Introduction
and
Review of Literature
1. INTRODUCTION AND REVIEW OF LITERATURE

1.1 Introduction

Everyone understands in a general way what is meant by growth. Being born, growing to material, having progeny, then dying are the constitutional stages of life in plant, animal and man akin. Growth is a fundamental phenomenon in all living organisms, though the time taken and the stages attained before the “adult biotype” sets in differs in every animal and man. Man however, takes the maximum time and undergoes various stages before attaining adult physique and total constitutional endowment of the body is the result of an interaction of heredity and environment. Growth and development engross a cardinal place in the study of the mechanisms of evolutionary change, and a central place in the study of individual differences in the structure and function within the human species. Biochemically, the human body is composed primarily of four elemental constituents: water, protein, mineral and fat. Increments of growth at the cellular level are discontinuous, but there is complete continuity at the level of bodily measurements with a velocity that gradually changes from one age to another.

1.1.1 Understanding Growth

Biologists, anthropologists and other researchers related to growth studies agree that the proper growth of a child is the best index of his/her optimal health and nutritional status. The period of growth, as Tanner (1962) states, occupies more than a quarter of a person’s lifetime. The evolution of morphological characters necessarily comes about through alterations in the inherited pattern of growth and development; hence the study of growth elucidates the mechanisms of evolution. Man, like all animals begins life as a single cell, the fertilized ovum guided by interaction of the genetic information provided by each parent and environmental factors, this cell divides, grows, differentiates and develops into the embryo, fetus, child and adult (Bogin, 1988).

The study of growth and development occupies an important place in the study of individual differences in form and function, that is, whether an individual is currently...
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growing at an acceptable speed falling within the normal range of variation of the particular age group or not. The study of physical growth and development becomes important mainly because they are normal physiological processes that are essential for the well being of human organisms. Organic growth, in all of its aspects, encompasses the entire life span, (prenatal and postnatal), of each individual living organisms.

All mammalian species start life as a single cell and growth in early stages of gestation depends on velocity of cell divisions. It is different for each species like hamster, rabbit and rat grow faster than pig, cat and man. Not only do species grow at different rates before birth but progress toward maturity is faster in some species than in the others (Krogman, 1972). Humans are very particular in this regard, as they are born immature and spend almost one third of their life growing, developing and training abilities to survive. Like other primates, humans experience puberty late during their growth period and it is accompanied by an exceptional acceleration of growth (McCance and Widdowson, 1978). Growth studies are important in elucidating the mechanisms of evolution, for the evolution of morphological characters necessarily comes about through alterations in the inherited pattern of growth and development. Growth also occupies an important place in the study of individual differences in form and function in man, for many of these differences arise through differential rates of growth of particular parts of the body relative to others (Harrison et al, 1977).

1.1.2 Definitions of Growth

Most of the authorities superficially agree to considerable extent but they do not agree, upon certain basic fundamental definitions of growth. Distinguished workers in this field entertain different conceptions.

- According to the British Medical Dictionary, growth can be defined as, “The progressive development of a living being or part of an organism from its earliest stage to maturity including the attained increase in size.”
Brody (1945) states that “Growth is biologic synthesis, production of new biochemical units. It is the aspect of development concerned with increase in living substance or protoplasm and includes one or all of these processes like cell multiplication, cell enlargement and incorporation of material from the environment. The third process in Brody’s definition means the inclusion of non protoplasmic substances like fat, blood plasma, cartilage etc., in the body. It is not a ‘true’ growth but a part of growth process”.

Weiss (1981) considers that “growth” is not a scientific term; it has come to connote all and any of these, reproduction, increase in dimensions, linear increase, gain in weight, gain in organic mass, cell multiplication, mitosis, cell migration, protein synthesis and perhaps more.

According to Garn (1973), “Growth refers to the increment in the size of organs, increases in the thickness of tissues or changes of size of individuals as a whole”.

Hurlock (1956) refers to growth as “Increase in the thickness of tissues or changes in the sizes of an individual as a whole, rather than changes in the magnitude”.

Comas (1960) define growth as “objective manifestation of hypertrophy and hyperplasia of the organisms constitute tissues and is determined by postnatal body size. The increase is limited by pre established constitutional hereditary factors and influenced by exogenous factors such as race, climate, diet, environment etc”.

Tanner (1962, 1978) considers growth as a “form of motion” and comments that different body tissues mature at different rate and time through highly complex series of changes, but all changes in the body occur in a highly regulated and controlled manner.

According to Meredith (1982) “Physical growth as a ‘common-place’ synonym for anatomical ontogenesis. Anatomical ontogenesis encompasses all of the structural modifications that a biologic organism undergoes during ontogeny. It
includes the gamut of changes sometimes sub-grouped under such captions as morphologic differentiation, dimensional growth, proportional development, and structural maturation”.

- Sinclair (1973) states “Growth precisely involves a series of changes, which include the addition of material to achieve an increase in size, specialization of various body parts and it also involves substitution, i.e. conversion of cartilage into bone or replacement of temporary teeth by permanent teeth”.

- Falker and Tanner (1978) state “Growth as we conceive it, is the study of change in an organism not yet mature. Differential growth creates form. External form, through growth rates which vary from one part of the body to another and internal form through series of time-entrained events which build up in each cell the specialized complexity of its particular function.

Thus, the above definitions tell us a good deal which can be concluded as follows.

1) First of all that growth involves a series of changes and not just the addition of material to achieve an increase in size. It may also involve substitution, for example, when cartilage is converted into bone, or when the permanent teeth replace the temporary ones.

2) Growth of the whole ‘living being’ is different from the growth of one or more of its part because not all parts of the human body grow at same rate nor do they stop growing simultaneously. Growth of one part may be controlled by the activity of another and the degrees of control depend on the stage of development reached by the controlling part.

3) Growth does not cease when maturity is attained.

4) Growth is continuous from the time the ovum is fertilized until death.

1.1.3 Growth and Development

The terms growth and development are often used interchangeably. But strictly speaking, they are not interchangeable but interdependent. Whereas growth refers to proportionate changes and quantitative increase in size or number of parts of an
organism, development reflects changes in function either quantitative or qualitative i.e. increasing complexity and progress towards maturity (Specialization).

Development on the other hand generally refers to the remaining changes occurring during the process of attaining the mature state such as the differentiation of organs and tissues during the embryonic period, the postnatal establishment of efficient digestive function, skeletal maturation throughout childhood and life long production of antibodies to produce immunities (Valadian and Ponter, 1977). According to Garn (1973) Growth and development are processes common to all living organisms, processes ultimately linked in time but partially independent unquestionably genetically determined yet uniquely susceptible to environmental modifications.

Development denotes concept often used in two distinct contexts, first one is biological (differentiation of cell along specialized functions) and second one is behavioral (development of competence in a variety of interrelated domains like culture). Thus, one can speak of the development of social competence, and emotional competence, or well being as the child’s individual personality emerges within the context of the particular culture in which the child was born and reared. Development includes three diverse processes viz., a) Growth b) Differentiation c) Maturation. Differentiation refers to the specialization of the cells according to the functions. Maturation refers to the changes in the function with or without an observed change in structure. Human growth and development encompass both prenatal and postnatal changes. Whereas growth tends to restrict to the anatomical and physiological changes, development includes psychological attributes, ideas and understanding (Sinclair, 1973). Physical growth involves minimally two components, status (size attained) and rate (tempo). Growth rate reflects current nutritional status while growth status is more related to nutritional history (Buschang and Malina, 1983).
1.1.4 Principles of growth

Major principles of growth and development provide a framework for understanding the complexity of human development and highlight the general pattern and trends underlying the process of growth and development.

I. There is continuous increase in body dimension from birth to maturity which is very high during two postnatal stages of life. The first stage comes during infancy and second period of rapid growth is roughly within 10-15 years of so called adolescent growth spurt. Growth also involves differentiation and integration of various parts of the body to perform different function.

II. Rate and pattern of growth are specific to certain parts of the body because not all parts of the body grow at the same rate or at same time. Each system or parts has its own timetable to grow so the body does not grow as whole. Apart from the nervous and lymphatic system, most of the tissue of the body shows growth curve similar to those for height.

III. There are wide individual differences in growth rate. Beside the individual difference, boys and girls also differ in most of growth rate and differences are especially wide during puberty spurt.

IV. Development in learning and acquiring the skills and functions proceeds sequentially from simple to complex and general to specific.

V. The development of the body as a whole follows two direction first is cephalo-caudal (direction of growth proceed from the head towards the toe region) and second is caudo-cephalic (growth progresses from the distal end toward the proximal region). Due to the effect of certain factor affecting growth the development direction at times may reveal a mixed trend of maturation which has been referred to as the operation of smaller area gradient (c.f Tanner, 1964). All the three situations may exist in different body segment at the same time or at different times.

VI. Rates of development vary. Certain period such as adolescence, seem to be evidence of abrupt changes in the child development.
VII. There is an inherent urge for the individual to grow and develop. Such tendency for growth has been described in various ways. This tendency can be enhanced or hindered by the environment.

VIII. Although physical growth may cease, development occurs throughout an individual’s life span. This principle brings a challenge to each individual to continue to strive for fullest development possible.

The growth and development studies have great importance in anthropological studies because of the following reasons:

1. The degree to which a population is adapted to its environment is reflected in growth and the growth of the individuals who comprise it.

2. It helps in examining the individual differences in structure and function.

3. It helps in investigating inter-population variations.

4. To understand the mechanism of evolution of morphological characters necessarily comes about through alterations in the inherited pattern growth and development (Tanner, 1962).

5. It is important for medical studies also viz. for pediatricians.

6. It is organized as a powerful tool for assessing the health and nutrition status of children in the population.

Thus growth studies become increasingly important in the evolution of health care (Tanner, 1978). Human growth and development follow a predictable overall pattern that is consistent within the individual but embraces a wide range of differences among individuals in the age of onset and the duration of specific stages as well as in the magnitude of the changes that occur during each stage. The basic developmental sequence is same for all children (Valadian & Ponter, 1977). Linear or Distance growth is overall growth at some point of time. Gradually, with time, there occurs increase in height and weight of a child which can be revealed by measuring at some point of time. Growth Velocity or Rate of Growth is increment in growth in a unit of time. The comparison of child’s height and weight with the growth-chart helps to
determine if the particular child is within the expected normal range for his sex and socio-economic stratum. It does not show whether the child’s growth was normal in the recent past. Measurement of velocity of growth is more fruitful. It helps in early assessment of retarding factors of growth as well as prediction of ultimate growth.

Growth periods are divided into developmentally functional stages. The life cycle may be said to begin with fertilization and then proceed through prenatal growth and development, birth, postnatal growth and development, maturity senescence and death. In reality, the course of life is cyclic—birth, the onset of sexual maturation in adolescent boy or girl, and even death are each fundamental attributes of the cycle of life. In the child and adult, old cells die and degrade so that their molecular constituents may be recycled into new cells formed by mitosis. At the population level, people grow, mature, age and die even as new individuals are conceived and born. Declaring one moment such as fertilization, to be a beginning to life is arbitrary in a continuous cycle that passes through fixed stages in the individual person and in generation after generation (Bogin, 1988).

1.1.5 Stages of Growth (Bogin, 1988)

A. Prenatal period- Conception to birth (averages about 40 weeks in length).

This period is divided into 3 stages:

i. Embryonic- Conception to 8 weeks

ii. Middle fetal period- 9 to 24 weeks

iii. Late fetal period- 25 weeks to birth

Or

The prenatal period is divided into 3 trimesters each of three months duration.

B. Infancy- First two years of life.

This period is further divided into 3 stages:

i. Neonatal- Birth to one month
ii. Infancy proper- One month to one year

iii. Late infancy- The entire second year

C. Childhood- Aged 2 to 10/12 years for girls and 2 to 12 years for boy.

This period is further divided into two periods

   i. Preschool years- Age 2 to 6 years

   ii. School years- Age 6 to 10 years (girls)

       Age 6 to 12 years (boys)

D. Adolescence- Age 10 to 18 years (girls)

       Age 12 to 20 years (boys)

This period is also divided into 3 stages

   i. Pre pubescence- Age 10 to 12 years (girls)

       Age 12 to 14 years (boys)

   ii. Pubescence- Age 12 to 14 years (girls)

       Age 14 to 16 years (boys)

   iii. Post Pubescence- Age 14 to 18 years (girls)

       Age 16 to 20 years (boys)

E. Adulthood- Prime and transition (between 20 years of age and end of child bearing years).

F. Old age and Senescence- From end of child bearing years to death.

There are two major periods of growth first is prenatal period and second is postnatal period.
1.1.5.1. Prenatal Growth

The human ovum at conception is about 0.1mm in diameter and it is like homogeneous mass. During the embryonic stage though the rate of growth is slow the process of differentiation takes place in the mass to form various regions which later on give rise to the different body parts (like head, leg and so on) and cells also get differentiated into specialized tissues like nerves and muscles. This process which gives definite shape to different parts is called morphogenesis. By 8th week the embryo becomes child like in appearance. At fetus stage the rate of growth in length as well as weight is considerably high but in length the peak is reached earlier than in weight. From about 36 weeks the growth rate of fetus slows down mostly due to the influence of mother’s uterus.

1.1.5.2 Postnatal growth

It starts from the time of birth up to the adulthood or the time of maturity and includes:

a. Infancy: It is further divided into two stages like neonatal and infant. Neonatal stage is also known as the adjustment age. The chance of death is very high in the neonatal stage because in first 24 hours most of the water is lost due to which neonate loses his or her weight. In Infant stage he or she starts growing on its own genetic potency or the constitution which results in increased rate of growth. During infancy the growth is very rapid more than 50% of the birth length and 200% of birth weight takes place during the first year of life. From this period onwards the rate of growth decreases sharply. Birth length represents approximately one fourth of the total height against one eighth in the adult and cranial capacity is about half of the adult. General chubbiness and relatively large dimensions of head and trunk are characteristic features of a child during infancy. The cervical and lumbar curvatures of the spinal column appear as the baby begins to straighten his/her head and tries to sit up and to stand.

b. Childhood: It is divided into two stages, like preschool age and school age. Preschool age period marks the eruption of deciduous or milk teeth and
beginning of permanent dentition. The rounded body form predominates to a lesser degree. During this period the growth is relatively more in width than in height. In school age stage the rounded form disappears. Size of head increase slightly and linear growth of the body takes place rapidly. Thorax becomes oval in transverse section and waist line becomes definable.

c. Adolescence: It is divided into three stages, like pre pubescence, pubescence and post pubescence. This period starts from the pre pubescence and continues up to post pubescence. During pre pubescence, which lasts for about two years, increase of weight is retarded. Legs and arms become long, height increases and trunk becomes short. In pubescence period sexual organs are matured and the body proportions are changed. In other words differentiation in primary and secondary sexual characteristics marks the adolescence period.

d. Adulthood or maturity: In this period height ceases to grow when the long bones femur, tibia and fibula loses its capacity in length. This cessation of growth in height is regarded as a sign of maturity. Another important sign of adulthood is reproductive maturity which begins but is not completed.

Senescence: In this period many molecular and cellular changes occur. The tissues do not renew and as a result cells show senile involution. The memory declines and aged person needs more time to learn and to react. Systolic blood pressure increases, reduction in density of long bones and vertebrae, arm span circumference of forearm and that of calf decreases and vital capacity and muscle tone decline. According to Comfort (1964), “Ageing is an increased liability to die, or an increasing loss of vigour, with increasing chronological age, with the passage of the life cycle.”

1.1.6 Adolescent growth spurt

Adolescent growth spurt is a constant phenomenon and occurs in all children during adolescence period, though it varies in intensity and duration from one child to another. In boys it takes place, on the average, from age 12 to 17, and is responsible for a gain in height of about 20 cm (range 10-30 cm) accompanied by gain in weight of about 20 kg (range 7-30 kg). The peak velocity of height growth averages about 10 cm (4 inches) per year, which is the rate the boy was growing at the age of 2 years.
The time at which this maximum velocity is reached averages about 14 years, though it may lie anywhere between 12 and 17. In girls the spurt begins about 2 years earlier than in boys, lasts on an average from 10 to 13, and is somewhat smaller in magnitude, the peak height velocity averaging about 8 cm per year. The difference in size between adult men and women is to a large extent the result of the differences in adolescent spurt occurrence like in males the spurt occurs later, allowing an extra period for growth, even at the slow pre-pubertal velocity and partly because of the greater intensity of spurt itself; prior to it, boys and girls are practically the same height.

Upon analysis of the size of various parts and organs of the body, Scammon (c.f. Sinclair 1973) proposed that the growth of different tissues and systems could be summarized in four patterns (or curves) of growth viz., General Curve, Neural Curve, Genital Curve and the Lymphoid Curve. Different body system and organs follow different patterns of growth and they also increase in absolute size and weight by very different amounts. The respiratory, digestive, and excretory systems follow very similar curves, and thus their relative sizes remain more or less constant during growth. It is also clear that the skeleton must behave similarly, since it is responsible for height, and this is corrected with weight. Other systems, however, follow different growth curves. The central nervous system, organs of special sense and skull together follow a curve in which there is very rapid growth in structures involved (about 90 percent of their adult size by the age of 6 years) in the early stages of childhood. From this time onwards the growth of nervous system is much slower than rest the body. The third pattern of growth is followed by the gonads and the external genitalia, which develop very slowly in the early stages of growth, but at puberty, begin to grow much faster than the rest of the body. Finally, the uterus and the suprarenal glands share a fourth pattern, being relatively large at birth, actually losing weight rapidly, and not regaining their birth weights until just before puberty.

Many of the sex differences of body size and shape seen in adults are the result of differential growth patterns at adolescence. The adolescent spurt in skeletal and muscular dimensions is closely related to the rapid development of the reproductive system which takes place at this time. As in boys, there is large variation in the time at
which the spurt begins, though the sequence of events is fairly constant. The appearance of the breast-bud is as a rule the first sign of puberty, though the appearance of pubic hair may sometimes precede it. The uterus and vagina develop simultaneously with the breast. Menarche (the first menstrual period) occurs almost invariably after the peak of the height spurt has been passed. Menarche marks a definitive and probably mature stage of uterine development, but it does not usually signify the attainment of full reproductive function. The early menstrual cycles frequently occur without an ovum being shed; during the first year or more after menarche there is a period of relative infertility, characteristic of apes and monkeys as well as the human.

The first sign of puberty in boys is the accelerated growth in the testis and scrotum. Slight growth of pubic hair also starts at the same time. The testicular growth accelerated due to the increase in the size of the seminal tubule the androgen producing leydig cells also appear to develop more or less simultaneously. Axillary hair growth starts after the 2 years of the pubic hair growth. In boys the facial hair begins at about the same time as axillary hair at the covers of the upper lip. Then the hair appears at the upper parts of the cheeks. The amount of hair generally depends up on the hereditary and the hormones. The enlargement of the larynx in boys occurs at the time of the penis growth. The areola enlarges in the diameter and darkens.

1.1.7 Indicators of maturity

Considerable changes in physiological function occur at the same time as the adolescent growth spurt. They are much more marked in boys than girls and serve to confer on the male his greater strength and physical endurance. Before adolescence, boys are on average a little stronger than girls, there being more muscularly built boys than girls in the population even then; but the difference is quite small. After adolescence boys are much stronger, chiefly by virtue of having larger muscles, and perhaps also by being able to develop more force per gram of muscle present. They have larger hearts and lungs relative to their size, a greater capacity for carrying oxygen in the blood, and a greater power for neutralizing the chemical products of muscular exercise.
Though all the events of adolescence usually occur together, linked in a rather uniform sequence, the age at which they happen varies greatly from one child to another. Some designation of physical maturity other than chronological age is needed, and in this instance the obvious one would be the degree of development of the reproductive system. But the same differences in tempo of growth occur at all ages, though less spectacularly than at adolescence. Thus we need a measure of developmental age or physiological maturity applicable throughout the whole period of growth. Three possible measures exist at present; skeletal maturity, dental maturity, sexual age and mental age.

1.1.8 Factors affecting growth

Growth charts show progressive changes in height and weight of a child with age. The growth chart depicts average and permissible range of variation for the particular age or attribute. If the growth measurements are recorded in a child over a period of time and are plotted on a graph paper, the deviation in the growth profile of the child from the normal pattern of growth for that age can be interpreted visually. The knowledge of growth would be meaningless without some understanding of the substance, which go to make up the individual and forces, which set the direction for growth. Growth is influenced by intrinsic or genetic factors and greatly channelized by several extrinsic or environmental factors. These two factors are very rarely separable and they almost invariably interact. The progress of any child is the result of a complex interaction of many different factors.

1.1.8.1 Genetic influence

The fundamental genetic infrastructure is one of the most important factors affecting the growth of an individual. The hereditary factors determine the future biotype of an individual to a considerable extent. Hereditary not only affects the ultimate result of the continuing processes of growth but also the rate of growth among different individuals. Hence they are of immense importance. Genes do not act independently but they operate by interacting 1) one with another 2) with the cytoplasm of the cell 3) with the chemical product of gene activity 4) with materials obtained from environment outside the organism. The fundamental plan of growth is laid down very
early, in the comparative safety of the uterus (Harrison et al, 1977). Varied genetic constitutions would invariably give rise to a variety of variations and conversely any similarity in the sequence of occurrence of the genes. There, however, lies the evidence that the genes controlling the growth of different segments of the limbs are independent of one another. The growth pattern of an individual is mainly affected by his genetics (Tanner, 1962) irrespective of conducive environmental factors which are instrumental to accelerate the growth and development, one can’t grow beyond one’s inherent potential.

Studies on identical and non-identical twins reveal the effect of genetic composition on individuals. The control of body size is a complicated affair that involves a co-ordinated functioning of many genes and the functioning of these genes is so well organized that disturbance in a single gene or a group of genes may produce a drastic and wide spread effect. Heredity affects not only the end results of growth, but also the rate of progress towards it, and thus the radiological, dental, sexual and neurological ages of identical twins tend also to be identical whereas those of non-identical twins may differ considerably.

Chromosomal abnormalities suggest genetic control on growth. Male individual with the Klienfelter’s syndrome (XXY) are taller than that of the normal male and females with one ‘X’ chromosome are shorter on average than normal females. Not all genes are active at birth. Some express themselves only in the physiological surroundings provided by the later years of growth; their effect is said to be ‘age limited’. The correlation of length at birth with adult height is very low, since birth length reflects uterine conditions and not child’s genotype. The child’s genes increasingly make themselves felt and the correlation rises steeply during the first two years; but after this only a small rise occurs until adolescence. It seems likely, that the magnitude as well as the time of spurt is genetically controlled. This is shown by the differences in the growth patterns of males and females. The growth patterns seem to be similar in girls and boys up to 10 years of age. The girls have their adolescent spurt two years earlier than the boys and the intensity of spurt in girls is relatively less. Onset of the spurt is probably genetically controlled, although its intensity and duration probably
depend on hormonal factors. There also occurs the racial difference in rate and patterns of growth leading to such differences in adult body built.

1.1.8.2. Neural control

In the hypothalamus of brain a possibility of a ‘Growth Center’ has been suggested which is considered to be responsible for keeping the child on his genetically determined growth curve wherever possible. The deviation from this curve, due to any possible reason viz. prolonged illness or malnutrition, cause a period of accelerated ‘Catch up growth’. The hypothalamus region of our brain releases two factors which stimulate the production of growth hormone, which in turn is transported to the anterior pituitary gland through the hypothalamic-hypophyseal portal vessels. These are Growth Hormone Releasing Hormone (GHRH) and Growth Hormone Inhibitory Hormone (GHIH) also called Somatostanin.

The hormonal concentration of Growth Hormone in the plasma of an adult is about 3 milli microgram/ml and in a child is 5 milli microgram/ml. Apart from its general effect in promoting growth; the Growth Hormone has many specific metabolic effects too like increased rate of protein synthesis in all cells of the body, increased mobilization of fatty acid from adipose tissue, increased use of fatty acids for energy, decreased rate of glucose utilization throughout the body. Growth Hormone enhances body proteins, uses up fat stores, and conserves carbohydrates.

There is also evidence that the peripheral nervous system may play some part in the control of growth. If somatic muscle is denervated it atrophies and similarly taste buds deprived of their innervations will degenerate, when a nerve supplying the hand or foot is cut the growth of nails within its territory is retarded in comparison with that of the nails supplied by other nerves and returns to normal with the regeneration of the nerve. These effects and others like them are not sufficiently explained by the disuse following injury, or by a diminution in blood flow consequent on this disuse. It is therefore suggested that the peripheral nerve fibers exert a nutrition of ‘trophic’ effect on the structure they supply and that this due to a chemical secreted by the nerve cells and liberated at the endings of the nerve fibers, the chemical in some way modifies the growth and repair pattern of the structure innervated.
1.1.8.3. Hormonal control

The endocrine glands and their secretion (hormones) are of the great importance in the control of the growth and the development. They act as chief mediator between the coded genetic instructions and ultimate reality of the adult organism. Fetal hormones can play no part in growth control before second fetal month, around the second month of fetal life the fetal hormones start acting and the maximum rate of growth in height occurring at around fourth month of fetal life is brought about by these hormones as well as the pituitary which by now is functional. The postnatal growth pattern is maneuvered by the resultant interaction of many hormones. Hormones are the organic substance and these are synthesized in the specific body tissues. Growth regulated by the actions and the interactions of the hormones and regarded as growth promoting substances. The changes during adolescence are caused by the hormones and any kind of imbalance or the disorder in the secretion of the hormones may lead to the abnormal growth. At least three hormones plays vital role in the regulation of the processes of the growth and these are pituitary, thyroid and adrenal hormones.

The most important hormones controlling the growth from the birth up to the adolescence is the “Somatotrophin” or “Growth Hormone” which is produced by the anterior lobe of the pituitary gland and it is present in fetus but not necessary for the fetal growth, from birth onwards it is essential if a normal rate of growth, is to occur. Growth hormone has direct action on the growing tissue and its affects are mainly due to the release of “Somatomedin” from liver and possibly the kidney. It also causes diminution of the amount of adipose tissue, shifting the metabolic balance from the laying down of fat to the laying down of the proteins. Thus, the children who lack this hormone are fat as well as small. The secretion of the growth hormone is apparently controlled by the central nervous system. This is suggested by the observation that a burst of growth hormones secretion occurs during early sleep and after electrical stimulation of the median of the eminence of the hypothalamus. Growth hormone is not released continuously out but secreted in pulses throughout the 24 hours of the day. Exercise, anxiety and sleep regularly cause its secretion.
Thyroid hormone plays a vital role throughout the whole of growth. The activity of thyroid decreases gradually from birth to adolescence, at which time it probably increases or at least falls rapidly for a year or so. So far as rate of growth in size is concerned, the action of the thyroid is permissive and not controlling. In hypothyroidism growth is delayed: skeletal maturity, dental maturity, and growth of the brain are all affected. The pituitary and the thyroid glands play little direct part in the adolescent spurt and it is supported by the abrupt change in the whole pattern of growth at this time for example the sudden appearance of the secondary sex characteristics, the closure of epiphysis, and so on.

The parathyroid gland secretes parathormone which withdraws calcium from the bones to maintain the concentration of calcium in the blood plasma as a constant level. Gonadotropins though released in small amount from the gonads of both the sexes right from the birth are responsible for the attainment of sexual characters in considerably larger quantity. These Gonadotropins as Estrogen, Progesterone and Testosterone. The level of Oestrogen shoots up fairly high in girls, but is at a limited extent in boys. The secretions of ovary have less apparent effect on growth. Cortisol and aldosterone are two major adrenocortical hormones produced by the adrenal circulate in the blood: the thyotropic hormone produced independently, by the anterior lobe of pituitary gland after stimulating the thyroid gland to secrete thyroxine and triiodothyroxins, are also stimulates for the general metabolism, growth and maturation sequence of our body.

The term environment encompasses a large number of variables. Some of which are interlinked with one another like diet, mineral contents of the soil, humidity, altitude, temperature, socio-cultural behavior, socio-economic condition etc are all included in the environment. Thus, environment is a very large complex of conditions. These conditions have influenced at the varied degrees of intensity at different phases of growth. Those factors which directly influence the growth are called as “Primary factors” and which influences the growth via primary are called as the “Secondary factors”.

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1.1.9 Primary factors

1.1.9.1. Nutrition

Nutrition in terms of a well balanced diet plays a vital role in directing the growth processes of an individual. The nutritional aspect of any ecosystem includes the exchange of energy within the system. This energy is essential for physical activities of animals to which man is no exception and the maintenance of balance between calories taken and calories spent is required for proper functioning of the internal system of man. For normal growth and maturation minimum essential sufficiency of food materials is required in balanced diet comprising of fat, carbohydrates, proteins, vitamins and mineral according to the sex and the developmental phase of growth.

Under nutrition at any given stage of development tends to accentuate the normal process of differential growth like growth of the sexual organs at puberty is relatively less depressed than that of the other tissues and organs. Starvation or semi-starvation also alters the composition of the body. The terms ‘nutrition’ and ‘health’ are synonymous as without good nutrition proper health can not be ensured. Children have great recuperative powers, provided the adverse conditions are not carried too far or continued too long for it is so happens the genetic potential for growth is not attained and the final height is reduced. In, general, the females are better buffered to face the effects of malnutrition than males because of the probable reason of female possessing two X- chromosomes, which provide better protection and regulatory forces as against the one X and the small Y-chromosome in males.

1.1.9.2 Socio economic status

The criteria of socio economic status vary considerably among studies and different countries. Commonly used indicators of socio economic status in developed countries include annual family income, per-capita income, occupation and education of the head of the household and place of residence. Children from better-off circumstances tend to be, on the average, taller, heavier and fatter than those from poor socioeconomic conditions. Overall health and nutritional circumstances associated with low socio economic status and limited social services in many developing countries magnify differences between the upper and the lower social strata.
1.1.9.3 Family size

For proper development and growth of an individual family size is an important causal agent, children in larger families are usually smaller, lighter and tend to get relatively lesser attention and care than in small families. The more mouths to feed and children to bother about, the less well the feeding and perhaps the general care, gets done. Such an effect would naturally be felt less in the well off than in the poor. Family’s sub nutrition affects the older as well as the younger sibs effect, in short, differs in no way from the general socio-economic class effects.

1.1.9.4 Psychological/emotional disturbance

In recent years it has been clearly established that in certain children under emotional/Psychological stress the growth hormone secretion is inhibited and the come closely to resemble case of ‘idiopathic growth hormone deficiency’. When children taken out of the stressful condition they begin to secrete growth hormone again and have the usual rapid catch-up growth.

The clearly controlled study made by Widdowson in 1951 (c.f. Sinclair 1973) is for this reason all the more valuable. In studying the effect of increased rations on orphanage children living on the poor diet available in Germany in 1948 she had the rare opportunity of observing the change brought about by replacement of one sister-in-charge by another. The design was to give orphanage A food supplement after a 6 month control period and to compare the growth of the children with those in orphanage B, which was not to be supplemented. The result, however, was the reverse of that expected; thought the A children actually gained more weight than the B children during the first, unsupplemented, 6 months, they gained less during the second 6 months despite actually taking in a measured 20 percent more calories. The reason appeared to be that at precisely the 6 month mark a certain sister had been transferred from B to become head of A. She ruled the children of A with a rod of iron and exacted from them far more discipline and obedience than they had previously been accustomed to. In addition, she frequently chose the times when the children were at their meals to administer to individual children public and often unjustified rebukes, which upset all present. All, that is, except her eight favorites.
whom she brought with her from orphanage B. These eight always gained more weight than the others, and on being supplemented in A gained still faster.

1.1.9.5. Disease

Minor and relatively short illness such as measles influenza or even pneumonia causes no discernible retardation of growth in the great majority of well nourished children. The effects of diseases in childhood are similar to the effects of malnutrition. Many diseases results in retarded growth, poor appetite, diminution in the secretion of somatotropin due to increase in the secretion of cortico steroids from the suprarenal cortex, reduction in hemoglobin amount in blood. In comparison of boys girls are more resistant. Apart from diseases various other factors like medical care, vaccination, proper hygienic condition, intra-uterine environment, and many physical anomalies like deafness, blindness etc affect the growth and development.

1.1.9.6 Skeleton Development

Variation in growth with respect to nutrition is an expression of the variation in rates if bone growth. The two aspects- rate of epiphyseal growth and the timing of the closure of epiphyses is a factor which determines the time at which growth in height ceases, and secondly, the rate of skeleton maturation, as determined by the time of appearance and development of ossification centers, are closely related, and both are affected by protein energy malnutrition. Correlation between physical and skeleton growth are high (Tanner, 1962), although apparently not so high as far sexual development.

1.1.9.7. Season and Climate

Most of the data from the industrialized countries in temperate areas shows a well marked seasonal effect on the growth velocity. Growth in height is on the average fastest in spring and growth in weight is fastest in the autumn. The average velocity of height from March to May is about twice that from September to October in most of the older western European data. Individual children differ surprisingly, however, both in time when their seasonal trend reaches its peak and in the degree to which they show a seasonal trend. Their differences may reflect individual variation in
endocrine reactivity. The area covered by the canopy of the forests and get less sunlight or vitamin D the children born are normally short height as they do not get inadequate amount of the vitamin D for the skeleton system to mature.

1.1.9.8. Altitude

Any elevation which is more than 3000 meters is a high altitude. These high altitudes retard the growth due to malnutrition and impose a number of stresses on people including hypoxia, high solar radiation, low humidity, high wind, etc. the prenatal growth retardation among infants as evidenced by low birth weight and small body size. The air becomes very thinner at the high altitudes and the pressure decreases per unit volume decreases. For the metabolism of the body the glucose is required in the form of food or the source of energy which can burn the oxygen.

1.1.9.9. State of health

The health status also determines the growth illness, major or minor may affect the normal growth. It works through the internal agencies like genetical, endocrinal and physiological or through environmental conditions. Malnourished people very often lack the power of resistance to different kinds of diseases. Malnutrition may be the cause of the diminished production of the growth hormone leading to the growth failure.

1.1.9.10. Urbanization and Migration

Migration from the rural to urban areas shows variation in growth and development of children. Indeed the tendency towards greater size and more rapid maturation in Europe in last 100 years has been held to be a consequence of urbanization (Eveleth and Tanner, 1990).

1.1.9.11. Secular trends

During the last hundred years there has been a striking tendency for children to become a progressively largest at all ages (Tanner, 1966). This is known as the ‘secular trend’ the magnitude of the trend in Europe and America is such that it draws the differences between socio-economic classes.
Increase in height and weight: Overall an economic condition of world has improved in last 100 years and there is found tendency for children to become progressively large in all ages. The trend has been operating since last many years and in some well-off industrialized nations the trend has virtually stopped indicating that children of these societies have attained their full genetic potential.

Extent of increase: Similar increase in heights and weights of children throughout the world has been registered. It is indicated that there is average increase of 1 c.m. in height and 0.5 k.g. in weight per decade between 1880–1950 in the 5-7 years age group. For adolescent group, the same data increases to 2.5 c.m. and 7 k.g. per decade. It is, however, indicated that maximum average increase occurred in 2.5 years age group though there is only scanty data to prove the point.

Fate of Increase: This trend of increase in size is still continuing in many parts of the world such as many European and Asian countries. In Japan, this increase has taken a peculiar form. There is average increase in the leg length, though trunk length has remained the same. Thus, trunk to leg length is similar in both Japanese and Europeans, though the former mature earlier and are slightly short.

Earlier Age of Menarche: There has been rather a fast reduction in the age of menarche. Western European data indicate that it occurred earlier by about 4 months per decade between 1830-1960.

1.2 REVIEW OF LITERATURE

A perusal of literature reveals that interest in the study of growth and development goes back to the first published work of Gabrielo de Zerbis in 1502. Literature review projects new ideas for research including the information on field under study and thereby helps in comparing different perspectives of research problem. Papers on human growth started appearing in India in early thirties (Krishnan and Vareed, 1932; Mason, 1932; Rahman, 1936. Nutritional viewpoint has been taken in growth studies since 1936 by several workers (Aykroyd and Rajgopal, 1937; Aykroyd and Krishnan 1937; Wilson et al., 1937).
First paper dealing with morphological measurements other than simple height and body weight statistics made its appearance with the socio-economic-cum-nutritional status in 1941 (Fabish and Hamburger, 1941). Boas (1935 and 1940) have contributed a great deal to the understanding of growth process, focusing predominantly different aspects of growth like adolescent spurt and patterns of growth. A number of researchers from different parts of the world have conducted studies pertaining to the problem of growth and development.

The study of growth and development has made possible the medical sciences to assess the abnormal or normal growth pattern occurring during growth period of a child, has helped sports scientists to get high accomplishment from sports men and women. It has been espoused by the physical anthropologists to study the population differences, nutritionists and dieticians used this to determine the physique and body composition. The conglomeration and volume of literature available on growth and development is extensive. In the present review an effort has been made to present an overview of the various aspects of growth and body composition.

The studies on growth and development are done from time to time and provide not only nation’s health standard but also help in the field of health issues. Literature of review was carried out to understand the intricacies of the subject under study for which information has been extracted from various books and articles. The first systematic attempt of studying growth and development of Indian children was made by ICMR from 1956 to 1965 in order to provide growth norms of Indian children on a regional basis and on different socio-economic groups.

In recent years, research work has been done on children in order to assess their nutritional status, physical growth, growth pattern, difference in either sex, secular changes, relationships between maternal educational status, socio-economic status, family size with nutritional status of children, socio-economic status in relation with growth pattern and age changes in girls and boys, age at menarche, malnutrition and other chronic energy diseases in both adults and children, growth and nutrition in different caste and tribal groups.
1.2.1 Physical growth and nutrition status

Adolescence is a period of increased nutritional requirements and adolescent anthropometry varies significantly worldwide (Himes and Bouchard, 1989; Bhadra et al., 2001). Undernutrition is documented as public health problem contributing substantially to children’s survival (Rahmathullah et al., 1990). The general growth has been repeatedly studied around the world to understand the growth process in children and adolescents. There are many studies ranging from observing height, weight and skinfold thickness to the comparison of physical growth performance of group with a representative standard group or any other comparable group and to find general trends of physical growth.

A longitudinal study conducted by the Indian Council of Medical Research (1996) to assess physical, sexual, skeleton and psychological development in 6829 children ranges from 10 to 16 years from 1986 to 1991. This anthropometric data was compared with cross sectional study conducted by the ICMR in seventies as well as with the growth of affluent children of India and NCHS standards. This study highlighted that rural area children were shorter and less weighed than urban slums area children and girls were shorter and less weighed than boys except at 11 to 14 years and 11-12 years respectively. Thakor et al (2000) studied growth pattern of 2250 adolescents aged 10 years and above from Surat (Gujrat) and found that their median parameters were comparable with ICMR but not with NCHS standards. Results shows that girls exhibited better nutritional status and BMI than boys.

Panda et al (2000), Kapil and Sethi (2004), Mukherjee (2008) and Shakya et al (2004) assessed health and nutritional status of 776 children (5-16 years) from Ludhiana, 768 children (6-9 years) from Delhi, 760 children (5 to11 years) from Pune and 818 children (5 to 9 years) from Dhankuta and Ineruwa towns of Nepal respectively. Results shows that in Ananthakrishnan et al (2001) study in Kerala, George et al (2000), Semwal et al (2006) study in Dehradun and Panda et al study on prevalence of wasting was high as 57.6%, 53.3%, 52.6%, 52.2% respectively in comparison to 21.2% (6 to 8 years) in Medhi et al (2006) study on children of Tea Garden worker of Assam, 13.1% in Tragler (Mumbai, 1981) and Verma et. al (Punjab, 1998), Kapil and Sethi study (11.1%) and Mukherjee study (6.71%).
Whereas 60% stunted children found in Yadav and Singh study on children of Bihar (1999) in comparison to 53.6% (9 to 14 years) and 47.4% (6 to 8 years) in Medhi et al study , 50.7% in Deshmukh et al on Wardha (2006), 48% in Shahabuddin et al study on Bangladesh (2000), 45.1% in Kapil and Sethi study which is same as in Tragler (Mumbai, 1981) and Verma et. al (Punjab, 1998) but more than 39% of Venkaiah et al study on rural adolescents (2002), Panda et al study (26.6%), Semwal et al study (26.3%) , Mukherjee study (13.81%), 17.2% in Bose et al study on rural Bengalee Hindu children (2008), 13.62% (girls) and 7.42% (boys) of Singh and Sengupta (2007) study on Sonowal Kachari Children of Dibrugarh. In study of Shakya et al combined prevalence of wasting and stunting was very less (5.4%).

The percentage of malnourished children is highest in Panda et al study on rural punjab in 1997 (87.4%) in comparison to Shahabuddin et al study (67.0%) , Shakya et al study (61%), Deshmukh et al study (53.8%), 51.7% (6 to 8 years) and 53.9% (9 to 14 years) in Medhi et al study, Dingra et al study in 1977 on Delhi’s children (50%), Kapil and Sethi’s study (52.5%), Indirabai et al study in 1976 on Tirupati’s children (47%), Gangadharan et al study in 1977 on Kerala (34.20%), Verma et al (40.2%), Bose and Bisai study on rural adolescent of West Bengal in 2008 (35.3%), Sunderam study on Chennai (32.6%) ,Goyal and Chavan study in 1993 on Ahmednagar (20%), Tragler (20.5%), Semwal et al (24.4% ) , Bose et al (16.9%)and Mukherjee study(9.87%).

Manna et. al (2011) studied 4457 primary school going children of Darjeeling and Jalpaiguri districts of West Bengal and observed that physical growth as well as nutritional status of boys was affected more than the girls. According to Waterlow’s classification (height for age) it showed stunting underweight for boys was 65.29% and for girls was 54.65%. While weight for age shows that 80.01% boys and 77.86% girls were suffering from different degrees of malnutrition. Whereas when Vashisht et al (2005) study was compared with Manna et al study it shows that weight for age results that Garhwali girls (90.66%) were more undernourished than girls from West Bengal (54.65%) but in case of height for age West Bengal girls (77.86%) were more undernourished than Garhwali girls (64.49%).
In Study by Kuriyan et al in 2011 on Urban South Indian Children mean waist circumference increased with age for both girls and boys and their waist circumference was higher than age and sex matched European children. The proportion of children with W/Ht ratio greater than 0.5 decreased as their age increased. These curves represent the first waist and waist height ratio percentiles for Indian children and could be used as reference values for urban Indian children.

The mean height, weight and BMI of Urban Bengalee boys and girls of Mukhopadhyay et al (2005) is lower than Amritsar girls and boys (Prabhjot et al, 2005) which in turn are equal or heavier than Well to do Indian children (Vijayaraghvan et al, 1971) and NCHS standards (1977). Urban Bengalee boys and girls of Mukhopadhyay et al (2005) study were taller than those reported among rural adolescents in study from India (Venkaiah et al., 2002) and have higher BMI than those among urban boys of Kolkata reported by de Onis et al. (2001).

The rate of undernutrition, regarding sex variation among adolescent boys of Mukhopadhyay et al study (41.08%) is distinctively lower than urban boys of Kolkata (50.50%) studied by de Onis et al. (2001) and rural boys of nine province of India (67%) reported by Venkaiah et al. (2002). The same is remarkably lower than those of Kenyan refugees (75%) reported by International Rescue Committee (1997).

1.2.2. Rural and urban status

The urban girls show consistently higher values of weight and height than the rural girls (Adak et al, 2002). The findings on nutritional status of rural adolescent girl beneficiaries of ICDS in north India (Malhotra and Passi, 2007) are consistent with the results of a study conducted among poor adolescent girls in rural Rajasthan (Chaturvedi et al, 1996) indicate that dietary intake met only two-third to three-fourth of the energy and protein requirements (Malhotra and Passi, 2007) where the energy and protein intake was 64- 74% and 65-77% of the recommended allowances respectively in Chaturvedi et al study (1996) . However, a lower caloric intake (55-64% of the RDA) has been reported by another study carried out on young girls belonging to a low socio-economic group in Delhi (Sharma & Sharma, 2005). Nearly 31% of the subjects in Malhotra and Passi (2007) study, were found to be thin and an
almost similar proportion stunted and these findings are comparable to other micro-
level studies like Anand et al (1999) and Kapoor and Aneja (1992) carried on 
adolescent girls in different parts of India . Anand et al. (1999) reported that the study 
in rural north India among adolescent school children recorded a prevalence of 
stunting (height for age) as 41 and 19.9 percent as per NCHS and Indian standards 
respectively. In Sangha et al study BMI (male: 22.75 and female: 23.39) is higher 
than and Bose and Bisai study (male: 16.7 and female: 17.3) study. The mean Mid 
Upper Arm Circumference of the male (23.75) and female (23.24) subjects of the 
Sangha et al study. The mean Mid Upper Arm Circumference of the male (23.75) and 
female (23.24) subjects of the Sangha et al study. Mean tricep skinfold thickness in 
Sangha et al study (19.35mm in male and 19.25 mm in female).

1.2.3 Nutritional problems regarding Obesity

Obesity is an emerging major public health problem throughout the world (Wang et 
al, 2000) and its prevalence has largely increased over the last decade in both 
developed and developing countries (Doll et al, 2002). While this global epidemic is 
well described in the adult population, not much data is available regarding the 
prevalence of overweight obesity in children or adolescents amongst developing 
countries (Asthana et al, 1998). Globally the prevalence of childhood obesity varies 
from over 30% in USA to less than 2% in Sub Saharan Africa (Mo-Sawan et al, 
1993). Currently the prevalence of school children is 20 %in U.K and Australia, 15% 
in Saudi Arabia, 15.6% Thailand, 10% in Japan and 7.8% in Iran (Al-Nuaim et al, 
1996). In India the problem of obesity has been scantily explored even in the affluent 
population groups. The prevalence of obesity according to the international cut off 
points (BMI criteria) was found to be 5.7% whereas the prevalence of overweight was 
19.9% (Cole et al, 2000) . When Indian standards were used, the incidence of obesity 
was 8.1% and 25.1% (Agarwal et al, 2001).

Despite the growing numbers of adolescent schoolgirls and the overall increasing 
obesity over the year, only few studies are available in India to determine the 
prevalence of obesity. Obesity prevalence (5.74%) among school children of 
Davangere city in study done by Kumar et al (2007) has supported by studies 
conducted at Delhi (7.4%) by Kapil et al (2002), Punjab (3.4%) by Agarwal et
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al(2008) and Pune (5.7%) by Khadilkar & Khadilkar. The prevalence is more in girls (8.82%) than boys (4.10%) observed by Kumar et al is similar to the observation of Agarwal et al (2001). In Sangha et al (2006) study on Punjabi Children the level of degree of obesity of the subjects indicated that just 17% of the boys and 10% of the girls were mildly obese and 40% of the boys and 63% of the girls were classified in moderate to severe category. 23% of the boys and 27% of the girls were found severely obese.

Among the factors influencing Obesity studied family history of obesity, snaking of high energy foods and lack of physical activity were the important influencing factors which is similar to the observation of Monga study (2004).

1.2.4 Nutrition in Tribes

Tribal population constitutes about 8% of the total population in India. They are particularly vulnerable to undernutrition, because of their geographical isolation, socio-economic disadvantage and inadequate health facilities. Recognizing the problem, Government of India launched different programmes for their welfare.

Rao et al (2006) made an attempt to assess the diet and nutritional status of adolescent population from the different tribal areas of India and utilized database collected by National Nutrition Monitoring Bureau during 2000 (12,789 adolescents between 10 to 17 years). The intake of all the nutrients was below the recommended level, while that of micronutrients were grossly inadequate in all the age and sex groups. About 63% of adolescent boys and 42% of girls were undernourished (<5th BMI age percentiles of NHANES). The tribal population is at a higher risk of under-nutrition, because of the socio-cultural, socio-economic and environmental factors influencing the food intake and health seeking behavior (Basu, 1990) Low female literacy (14.5% against 47%) (NSSO, 1991), high maternal (992 against 195) and infant mortality (85 against 64) have been reported among tribal populations as compared to their rural counterparts (Vijayaraghavan et al, 2001).

It has been observed in Bhasin and Jain (2007) study that there is an increase in the mean values of BMI with age. Among females, Damors tend to have the minimum value of 11.04 at 8 years followed by Bhils. Minas exhibit the maximum value of
19.11 at 19 and above age group. All the populations at most age groups show an increase in the mean values of BMI in both the sexes with advancing age (Rossenbaum et al., 1985; Bhasin and Singh, 1991; Singh, 1992; Kaur and Singh, 2000). Among females, Bhils show the lowest mean BMI values at preadolescent ages, whereas among adults Kathodi females tend to have least BMI. In the preadolescent age group from 8 to 10, Minas have the highest values of BMI, after which the values increase among Sahariya girls such that during adolescent age groups they achieve the highest values than their counterparts in other populations. It is suggested that 40% of population, which falls below the BMI of 18.5, show very high prevalence of critical situation of malnourishment. The Bhasin and Jain (2007) sample shows that among females, except Minas and Sahariyas, other four populations are in critical situations of malnourishment. High prevalence of undernutrition was observed in both adolescent boys and girls of the Bhasin and Jain study (2007) on the basis of BMI as is reported elsewhere also (Kapoor and Aneja, 1992; Sawaya et al., 1995; Abahussain et al., 1999).

Rao et al. (2005) reported widespread undernutrition (60% underweight) among the preschool children of Gond tribe of Madhya Pradesh. In West Bengal, 54% of children (6-12 years of age) of Oraon tribe are suffering from severe malnutrition Mittal and Srivasatava (2006). In Rao et al study, undernutrition among Santal children of Puruliya district is not severe like Gond and Oraon tribes. Rao and Vijay (2006) observed similar percent of severe underweight (6%) among the Santal children of Purnia district of Bihar. The stunting among Santal children in Chowdhury et al (2008) study is less than Gond tribe, which showed 30.1% of children as severely stunted compared to 4.98% of Santal children of Puruliya district. The prevalence of undernutrition among Santal children was as follows: stunting (17.9%), underweight (33.7%) and wasting (29.4%). Severe (below -3 Z-score) stunting, underweight and wasting were found in 4.98%, 7.92% and 9.51% of Santal children, respectively. In girls, prevalence of stunting (21.7%) and wasting (35.8%) was higher in comparison to boys (13.8% stunting and 22.7% wasting).

The growth pattern of Santal children of Ghatsila is similar to that of Bolpur (Chakraborty et al, 2008). It has also been found that Santal boys showed almost
similar growth pattern with Santal girls in both regions. Poor growth pattern of Santal children compared to NCHS data of height and weight may be supported by other anthropometric parameter like MUAC (Mid upper arm circumference). Although, growth patterns in height, weight and MUAC of the surveyed children are similar in Ghatsila and Bolpur, the BMI-for-age curves of Santal children of Ghatsila (i.e. around 5th percentile of NCHS standard) are remarkably different from that of Bolpur (around 25th percentile of NCHS standard). Overall prevalence of underweight (in terms of weight-for-age) and stunting (in terms of heightfor-age) was found to be similar between Santal children of Ghatsila and Bolpur. The growth pattern in height and weight for Santal children of Ghatsila and Bolpur are also poor in comparison to Santal children of Puruliya district (Chowdhury et al., 2007). Height-for-age curves for Santal children of Puruliya district remained at 25th percentile of NCHS reference, which seems to be much higher than the Santal boys (10th percentile of NCHS) and girls (5th percentile of NCHS) of Ghatsila and Bolpur. Similarly, weight-for-age values for Santal boys (10th percentile of NCHS) and girls (15th percentile of NCHS) of Puruliya district were also higher than that of Santal children (5th percentile of NCHS) of both Ghatsila and Bolpur regions.

Prevalence of undernutrition is also higher in Santal children of the present study compared to that of Puruliya district. For example, severe stunting in boys was 12.31% in Ghatsila and 14.28% in Bolpur compared to 4.17% in Puruliya. Rao and Vijay (2006) also observed a lower percentage of severe underweight (6%) among the Santal children of Purnia district of Bihar than the present study. There is a great variability in the prevalence of stunting and underweight among tribal population in different regions of India. Rao et al. (2005) reported widespread undernutrition (60% underweight and 51% stunting) among the preschool children of Gond tribe of Madhya Pradesh. High prevalence of underweight and stunting are also found among children of Kamar tribe (58% underweight and 63% stunting) of Chattisgarh (Mitra et al., 2007), preschool tribal children (55% underweight and 60% stunting) of Bihar (Yadav and Singh, 1999) and tribal adolescent (47% underweight and 44% stunting) of nine different states of India (Rao et al., 2006). In the present study, the prevalence of undernutrition in terms of underweight and stunting in the Santal children of Ghatsila and Bolpur is much more severe than the above mentioned studies. The total
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percentage of undernutrition from BMI of Santal children is much higher than the Kondth tribe (75%) of Orissa (Ghosh and Bala, 2006), Bathudi tribe (58%) of Orissa (Bose and Chakraborty, 2005), Oraon children (88%) of West Bengal (Mittal & Srivastava, 2006), and tribe adolescent of nine state (53%) (Rao et al., 2006).

In Tiwari et al (2007) study weight and height of the Bharia boys and girls from Madhya Pradesh were higher than Mitra et al study (2007) on Kamar tribe from Chhattisgarh and Sugalis tribe community of South (2007). Kamar tribe children of Chhattisgarh were suffered more than 80% by underweight, stunting and wasting in 4-6 age group in comparison to Saharia primitive tribe of Rajasthan (which were less suffered by prevalence of underweight and stunting (60.40%) in 3-5 years. National family health survey (NFHS II) also reported high prevalence of undernutrition among the tribal children of Chhattisgarh. Children of Udaipur district of Rajasthan were receiving highly (73%) inadequate energy and protein intake than RDA in comparison to Khasi girls of Meghalaya which were better than Kamar children of Chhattisgarh. Prabhakar and Gangadhar (2011) evaluated the dietary status of Jenu Kuruba (176) and Yerava (161) tribal children (6 - 10 year) of Mysore district, Karnataka State. It reveals that the percentage of energy and protein intake among both was more or less same and below the respective RDAs.

In the adolescent growth spurt of body weight, chest circumference and triceps skin fold (12 and 13 years), Khond girls are observed to be similar to that of Gadaba (Dharma Rao et al., 1999), Chenchu (Dharma et al.,1997) and Jatapu (Dharma and Busi, 1997). With regard to biceps skin fold, they are observed to be similar to that of Gadaba girls and in sub- scapular (12 and 13 years) skinfold, they show affinity to that of Chenchu and Jatapu girls of Andhra Pradesh. In the medial calf skin fold (13 and 14 years), Khond girls are observed to be similar to that of Porja girls (Dharma Rao et al, 1999) and in the remaining dimensions Khond girls were observed to differ with the condition noticed among Gadaba, Porja and Chenchu girls. It will be apparent that the findings on Khond girls indicate that they are lighter in weight and shorter in height than the findings of Singh (1980), Bharati et al. (1991) and Dharma et al., (1997, 1999, 2000), Dharma Rao and Busi (1998, 1999) and also lighter and shorter than the findings of Hauspie et al. (1980). Khond girls are also observed to be
shorter and lighter with broader head and chest circumferences than I.C.M.R. (1984) Standards. Khond girls are also observed to be taller and heavier than Chenchu and Jatapu and shorter and heavier with narrow chest, abdomen and broader head than Porjas and also similar chest circumference, upper arm and calf circumference to that of Savaras and Konda Reddis.

Chakrabarty et al 2008 study on Shabar tribal children from Orissa in 2010 results that forest regions had the highest prevalence of under-nutrition followed by their rural and urban counterparts, 33.87%, 24.62% and 20.16%, respectively. However, the prevalence of underweight among the Gond tribal children of Kalahandi district of Orissa (89.30%) was higher. In study by Chakma et al (2009) on Baiga tribe of Madhya Pradesh the mean anthropometric measurements indicated that the growth spurt of boys is around 16 years at that age they overcome the girls of same age in both height and weight. Similar trend was reported by various other studies (Hanumanth and Mallikharjuna 1994). The magnitude of wasting in pre-school children was more (37.2%) as compared to NFHS II (29.6%) and NNMB (23.7%) report for tribals of Madhya Pradesh and this proportion was observed significantly higher (P<0.05) (NFHS, 1998 and NNMB, 2000). The high prevalence of malnutrition observed in the Chakma et al (2009) study.

Mandot et al (2009) conducted study in the schools of Sirohi district on tribal (Garasia)children. And found Prevalence of stunting was 44% and 46.9% among boys 1255 and 762 girls aged 5-16, respectively using NCHS reference. Prevalence of thinness was higher among boys (69.7%) than girls (59.3%).

Dhingra (2011) study revealed that adolescent Gujjar tribal girls) showed that the body mass index (BMI) of the majority (88.1%) of the subjects was low (less than18 kg/m²) indicating the highest prevalence of malnourishment among girls of 13 yrs of age.

1.2.5 Age at Menarche

The relationship of physical growth to menarcheal age in humans continues to intrigue the researchers. Mokha et al (2006) assessed the age at menarche of 404 (202 each urban and rural) Jat Sikh girls ranging in age from 14 to 16 years from Ludhiana...
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district. Results showed that Age of menarche is delayed in the rural girls as compare to the urban girls. Mean age at menarche for rural and urban girls are 13.62 and 13.31 years respectively. Similar results have been reported by Kaul and Corruccini (1985) and Madhavan (1965) that the menarcheal age in rural girls is 13.65 as compared with the urban girls 12.55 years and delayed in rural girls by 1 year in Punjabi girls, 12.76 years in urban and 14.16 years in rural girls of Madras showing a delay of 1.40 years in rural girls respectively. Caste-wise analysis of Bagga and Kulkarni study on Maharashtra girls (2000) showed that mean age at menarche for Brahmin (12.58) and Maratha girls (12.60) was more or less the same but in the Scheduled caste girls (13.16) menarche was delayed by about seven to eight months whereas in the study by Veena and Bhat in 2009 among Adikarnatakas girls of Mysore the mean age at menarche among them is 13.64. The mean age at menarche was found to be 12.67 years among girls of Meghalaya tribals parts (2010) study by Nagar and Aimol.

Talwar et al (2012) study on Pinjore girls of Panjab having similar median age at menarche as that of Bania girls (12.88 years) of Mandi Gobindgarh, Punjab (Talwar and Kaur, 1999). They showed an early median age at menarche as compared to Punjabi girls of Chandigarh from lower socio-economic status (13.18 years) studied by Kaul et al. (1997); Meitei girls of Manipur (13.34 years) reported by Talwar & Singh (1994); Punjabi twins (13.03 years) reported by Sharma (1982); Solan Rajput girls (13.00 years) studied by Talwar & Bajwa (2005); rural (13.62 years) and urban (13.31 years) Jat Sikh girls studied by Mokha et al.(2006); Scheduled caste girls from Naraingarh (13.40 years) reported by Sharma and Shandilya (2005) and Rajput girls of Theog (13.7 years) studied by Talwar et al. (2010), but later median age at menarche than Punjabi girls (12.54 years) from higher socio-economic status (Kaul et al., 1997); Punjabi urban (12.06 years) and rural girls (12.74 years) reported by Sharma & Sharma (2005); Bengali girls (12.03 years) from Kolkata (Ghosh et al., 2005) and rural girls from Puruila, West Bengal (12.60 years) reported by Banik, (2011).

The differences are very small in Australia girls (Just over 2 months) and Finnish girls (six months). In USA also urban rural differences are very small (MacMohan, 1973).
1.2.6 Socio-economic status in relation with growth pattern

Two earlier large nation wide surveys have been conducted in India to assess growth parameters: ICMR survey from 1956-1965(8); and Agarwal, et al. 1991. While the ICMR study largely recruited from LSES, the Agarwal charts represented children from USES. Marwaha et al (2006) studied that children from USES were significantly taller and heavier and consequently had a significantly higher BMI compared with their age matched counterparts from LSES. The prevalence of overweight and obesity in USES children was 16.75% and 5.59% in boys and 19.01% and 5.03% in girls respectively. As per 1999-2000 NHANES data, 30.3% of children (ages 6 to 11) exceeded 85th percentile of weight for age charts comparable to the overweight category in the Marwaha et al. 2006 study. This included 15.3 % children who were more than the 95th percentile of these charts (comparable to the obese group in the Marwaha et al study). For adolescents (ages 12 to 19), 30.4% were overweight, of which 15.5 % were obese.

Ramachandran et al study in 2002 on Chennai, reported that 17.8% boys and 15.8% girls were overweight, while obesity was reported in 3.6% boys and 2.7% girls. Prevalence of overweight in low, middle and high socioeconomic group was 4.2%, 13.9% and 23.5% respectively for boys and 5.0%, 17.6% and 21.5% respectively for girls. In Marwaha et al study, in a comparable age group, the prevalence of overweight and obesity in USES is 20.27 and 4.76% respectively. Two other studies from India have evaluated prevalence of obesity among affluent school children using cut-offs proposed by Cole et al., 2000 and Agarwal et al.

In a study from Delhi by Kapil et al, the prevalence of obesity was 8% for boys and 6% for girls, compared to 4.6% and 4.9% for boys and girls from the same age group in the Marwaha et al study. In the second study from Pune by Khadilkar and Khadilkar 2004), the overweight and obesity prevalence in boys aged 10-15 years was 19.9% and 5.75% respectively, whereas the mean BMI values are higher than the national and international standards from 10 to 15 years except at 15 year where mean values of national and international standards are higher for children from affluent schools. The above studies suggest that there is a significant problem of childhood overweight and obesity in urban India. In Deshmukh et al (2006) study, thinness was
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significantly more prevalent in girls than boys. But, Shahabuddin et al reported that boys were affected more (75%) than the girls (59%). Chaturvedi et al reported prevalence of chronic energy deficiency to be 93.5% among adolescent girls of rural Rajasthan. de Onis et al reported prevalence of thinness to be 50.5% among Indian adolescent boys. NNMB reported no sex difference in undernutrition in age group 10-13 years, but in age group 14-17 years, undernutrition was more (73%) prevalent in boys than their female counterparts (60.4%).

1.2.7 International studies

In study by Shariff et al in 2000, approximately 52% (n = 4149), 50% (n = 3893) and 30% (n = 2568) of the children were found to be underweight, stunted and wasted respectively. However, the majority of the children were either mildly underweight (37.4%), mildly stunted (32%) or mildly wasted (23%). Although the prevalence of mild malnutrition (underweight, stunting and wasting) is higher than the prevalence of severe malnutrition, the former cannot be ignored as it too has its implications not only on the child’s consequent development (e.g. cognitive skills) (Johnston et al., 1987; Clarke et al., 1991; Grantham-McGregor & Walker, 1998) but also on his chance of survival (Pelletier, Frongillo & Habicht, 1993; Pelletier et al., 1995).

As stunting reflects past nutrition, the finding indicates that these children may have had experiences with poor diets and infections during their early childhood and perhaps were continuously living with similar continuously living with similar conditions as a consequence of poverty. Linear growth retardation occurs primarily in the first 2-3 years of life but is intensified between 3 and 18 months and is a reflection of the interactive effects of poor energy and nutrient intakes and infection (Martorell & Habicht, 1986). This finding also agrees with other findings on the prevalence of stunting among school children from low income households in less developed countries which indicate that shortness-for-age is a common nutritional problem among these schoolchildren compared to wasting (Ahmed et al., 1991; Baba, Hamadeh & Adra, 1991; Pelto et al., 1991, Sichieri, Mathias & Moura, 1996; Stoltzfus et al., 1997).
Chen (1976) studied the prevalence of stunting and wasting among primary school children (6-9.9 years old) from schools in Kuala Lumpur and Selangor were reported to be 25% and 9% respectively (stunting is <90% of height-for-age and wasting is <80% of weight-for-height). Chee (1992) in her study of growth status among children aged 5-10 years old (n=107) from a squatter settlement in Selangor found that 19.8% were significantly stunted and 33.8% were mildly stunted. The prevalence of significantly and mildly wasted was 9.3% and 32.7%, respectively. Another study by Cheng, Rahman & Abdullah (1988) on dietary intake and growth assessment of school children (of Malay, Chinese and Indian ethnicity) from three primary schools in Selangor reported that the overall prevalence of underweight, stunting, wasting and both stunting and wasting was 22.2%, 19.8%, 11.3% and 1.4% respectively (underweight, stunting and wasting were defined as below minus 2 of the NCHS median).

In Shariff et al (2000) study found that the prevalence of significantly underweight (14.5%), stunting (16.7%) and wasting (9.2%) were lower than that found by Cheng et al., (1988) but the prevalence of both stunting and wasting (SW and SS) was higher (6.6%). However, the prevalence of under nutrition among Malay children in the study by Cheng et al., (1988), (underweight = 8.4%, stunting =15.3%, wasting = 2.8% and wasting + stunting = 0%) was lower compared to the findings in the Shariff et al (the majority of the school children were Malays). In Shariff et al study also found that the prevalence of overweight is 5.8% with more male (6.0%) than female (5.6%) children being overweight. This is higher than the prevalence among 7-year-old children (3.6%) in Kuala Lumpur found by the school Health Service Unit of the Health Department of the City hall of Kuala Lumpur (City Hall Kuala Lumpur, 1990). Similarly, the prevalence of overweight in this present study is higher compared to the prevalence of overweight and obesity among Standard 1 children (from both rural and urban schools) in Selangor (4.4%) Bong and Jaafar, 1996). In another study by Kasmini et al. (1997), the prevalence of overweight (+1 SD < +2 SD) and obesity (> +2 SD) among 7-10-year-old children attending primary schools in Kuala Lumpur are 1.7% and 1.3% respectively. Again, the prevalence of overweight (5.8%) in this present study (defined as > +2 SD) is much higher compared to 1.3% found Kasmini et al., (1997).
Harris et al, (2001) found evidence of substantial malnutrition among Tibetan children. Over 50 percent of the children we examined had moderate-to-severe stunting of growth. The proportion of children with stunted growth was greater in nonurban areas than in urban areas. The association between community location, altitude, and stunting was partially confounded by the fact that all the nomadic children were in the highest altitude group and all urban and periurban children were in the middle altitude group. Tibetan children have clinical signs of malnutrition as well as high morbidity and mortality. A 1991 study of 7-to-18-year-old children in Lhasa revealed that these urban children were taller than children in that group in 1985 (Huo, 1991).

Generalizations about the growth of children living at high altitudes may deflect attention from the urgent need for maternal and child health programs in Tibet. Malnutrition and common childhood illnesses can be modified by changes in health education and health care. Culturally specific programs should be implemented to address the constellation of physiologic, socioeconomic, agricultural, and environmental factors that affect the health of children on the Tibetan plateau (Hass et al, 1980 and Beall, 1981).

1.2.8 Comparison of national with international studies

When undernutrition prevalence is compared with international studies it was found that In Indian studies including Kurz in 1996 (53%) and Mukhopadhyay et al (36.49%) the extent of undernutrition was lower than those reported by two Kenyan investigations, i.e. 61% (Cookson et al., 1998) and 57% (Woodruff et al., 1998). While among Nepali refugees reported by Woodruff et al. 1999 (34%) it was higher than those observed among rural African adolescents reported by Kurz 1996 (23%). However, the rate of undernutrition of the Mukhopadhyay et al study was quite similar to those of rural Nepalese (36%, Kurz1996). On the other hand, the rate of under nutrition among adolescent girls of Mukhopadhyay et al study (30.61%) demonstrated a significantly higher rate of under nutrition compared to Bangladeshi girls (16%) studied by Ahmed et al. (1998), but lower than Kenyan refugee girls (55%) and rural Indian girls (40%) reported by IRC (1997) and Venkaiah et al. (2002) respectively.
In Tanasescu et al. (2000) study on Puerto Rican Children it was observed that mean weight of the male and female subjects are reported to have a higher range of weight and heights of 7-10 years old male and female subjects compared to Sangha et al (2006) study, which exceeded the standards. (NCHS, 1977 and ICMR, 1990). Tanansescu et al. (2000) reported that mean BMI in their obese male (28.29) and female (24.19) was higher than the subjects of the Sangha et al study (male: 22.75 and female: 23.39) and Bose and Bisai study (male: 16.7 and female: 17.3). The mean Mid Upper Arm Circumference of the male (23.75) and female (23.24) subjects of the Sangha et al study. Tanasescu et al. (2000), in their finding reported a higher range of mean tricep skinfold thickness of the male (25.25mm) and female (23.09mm) subjects in comparison to Sangha et al study (19.35mm in male and 19.25 mm in female).

The present critical review of literature reflects the changing scenario in growth and nutritional studies of both national and international populations, which in turn are affected by many factors. Keeping this view in mind, present study was carried out to investigate the growth and nutritional pattern of Garhwali (non tribe) and Jaunsari (tribe) Rajput females (ranging 8 to 18 years) of Uttarakhand sharing common environment and more or less similar socioeconomic backgrounds.