UNIT 2 METHODS AND INFLUENCING FACTORS

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Learning Objectives
After going through this unit, you should be able to
- understand the longitudinal, cross-sectional and mixed-longitudinal methods of studying growth;
- define and describe “Secular trends” as observed in different populations;
- describe growth gradients as observed in different segments of human body;
- understand the concept of catch-up growth; and
- understand and describe the influence of genetic, biochemical and environmental factors including nutrition, disease, socio-economic status, urbanization, seasonal and climatic variations and psychosocial stress on human growth and development.

2.1 INTRODUCTION

We feel extremely happy while introducing you to the fascinating study of human growth and development with special reference to its methodology and various factors affecting it. Let me tell you that the process of human growth and
Methods and Influencing Factors

...development which takes almost twenty years to complete, is a complex phenomenon. To have a complete understanding of this process we must have the knowledge about various methods of studying it, along with their advantages and disadvantages. Both genetic and environmental factors influence human growth and development. Every child acquires his genetic potential for a particular adult size and shape from his parents and realises this potential when the environment supports the genetic model that regulates development. The term “genetic potential” usually means that every human being has a genetically determined upper limit for adult stature, the ratio of leg length to sitting height and other anthropometric dimensions/ratios. Growth can be impaired when there is a negative influence of the environment i.e. the child is suffering from malnutrition or illness, or hormonal deficiency etc. However, the ability of environmental influences to alter genetic potential depends on a number of factors including the time at which they occur; the strength, duration and frequency of their occurrence and the age and gender of the child. Therefore, it is extremely important to have a clear understanding of how children grow under different circumstances. What are the factors which influence human growth and development? What is the velocity of growth of a child during recovery after the nutritional stress (concept of catch-up growth)? What is the sequence in which different segments of our body attain maturity (growth gradients)? It is a well documented fact that children have been getting larger and growing to maturity earlier over time in both developed and developing countries. This has been referred to as “secular trends.” We must know about the causes for secular trends observed in different populations.

In this lesson you will get answers to all these questions raised above. We are going to learn in detail about various methods of studying human growth and development along with their advantages and disadvantages. What do we mean by secular trends? What do we understand by catch-up growth? What are growth gradients? What is the role of genetic and environmental factors in regulating human growth and development? The knowledge of all these aspects is very important because of their implications in public health. Data gathered through different methods of studying growth are used to establish growth standards or norms of a population. Growth of children can be monitored using these standards. With the help of such studies we are aware of the relationship between growth and need for proper environment. We may change our children’s diets according to the requirements for specific ages, which may lead to their improved growth status. An attempt has been made to make you understand these important aspects with the help of suitable examples wherever required to inculcate interest in this subject.

2.2 METHODS OF STUDYING GROWTH

A well designed growth study is a prerequisite to monitor the health status of a population. Rigorous thought should precede collection of data, regarding method of study, time and cost involved with precise planning of sampling procedures, careful training in anthropometric measurements and statistical methods to be used for data analysis. In order to gain an understanding of the dynamics of human growth and average growth patterns it is essential that the appropriate methods are selected. Auxologists, anthropologists, nutritionists and health professionals use precise methods of studying human growth while conducting
growth surveys of children in different populations. The most commonly employed methods by researchers to obtain age and sex specific growth data are either cross-sectional or longitudinal. Both types of methods are required for a full understanding of the growth process. These methods have been described below:

Cross-sectional method

Human growth can be studied using cross-sectional method, which involves measuring children only once during the entire span of the study. In this method for example, all the children being measured by an investigator at age 9 are altogether different from those at age 8, which in turn are different from children being measured at 7 years and so on. In other words, the method of study using different children at each age is called cross-sectional. In this method there is no element of periodic assessment. Cross-sectional surveys provide information about the distance curve of growth of any dimension of the body.

Advantages

Cross-sectional methods are obviously cheaper, less time consuming, can include much larger number of subjects in a brief duration and provide important information about the distance attainments or gross size attained by children during a span of time (e.g., on average, a newly born child attains 10 kg of weight and 78 cm. of supine length at 1 year of age.). This method is very useful for constructing growth standards for communities. Cross-sectional surveys are valuable in assessing the nutritional status and health related problems of children prevailing in different communities at any given point of time.

Disadvantages

The major drawback in cross-sectional studies is that they can never reveal individual differences in rate of growth (i.e. growth velocity) of different body dimensions of children, since in this method we measure each child only once without any periodic follow up. In fact, it is these individual differences which reflect the cumulative effect of various genetic, environmental, hormonal, nutritional, psychological, and socio-cultural factors on human growth. Moreover, cross-sectional data do not provide precise information about timings of particular phases of growth like onset of “Juvenile growth spurt” attainment of “Peak height velocity”, “Peak weight velocity” etc. Though they give us an estimate of the mean rate of growth of a population (by subtracting the mean height at 8.0 e.g., from that at 9) they tell us nothing about variability around that mean. Therefore, as a caution, we should not compute “growth velocity” of any body parameter based on cross-sectional data.

Discuss various methods of studying human growth giving their merits and demerits.

Longitudinal Method

The method of study using the same child at each age is called longitudinal method. In this method of studying human growth every child enrolled in the study is periodically measured for one or many body measurements at fixed intervals of time throughout the period of study. All children, say measured at age 5.0 years will remain the same as those who were examined at 4.0 years. Constancy of sample size and strict adherence to stipulated periodicity at which
children are to be followed up remain the most important prerequisite of this method. A growth study may be longitudinal over any number of years. To obtain the simplest type of velocity standards, individuals have only to be measured twice i.e. once in a year. There are short term longitudinal studies extending from age 3 to 6 for instance and full birth to maturity longitudinal studies in which children may be examined once, twice, quarterly or even more times every year from birth until 20 years or more depending upon the objective of the study. However, in practice, due to various reasons it is not possible to measure exactly the same group of children for a prolonged period.

The main drawback of a comprehensive longitudinal study is that it takes a long time to complete and relatively small number of subjects can be followed. To overcome these problems, ‘Linked longitudinal studies’ are undertaken i.e., studies covering the ages 0 to 6, 5 to 11, 10 to 15, 14 to 20 years. Through this design within a period of six years, whole age range of growing phase of human life is spanned. However, efficient sampling of the population is crucial to obtain smooth joins of the data collected during short intervals. For an intensive investigation of the relation between continuously unfolding events in individuals and very often for clinical investigations of growth disorders, long term longitudinal studies even from birth to maturity are necessary. We need to use appropriate statistical methods while working out the results of each type of study.

**Advantages**

Longitudinal studies besides providing information about the distance (gross size), growth attainments also provide growth velocity related data i.e., about individual rate of growth measured by increment between two successive periods. Such studies also tell us about the timing of particular phases like ‘onset of juvenile growth spurt’ or ‘adolescent growth spurt’ of individuals. As the growth velocity denotes inherent capacity of a child to grow and develop, so these studies help to understand the influence of genetic and environmental factors on the growth dynamics of children.

During childhood we often have illnesses which are short-termed. Longitudinal studies provide opportunity to have information about the duration of any disease or nutritional insult with which any child might have remained afflicted with for a longer period. Similarly, effect of intervention (medical/nutritional etc.) may also be assessed with the help of these studies as children included in such surveys are often monitored periodically.

**Disadvantages**

i) Longitudinal studies are very expensive and require great skills to organise.

ii) Studies are very laborious and time consuming. These studies require patience, perseverance and motivation on the part of both subjects as well as researchers who undertake it. The researchers have to stick to the already planned periodic schedule during the entire duration of the study, which at times becomes difficult to adhere to because of certain compelling circumstances.

iii) Longitudinal studies involve examination of limited number of children. It is not always possible to maintain consistency of sample size throughout the entire span of study. Many subjects leave the study as they move to new places because of social as well as occupational reasons.
**Mixed-Longitudinal study**

A serial study in which a group of children is followed such that some children leave the study and others join it as new entrants at different ages, giving various degrees of longitudinally is termed as mixed longitudinal study. On one end such a study results in accumulation of data with missing values, on the other hand this design provides an opportunity to make up for the simple loss by enrolling new subjects at any requisite age points. Mixed-longitudinal studies are relatively cheaper to conduct and also less time and effort consuming as compared to pure longitudinal studies. These studies also provide us with both distance and velocity curves, however, estimation of growth velocity of different body parameters from mixed longitudinal data involving missing values is a tedious task and special statistical methods are required to get relevant information out of such data. In some circumstances the manipulation of increments derived from each individual measured twice or more is reasonably efficient and simpler. The means of such increments may be used to calculate more efficient measurement-at-given age or distance means at successive ages.

### 2.3 SECULAR TRENDS

Over the past hundred years in industrialised countries, and recently in some developing nations, children have been getting larger and growing to maturity more rapidly. This has been referred to as ‘the secular trend’ in growth. In other words, the acceleration or retardation of growth and maturation as indicated by changes in height, weight or other variables over time is called secular trend. Many factors such as improved nutrition, control of infectious diseases through immunizations and sanitation, widespread health and medical care, better living conditions, changes in environmental and socio-economic factors, population mobility (both geographically to urban areas and socially upward) may account for increase in body size and biological maturation resulting in secular trends. On the other hand wartime deprivations or natural calamities like famine, tsunami may cause a decrease in growth.

The occurrence of a secular increase in height and weight has been well documented from many European countries like, Sweden, Finland, Norway, France, United Kingdom, Italy, Germany, Czechoslovakia, Poland, Hungry, the Soviet Union, the Netherlands, Belgium, Switzerland and Austria. From the rest of the world there are reports from Canada, the United States, Jamaica, Chile, Australia, New Zealand, Japan, Hong Kong, China, Sechychelles and India showing increase in height and weight over decades. Even the adult height of Kalahari Bushmen in South Africa and Australian Aborigines has shown an increase due to a more settled existence from the traditional hunting and gathering life. The average secular increase in height in Europe and North America is greatest during adolescence (2 to 3 cm. per decade), less during childhood (1 to 2 cm. per decade) and least for adults about 1cm per decade or less. Comparable changes have been occurring in weight and other body dimensions. Secular trend in birth length has also been observed in new born babies. Studies have noticed rising trends in 11 European countries. Rates of 30 mm. per decade have been achieved in Eastern Europe and Japan.

There has also been a secular change in the tempo of growth as is shown by an advancement of age at menarche and age at peak height velocity. Maturation has
been getting earlier during the last hundred years by 3 to 4 months per decade in most European countries. This trend is slowing down now in developed countries, both in body size as well as in maturation. Recent studies have shown that the increase has reached a plateau in countries like Germany and Poland due to the fact that the corresponding populations had achieved their full genetic potential or that their socio-economic conditions had ceased to further improve. Its magnitude is such that in Europe, America and Japan it has dwarfed the differences between occupational groups. In developing countries due to continuous improvement of living standards, nutritional and health care, the secular trend in various biological parameters is still observed. In India studies have reported positive secular trends in height among high altitude Himalayan populations over last three decades. A comparison in the heights and weights of Punjabi boys from Patiala between 1950 and 1975 showed a negligible average increase in magnitude of stature from 1950 to 1955, from 1955 to 1965 there is an increase of 2.20 cm. and from 1965 to 1975 it is 4.90 cm. per decade. In the total period of 25 years, an overall increase of 7.45 cm. has been noticed giving an increment of height of 2.98 cm. per decade and for weight of 1.48 kg. per decade.

In three decades i.e., from 1962 to 1991 the age at menarche in Maharashtrian girls has lowered by two years. Among Bengali Hindu girls a decrease of 5-7 days per annum was observed. In general, girls from upper socio-economic group experience menarche earlier than the girls from lower socio-economic status. Reports on stature and age at menarche of Punjabi Arora mothers and daughters from Delhi also show a substantial increase in stature of daughters and an advanced age at menarche as compared to their mothers indicating secular trends towards increase in height and decrease in age at menarche.

Secular trends in growth in terms of the narrowing of ethnic differences in stature have been discussed in some studies. Asiatic populations’ seen since 1990 are much more comparable in stature to their counterparts to a different place in the world. A comparable evaluation among affluent adolescents illustrates Asiatic populations to experience earlier onset of pubertal growth spurt in stature than other major populations but have similar peak height velocities. Studies on secular changes in height and weight in populations are invaluable as they give information on nutritional status in early life, evaluating the growth reference standards and providing perception with regards to epidemiological trends of lifestyle diseases.

### 2.4 GROWTH GRADIENTS

The bodily proportions of a child change with the advance in age. An estimation of this change provides a measure of maturity. It is well known that different parts of the human body grow at different rates and the sequence of their reaching adult size also differs from one segment to another. One way in which the organization of growth shows itself is through the presence of maturity gradients. To explain it let us take the example of foot length, calf length and thigh length in boys. When we plot the percentage of the adult value at each age for foot length, calf length and thigh length, we find that the foot is nearer its adult status than calf, and the calf is nearer than the thigh. Thus, our foot gets matured fastest, followed by calf and thigh is the last in the sequence to achieve adult value. A maturity gradient is said to exist in the leg, running from advanced maturity distally to delayed maturity proximally. Similar gradient occurs in the upper
limb, where hand achieves its maturity status earlier than forearm, which in turn, acquires maturity earlier than upper arm. Moreover, girls are more advanced in maturity at all ages than boys but the sequence of maturity in them remains the same i.e. the-distal proximal gradient.

What are different types of growth gradients observed in different segments of our body?

Many other gradients exist, some covering small areas only and operating for short periods, others covering whole systems and operating throughout the whole of growth. The head, for example, is at all ages in advance of the trunk, and the trunk in advance of the limbs. This type of gradient is called cephalo-caudal gradient. From early foetal life onwards the brain, in terms of its gross weight is nearer to its adult value than any other organ of the body, except the eye. At birth it is about 25 per cent of its adult weight, at 6 months nearly 50 per cent, at two and a half years about 75 per cent, at 5 years 90 per cent and at 10 years 95 per cent. This contrasts with the weight of the whole body, which at birth is about 5 per cent of the young adult weight and at 10 years about 50 per cent. Growth gradients are easy to compute. Percentage of the adult value can be easily calculated for each age group under study and plotted in a graph against each age group.

2.5 CATCH-UP GROWTH

The term catch-up growth refers to the acceleration seen in many children during recovery from serious illnesses or from environments that retard growth. Two conditions are necessary for this designation

i) growth retardation as shown by previous low percentile levels of measures

ii) subsequent increase in these percentile levels.

It has been well documented that whenever a child suffers for a short period of time from an illness or starvation he/she is able to return to his regular course of growth, when conditions improve due to proper treatment given for the respective problem. In doing so his initial growth velocity after recovery is unusually large (higher than normal) than expected of children of his age. Such a higher than normal velocity has been named ‘catch-up growth’ by Prader, Tanner and Von Harnack in 1963. For example, if there are three children suffering from different problems, first child from malnutrition, second from hypothyroidism and third from cortisol producing tumour (growth-inhibiting), all three will show growth retardation. However, when all three children get completely treated for the respective conditions, then during recovery catch-up growth will occur in all of them. The velocity during the initial period of catch up may reach three times the normal for age, where after, it slows down to its normal velocity. The power to stabilize and return to a predetermined growth curve after being pushed off the trajectory is called by Waddington ‘canalization’ or homeorhesis (homeostasis being the maintenance of a static condition and homeorhesis being the maintenance of a flowing or developing one). The effect of unfavourable conditions on growth seems to depend upon the duration and the severity of the insult and age at which it occurs. Catch-up growth may completely restore the
situation to normal or it may be insufficient to do so. In less favourable circumstances where treatment is incomplete or less effective, the child may resume growth at a normal, but not higher than normal velocity. The result of this may still be satisfactory, since if skeletal maturation is delayed, as is usual in such circumstances, the growing period will be extended and thus the final height will be close to normal, though reached late.

2.6 GENETIC FACTORS INFLUENCING GROWTH AND DEVELOPMENT

Children tend to resemble their parents in stature, body proportions, body composition and rate of development. It may be assumed that barring the action of obvious environmental influences (such as chronic illness or long term malnutrition) these resemblances reflect the influence of genes that parents contribute to their biological offspring. The term “genetic potential” usually means that every human being has a genetically determined upper limit to adult stature, the ratio of leg length to sitting height and other anthropometric dimensions. An individual may achieve this genetic potential if the environment is free of insults that delay or retard growth. The child’s development may be shunted from one line to another in a situation when a particular environmental stimulus is lacking at a time when it is necessary for the child. It is inferred that the ultimate size and shape that a child attains as an adult is the result of a continuous interaction between genetical and environmental influences during the whole period of growth.

Discuss the role of genetic factors in regulating human growth.

Now let us understand the role and importance of genetic factors in regulating human growth. Genetic factors are clearly of immense importance. Factors affecting the rate or tempo of growth must be considered separately from factors affecting the size, shape and body composition of a child. The genetical control of tempo seems to be independent of genetical control of final adult size, and to a large extent of final shape. Environmentally produced changes in tempo do not necessarily seem to be separately controlled by genetical and environmental factors. The genetical control of shape is much more rigorous than that of size, presumably because shape represents chiefly how the cells are distributed, while size represents more the sum of sizes of the various cells.

The most striking similarity in growth is seen in monozygotic twins, who share the same genes and most aspects of the family environment. Siblings share fewer genes and possibly few aspects of family environment also, but resemble each other a great deal more than unrelated children. Family patterns of growth exist, and closer the genetic relationship, the closer in general the growth pattern. This is probably because growth and adult size and shape are controlled by numerous genes, each of small effect, rather than by few major genes. Data on monozygotic twins (MZ) reared together and apart have been reported by Shields (1962). Those reared apart were more different in adult stature than those reared together, but they were more similar than dizygotic (DZ) like-sexed twins. Shield illustrates some individual cases of MZ twins reared apart where one twin was subject to illness or neglect, showed considerable differences in size, showing the overriding effect of a poor environment.
Tempo of growth in height from birth to 4 years has been studied in twins in the longitudinal Louisville Twin Study. The analysis of the growth curves indicated a strong genetic control of the rate of growth and especially, in change in rate. Studies of the resemblance of siblings at the same age have been reported by Garn and Rohmann (1966). In general correlation co-efficient of body length measures between siblings are of the order of 0.3-0.5, though in some measurements sister-sister values are higher than brother-brother ones. Siblings are also highly correlated in birth weight, but this is mainly due to maternal uterine factors.

The resemblance of body measurements between parents and children is also marked, though not before the children are of about 2 years and showing more effect of their own genes than the effect of uterine environment in which they grew. From 3 to 9 years correlation coefficients of height between parents and offspring are slightly under 0.5 and have been made the basis of standards for childhood height allowing for height of the parents. There is little evidence that on average one parent predominates in their effect on size, or that sons resemble fathers and mothers daughters more than conversely. When the parents’ height is known, the range of variation in adult height, represented by ± 2 standard deviation of the mean is from 25 cm. in the general male populations to 17 cm. in a given family, 16 cm. among brothers and 1.6 cm amongst monozygotic twins reared together. At the same time length of limbs and trunk are also under genetic control, while skeletal breadths and of course fat are less so.

Not only is physical size heritable but the timing and tempo of maturation also are significantly controlled by genes. The genetical control of tempo of growth is best shown by the inheritance of age at menarche. Monozygotic twin sisters growing up together under best conditions reach menarche on an average 2 months apart, whereas dizygotic twins differ on average by 12 months. The sister-sister and mother-daughter correlations are close to 0.50, indicating high degree of genetic determination of age at menarche. Thus, a large proportion of the variability in age at menarche under these conditions is due to genetical influence. It is thought that mother and father exert an equal influence on tempo of growth.

There are number of early studies of dental development that show calcification and dental emergence were highly correlated within MZ twins than DZ twin pairs, thus suggesting a heritability of 0.85-0.90. The general pattern of skeletal maturation (i.e. the tendency to be an early or late maturing individual) also suggests that the tempo of development is highly heritable with sib-sib correlations of 0.45. The process of maturation is commonly believed to be controlled, at least partially by genes independent from those controlling final size. Studies have shown that siblings may reach identical adult height even though they differed in the timings of maturational events.

Differences between populations are also due to differences in their gene pools, in their environments and in the interaction. Studies have shown that Afro-American children growing up under favourable conditions are a little taller and heavier than Europeans and Euro-Americans living in the same cities. This is partly or wholly because they are a little more advanced in maturity. Asians, on the other hand, under equally favourable circumstances are smaller despite being still further advanced in maturity. Even bodily proportions are different among different three major racial groups. The relatively longest legs characterise the Australians Aborigines and the Africans in Ibadan, with the former far exceeding
the latter. Londoners and Hong Kong Chinese both have relatively shorter legs than Africans, but the Chinese pattern of growth seems to be different from the European. Initially Chinese have relatively longer legs than the Londoners, but during growth they consistently gain less in leg length per unit sitting height. Asiatics have their characteristically short legs from about mid-childhood onwards, to a degree which rapidly increases until growth ends than the Londoners.

Racial differences in shape can also be seen in the relation of biacromial to biiliac width. Afro-American boys and girls in Washington have considerably narrower hips relative to shoulders than either Londoners or Hong Kong Chinese. Chinese are not greatly different from Londoners in this respect except that adolescent girls appear to gain more in hips. There are differences in body composition also, Africans having more muscle and heavier bones per unit weight at least in males, together with less fat in the limbs in proportion to fat on the trunk (Eveleth and Tanner, 1976). The African new born is ahead of the European in skeletal maturity and motor development. He maintains this advance for some 2 or 3 years in most areas in Africa after which nutritional disadvantage interrupts. In America and Europe the African stays in advance in bone age and also in dental maturity. The mean age at menarche for African descended was 12.5 years and 12.8 years for European descended. Well off Asiatic groups have as fast a tempo as Africans, in later childhood if not in earlier years. Mean age at menarche in Hong Kong girls from affluent families was found to be 12.5 years.

Inherited differences of body build may arise by either genetic drift or natural selection. If a small population colonizes a remote habitat, this group may by chance have an unusual frequency of genes favouring a particular body form, and because of limited opportunities for mating, these characteristics will persist in subsequent generations. Moreover, there will be fewer heterozygotes than in larger communities, and some gene combinations with a low initial frequency may disappear from the population by mere chance. However, if a particular body form has favoured survival, there will also be selective pressure increasing the frequency of any related gene combinations with in the population. Further, in an isolated population the apparent advantages of a particular body form might be exaggerated by emergence of unusual pattern of diet and lifestyle within the community.

2.7 BIOCHEMICAL METHODS

Growth trends and nutritional status of a child/community can be evaluated by means of field surveys, with the help of clinical examination, anthropometric measurements, biochemical tests and dietary intake along with information on socio-economic, demographic and ecological variables. Nutritional anthropometry is concerned with the measurement of the physical dimensions and the gross composition of human body at different age levels. However, it does not give specific information about the nutrients. For that information a variety of biochemical tests are useful. Although biochemical estimations of nutritional significance can be carried out on a variety of body tissues including liver, muscle and bone. In practice in field surveys, tests are confined to two fairly easily obtainable body fluids, blood and urine. Laboratory tests can be altered by medications, hydration status, disease status or other metabolic process such as stress. Biochemical tests can be employed to test the relative adequacy
of dietary intake, metabolic changes due to tissue malnutrition and depletion of body stores of proteins. Alterations in amino acid metabolism have been demonstrated in Kwashiorkor caused by enzyme defects and inadequacy of plasma proteins especially albumin.

Plasma from blood sample is required for examinations for albumin, vitamin A, carotene, ascorbic acid and alkaline phosphatase. Fresh whole blood is used for the determination of haemoglobin. Anaemia can occur from iron deficiency of various nutrients. The principal ones are iron, folic acid and vitamin B₁₂. Iron deficiency may exist in the body as a result of inadequate dietary intake, poor absorption or a combination of both. This is especially likely to happen in early childhood when the iron needs are high and the food eaten tends to be poor source of iron. We can detect anaemia by testing haemoglobin levels of children/population and can compare these with standards of haemoglobin suitable for the particular age groups. Haemoglobin levels are independent of climate, but attention may be paid to the effects of high altitude as well as other causes of anaemia, such as malaria, sickle cell diseases and folic acid deficiency. Urine samples are used for detection of urea, thiamine, urinary iodine, and riboflavin etc. However, when used as a measure of body muscle mass for creatinine estimation, urine has to be collected over a time period- minimally three hours and preferably twenty four hours. Creatinine, a product of muscle metabolism is excreted into the urine and can provide accurate estimate of muscle mass utilisation. This measurement can be affected greatly by renal function.

Biochemical investigation may give information on the nutrient supply to the body as reflected by levels in a particular tissue, most often the serum, e.g., ascorbic acid. However, the concentration of an essential nutrient in a body fluid may be reduced as a result of dietary deficiency, poor absorption, impaired transport (as can result from plasma protein in protein calorie malnutrition), abnormal utilisation or a combination of these. While the measurement of nutrient concentration is helpful in suggesting the possibility of malnutrition, it does not indicate the presence or define the degree of nutritional disease.

Some biochemical test can be undertaken that reveal metabolic changes resulting from tissue malnutrition due to inadequate levels of essential nutrients, often of long duration. The detection of such metabolic changes aids in the assessment of nutritional status and in many instances indicates a state of deficiency with greater certainty than does a mere lowering of tissue concentration of essential nutrients. These changes sometimes precede the appearance of clinical manifestation of malnutrition. A decreased availability of iodine to the thyroid may be the result of its inadequate intake and can be detected as thyroid enlargement especially in school children. The nutritional significance of the results of biochemical tests in a community has to be correlated with all the other findings i.e. clinical, anthropometric, dietary and ecological.

### 2.8 ENVIRONMENTAL FACTORS

Growth is a product of continuous and complex interaction of heredity and environment. A considerable proportion of the mean differences in body size between the populations being observed are due to the effects of environmental conditions. Some of the differences between individuals within populations are also due to differences in environment. In the better-off populations of
industrialised countries these differences are relatively small, while in developing
countries the gap between well-off and poor is greater. A child may receive
numerous insults (diet low in calories or proteins) during growth and yet survive,
but bodily adaptations for survival are made which may result in smaller body
size. When environmental conditions improve the size of child also improves.

Many environmental factors influence rate of growth but most of them hinge
upon the level of nutrition besides infections from disease, socio-economic level
and family size, urbanization, climate and seasonal effects and psychosocial stress.

Enumerate the role of various environmental factors in regulating human
growth.

2.9 NUTRITIONAL FACTORS

Adequate nutrition is essential for normal growth at all ages. Malnutrition delays
growth. The period when the child is most at risk from the combination of
malnutrition and infection is from birth to 5 years. Many populations in developing
countries have mean birth weights at the same level as those in developed countries
but it is only after 6 months that the weight gains diminish as a result of the
interaction of undernutrition and infection. The slowing down in weight growth
in some areas coincides with age of weaning and the substitution of high starch,
low protein foods. It is also the age at which the mother’s lactating ability declines
so that satisfactory growth cannot be achieved by breast milk alone.

Researchers have discussed the question of whether under nutrition in the first
or second year of life necessarily leads to an adult deficit on body size. It has
been seen that children with severe protein-calorie malnutrition in early infancy
due to malformations or malfunction of the gut make a complete recovery in
height after surgical correction when brought in well off homes in a developed
country.

Evidently much depends on the circumstances when the severe episode of
malnutrition is over. Children less than five years admitted to hospital in tropical
countries with severe protein-calorie malnutrition (Kwashiorkor or Marasmus)
were followed after discharge. In most of such children complete equality of
height and weight with sibling controls was attained before puberty. In other
long term deficits were reported and their growth was not equal to their siblings
but was more close to the general population, a less appropriate control. Long
periods of under nutrition, often combined with chronic infections; certainly
have lasting effects on body size.

Body shape is made more resistant to nutritional stress or even disease than is
body size. Malnutrition in man does not alter significantly the shape of the body;
a malnourished European child by no means acquires the short legs of the Asiatic.
These days along with malnutrition, overweight is also causing an increasing
problem of obesity not only in developed countries but also in developing
countries. Recent evidence suggests that overfeeding in first year or 18 months
after birth may have much to do with the tendency to become obese later.

During the period of 5 years to adolescence the child is growing less rapidly and
presumably because of this few populations show height and weight means
decreasing further. A second period when the child may be especially sensitive
to influence of under nutrition is at adolescence. The calorie requirement increases at this time in level with the increased growth of the adolescent spurt. Lack of sufficient calories may result either in a smaller spurt or a delay in the age of the spurt. The latter reflects chiefly on accumulating deficit in the years preceding adolescence. Tempo seems usually to be first thing affected. In data from well off families in all populations, age at menarche is earlier than children from underprivileged section. Girls from larger families also had consistently late maturation than those from smaller ones. Poor nutrition during childhood slows up skeletal maturation and also affects width of cortical bone. Thus, level of nutrition of children in a population has to be studied in relation to their ecological aspects and most importantly its implications on human growth and maturation.

### 2.10 EFFECT OF DISEASE

In well-nourished children the effects on growth of minor diseases are minimal. An ill child is a poorly growing child, although the extent of slowing down depends on number of factors. Poorly nourished children are more susceptible to and more severely affected by infection than well-nourished children. Infection in turn lowers the nutritional intake of the child, who in turn becomes prone to repeated infections. Measles and whooping cough are severe diseases in developing countries where chronic undernutrition may affect two third of the population. In malnourished children suffering from measles the mortality is many times higher than in well nourished children.

In developed countries with good nutrition measles is no longer considered a severe disease and when it occurs it is more frequently in older children from 3 to 5 years rather than under two years. But in poorly nourished children the weight loss associated with measles may take from 4 weeks to 3 months to regain. Longitudinal studies have been carried out by researchers in Guatemala and Jamaica to examine the effect of infectious disease on growth in the first three years. Short term weight loss was frequently seen. In Jamaica the long term picture was one of catch-up growth causing complete restoration of growth status, but in Guatemala it was not completely restored. Therefore, it is very important to protect children from catching infections by taking preventive measures for their overall better growth.

### 2.11 SOCIO-ECONOMIC STATUS AND FAMILY SIZE

Children from families belonging to the high or middle socio-economic groups in any country are on average larger in body size than their counterparts in the lower economic groups. High income and high educational level imply not only better nutrition but often also better child care and better use of medical and social services. Differences between socio-economic classes in height and weight are found in developed as well as in developing countries. In the British National Child Development Survey, a nationwide sample of children consisting of all those born in one week of March 1958, an overall difference of 3.3 cm was reported between seven years olds from the professional and managerial classes and those from the unskilled, manual working class. Similarly in the U.S. national sample of children measured by the National Centre for Health Statistics, children aged 6 to 11 were some 3 cm taller in the rich families than in the poor ones.
the University of Paris, the tallest students were children of parents in intellectual professions while the shortest and heaviest from worker and peasant families. Reports of socio-economic class differences in growth from developing countries including India show the very great differences in height and weight of 5 years olds in upper and lower social classes that exist in many cities.

These differences are compounded by differences in height and tempo according to number of sibs in the family. First born children are somewhat taller than later born children with the same number of sibs, since they have had a period of being an only child. The more mouths to feed, it seems or simply more children grow. This difference is solely of tempo, because children do not differ systematically according to birth order when they are fully grown. All the differences in social class may not be of direct environmental origin, however classes are to some extent endogamous, and movement from one social class to another in some countries is linked with size as well as ability.

In Belgium, young men who were moving up the scale occupationally (i.e. entering a more prestigious and better rewarded occupation than their fathers) were larger, healthier and scored higher on intelligence test than those who stayed in the same or equivalent occupation. The downwardly mobile showed approximately the opposite picture.

2.12 URBANISATION

Children in urban areas are usually larger than children in the surrounding rural areas. Indeed the tendency towards greater size and more rapid maturation in Europe in the last hundred years has been held to be a consequence of urbanization. By urbanization we do not mean simply a high population density, other features such as a regular supply of goods, health and sanitation services, large medical institutions, educational, recreational and welfare facilities must be present. A European or North American city is considerably different from urbanized area in Africa or even a city in India or Japan.

Data from European countries on height and weight from Finland, Greece and Rumania also shows that children in the cities are larger than those in rural areas, but the amount by which urban children were taller and heavier varied. Eight year old boys in Helsinki, for example, were 2.4 cm taller and 1.6 Kg heavier than rural Finnish boys, while in Greece the urban-rural differences were twice as great. During puberty the differences became greater, presumably because of the earlier appearance of the adolescent spurt in city children. While part of urban-rural differences results from earlier maturation. In developing countries also the same trend is being witnessed, urban children being taller and getting matured earlier than the rural children. Better off children, that is children who live in parts of towns that are nearer to urban areas are considerably taller and heavier than the rural children.

In every urban-rural comparison so far reported urban girls have an earlier menarche than rural girls. As with growth in body size, age at menarche is closely related to the health and nutritional level of an individual or a population. In a study from Bombay even urban slum children have been reported larger than children in the corresponding rural areas where even the poor were said to have received more food in the first two years after birth than children in rural areas.
Many studies conducted in India on growth of rural-urban children also show better overall growth and earlier maturity among urban children than their rural counterparts.

### 2.13 SEASONAL AND CLIMATIC VARIATION

A seasonal variation in rate of height growth has long been recognised in the temperate zones. Children tend to grow faster in height in the spring and summer and faster in weight in the autumn and winter. Marshall (1971) in a longitudinal study found that in children 7 to 10 years of age maximum height velocities were reached in 3 month periods ending between March and July, and minimum height velocities in the periods ending between September and February. During the 3 months of fastest growth, a child on average grew three times as much as during the 3 months of slowest growth. The cause of these differences is unknown. Totally blind children showed similar variations in rate to sighted children but failed to synchronize them with season of the year. Length of daylight seems to play only a minor part.

Seasonal variation in height and weight growth is governed by the rainy and dry periods in tropical areas. The rainy season is marked with food supply running low and the frequency of infections is highest. In Gambia, children under 3 years had good weight gains during the dry season but experienced low gains and even weight loss during the wet period. In Tanzania, both African and European school children displayed seasonal changes in height and weight gain, however the differences in weight were not constant in both the groups. Change of season has an impact on diet of an African child whereas that of the Europeans remains relatively constant. Thus, it can be concluded that different factors may be responsible for seasonal variations in the two areas.

Moreover, the effect of altitude on growth has also been studied. In general, people living at high altitude are smaller than those living at sea level or plains. The principal environmental factor affecting human physiology at altitude 3000 meters is the low atmospheric pressure which reduces the partial pressure of oxygen in the inspired air. It results in hypoxia, a condition in which haemoglobin carries less oxygen than at sea level and oxygen tension in the plasma is reduced. Other factors which affect growth of man at higher altitude are cold, lower air density and nutrition. As a result of adaptation to high altitude, the period of growth is slow and prolonged; Individuals have larger chest circumference, higher average lung size and higher haemoglobin concentrations as compared to individuals living in plains and at sea level.

### 2.14 PSYCHOSOCIAL STRESS

Psychological stress has been found to be contributing towards relative failure to grow in some children. It does this by affecting the secretion of growth hormone. As soon as stress is removed secretion of growth hormone starts again, and in clinical cases, a catch–up occurs. This is indistinguishable from the catch-up as a result of administering of human growth hormone to a child who is permanently deficient in growth hormone for structural reasons.

Studies have shown that the majority of children suffering from fairly severe stress continue to grow when given sufficient food, even in astonishingly stressful
circumstances. Let us narrate the famous experiment of Widdowson of Cambridge University who provided some proof that the presence of a sadistic school teacher was a reason for affected growth in children in orphanage by slowing it down, even though a simultaneous increase in the amount of food eaten is there. Some earlier studies have shown that certain boarding-school boys grew more slowly in term-time than they did in holidays at home. Tanner and Whitehouse confirmed this finding. On the other hand it is quite possible that a boarding school may provide the friendly atmosphere required for catch-up to a child whose growth has been stunted by an adverse home. Thus, psychosocial stress can contribute towards slowing down the growth of a child. Therefore, it is important to have a congenial atmosphere at home as well as in schools and working places for the normal growth of an individual.

2.15 SUMMARY

Growth is the result of three forces: the genetic program, action of environmental factors and the interaction between the two. Potentialities of growth are inherent at the time of the conception and are determined by genes but without a favourable environment normal growth cannot occur. Different sets of hormones influence growth at different ages. There are many environmental factors that influence growth; an adequate supply of proper nutrients being one of the greatest importances.

In this chapter we have tried to explain different methods of studying growth keeping in mind the nature of the study and discussed their advantages and disadvantages. This information will help you in choosing the most appropriate method to be employed while undertaking growth studies. Short-term changes in body size occurring between consecutive generations are called secular trends. This word has been taken from a Latin word “Saeculum” meaning “for a generation”. You may now be in a position to define and describe secular trends as observed in different populations with the help of examples given in the lesson. The role and importance of genetic factors has been explained in relation to body size, body shape and tempo of growth with the help of family and population studies. The environmental factors (nutrition, disease, socio-economic status, family size urbanisation, seasonal and climatic variations and psychosocial stress) which play an important role by acting on the genetic potential have been explained in detail and it will be easier for you to understand the cumulative effect of all these factors on human growth and development. The concept of catch up growth i.e. accelerated velocity during recovery is a very fascinating phenomenon and perhaps now you will be able to understand in your day to day life while observing it in the family and among friends. Similarly, you can understand the differential growth and maturity status of different body segments. Anaemia and malnutrition are the most prevalent disorders prevalent in developing countries. Biochemical methods can be used to detect anaemia, malnutrition, hormonal levels and various other deficiencies as has been described in the chapter. Thus, for anthropologists, growth data as an indicator of public health and nutritional status of children assume ever increasing importance because growth monitoring in children can serve as a powerful tool for appropriate action to promote improved health and nutritional status.