conception. However, in case of females it is shorter by approximately two years i.e. takes place up to eighteen years.

According to Malina (1980) “Growth is a dynamic process, implying movements towards adulthood or maturity. It involves a series of changes from conception to adulthood during which time the individual increases in size as a whole and of its component parts and eventually matures.”

There are three fundamental stages viz. formation, growth and completion or perfection in the growing period of a human being, more or less all these three stages are of six to seven years each. The formation stage is early childhood, the growth stage is during school age and completion or perfection stage is during adolescence.

Overall, growth remains dominant biological activity mostly during the first two decades of life. By description it is the distance travelled by a child along the road to adulthood and continues from birth till full form is attained. During the growing period growth passes through many stages during which, the rate of growth never remains constant. It is some times faster and becomes slower at another time (this is also known as tempo of growth). It is maximum during the infancy i.e. first two years of life from birth. During this period human body quadruples in weight and grows 14 inches, reaching half the height adult size. The five senses, language skills, and muscle control all develop rapidly during this time. Thereafter, it slows down. Then from the age of six years, it again starts increasing up to the age of 8 years. This period is known as mid-adolescent growth period. The rate of growth during this period is slower as compared to rate of growth of first two years of life. After mid-adolescent growth period, it remains almost constant or comes to gradual halt till the initiation of adolescent growth period. This period includes two major events:
1. Adolescence growth spurt (somatic maturation)

2. Sexual maturation

During this period from 10 to 15 years of age, growth is at its maximum. The rate of growth during adolescence and rate of growth up to two years of life from birth is almost the same. In the adolescent period, there is a marked acceleration in the rate of growth, which is known as adolescent growth spurt. Adolescent growth spurt is a constant phenomenon and occurs in all children but intensity and duration varies from one child to another even among boys and girls. In case of boys, this period comes at the age of 12.5 to 15 years and in females from 10 to 14 years (Tanner, 1955). During this period velocity (rate of growth) is at its peak and is responsible for maximum gain in height (approx. 20 cm) and weight (approx. 20 kg). In case of boys, peak velocity in growth is at the age of 14 years though it lies anywhere between 12 to 17 years. In case of females, it is two years earlier but somewhat smaller in magnitude than boys. This is the reason why adult man and woman have differences in their sizes and body dimensions.

1.1.1 Factors Affecting the Rate of Growth

Nevertheless, the process of growth is highly organized. A child grows to an adult along a pre-destined curve under optimal environmental conditions. Thus, there is a complex interaction between the genetic makeup of a person and his environment. The genetic makeup sets the upper limits of growth while, the favorable and optimal environmental factors help to accomplish that target. When the environmental factors are not favorable, the upper limit of growth which genetic makeup has set may not be achieved. Thus this nature-nurture interaction is complementary to each other. Many environmental factors including nutrition, the socio-economic conditions, climate and seasons of the year, physical activity, psychosocial factors, level of urbanization etc. have been found to affect the growth process. A brief mention of these factors is as below:
1.1.2 Effect of Nutrition

Nutrition plays a very important role in the growth of a child. The nutrients like carbohydrates, proteins, fats, vitamins and minerals etc. in their adequate quantity and proportion are very important in the normal growth of a child. If the quantity of these nutrients changes either decreases or increases, it will affect the rate of growth or we can say a deviation in growth occurs. Time and occurrence of adolescent growth spurt is more sensitive indicator of nutritional deficiency (Tanner, 1955). Malnutrition during childhood delays growth and if it occurs before adolescence, appearance of the adolescent spurt delays.

Effect of nutrition starts during intrauterine life. Pregnant mothers taking optimal nutrients give birth to a healthy child having greater birth weight as compared to others.

Studies show that children may revert to normal growth or show catch-up growth if optimal nutrition is given to a malnutrient child. Poor and inadequate nutrition retards the growth of skeleton, Garn et al (1964) found that children suffering from malnutrition had smaller thickness of the cortical bone as compared to counter parts that had normal nutrition.

Orr (1928) and Leighton & Clark (1929) also studied the effect of malnutrition on rate of growth. Scottish school children were given extra milk or skimmed milk a day for 7 months and found that they showed greater height and weight gain at the ages 5-6, 8-9 and 13-14 than the control group children. This experiment was repeated by Roberts et al. (1938).

Jackson (1936, 1937) studied the effect of malnutrition on rats and found that severe malnutrition for a large part of growth period may cause some permanent stunting.

If severe malnutrition is prolonged for a long period during growth, permanent stunting may occur. (Jackson 1936,37)
Howe and Schiller (1952) studied the height and weight of school children in Stuttgart, Germany from 1911 to 1953 and found that during 1939-45 war, due to scarcity of food intake there was a sharp decrease in both height and weight of school children but after war, in 1947 conditions improved greatly and reflected through increased size of children.

Fawzi et. al. (1997) studied the effect of vitamin-A and the growth of preschool children in Sudan (n=28,740) the children were 6 to 72 months of age. The result of the study shows that vitamin-A has no effect on the role of weight or height gain.

1.1.3 Effect of Heredity

The fundamental control of growth is genetical (Palmar, 1933b,c, 1934a, 1935). The genetic aspects of physical growth can be studied using twin and family data. Differences between monozygotic and dizygotic twins are assumed to be due to the environment. The size of the body and its parts, rate of growth and onset of growth events are under the genetic control. For example, height of a child depends on his/her parents and grand parents.

There is a high correlation between time of menarche of mothers and daughters (Bolk, 1923, 1926; Popenoe, 1928; Gould and Gould, 1932) and between sisters (Boas, 1932) and a very much higher correlation between identical twins (Petri, 1935; Tisserand-Perrier, 1953).

Genetic control operates throughout the whole process of growth, and the conclusions regarding age at menarche apply equally to the rate of development. Boas (1932) was the first to study in this field. He found that brothers had a correlation of 0.34 at the age of adolescence when they reached peak velocity of height growth. According to Hewitt (1958) genes controlling rate of growth and onset of adolescence are wholly or partly independent of action of those controlling final size achieved. Only a proportion of all the genes controlling rate of growth and development are active at birth. Many
exert their effect later on as for example in controlling the magnitude of adolescent spurt. A few longitudinal studies were also done on twins to show how closely uniovular twins and triplets resemble each other in growth-rate and developmental ages (Sontage and Nelson, 1933a, b; Sontag and Reynolds, 1944; Reynolds and Schoen, 1947).

A number of studies have also been done on the genetic control of skeletal maturity at various ages (Buschike, 1934; Reynolds, 1943; Sontag and Lipford, 1943; Sontag and Reynolds, 1944). The degree to which siblings resemble each other in growth-rate, skeletal maturity and tissue composition of calf during the first 5 years of life has been studied by Hewitt (1957, 1958). Scores for skeletal maturity were obtained by the maturity indicator method applied to the hand and wrist. The correlation for these scores in case of brother was 0.56 and in sisters it was 0.40.

1.1.4 Effect of Illness

If the illness is minor, like cold, measles, pneumonia, bronchitis etc. rate of growth may not be affected provided the child is well nourished (Hardy, 1938; Martens and Meredith, 1942; Sontag and Lipford, 1943; Evans, 1944). But when the illness is a major one, such as nephrosis, the effect on growth and maturation is quite significant. During major illness, there is retardation in growth, skeletal maturity and adult height of child (Singh et al. 1992). For example, if a child is suffering from thalassaemia, he will show significant reduction in rate of growth. The cystic fibrosis is also found to affect the growth of the children (Constantini et.al, 1991). When recovery takes place a 'catch-up' period of growth ensues, during which growth may proceed at as much as twice its normal rate.

Bauer (1954) studied the growth of 34 children suffering from nephrosis. At the beginning of illness, their length was 97% of normal children of comparable age. After one year of illness, they shrunk to 83% and after two years to 71%. The children with greatest slowing of growth, died. The others who recovered catch-up from 84% at the
beginning of recovery to 90% after one year and 94% after 18 months.

The actual mechanism by which growth is slowed probably vary at least somewhat from one disease to another, though nothing certain is known about this. In the nephrosis syndrome, the hypoproteinaemia appears to be an important factor (Bauer, 1954). In other forms of prolonged renal diseases perhaps in some cases of nephrosis too, the presence of chronic acidosis seems to be the thing which determines whether or not retardation occurs (West and Smith, 1956). A more general cause common to many major disorders may be an increase in cortisol secretion. In Cushing’s syndrome, a large increase in secretion of corticosteroid results in greatly decrease in growth in length (Hubble & Illingworth, 1957).

The chronic diseases of the tropics are thought to be responsible for retardation in the growth of children in areas in which they are endemic. Children with repeated heavy malarial infection grew less in the first two years than those protected by chloroquinine, but by 3½ years, differences disappeared as immunity developed (McGregor et al., 1956).

Generally child’s growth and maturation is strongly affected by duration and severity of the illness. Children who are treated for malnutrition, growth, normal deficiency, and hypothyroidism show higher than normal growth velocity which has seen ‘Catch-up-growth’ by Prader, Tanner and Ven Harnack. (1963)

1.1.5 Effect of Hormones

Hormones are chemicals produced by special cells in endocrine glands. These hormones are produced in very small amount and released to the blood stream to reach the target organ or tissue where they exert their effect.

Several hormones are involved in regulating growth. Some act directly while others act by triggering the production of other hormones, which activate specific organ function necessary for growth.
Pituitary gland is known as master gland as it produces several hormones which control the functions of other gland. Growth hormones are secreted by interior lobe of pituitary gland. The major effect of this hormone is to promote growth of the body tissues. Other pituitary hormones affect growth indirectly by working through other glands. These include:

a) **Thyroid Stimulating Hormone (TSH)**

This hormone stimulates thyroid gland to produce thyroid hormone which is essential for normal growth of a child.

b) **Adreno-Cortico Tropic Hormone (ACTS)**

This stimulates adrenal gland to produce cortisol (stress hormone) which responds to stress. Too much cortisol will cause growth failure in a child.

c) **Luteinizing Hormone (LN) and Follicle Stimulating Hormone (FSH)**

These hormones stimulate sex glands to produce sex hormones, which are necessary for adolescent sexual development and growth spurt.

Growth hormone deficiency occurs by itself or in combination with one or other pituitary hormone deficiencies. These growth hormone deficiencies result in small height, immature face and chubby body build. The rate of growth of all body parts becomes slow. Scientists are trying to learn more about the causes of growth hormones.

The growth deficiency hormones can be treated with injection of growth hormones. This treatment will take several years till the child achieves an acceptable adult height or maximum growth potential is reached.
1.1.6 Effect of Season and Climate

Weather and the climate also effect the rate of growth in the tropic regions, where there is no winter but only summer seasons. There are only rainy periods and dry periods. In rainy periods, there is fall in food supply and increase in infection. The maximum gain in weight takes place during dry seasons as compared to the wet seasons.

Nylin (1929) said that faster growth in height during summer is due to longer daylight. But Marshel (1975) said that daylight duration plays minor role in seasonal variation in growth.

According To Tanner (1962), In the temperate zone of northern hemisphere, children grow faster in height in spring and summer months and faster in weight gaining during winter months. Maximum height velocity is seen during the summer months. Similar findings were done by Singh et. al. (1992).According To Singh et. al.(1992), children of temperate zone grow faster in height in spring and summer seasons and grow faster in weight during autumn and winter seasons.

1.1.7 Effect of Socio - Economic Status

Socio-economic factors also affect rate of growth. If parents are socially and economically sound, they will provide best environment and better nutrition to their children to grow as compared to the parents who are socially not sound. Children of higher socio-economic status are generally taller and heavier than there Low socio-economic counterparts. Such similar findings have been reported throughout the world. Socio-economic differences in growth are more in developing countries as compared to developed countries. British National Child Survey was conducted nationwide on 7 years old children of higher
social class (Professional and managerial classes) lower social class (manual and unskilled workers) showed a difference of 3.3 cm in height (Goldstein et al. 1971 Denie et. Al 1972, Millar et. Al. 1972,) Similarly Meredith (1978) studied 7 years old boys of Philadelphia from upper and lower social classes and found that difference in height is about 2.8 cm.

In India, Punjabi children of higher socio-economic class were 14.6 c.m and 10.7 c.m taller as compared to their lower socio-economic counterparts at the age of 8 and 12 year, respectively (Singh et al. 1987).

1.1.8 Effect of Exercise

Children indulge very naturally in physical activity and recreations. As we know that physical activity may be mild, moderate or excessive and its duration may also vary while exploring its effects on growth of a child.

There are many studies, which show that regular training accelerates the growth process. Increase in stature and weight has also been seen when regular endurance training was given. (Godin 1920, Ekbom 1969, Erikson 1972). It is important to know that children subjected to training were adolescents. Thus it is very difficult to attribute these differences to the specific effect of exercise.

Malina (1977) compared maturity status of male athletes with non-athletes and found that athletes are generally advanced in their maturity status as compared to their counterpart non-athletes. But the findings, in case of female adolescent athletes were generally opposite to those of male adolescent athletes. In female athletes maturity was delayed.

According to Mokha and Sidhu (1989), in India menarcheal age of basketball and volleyball players at various levels of competitions is 15.53 and 15.26 years
respectively as compared to non-athletes having menarcheal age 14.39 years. This also shows that maturity in female athletes is delayed as compared to female non-athletes. Menarche is significantly related to other measures of maturity e.g. breast development, pubic hair, skeletal development etc. in normal girls (Singh et. al 1992).

To conclude, it can be said that exercise and physical activity may or may not have significant effect on stature but lean body mass, and maturity status do have significant effect of exercise.

1.1.9 Effect of Urbanization

According to Eveleth and Tanner (1976) urbanization does not only mean a high population density. It also includes other features like regular supply of goods, health and sanitation services, recreational and educational facilities etc. Children living in Urban areas are larger and taller as compared to the children of rural areas. (Hamil et. al 1972, Jones et. al 1973, Singh et al.1987).

In India, studies showed that differences in body size of children living in the rural areas to the children living in urban areas are very small. The reason for this may be that in India population in urban areas lives in slums and basic facilities of health and sanitation are even not present in many crowded areas and secondly now-a-day facilities present in urban areas are also available in rural areas.

But children living in posh colonies do have differences in body sizes as compared to rural areas. The differences of height of Indian boys of urban and rural areas are 2.1cm (ICMR 1996). Urban girls are also faster in their maturity as compared to rural girls. Urbanization can exclusively be considered as responsible for shifts in similar trends also.
1.1.10 Effect of Development

Development in its broader concept accompanies growth, maturation, learning and experience or training. It is thus becoming competent in a variety of tasks, viz. cognitive development, motor development, and emotional makeup as the child’s personality emerges from the particular culture in which he/she is reared. (Eston and Relly, 1996).

The process and pattern of development is characterized by a set of principles. These principles or characteristics describe development as a predictable and orderly process, that is one can predict how much children will develop and whether they will develop at the same rate and at the same time as other children, or not. Though there are individual variations in the person’s personality, activity level and timings of development but principle pattern of development is universally the same. A brief description of these principles is given as below:

- Development proceeds from the head downward:

  This is called the cephalocaudal principle. This principle describes the direction of growth and development. According to this principle, the child gains control of the head first, then the arms, and then the legs. Infants develop control of the head and face movements within the first two months after birth. In the next few months, they are able to lift themselves up by using their arms. By 6 to 12 months of age they gain control on their legs and start to crawl, stand, or walk. Coordination of arms always precedes coordination of legs.
• **Development proceeds from the center of the body to outward:**

This is also called as the principle of proximodistal development. It also describes the direction of development. This means that the spinal cord develops before outer parts of the body. The child’s arms develop before the hands and the hands and feet develop before the fingers and toes. Finger and toe muscle are the last to develop in physical development.

• **Development depends on maturation and learning:**

Maturation refers to the sequential characteristic of biological growth and development. The biological changes occur in sequential order and give children new abilities. Changes in the brain and nervous system help children to improve in thinking (cognitive) and motor (physical) skills. Also, children must mature to a certain point before they can progress to new skills (Readiness). For example, a four-month-old child cannot use language because the infant’s brain has not matured enough to allow the child to talk. By two years old, the brain has developed further and with the help from others, the child will have the capacity to say and understand words. Also, a child can’t write or draw until he has developed the motor control to hold a pencil or crayon. Maturational patterns are innate, i.e., genetically programmed. The child’s environment and the learning that occurs as a result of the child’s experiences largely determine whether the child will reach optimal development. A stimulating environment and varied experiences allow a child to develop to his or her potential.
• **Development proceeds from the simple to the more complex:**

Children use their cognitive and language skills to reason and solve problems. For example, learning relationships between things (how things are similar), or classification, is an important ability in cognitive development. The cognitive process of learning how an apple and orange are alike begins with the most simplistic or concrete thought of describing the two. Seeing no relationship, a preschool child will describe the objects according to some property of the object, such as color. Such a response would be, “An apple is red (or green) and an orange is orange.” The first level of thinking about how objects are alike is to give a description or functional relationship between the two objects. “An apple and orange are round” and “An apple and orange are alike because you eat them” are typical responses of three, four and five year olds. As children develop further with all cognitive skills, they are able to understand a higher and more complex relationship between objects and things; i.e. that an apple and an orange exist in a class called fruit. The child cognitively is then capable of classification.

• **Growth and development is a continuous process:**

As a child develops, he or she adds to the skills already acquired and the new skills become the basis for further achievement and mastery of skills. Most children follow a similar pattern. Also, one stage of development lays the foundation for the next stage of development. For example, in motor development, there is a predictable sequence of development that occurs before walking. The infant lifts and turns the head before he or she can turn over. Infants can move their limbs (arms and legs) before
grasping an object. Mastery of climbing stairs involves increasing skills from holding on to walking alone. By the age of four, most children can walk up and down stairs with alternating feet. As in order of further maturation, the children to write or draw, develop the manual (hand) control to hold a pencil and crayon.

- **Growth and development proceed from the general to specific:**

  In motor development, the infant will be able to grasp an object with the whole hand before using only the thumb and forefinger. The infant's first motor movements are very generalized, undirected, and reflexive, waving arms or kicking before being able to reach or creep towards an object. Growth occurs from large muscle movements to more refined muscle movements.

- **There are individual rates of growth and development:**

  Each child is different and the rate at which individual child grows is different. Although, the patterns and sequence for growth and development are usually the same for all children but the rate at which individual child reaches developmental stages will be different. This fact of individual differences in rate of development dismisses the notion of the 'average child'. Some children will wake at ten months while others wake a few months older at eighteen months of age. Some children are more passive. But this does not mean that passive child will be less intelligent as an adult.

  These principles of development provide us the basis for understanding how to encourage and support young children in this learning process (Lakshmi, 2005).
1.2.1 Effect of Maturation

Maturation is a process, whereas maturity is a state. Maturation implies progress towards maturity. In case of children and adolescents, the term maturity refers to the extent to which individual has progressed to the mature state or adulthood.

According to Malina (1980) maturity is a variably used term and in growth studies most commonly used term to indicate sexual maturity or attainment of adulthood, through various physiological and hormonal changes that occur in the human body. These changes occur during adolescent growth period. But according to Tanner (1978) these changes do not arise suddenly during maturation (adolescent period) though these are more obvious then, as these are present in all stages of life from birth to death. Just as an average girl is always ahead in maturity than an average boy, similarly an early maturing boy is always ahead than a late maturity boy. It is interesting to note that each child has an inborn biological maturation that influences progress to the mature state. A child’s biological maturation does not necessarily proceed in concern with the child’s chronological age with a group of children of same sex and same chronological age variation will occur in biological age. Some children are biologically in advance of their chronological age and others lay behind. For example during adolescent period children are seen in all stages of their development i.e. in a group of children having chronological age of 14 years, there are three possibilities regarding their biological age or developmental age. There will be certain number of children who have completed their adolescent period, they look like adults and are termed as 'early matures'. Another group of children are those who are
still to enter in their adolescent period, they look like younger and termed as ‘late matures’. There is another group of children who enter in the adolescent period; they are termed as ‘normal matures’ (Singh and Malhotra, 1989). Thus during maturation (adolescence) there are three possibilities of developmental age i.e. early matures, normal matures and late matures. Thus, in growth studies developmental age plays very important role. To access one’s developmental age, there are many methods. These are broadly categorized as

- Method of morphological age
- Method of dental age
- Method of secondary sex characteristic age and
- Method of skeletal age

These are briefly discussed as below:

1. **Morphological Age:**

   Morphological maturity refers to the development of morphological characteristics i.e. size and shape. All the human beings do not attain the same size of their body, since height does not reach the same end point, therefore it cannot be used as maturity indicator. But if the child is followed longitudinally till adulthood then height or size can be used as maturity indicator (Singh et.al 1992).

   Shape age can be studied with the help of body proportions. The various body proportions are used to measure shape age, e.g. the head at birth is advanced in maturity to the trunk followed by the extremities. The idea of shape age is an old one. There are many maturity gradients in the body, which are used as shape age indicator. Godin (1903, 1919) used volume of trunk/volume of limbs to characterize physiological age. Human shape is more stable as compared to height and weight, thus more
2. **Dental Age:**

Dental development can also be used as maturity indicator between the time period from 6 months to 2 years and from 6 years to 12 years as deciduous and permanent teeth appear in the oral cavity of children during these periods of growth respectively. In case of permanent teeth the incisors and canines appear earlier in lower jaw in both girls and boys during 6 to 7 years of age and premolars and first and second molar emerges during 10 to 12 years of age. The situation for emergence of third molar is very peculiar. In many cases this does not emerge and in other cases it emerges from 16 to 20 years of age. (Singh et. al 1992).

Dental maturation is slightly correlated with percentage of attained final height (Eveleth and Tanner 1976). It indicates that taller and heavier children have higher number of erupted teeth as compared to the smaller and lighter children.

3. **Sexual or Secondary Sex Characteristic Age:**

Sexual maturity is related to the maturation of secondary sex characteristics of an individual and physiological and hormonal changes leading to the adult reproductive functions. These changes occur during the adolescent period. Therefore, as an individual matures sexually during this period it is also known as pubertal period. (Singh et al. 1992). There are large variations among the children to pass through various characteristics of sexual maturity. The first sign of initiation of puberty is the enlargement of sactorum in boys and appearance of breast buds in girls. Other characteristics of sexual maturity are
appearance of pubic and axillary hair in case of both male and female and development of moustaches, beard, enlargement of lrynx and first ejaculation or oigarche in case of boys and development of breast, broadening of hip, and onset of menarche (the first menstruation cycle) in case of girls. Many methods at present given by different scientists to measure sexual maturity (Greulich et. al 1942, Schoenfield and Beabe 1942, Dupertuis et. al 1945, Tanner 1962, Singh and Sidhu 1981, Roede and Van Veiringen 1985).

4. **Skeletal Age:**

Skeletal Age is the most commonly used and best indicator of physiological maturity. It is a measure of how long the bones are in their course of maturity as recorded by radiographs. The sequence of events of ossification in each bone is essentially the same in all individuals, irrespective of whether the bone is advanced or retarded in relation to chronological age. There are many methods to measure the skeletal maturity, but the most commonly used and the most authentic method is the TW$_2$ hand-wrist X-ray method given by Tanner and Whitehouse (1975). According to this method, description of developmental stages of bones of hand and wrist are used for assessment of skeletal maturity. In this method hand-wrist radiograph of left hand is used, because it is very much convenient to take radiograph of this part and secondly effect of radiations is almost negligible or least by using this part of the body instead of using any other part of the body. Left hand is also used because of less chances of fractures or injuries and extra enlargement of bones due to physical activity. Hand should be in correct position as described by Tanner et. al (1975). Twenty bones of hand and wrist are examined
in the order as radius, ulna, metacarpals 1, 3 and 5, phoximal phalanges 1, 3 and 5, middle phalanges 3 and 5 distal phalanges 1, 3 and 5 and carpals – capitate, hemate, triqueletral, lunate, scaphoid, trapezium and trapezoid. Using scoring method of Tanner and Whitehouse a stage is given to each bone and for every stage there is a separate score. These scores are sex specific i.e. separate for boys and girls. From these scores of particular stages the skeletal ages (RUS age, Carpal Age, TW2-20 bone age) are obtained by summing 13 RUS bone scores, 7 Carpal bone scores and 20 TW2-20 bone scores respectively. Each of these has been scaled to pass from o (invisible) to 1000 (fully maturity)

1.2.2 Effect of Growth on Physical Performance

It is scientifically proved that growth is directly related to one’s level of physical performance i.e. if growth is maximum; the physical performance of a child is also maximum. As we know that growth is at its peak during adolescent period, physical performance of a child is also at its peak during this period.

Studies show that if one has to excel in the particular sport, he/she has to know his/her maturity status. Not only champions but the participants of competitive sports are advanced in their maturity status. This is the reason why age based competitions have been started in various parts of the world. Age based competitions are helpful to encourage and motivate young children to participate and excel in his/her chosen physical activity. These are also helpful in eliminating adults and to allow only those children who are equal in their chronological age. But as we know that the chronological age is a poor indicator of maturity status in growing children because, for any
particular chronological age during adolescence there are three possibilities of maturity status of the children viz. early matures, late matures or normal ones. Thus, age based competitions especially during adolescence allow participation of a group of children who are different in their maturity status and as we know physical performance is directly related to maturity status of a child. Therefore, these chronological age based competitions are of no use because early matures are always ahead. They leave no further avenues for late matures to show their abilities. Therefore it is suggested that to achieve excellence in the field of sports the best period is the adolescent period and by keeping in mind this, the regular and systematic training can be scheduled so that better results can be achieved later on. Thus, to excel in sports one aspect should always be kept in mind and that is the 'maturity status' or 'the developmental age' of a child instead of his/her 'chronological age'.

In India also not only the competitions but participations in a particular game are generally chronological age based. Most of the sports federations arrange the sports competitions of children according to age categories viz. Sub Juniors, Junior and seniors. Though, the idea of age based competitions in the field of sports was to motivate and select the talent at early age but this aim has never been achieved because the participation is based on the chronological age. As the participation is chronological age based, older children or the seniors get entry to junior level competitions and win the medals. They might do this either by producing false documentary proof of their chronological age or as they are early matures. These medal winners are then selected for higher level
competitions with such expectations that they will perform much better in future also. But these expectations are not fulfilled because these winners have already given their best performance by virtue of being early matures at the time when they participated with the children of the same chronological age.

The participations of seniors or early matures leave no avenues for the juniors or late matures to show their excellency. As the early matures excel in early ages because of their period of peak performance and leave no further improvement in tactics and technical aspects of sports. On the other hand, the peak performance of juniors or late matures has yet to come but as they are shed behind by their counterpart viz. senior/early matures having the same chronological age, their capabilities become neglected. This is the reason why in India the champions of Junior Level are not the champions of senior level. This is one of the major drawbacks of India for not getting excellence at higher level of sports competitions. Furthermore, the early matures are generally heavier and taller and have more muscle mass, bone mass and lean body mass as compared to the late matures. So, the question arises why not to select the boys and girls on the basis of their developmental age even for imparting training and making them perfect/best athletes.

The best approach in this connection is to assess maturity status of the athletes and to know their developmental ages. To assess one’s developmental age the best or the most authentic method is the hand wrist X-ray method, but it is not possible in India to have radiographs of the children to assess the developmental age due to many reasons.
Beunen (1989) also stated that, “It is clear that biological maturity status should be considered in the evaluation and the performance capacity of the children”.

The evidences present show that early matures perform better in sports competitions.

1.2.3 Types and rates of human growth

Different tissues and different regions of the body mature at different rates, and the growth and development of a child consists of a highly complex series of changes. It is like the weaving of a cloth whose pattern never repeats itself. The underlying threads, each coming off its reel at its own rhythm, interact with one another continuously, in a manner always highly regulated and controlled. The fundamental question of growth relates to these processes of regulation, to the program that controls the loom, a subject as yet little understood. Meanwhile, height is in most circumstances the best single index of growth, being a measure of a single tissue (that of the skeleton; weight is a mixture of all tissues, and this makes it a less useful parameter in a long-term following of a child’s growth). And this section, the height curves of girls and boys are considered in the three chief phases of growth; i.e. from conception to birth, from birth until puberty, and during puberty. Also described are the ways in which other organs and tissues, such as fat, lymphoid tissue, and the brain, differ from height in their growth curves. There is a brief discussion of some of the problems that beset the investigator in gathering and analyzing data about growth of children, of the genetic and environmental factors that affect rate of growth and final size, and of the way hormones act at the various phases of the growth process. Lastly, there is a brief look at disorders of growth.
Throughout, the emphasis is on ways in which individuals differ in their rates of growth and development.

The changes in height of the developing child can be thought of in two different ways: the height attained at successive ages and the increments in height from one age to the next, expressed as rate of growth per year. If growth is thought of as a form of motion, the height attained at successive ages can be considered the distance traveled, and the rate of growth as, the velocity. The velocity or rate of growth reflects the child’s state at any particular time better than does the height attained, which depends largely on how much the child has grown in all preceding years. The blood and tissue concentrations of those substances whose amounts change with age are thus more likely to run parallel to the velocity rather than to the distance curve. In some circumstances, indeed, it is the acceleration rather than the velocity curve that best reflects physiological events.

In general, the velocity of growth decreases from birth onward (and actually from as early as the fourth month of fetal life), but this decrease is interrupted shortly before the end of the growth period. At this time, in boys from about 13 to 15 years, there is marked acceleration of growth, called the adolescent growth spurt. From birth until age four or five, the rate of growth in height declines rapidly, and then the decline, or deceleration, gets gradually less, so that in some children the velocity is practically constant from five or six up to the beginning of the adolescent spurt. A slight increase in velocity is sometimes said to occur between about six and eight years.

This general velocity curve of growth in height begins a considerable time before birth. The peak velocity of length is
reached at about four months after the mother's last menstruation. (Age in the fetal period is usually reckoned from the first day of the last menstrual period, an average of two weeks before actual fertilization, but, as a rule, the only locatable landmark.)

Growth in weight of the fetus follows the same general pattern as growth in length, except that the peak velocity is reached much later, at approximately 34 weeks after the mother's last menstrual period.

There is considerable evidence that from about 34 to 36 weeks onward the rate of growth of the fetus slows down because of the influence of the maternal uterus, whose available space is by then becoming fully occupied. Twins slow down earlier, when their combined weight is approximately the 36-week weight of a single fetus. Babies who are held back in this way grow rapidly as soon as they have emerged from the uterus. Thus there is a significant negative association between weight of a baby at birth and weight increment during the first year; in general, larger babies grow less, the smaller more. For the same reason there is practically no relation between adult size and the size of that person at birth, but a considerable relation has developed by the time the person is two years old. This slowing-down mechanism enables a genetically large child developing in the uterus of a small mother to be delivered successfully. It operates in many species of animals; the most dramatic demonstration was by crossing reciprocally a large Shire horse and a small Shetland pony. The pair in which the mother was a Shire had a large newborn foal, and the pair in which the mother was Shetland had a small foal. But both foals were the same size after a few months, and
when fully grown both were about halfway between their parents. The same has been shown in cattle crosses.

Poor environmental circumstances, especially of nutrition, result in lowered birth weight in the human being. This seems chiefly to be caused by a reduced rate of growth in the last two to four weeks of fetal life, for weights of babies born in 36 or 38 weeks in various parts of the world in various circumstances are said to be similar. Mothers, because of adverse circumstances in their own childhood, have not achieved their full growth potential who may produce smaller fetuses than they would have, had they grown up in better circumstances. Thus two generations or even more may be needed to undo the effect of poor environmental circumstances on birth weight.

The great rate of growth of the fetus compared with that of the child is largely due to the fact that cells are still multiplying. The proportion of cells undergoing mitosis (the ordinary process of cell multiplication by splitting) in any tissue becomes progressively less as the fetus gets older, and it is generally thought that few if any new nerve cells (apart from the cells in the supporting tissue, or neuralgia) and only a limited proportion of new muscle cells appear after six postmenstrual months, the time when the velocity in linear dimensions is dropping sharply.

The muscle and nerve cells of the fetus are considerably different in appearance from those of the child or adult. Both have little cytoplasm (cell substance) around the nucleus. In the muscle there is a great amount of intercellular substance and a much higher proportion of water than in mature muscle. The later fetal and the postnatal growth of the muscle consist chiefly of building up the cytoplasm of the muscle cells; salts are incorporated
and the contractile proteins formed. The cells become bigger, the intercellular substance largely disappears, and the concentration of water decreases. This process continues quite actively up to about three years of age and slowly thereafter; at adolescence it briefly speeds up again, particularly in boys, under the influence of androgenic (male sex) hormones. In the nerve cells cytoplasm is added and elaborated, and extensions grow that carry impulses from and to the cells the axons and dendrites, respectively. Thus postnatal growth, for at least some tissues, is chiefly a period of development and enlargement of existing cells, while early fetal life is a period of division and addition of new cells.

1.2.4 Human Growth and Development

**Infancy**

Period of rapid growth

From birth to 2 years of age, the human body quadruples in weight and grows 14 inches, reaching half the height adult size. The five senses, language skills, and muscle control, all develop rapidly during this time.

**Early Childhood**

Between the ages of 2 and 6, the human body grows taller and slimmer, and becomes more proportionate. Large muscles become stronger, and skills are learnt primarily through play.

Early childhood describes the years from ages two to six. During early childhood, the body no longer grows at the rapid pace that it did during the first two years of life. The average children add two to three inches in height and about 5 pounds in weight each year (Berk, 2006). The weight increase is due mainly to increases in the size of the
skeleton and muscular systems as well as some body organs. Consequently, posture and balance changes that support gains in motor coordination, cognitive development – children begin to make gains in tasks that depend on the frontal cortex and thus language skills and motor coordination increase at an astonishing rate. Children begin to gain the ability to control impulses. During the early school-age period, children are constructing a broad overview of how their interpersonal world is structured and where they fit in. They are devising a scheme for self in society. Because children's life experiences are limited and they are still highly impressionable, the nature of this initial worldview is likely to be very compelling, permeating their outlook in the years ahead.

The period of middle and late childhood involves slow consistent growth. This is a period of calm before rapid growth spurt of adolescence. Among the important aspects of body changes in this developmental period are those involving the skeletal system, the muscular system and motor skills.

**Motor-Development**

During middle and late childhood, children's motor development becomes much smoother and more coordinated. Children's center of gravity begins to shift and they become more steady on their feet making it easier to balance and complete tasks such as throwing, hitting, catching, hopping, and jumping. As children move through the elementary school years they gain greater control over their bodies and can sit still and pay attention for longer periods of time.
School Age

From age 7 to 11, growth slows. The body develops an increased control over fine muscle movements. This is a period when humans are curious and eager to learn.

Puberty

Around the age 10 until 19, puberty racks the human body with growth and changes. This period of development is characterized by frequent emotional shifts and the physical maturation of the reproductive system.

In their teens, children put on an amazing growth spurt to reach their final adult height. At their fastest, boys can grow taller by as much as 9cm a year and girls at a rate of 8cm a year. It's no wonder teenagers are clumsy. Their body is shooting upwards at a speed their brain simply cannot keep up with.

This phenomenal growth starts at the outside of the body and works in. Hands and feet are the first to expand. Needing new shoes is the first sign of trouble.

Next, arms and legs grow longer, and even here the 'outside-in' rule applies. The shin bones lengthen before the thigh, and the forearm before the upper arm.

Finally the spine grows. The very last expansion is a broadening of the chest and shoulders in boys, and a widening of the hips and pelvis in girls.

Growing up and tripping over

Many teenagers shoot up so fast that their brains cannot keep up. As their height increases, their centre of gravity lifts. This happens so quickly that the brain does not get a chance to calculate the new rules for balancing. Clumsiness is often unavoidable.
Adolescence

Adolescence is the human body’s natural progression and transition from childhood to sexual maturity. Adolescence is also called puberty. Adolescence is generally marked by significant growth in both boys and girls. Children will grow in height, as well as weight. Many people call adolescence a “growth spurt.” Girls can enter puberty as early as eight years of age, and boys can enter as early as nine years of age. However, puberty can also start as late as 13 for both sexes. A child who enters puberty at eight or nine, or who has not entered puberty by the middle of their 13th year, should be consulted by his or her doctor.

Adolescent Girls

During puberty, girls can grow an average of three inches per year for up to two years. Once a girl starts her menstrual cycle, she will only grow an average of one or two inches each year. Most girls reach their adult height by their 15th year. Girls will gain approximately 20 pounds during puberty.

Girls should be fully educated about their body, reproductive system, and be prepared for their menstrual cycle. It is important that girls are given the proper terms for their genital area, and that they are not made to feel ashamed about the changes their bodies are going through. The first outward sign a girl is in puberty is that her nipples will enlarge and sparse pubic hair will appear. This will soon be followed by a gradual growth in the breasts, more pubic hair, underarm hair, oily skin, and menstruation.
Adolescent Boys

Boys should be fully educated about their body and their reproductive system, as well. When talking to a boy, try to use the correct terms for their body parts, and reproductive organs. One of the first signs of a boy is in puberty is that his testicles will become larger. He may also notice that he has body odor coming from his armpits. As he enters advance stages of puberty, sparse pubic hair will begin to grow, and ejaculation may start occurring during sleep. Voice changes may occur and boys may sound pitchy or scratchy. Next, a boy may notice that his penis is becoming longer or thicker. Hair will start growing thicker in the groin area. Hair will begin to grow in the armpits, and on the chin and upper lip. Lastly, chest hair will grow.

Boys will grow an average of four inches each year during puberty. They will continue to grow taller, and generally reach their adult height during their 19th year. Boys will gain an average of 30 pounds.

Early Adulthood

From age 20 to 35, the human body is in peak physical health and strength. Major life changes such as marriage, child birth and career opportunities usually occur during this time.

Adulthood

Ages 35 to 65 span middle adulthood. This developmental period involves physical changes such as wrinkles, menopause and a dulling of the senses. From 65 onward, the body continues to change with dryer, thinner skin, thinner hair, and bone and muscle loss.

1.2.5 THE PROBLEM

The reviewed studies are silent about the motor performance and its relationship with the developmental
age, which is of great importance in the field of sports, since motor performances and physical fitness components have direct relationship with maturity status. Since there is lack of studies in India and particularly in Punjab, especially longitudinal, to look into maturation process during adolescence among school going students, the proposed study is an attempt in this direction.

The study is predictable in regards with the peak performance age of an athlete-the factor which has no space in the previous studies. This factor is of great importance especially for our nation, as we are nowhere in International sports arena.

1.2.6 HYPOTHESIS

The body development index is the true reflection of the developmental age, as assessment of developmental age through morphological age is a valid and well established method.

1.2.7 DELIMITATIONS

The present study has been delimited only to the of assessment of developmental age and its relationship with motor performance tests have been seen longitudinally of 12 to 18 years boys of age from different schools of Punjab.

1.2.8 LIMITATIONS

The following were the limitations of the study:

1. The study was limited to the boys of age group of 12 to 18 years only.

2. Assessment of their developmental age and its relationship with motor performance tests have been examined longitudinally.

3. No specific motivational techniques were used while collecting the data on motor performance variables.
1.2.9 TITLE OF THE RESEARCH PROBLEM
A LONGITUDINAL STUDY OF ASSESSMENT OF DEVELOPMENTAL AGE AND ITS RELATIONSHIP WITH MOTOR PERFORMANCE TESTS IN BOYS.

1.2.10 NEED OF THE STUDY
This study is needed to assess the age of high performance athletes well in time. The study can significantly provide cheaper methods to assess the maturity status. This study is also necessary for coaches and sports sciences for the plan of scientific training programmes. The study can play a significant role to recognise the status of children-early, late and normal matures. In future this study can provide empirical base for the competitions to be conducted on the developmental age base and not on chronologically age base which ultimately boosts the sports participation at grass-root level.

1.3.1 SIGNIFICANCE OF THIS STUDY:
The present longitudinal study will help to assess:
Firstly, the developmental age of male children of Punjab state. Secondly, whether they have the same growth rate throughout the growth period i.e. in the early matures, be the early matures in pre and post adolescent period also or not. Thirdly, the relationship of their maturity status with their physical performance. To assess the developmental age, an easy and economical method i.e. “Body Developmental Index Method” has been used. In this method only five anthropometric measurements are required, and these measurements are height (cm) and weight (kg), Fore-arm circumference (cm), biacromiale diameter (cm) and biliospinale diameter (cm). A standardized-formula is employed to find out the middle breadth and corrected fore-arm circumference. Whatasoever the value to BDI is obtained that has to refer to the norms
available for body development index in order to find out the developmental age of a child. It is hypothesized truly that the body development index is the true reflection of developmental age. This method is categorized under morphological age method, which is easy, economical and practical in nature.

This study will highly be useful for the coaches, physical educationists, sports scientists and sports administrators to know the developmental age or maturity status of the children who are willing to opt sports as a career. The sports training can be scheduled accordingly and other scientific parameters can also be evaluated at par with the maturity status. Further, if developmental age of the children is known then it may help to solve the disputed cases of chronological ages, especially during the competitions as both these ages are strongly correlated with each other.

**1.3.2 OBJECTIVES OF THE STUDY**

1. To assess the developmental age of boys of 12 to 18 years.
2. To find out the maturity status of boys in terms of early, late and normal developers.
3. To observe changes in maturity status of boys longitudinally.
4. To find out the status of motor performance of boys in terms of speed, cardiovascular endurance, agility and explosive strength of legs.
5. To co-relate the relationship between maturity status and motor performance among boys.
6. To observe the relationship between maturity status and motor performance among boys longitudinally.