# NUTRITIONAL STATUS AND PHYSICAL GROWTH OF LOTHA CHILDREN OF WOKHA DISTRICT,NAGALAND

BY
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# DECLARATION

I, **Thungchamo Tsopoe**, hereby declare that the subject matter of this thesis entitled "**Nutritional Status and Physical Growth of Lotha Children of Wokha District, Nagaland**" is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the North Eastern Hill University for the degree of Doctor of Philosophy in Anthropology.

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# CHAPTER - I

# INTRODUCTION

Growth and development are ubiquitous to all living organisms including human beings. Growth and development are the two distinct biological processes that occur simultaneously from the beginning to the end of the life of an individual. **Growth** is defined as a regular process of quantitative increase in size or mass of different tissues and organs of the body especially from conception to adulthood. For example, the growth in height and weight can be measured from one age group to another, or the number, weight and size of cells can be used to measure the growth of body organs like liver and kidney *from one stage to another. On the other hand,* ***development*** *consists in the* "progression of changes" in form and function, thus, it can be defined not only as a change in functional capacity due to increase in size or mass, but also as a unified network of the differentiation and modification that translates a single fertilized egg into a complex-multicellular individual of mature state. For example, the development of skills and functional capacity to stand up and walk on two feet due to increase in size of locomotion parts of the body, or the development of an embryo into fetus, or the development of reproductive organs plus their functions, and so on. Thus, according to Bogin (1999), development refers to the "progression of changes, either quantitative or qualitative, that leads from an undifferentiated or immature state to a highly organized, specialized, and mature state."

It is obvious from the above that the term "development" is broader than that of "growth" or the former includes the latter. On the other hand, other authors have considered growth as the "developmental process lasting from conception to adulthood through which the genome is translated into adult structure" (Strickland and Tuffrey, 1997). Nevertheless, physical growth and development are interdependent through which an individual attained adulthood in terms of forms and functions. Therefore, these two terms are often used simultaneously, and sometimes synonymously. According to Garn (1952),"the terms 'growth' and 'development' as used in physical growth studies refer to processes common to all living organisms, processes intimately linked in time but partially independent, unquestionably genetically determined, yet uniquely susceptible to environmental modification."

Growth process takes place continuously throughout childhood; it is very rapid in the first two years and less so during the middle years of childhood (Emslie-Smith *et al.*, 1988). The regular human growth curve appearing in sigmoid shape indicates that a rapid growth rate occurs during the early fetal life and infancy stage, and begins to decelerate gradually in the later growing phase. Again, during adolescent stage there is a remarkable spurt of growth known as **adolescent growth spurt**. However, when an adverse condition prevails in child's environment the accelerating growth rate diminishes and this condition begins to reciprocate with the improvement in the child's environment. This sudden rise in the magnitude, or an increase in growth rate of the children with the improved environmental quality is known as catch-up-growth (Bogin, 1999).

The study and conceptualization of human growth and development can be traced back to the very early part of the history of human civilization. The earliest written record on human growth, dated about 3500 BP from Mesopotamia, gives an account of fertilization to birth (Bogin, 1999). Nevertheless, the genuine observation of children's growth is that of Hippolyt Guarinoni of Germany published in 1610 when he wrote his observation on growth retardation caused by emotional stress at school, and the late development of peasant girls (Tanner, 1998). Forty-four years later, Johann Sigismund Elsholtz (1623-1688), a German Physician, wrote his thesis entitled

"Anthropometria"(1654), meaning "measurement of man" and called the instrument he used for measurement as "Anthropometron." Then, the real story begins with the first textbook on human growth written by Johann Augustin Stöller (1703-1780) in 1729. According to Tanner (1998), Stöller was the first to give a clear description of catch-up growth. However, he confused "post-illness catch-up growth" with normal adolescent growth spurt, and such confusion lasted right through the time of Quetelet (1716-1874), who proposed the body mass index and introduced the statistics of normal growth curve. Anyway, the first thesis on human growth was presented at Halle in 1754 by C. F. Jampert, i.e., twenty-five years after the work of Stöller. Jampert's thesis entitled *Causas incrementum corporis animalis limitantes* (factors which control the growth of the animal body) was considered the first work that was comparable to the modern writing. The thesis consisted of cross-sectional data on growth of the children at the Berlin Friedrich's orphanage, and it pointed out the problems of sampling variation. Jampert was also the first to point out the difference between longitudinal and cross-sectional methods of growth study. Consequently, Count Phillip Gueneau de Mountbeillard made the first longitudinal growth study during 1757 to 1777. Mountbeillard was inspired by G. L. Buffon, the father of modern geology and the first to study the growth of fetuses and newborns, to take measurement on the height of his son from birth to adulthood. Mountbeillard's growth study was well known to Quetelet and others during the 19th century, and it is still considered to be one of the best in the history of longitudinal growth study.

Nowadays, the study of physical growth and development of children has become the major interest not only among the auxologists, but also among the biologists, anthropologists, nutritionists and other social and behavioural scientists with different interests and objectives of study. To paediatricians and other medical researchers, the main focus of attention is on the impact of the environment on the individual or a small group of individuals and the aim is to cure or alleviate ill-health and distress. To human biologists, growth is a major concern in understanding the complexity of nutritional and hormonal mechanisms that control changes in the human body. To epidemiologists, growth is often used as a summary measure of environmental influences and increasingly as a proxy for environmental influences during childhood and adolescence, which may affect the later health of an individual. To practical nutritionists, growth is the measure of success of intervention in dietary supplementation. To economists, physical growth and strength help to determine individual labor productivity and the magnitude of poverty in a population since growth is a good indicator of nutritional status which is greatly influenced by economic condition of a given individual or population. To anthropologists, growth is of considerable interest in understanding human adaptation to physical, biological and cultural environments.

As for anthropology, the study of human growth and development has been an essential part of anthropological research since the birth of the discipline itself. Early anthropologists, especially Franz Boas are well known for their contribution to growth studies. One of the main reasons for such an interest in growth studies is that human growth serves as a mirror that "reflects the biocultural evolution of our species" (Bogin, 1999). Of course, the basic objective of anthropology is to understand the biological and cultural evolution of human population. Human growth and development may be considered as the product of the interplay between the biology of our species, the physical and the socioeconomic environment where we live (Bogin, 1999). Therefore, the pattern of human growth and development reflects the biological and socio-cultural aspects of our society as well as the evolutionary history of our species. According to Tanner (1988), "The study of growth is important in elucidating the mechanism of evolution, for the evolution of morphological characters necessarily comes about through alteration in the inherited pattern of growth and development. Growth also occupies an important place in the study of individual differences in form and function of man, for many of these also arise through differential rates of growth of particular parts of the body relative to others." Thus, growth as a constant and regular process is important in identifying population variations, differences in sexes, variation within the population and other health implications. Thus, the study of human growth is essential in understanding not only the health and nutritional status of a population, but also the interaction between biology and culture. For example, the pattern of human growth is indirectly influenced by several socio-economic factors through their direct influence on nutrition and infection. Several studies have revealed that children belonging to different socio-economic groups have shown differences in their growth pattern (Tanner, 1962, 1966; Garn, 1966, 1980; Eveleth and Tanner, 1976; Frisancho, 1978; Hauspie *et al.*, 1992; Misuraca *et al.*, 1995; Edward *et al.*, 1996; Milani *et al.*, 1999; Reddy and Rao, 2000; and many others).

Further, Eveleth and Tanner (1990) have also observed that, "A Child's growth rate reflects, perhaps better than any other single index, his state of health and nutrition; and often indeed his psychological situation also. Similarly, the average values of children's height and weight reflect accurately the state of a nation's public health and the average nutritional status of its citizens, when appropriate allowance is made for differences, if any, in genetic potential. This is especially so in developing and disintegrating countries". Therefore, a well-designed growth study is very important tool for assessing the health status of the population concerned. Since human growth and development is also largely influenced by socio-environmental factors like nutrition, infection, occupation, income and religion, it is very vital to understand the bio-cultural variation and evolution of human populations (Tanner, 1988; Eveleth and Tanner, 1990, etc.).

In the light of the above circumstances, physical growth is not only helpful in understanding the process of human evolution and variation, but also reflects the health and economic condition of a population. In India, the large sample of growth study was first carried out by the Indian Council of Medical Research between 1956 and 1965 and reported in 1972, although stray researches began since the 1930s by workers like Aykroyd and Rajgopal (1936), Narinder Singh (1939), and others. However, growth studies in India are still limited in number especially those which are concerned with the assessment of health and nutritional status of different ethnic groups in the country

(Sharma, 1992). Therefore, it is essential to conduct more researches on physical growth and development of children with a view to understand the economic conditions and nutritional status of the different populations in different parts of the country.

**Population Variation**

There is a considerable difference between and within populations in the rate of physical growth and attainment of body size at any given age (Eveleth and Tanner. 1990; Bogin, 1999). It has been observed that the largest differences take place between the developed and developing countries as well as between the higher and lower socioeconomic groups within the same population (Ulijaszek, 1994). The basic causes of such differences are believed to be due to both genetic and environmental factors. However, it is believed that the growth patterns of all major population groups are likely to have a similar genetic potential for growth and development, and the differences between them are mainly due to environmental factors including infections and socioeconomic conditions (Waterlow, 1988; Neumann and Harrison, 1994; Ulijaszek, 1995). According to Ulijaszek (1995), from the anthropological point of view, these differences may be considered as 'adjustment and adaptation to both the nutritional and disease environments: smaller body size may offer an advantage if it adjusts the size of individuals to available nutritional and energetic resources, but it may be disadvantageous in other respects such as greater susceptibility to infectious disease, or lower physical work capacity.'

The assessment of growth status of children's are generally carried out by comparing the attained height or weight for a given age with some growth references. For example, the U.S. National Center for Health Statistics (NCHS, 1977) growth references, recently revised (Kuczmarski *et al.*, 2000), are used internationally. The basic reason for the use of such international growth references is related to the empirical evidence that children belonging to higher socioeconomic strata of developing countries have shown similar growth patterns of their coevals at a given age group in the developed or rich countries. For this reason, Gopalan (1989) is of the opinion that "the genetic potential for growth and development is nearly similar among most people of the world." In fact, the Lancet (1984) concluded in its editorial part that "growth of privileged groups of children in developing countries does not differ importantly from those in the developing countries", and that "the poorer growth so commonly observed in the underprivileged is due to social factors - among which malnutrition-infection complex is of primary importance - rather than to ethnic or geographical differences." Thus, the growth curves of well-nourished children in the developed world were used to determine desirable rates of growth, and optimal anthropometric standards for assessing the nutritional status of children all over the world. The underlying principle is as follows: since the children in the reference group are unhindered by nutritional deprivation and hence are enjoying the maximal growth permitted by their genetic potential, they constitute an ideal standard against which to judge the nutritional adequacy of all other groups. As results, international standards, or growth references, like NCHS standards, or references, (Kuczmarski *et al.*, 2000) are developed for assessing the growth and nutritional status of children. The children who are below these standards are considered to have failed to achieve genetic potential, and they are therefore regarded as undernourished. Thus, it is clear that the main objective of the genetic potential theory is to set a normative target of growth, which every community could aspire to achieve.

However, there has been a limited consensus over the use of these growth references especially in populations of Southeast Asia like India (Seckler, 1982; Ulijaszek, 1994). Ulijaszek (1995) has argued that "any use of growth references internationally should acknowledge that they can act, at best, as imperfect yardsticks, since human populations may show similar growth characteristics, but are unlikely to ever become so homogeneous that they show the same genetic potential for growth" because these growth references do not represent the greatest possible human potential for growth. Of course, the population differences in growth and development may be considerable that need further studies to have a better understanding of the problems, especially in populations of developing countries.

In his observation on the populations of India and Nepal, Seckler (1982) has argued that the children treated as mild and moderate undernourished, according to height for age with reference to international standards, may be considered as "small but healthy." According to Seckler (1982), about 90% of all the malnutrition found in these countries involved people with low height for age but *with proper weight for height ratio*. Now, if one thinks of malnutrition in the conventional imaginary of thin, wasted bodies, rather than in terms merely of short people, the incidence of malnutrition must be considerably reduced. Of course, since short people with proper weight for height ratio will also be light people, their consumption requirements will also be less than conventionally estimated. Seckler is of the view that there are no impairments in the range of mild to moderate malnutrition according to conventional standards, "because this range represents an adaptive response of body size to adverse conditions *in order to avoid these impairments*." To support his argument, he also writes, "I have tested this conjecture on a sample of Indian children who were medically screened and known not to be malnourished or unhealthy and who had a normal medical history. Over 90% of the 17 year olds in this healthy study would be considered malnourished, and some even severely malnourished." Accordingly, he suggests that appropriate reference standard for the assessment of undernutrition should be lower than the maximal growth path permitted by genetic potential theory. Payne (1992), though in a different way, has also supported that the scientific concept of nutrition refers not to the failure to meet some normative targets, but to the failure of maintaining the functional capabilities that depend on the level of nutrition. On the contrary, most of the individuals below the standards as proposed under the genetic potential theory do not show such functional impairment. Payne (1992) has criticized the genetic potential theory as supporting the armpit of obesity, which is generally associated with cardio-vascular diseases and risks of morbidity and mortality.

It may be mentioned that the origin of Seckler's hypothesis – small but healthy - can be traced to a group of biologists who have been much concerned with the processes of human growth. For instance, J.M. Tanner, who is one of the leading authorities on human growth and whose influence was acknowledged by Seckler, explicitly warns against assuming that being small is necessarily bad. In fact, he coins the phrase "bigger not better" and argues that, "Though rate of growth remains one of the most useful of all indices of public health and economic well-being in developing and heterogeneously developed countries, it must not be thought that bigger, or faster, is necessarily better." (Tanner, 1978). The advantage consists in the fact that a small body enables a person to survive and sustain his level of activity in a world of nutritional constraint, because a smaller body requires less energy both for maintaining itself within certain bounds and for performing physical activity relative to the environment where the people live. However, if the level of productivity in such small people is low, it proves to be disadvantageous (Ulijaszek, 1995; Strickland and Tuffrey, 1997; Shetty, 1999).

## Growth Curve

Most of our knowledge about the growth of children is concerned with the post-natal period based on sequential measurement of sizes like height, sitting height, etc. which are taken on the same subject (longitudinal) or a group of subjects with different ages (cross-sectional). These data, especially longitudinal data, allow us to determine the underlying continuous process of growth, that is, to produce a smooth growth curve which fits our observations, and which can be used to estimate the different biological parameters taken during growth and development (Hauspie, 1998). Different mathematical models have been proposed in order to develop a growth charts or standards for growth monitoring, to understand and describe the distance and velocity curves, and to figure the pattern and process of growth, apart from predicting and describing the final height of the children (Preece and Baines, 1978; Cole, 1990, 1998; Jolicoeur *et al.*, 1992; Karlberg, 1998; Hauspie, 1998). Besides, since growth is a continuous process, the cessation and default of growth in man raised some problem, therefore, the smooth-distance curve is used to suppress the measurement error and determine the final attainment in body size, and to monitor whether an individual has been growing satisfactorily (Preece and Baines, 1978; Cole, 1990, 1994).

The fit of a model to growth data is nothing but a regression technique, which consists of a set of values for the function parameters that are used for obtaining the best-fitting criterion. The oldest and most widely used method in curve fitting is the "least-squares" method, which gives the values of the function parameters that minimize the sum of square deviations of the observed values from those predicted by the equation. There are basically two types of growth models, namely "structural" and "non-structural." Non-structural models merely give a description of the growth process as given by the empirical data, and they are linear in nature. On the other hand, "structural models are based on the idea that growth pattern has a basic functional form to which a direct biological interpretation can be attributed" (Hauspie, 1998). As a matter of fact, structural models are basically non-linear in nature and gives a good description of growth pattern. They are often used to estimate the biological parameters of the growth curve such as age, size and velocity at take-off of adolescent growth spurt, and at the age of peak velocity during adolescent growth spurt. Such biological parameters include age at take-off, size at take-off, velocity at take off, age at peak velocity, size at peak velocity and peak size velocity. Many other quantities, characterizing some aspect of the shape of the growth pattern, are also derived from the smooth fitted curve. According to Hauspie (1998), these "biological parameters form the basis for studies comparing growth pattern between individuals or between groups of individuals." Thus, it is generally believed that curve fitting is a technique, which allows the estimation of smooth growth curves based on empirical data. It can also be used to summarize growth data with certain number of biological parameters which carry the same meaning for all subjects and which can easily be used for further analysis of the shape and form of growth pattern. In the present study, Preece-Baines model 1 (PB1) was adopted for fitting the mean values of certain anthropometric variables (Precee and Baines, 1978) as used in many other studies (Cameron *et al.*, 1982; Lindgren and Hauspie, 1989; Dasgupta and Das, 1997; Milani 2000; Ward *et al.*, 2001). We shall describe this model in the next chapter.

**Sex Dimorphism**

One of the focuses of growth studies is sexual dimorphism. Difference between the sexes in growth pattern has long been the major interest in the study of human growth and development since the 19th century (Garn, 1980). Many of the sex differences in adult body size and form are believed to be due to the differential growth patterns at adolescence. The adolescent growth spurt occurs in all children, although it varies in intensity and duration from one individual/population to another. It is reported that the "peak velocity of growth in height averages about 10 centimeters a year in boys, and slightly less than this in girls. In boys, the spurt takes place on average between 12.5 years and 15.5 years of age, and in girls some 2 years earlier" (Tanner, 1992). Several authors have suggested that this feature of sexual dimorphism in boys and girls is a consequence of the timing difference, a positive value for the growth spurt and intensity of the adolescent spurt (Tanner, 1978; Bogin, 1999; Bhowmik, 1993). Tanner (1992) has also suggested that the differences between the sexes in height during adulthood are mainly due to the longer period of male growth. The difference in prepubertal growth males have a relatively much greater spurt than females in respect of shoulder width, whereas in the case of hip the latter exceeds the former. However, "the greater length of the male legs relative to the trunk is a consequence of the longer prebubescent period of male growth, because the legs are growing faster than the trunk at this time. Other sex differences still earlier. The male forearm is longer, relative to the upper arm or the height, than the female's. This difference is already established at birth, and increases gradually throughout the whole growing period" (Tanner, ibid). Marshall (1978) also claims that the longer period of pre adolescent growth in boys is largely responsible for the fact that the men's leg are relatively longer then women's because the legs grow faster than the trunk before adolescence.

During the process of growth and development, girls are reported to be more tolerant to the effects of different stresses as compared to boys. According to Wolanski (1973), one of the basic reasons is perhaps related to the differential number of X-chromosomes, which are two in females and one in males. Nevertheless, it is generally pointed out that growth during childhood and juvenile stages is more sensitive to environmental factors and during adolescence is determined more by genetic factors, and girls are better 'buffered' against environmental determinants of growth, especially undernutrition and diseases (Bogin, 1999).

The achievement of adolescent growth spurt is an important biological event in identifying the process of children's growth and development. The peak velocity is one of the unique features in the process of human growth and development. Children's body dimensions attain peak velocity at different time and in varied magnitudes. According to Bogin (1999), the adolescent growth spurt must have its own intrinsic evolutionary value, and is not just a by-product of slow pubertal development. The earlier appearances of adolescent growth spurt in girls over the boys by about 2 years of age is normally seen in growth process and for this reason the body dimension of the girls remain greater during this stage. During puberty there is a spurt in growth and the body undergoes functional and structural changes making it capable of procreation; the sexual organs mature and the secondary sexual characteristics develop (Emslie-Smith, *et al.*, 1988). Attainment of adolescent growth spurt during pubertal stage is generally followed by the slow growth rate, and finally by growth cessation.

## Growth as Indicator of Nutritional and Socioeconomic Inequality

Human growth is a regular process that is characterized by the changes in form, or size and function of an individual from conception till attainment of adulthood. It is believed that environmental factors, especially nutrition, are of crucial importance in the expression of genetic potential of growth. In other words, although growth is subject to the genetic influence, it is considered that environmental factors, particularly nutrition, are very important in influencing human growth and development. Therefore, physical growth of children is regarded as one of the best indicator of the nutritional status of a given population. In fact, the effects of undernutrition and overnutrition on growth and maturation of children are the major research problems in the field of nutrition and auxology.

One of the major health problems in many developing countries is the widespread prevalence of undernutrition and infectious diseases (WHO, 1990). It is generally reported that the basic causes of undernutrition and infections in developing countries are poverty, poor hygienic conditions and little access to preventive and health care (Mitra, 1985; WHO, 1990). Hence, the assessment of nutritional status of population has attracted the attention of not only the nutritionists and other biological scientists, but also the economists and other social scientists with a view of understanding the health and socioeconomic status of the population (Gopaldas and Seshadri, 1987; Osmani, 1992). Nutritional status is defined as the physical expression of the relationship between the nutrient intakes, or bio-availability of nutrients, and the physiological requirements of an individual (Brown, 1984). This physical expression of the relationship between nutrient intakes and physiological requirements of a person can be measured by a number of methods. Of different methods, anthropometry is one that is generally used for measuring the magnitude of undernutrition at both individual and population levels. Anthropometric measurements and indices like weight, height, mid upper arm circumference, skinfold thickness, weight for age, height for age, weight for height, body mass index, indices of upper arm circumference, etc. (Jelliffe, 1966; Frisancho, 1990) are used for assessing the nutritional status of children.

According to Tanner (1986), growth may be described as "mirror of the conditions of the society" and height as a proxy for health. It is observed that growth retardation, or delay in growth appropriate for an individual or a population, takes place even in some sections of the populations in developed countries due to deprivation, illness, psycho-social stress and increased family size (Norgan, 2000). Growth retardation due to inadequate nutrition and infection is reported to be common in developing countries especially in the early stages of growth and development.

Martorell *et al.*, (1994) has suggested that after 3 years of age, the growth patterns of children in developing countries are similar to that of the international growth references. On the other hand, other authors have rejected this claim and argued the growth pattern of children in developing countries deviate significantly at the lower rate after 5 years of age. For example, Cameron (1992) has shown that the rural South African children followed near the 50th percentile at 5 years of age, but thereafter growth rate was slower than the reference rate, and it was near the 3rd percentile by the onset of adolescence. Similar findings can be observed in the growth studies in Northeast India (Begum and Choudhury, 1999; Khongsdier and Mukherjee, 2003). Earlier findings have, however, indicated that the affluent Indian girls are similar to the 50th percentile of the NCHS growth references up to 12 years of age, and thereafter the increments in height of the Indian girls were significantly lower than the NCHS references (Gopalan, 1996). Thus, if growth is also a good indicator of socioeconomic status, the earlier findings indicate that there is an urgent need to conduct more research works on growth patterns of children in different populations of India with a view to understand the population variation in socioeconomic conditions.

Several studies have revealed the association between physical growth and socio economic condition of populations (Lindgren, 1976; Smith *et al.*, 1980; Garn *et al.*, 1984; Johnston, 1986; Lasker and Mascie-Taylor, 1989; Visweswara Rao *et al.*, 1990; Terrell and Mascie-Taylor, 1991; Hauspie *et al.*, 1992; Khongsdier, 1993; Misuraca *et al.*, 1995; Mockus *et al.*, 1995; Post *et al.*, 1997; Milani *et al.*, 1999). Some studies suggest that within a given country children from economically advanced areas are taller and heavier than children belonging to the economically underprivileged areas (Ferro-Luzzi, 1967; Ferro-Luzzi *et al.*, 1979). It is generally agreed, on the basis of data from different continents, that variation in growth pattern of children in developed countries of Europe and North America on one hand and in the developing countries of Asia, Africa and Latin America on the other are mostly due to differences in their socio-economic status, and not because of genetic differences (Habicht *et al.*, 1974; Stephenson *et al.*, 1983; Eveleth and Tanner, 1990; Gopalan, 1992). Thus, growth and development of children may also be considered an indicator of socio-economic status of a given population. In the present study, we shall also consider the variation between populations in respect of growth pattern as mainly due to variation in nutritional status, which is greatly influenced by the socio-economic condition of an individual, or a population.

Some studies in India also revealed that children from the well-to-do sections of the same community have higher values of height and weight than their counterparts of poor economic groups (Mitra, 1939; Mukherjee, 1951; Dutta Banik *et al.*, 1970; Bharati and Basu, 1990). Rajyalakshmi (1981) has also observed that the children of higher income groups are heavier and taller than those of lower income groups. Indian Council of Medical Research (ICMR, 1972) has also reported that the height, weight, subcutaneous tissue and other anthropometric variables are positively associated with socio-economic status. Similarly, Vijayaraghavan *et al.*,(1974) and Visweswara Rao *et al.*,(1980) reported that the arm circumference and fat fold at triceps of Indian children belonging to low socio-economic groups were considerably smaller than those of well to do children of corresponding ages. The effect of socio-economic condition on growth pattern of Indian children also been revealed in other studies (Rao and Sastry, 1977; Satyanarayana *et al.*, 1980; National Nutrition Monitoring Bureau, 1980; Bharati and Basu, 1990).

## Objectives of the Study

It may be worthwhile to mention here that in Northeast India, only few growth studies have so far been published (Khongsdier and Ghosh, 1998; Chelleng and Mahanta, 1998; Begum and Choudhury, 1999). Moreover, most of growth studies in Northeast India have been carried out among some populations of Assam only. Very few studies have been carried out in other states of Northeast India (Singh and Singh, 2000; Gaur and Singh, 1995; Talwar and Singh, 1995; Khongsdier, 1996, 1999,2001) especially in the state of Nagaland. Moreover, the growth studies carried out in Northeast India were mainly concerned with the assessment of growth pattern only. Very few studies are also concerned with the assessment of the nutritional status of children. Therefore, the present study entitled **Nutritional Status and Physical Growth of Lotha Children of Wokha District, Nagaland** was carried out among the Lotha children of rural areas in Wokha district of Nagaland taking into consideration the following objectives:

1. To describe the growth pattern of Lotha adolescent children aged 9 to 18 years in terms of anthropometric variables.
2. To assess the nutritional status of these children, using certain anthropometric indices.
3. To find out the frequency of some common nutritional deficiency signs.
4. To compare the physical growth and nutritional status of Lotha children with those children reported for other populations, especially in Northeast India.

## Study Area

Nagaland is one of the Northeastern states of India. It is situated approximately between 25° 60' and 27° 40' north latitude and between 93° 20' and 95° 15' east longitude (Figure 1.1). The state of Nagaland is bounded by Assam in the west, Myanmar (Burma) in the east, Manipur in the south and, Arunachal Pradesh and Assam in the north. It has a total area of 16,579 square kilometers (Census, 1991). Nagaland has eight districts, namely, Kohima, Dimapur, Mokokchung, Mon, Phek, Tuensang, Wokha and Zunhuboto.

The district of Wokha is located in the mid-western part of Nagaland, forming a triangular shape (Figure 1.2). The district lies at about 26° 8' north latitude and 94° 18' east longitude, covering an area of 1,628 square kilometers (Census, 1991). The average altitude of the district is about 1200 meters above sea level. The district has a border with Kohima on the south, Mokokchung and Zunheboto on the east and Sibsagar district of Assam on the north and west.

The highest mountain peak in the district is Tiyi Elung with an altitude of 1969.61 meters above sea level, while Doyang is the biggest river. Other rivers passing through the district include Nzhu, Chudo, Sosuroju, Longphiju, Mikhi and Chubi. The district has rich deposits of coal and petroleum. According to the Directorate of Information and Public Relations of Nagaland (DIPR, 1994), the Champang Oilfield produces about 400 tonnes of crude oil. The district was once very rich in flora and fauna, but now most of the flora and fauna are in the mist of extinction due to the practice of shifting cultivation.

The district enjoys a monsoon climate with dry winter. During winter the temperature fall between 11° to 15° C and in summer between 25° to 30° C, with a humidity of 70 % to 80 % in January, and 70 % to 90 % in July (Census, 1991). The low temperature keeps the climatic condition cool throughout the year, and therefore the district has both deciduous and evergreen types of forest. Rainfall in the district is highest between the months of June and August with an annual fall of 200 to 300 cm.

The district is predominantly inhabits by the Lotha tribe. According to the 1991 census, the total population of this district is about 82,612 with a density of 51 persons per square kilometer. It has a literacy rate of 73.92%, which is higher than the literacy rate (61.30%) for the state of Nagaland. The district has a rural population of about 68,235 or 85.79% of the population. The present study was carried out in seventeen rural villages of Wokha district, namely, Changsu, Chukitong, Elumyo, Humtso, Koio, Longsa, Longsachung, Niroyo, Nru-Longidang, Phiro, Pongitong, Sankiton, Shaki, Wokha-yan, Yanthamo, Yikhum and Yimkha (Figure 1.2). These villages were located within a radius of 20 kilometres from Wokha town, which is the headquarters of the district.

## Study Population

The Lotha are the major tribal group in Wokha district of Nagaland. In fact, this district is known as the homeland of the Lotha tribe. The name "Lotha" is derived from two words 'Loa' meaning pay or payment, and 'thata' meaning well paid or payment in full without any due. Thus, the term Lotha literally means people who pay fully with no liabilities. They are also called as *Kyon* or *Kyontsu*, which means our people. They belong to the Indo-Mongoloid race and speak the Tibeto-Burman language. The Lotha called their language as *kyongyi*. However, Nagamese, a concoction of Assamese, Hindi and Nepali is used to communicate with people from other communities.

Generally, the Lotha are thin, medium in stature and dark to fair in complexion (Sen, 1987). The inhabitants of upper and middle regions of the district have lighter skin colour than those living in the border area of Assam. Ghosh (1979) describes that the Lotha skin colour is generally dark-brown with few yellowish. Their hair form is commonly straight, although some of them show a wavy form as well. Their hair colour varies from light brown to black. Body hair is scanty. Eyes are epicanthic and the eye colour varies from dark brown to light brown in colour. Lips are moderate and nose is by and large high in form.

The story about the origin and migration of the Lotha remains ambiguous. Traditionally, the Lotha have no written records of their customs and folklore or tales but it is said to have transmitted orally from one generation to the next and therefore no historical materials have substantiated their story of migration. One of the legends says that the Lotha reached the present inhabited area while chasing a deer. It so happened that the deer passed through a hole leading them to the present world that was flourished with chilly and gooseberries. Since they were fond of these food items, they decided to abandon their old habitat and settled in this new place. Another legend says that the ancestors of Lotha migrated from Lengka through Tibet and reached Assam where some of their relatives separated and settled on the bank of the Brahmaputra river, while the present Lotha moved towards south and reached Wokha, their present homeland. The most common belief is that the Lotha migrated along with the other Naga tribes from Manchuria passing through Burma and from Khezakenoma, the Nagas were dispersed to different places. From this place the Lotha probably passed through places like Khayima (Kohima), Nerehma, Chichama Honohoyonton, and reached Tiyi Longchum in Wokha district.

The Lotha follow the patrilineal system of society. Clan exogamy is strictly followed in the society, i.e., any Lotha member cannot marry within his/her own clan. The common type of marriage in Lotha society is monogamy although polygamy is also present. Arranged marriage or marriage by negotiation is generally followed, although love marriage is also practised especially in modern days. Payment of bride price is still practised in the Lotha society. Presently, the bride price carries one hundred and fifty kilograms of pork known as *Hanlam* and it is given to the elders of the bride's clan. Previously, the price paid for a wife is usually about Rs. 100/- (Elwin, 1969).

Lotha religion is basically animism in nature. The people have a strong belief in supernatural powers. Their notion in the existence of the benevolent and malevolent spirit residing among the giant trees, massive stones, mountains and rivers makes them to propitiate these spirits at the time sickness or any eventualities in life to avoid misfortunes. The spirit of benevolent is invoked into their family as it brings good fortune and prosperity, but the spirit of malevolent is send off by sacrificing cock or keeping eggs on the outskirts of the village in order to stay free from sickness, poverty and other misfortunes. Nowadays, many Lotha's have abandoned their traditional religion and embraced Christianity, which was first spread in 1885 (Ghosh, 1979). The Lotha have celebrated many festivals till today. Among all, Tokhu Emung is the most recognized one and is celebrated on the 7th of November every year. This festival takes place after the harvest to enjoy the fruits of their labour, and is also a time to build friendship and reconciliation. Most of their festivals are associated with agricultural events. The Lotha men and women are very fond of wearing their traditional shawls. At home or in any auspicious occasions they will be wearing their traditional shawls.

### *Food habit*

The Lotha are well known for their nature of food delicacy. They are non-vegetarian. Their favourite food item is bamboo shoot curry. Therefore, other Naga tribes referred to them as 'bamboo shoot tribe'. Their fondness of this type of food item makes them to become specialized in preparing varieties of bamboo shoot, namely, *Rhujak* (fermented bamboo shoot), *Rhujon* (dried bamboo shoot) and *Rhuju* (liquid or distilled form of bamboo shoot). In their food preparation, one variety of bamboo shoot is included as one of the ingredients. The Lotha are also recognized as connoisseur in cooking among the Naga tribes.

Rice is the staple food of the Lotha. Their food item largely consists of rice, bamboo shoot, yam, salt, chilly, dry fish and other seasonal vegetables produced either from the garden or gathered from the jungle. Except for some of the cultivated vegetables like chilly, yam, brinjal and squash; they use to collect many food items from forest, such as mushroom, green leaves and, fruits and nuts for their living. The Lotha consumes meat in large quantity. However, it can be considered as a seasonal food in the rural areas because meat is sufficiently available only at the time of ceremonies and festivals. Their favorites among meats are pork, chicken, beef, fish, and wild hunts. "Pork is more relished and so pigs are more in number than other animals. Cows are also kept by many people mainly for meat, not for milk " (Ghosh, 1979). They are also fond of other wild animals like bears, deer, wolves, squirrels and jungle fowls. Most of the time, Lotha prepare their curry by boiling and rarely use oil and spices in their food.

The traditional taboos on certain food items are still in practice, and especially for the pregnant women and children. They are restricted from eating monkey meat, cock, owl, eagle, and water snake and are even forbidden to touch them. Their belief is that eating or touching of these kinds of animals will make the person mimicked the animal they ate or touched. Children's are not allowed to eat the brain of animals because of the belief that their hair would turn gray or white at young age. When a child is able to eat, the first food item *shunga* to be given is the meat of some swift or intelligent animal. This is done with a belief that the child will grow up strong, intelligent and fast like the species they feed. Usually the animals that are bright, fast, strong and steady are the favorites.

Consumption of milk is not common to the people, although they provide cow milk to sick and weak person. In rural areas, the people are habituated to drinking sweet tea every now and then but basically without adding milk. Rice beer is their traditional drink, but its consumption is decreasing with the increasing conversion to Christianity.

The people use to take three meals in a day, irrespective of the kind of work they do. By and large, the Lotha people are not aware of the idea of balanced diet. The same foodstuff is generally served in all the three meals of the day. They regularly take rice with chilly, dry fish, yam and tangy meat in their meal.

### *Occupation*

The main occupation of the Lotha is cultivation, although a small proportion of them are also engaged in business and services. The Lotha practise both shifting and terrace methods of cultivation, but shifting cultivation is the most popular method used by the people. All members of the household contribute in the cultivating activities, irrespective of age and sex. Women are also engaged in weaving, stitching, and knitting, apart from working in the field and taking care of the entire household duties. The major agricultural produces include rice, maize, pulses, cereals, pumpkin, beans, pea, and yam etc.

The economic condition of the Lotha largely depends on what they could produce from the field and what nature substantiated them. Some people face hardship because the harvest is not sufficient to meet the annual requirements of the family. The people either cultivate in their own land or clan's land, and some use to rent land for cultivation on the basis of exchanging labour. If the land that is to be cultivated is large, the cultivator take the service of his clan members, on the condition that labour is exchanged, or that labours are paid in kind or cash. In short, the economic condition of the people depends largely on agriculture. Their annual income in terms of money is on average Rs.10,000/- ( Rupees ten thousand only), since most of the agricultural produces are basically for household consumption rather than selling them in markets.

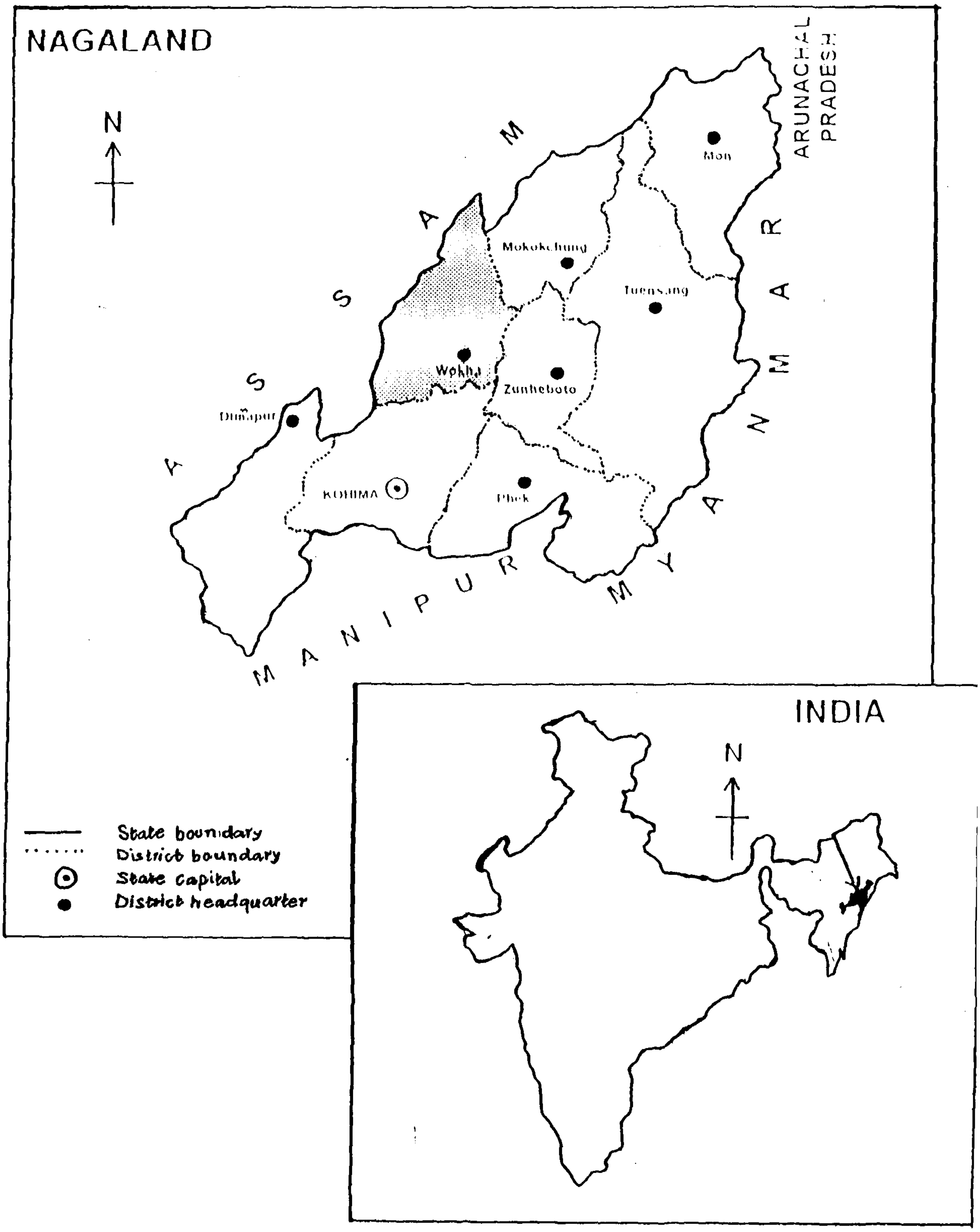

Figure 1.1 : Map of Nagaland

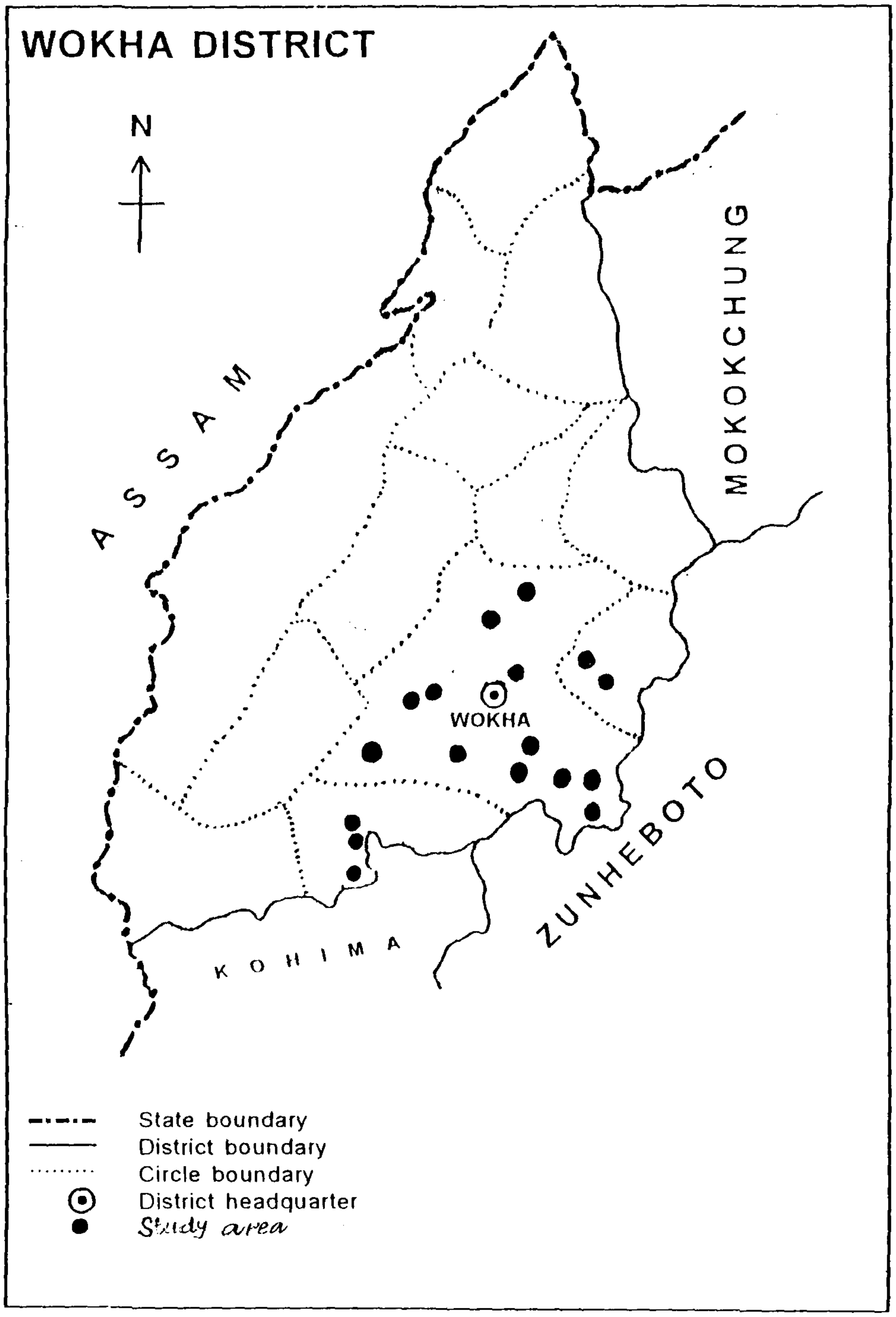

Figure 1.2 : Map of Wokha District (Nagaland)

# CHAPTER - II

# MATERIALS AND METHODS

In this chapter, we shall describe the materials and methods adopted for collecting, analysing and interpreting the data in the present study.

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## SELECTION OF SAMPLES

The present study was conducted among the Lotha tribe in rural areas of Wokha district, Nagaland. The fieldwork was carried out during the period from January 1998 to August 1999. No statistical sampling technique was applied for the selection of villages or individuals covered under study. However, an attempt was made to include in our sample almost all villages, which are located within a radius of 20 km from Wokha town, keeping in view that distance from town might have influenced the socioeconomic and nutritional status of the population. The villages included in our study are Changsu, Chukitong, Elumyo, Humtso, Koio, Longsa, Longsachung, Niroyo, Nru-Longidang, Phiro, Pongitong, Sankiton, Shaki, Wokha-yan, Yanthamo, Yikhum and Yimkha (Figure 1.2). The total number of individual samples is 741 of which 366 are boys and 375 are girls who are aged 9 to 18 years of age. As hinted above, these boys and girls were selected not on the basis of any statistical sampling because of the operational difficulties in the field. However, efforts were made to include in our sample all those boys and girls who were willing to co-operate to the present study with the help of school teachers and parents.

## METHODS OF DATA COLLECTION

In the present study we have taken into consideration the following anthropometric measurements for assessing the growth and nutritional status of children:

1. Weight (kg)
2. Height (cm)
3. Sitting height (cm)
4. Subischial length (cm)
5. Biacromial diameter (cm)
6. Bi-iliac diameter (cm)
7. Head circumference (cm)
8. Mid upper arm circumference (cm)
9. Chest girth (cm)
10. Calf circumference (cm)
11. Triceps (mm)
12. Biceps (mm)
13. Subscapular (mm)
14. Suprailiac (mm)

The above anthropometric measurements were taken following a cross-sectional method of study in which children of different age groups was measured only once (Eveleth and Tanner, 1990). The age of children was based on the school registers and the date of birth given by the parents. The date of birth for every individual was converted into decimal age following the method of decimal age calendar given by Tanner (Weiner and Lourie, 1981). For example, the age group 9 years includes all the children whose decimal age falls between 8.500 to 9.499 years. Table 2.1 shows the sample sizes according to sex and different age groups.

**Table 2.1.** Number of boys and girls by age groups

| Decimal age (years) | Age groups (years) | Boys | Girls | Total |
|---|---|---|---|---|
| 8.500 - 9.499 | 9 | 36 | 36 | 72 |
| 9.500 – 10.499 | 10 | 38 | 37 | 75 |
| 10.500 – 11.499 | 11 | 36 | 39 | 75 |
| 11.500 – 12.499 | 12 | 36 | 38 | 74 |
| 12.500 – 13.499 | 13 | 38 | 38 | 76 |
| 13.500 – 14.499 | 14 | 37 | 40 | 77 |
| 14.500 – 15.499 | 15 | 36 | 35 | 71 |
| 15.500 – 16.499 | 16 | 37 | 37 | 74 |
| 16.500 – 17.499 | 17 | 35 | 39 | 74 |
| 17.500 – 18.499 | 18 | 37 | 36 | 73 |
|  | Total | 366 | 375 | 741 |

## METHODS OF TAKING THE MEASUREMENT

Standard techniques of measurements described in Hooton (1946), Weiner and Lourie (1981) and Sen (1994) were followed while taking the anthropometric measurements of children. The techniques may be briefly described as follows:

## Weight

The body weight was taken with a spring weighing machine, asking the subject to stand on it with an erect posture and light apparel. The weighing machine was checked from time to time with a known standard weight. No deduction was made for the weight of light apparel while taking the final reading.

## Height

It measures the vertical distance from the floor to the vertex. The subject was made to stand as erect as possible with his/her arms hanging at the sides with thumbs forward. heels holding together and eyes directing towards the horizon (Hooton, 1946). The anthropometer was placed at the back and between the heels of the subject, taking care that it is kept absolutely vertical. The sliding sleeve of the anthropometer was then lowered down towards the middle of the head (Sagital line) so that it would touch the vertex lightly. Reading in centimeter and its fractions was recorded.

## Sitting height

It measures the vertical distance from the vertex to the sitting surface of the subject. The subject was made to sit on the stool, or a flat wooden chair, or at the end of wooden bench. Then he/she was positioned in an erect sitting posture, with ankles crossed. knees spread about 20 cm apart and hands rested on the thighs. The anthropometer was placed at the back and between the two buttocks, taking care that the lumbar curve of the subject was not flattened, but concave from behind. The sliding sleeve was then lowered down to touch the vertex lightly.

## Subischial length

Subischial length or lower extremity was obtained by subtracting stature by sitting height.

### Biacromial diameter

This measurement is the maximum breadth of the bony shoulder girdle taken from acromion to acromion. The measurement was taken from the back of the subject with the rod compass (i.e., the first segment of anthropometer), while he/she was standing in an erect posture with his/her arms hanging at the sides. When the two acromion points were located by palpating along the outside edge of the scapular spine, the measuring points of the left and right hand bars were pressed against the left and right acromia, respectively. Reading was then recorded. This measurement was taken with moderate pressure to indent the deltoid muscle, but not to cause discomfort to the subject.

### Bi-iliac diameter

It measures the straight distance between the two most lateral points of the iliac-crests. The measurement was taken from the back of the subject with a rod compass, holding the fixed sleeve of the compass on the left hand and the sliding sleeve on the right hand. As in the case of biacromial diameter, the most lateral points on the illiac crests were palpated with forefingers while holding the two sleeves of the rod compass.

### Mid upper arm circumference

The measurement was taken with a steel tape at the middle (midway between acromion and elbow) part of the left upper arm on the naked skin (Sen, 1994), while the arms are hanging at the sides of the body.

### Head circumference

The measurement was taken with a steel tape taking into consideration the glabella and opisthocranion points in such a way so as to get the maximum circumference.

### Chest circumference

It measures circumference of the chest of subject when he is breathing normally. This measurement was taken with a steel tape (Precision–1mm) at the level of the mesosternale, at the right angle to the axis of the body and reading was taken.

### Calf circumference

The measurement was taken at the most developed muscle of the lower limb by moving the steel tape vertically up and down horizontally with the subject standing and the legs slightly apart, then the reading was recorded to the nearest 0.1cm.

### Measurements of skinfold thickness

In the present study, we have taken four skinfold thicknesses, namely, triceps, biceps, Subscapular and suprailiac. The measurements were taken with Holtain Skinfold Caliper (Indian Made). The methods of measurements are briefly described as follows:

#### *Triceps*

The skinfold was picked up halfway down in between the point of acromion process and olecranon process of the ulna at the back of the left arm. The measurement was read 2 seconds after the gentle pressure of the caliper jaws was applied to the skinfold. An attempt was made to allow the skinfold running parallel to the long axis of the arm, while the subject was in normal position.

#### *Biceps*

The skinfold was picked up at the region between the point of acromion and cubital fossa of the left arm, which is by and large at the level of the triceps measurement. Methods of reading and applying the caliper were similar to those taken for the triceps skinfold measurement.

#### *Subscapular*

The skinfold was picked up at the lateral and inferior angle of the left scapula with the fold inclining approximately 45° to the spine in the natural line of the skin cleavage. The subject was made to stand with his hand on the side of the body.

*Suprailiac*

The skinfold was measured by applying the jaws of the caliper at fold which was pick up approximately 1 to 2 cm above the medial left anterior superior iliac spine with the subject standing erect and relaxed.

### Preece-Baines Model 1 (PB1)

In the present study, we have used the mathematical model proposed by Preece and Baines (1978), which is referred herein as PB1 model. This model was adopted for fitting the means of weight and some important linear measurements (Precee and Baines 1978), using Levenberg-Marquardt method through SPSS (version 10.0) and Origin Software (Version 7.0) for Windows. The model is expressed as follows:

$Y = h_1 - [2(h_1 - h_0)]/[\exp\{s_0(t-\theta)\}+\exp(s_1(t-\theta)\}]$

Where, Y = anthropometric measurement, t = age (years), $s_1$ and $s_0$ = rate constants, $\theta$ = time constant, $h_1$ = final size of a measurement, $h_0$ = is a measurement at t = 0.

Although PB1 model is primarily meant for fitting individual-longitudinal data, its use in the present study was but to estimate graphically some biological parameters (like adult size, age at maximum increment, or peak velocity, and peak size velocity) with a view to understand the nature of variation in growth patterns. Of course, the application of this model to cross-sectional data has been also revealed by many studies (Cameron *et al.*, 1982; Lindgren and Hauspie, 1989; Dasgupta and Das 1997; Milani, 2000; Ward *et al.*, 2001).

## ASSESSMENT OF NUTRITIONAL STATUS

For assessing the nutritional status of children, we have adopted three anthropometric indices, that is, weight for age, height for age and body mass index (i.e., weight in kg/height$^2$ in mts) for age, which are considered as good indicators of nutritional status.

These indices were derived both as Z-scores and percentages of the international standards or references, i.e., the growth references of the U.S. National Center for Health Statistics (NCHS) recently revised (Kuczmarski *et al.*, 2000). For determining the sex differences according to different age groups, we have calculated the means and standard deviations of the percentages of the NCHS growth references. For example, in the case of weight for age index, the percentage of the NCHS growth references was computed as follows:

Weight for age (%) = (Weight in kg of an individual at a given age)/(Median value of the NCHS growth references at the same age) × 100

For classifying the children into different grades of nutritional status, we have calculated the Z-score of individuals in relation to the NCHS growth references, using LMS method (Kuczmarski *et al.*, 2000). This method was based on the median (M), the standard deviation (S), and the power in the Box-Cox transformation (L). In order to obtain the Z-score (Z) for a given measurement, we used the following equation:

$$Z = \frac{((X/M)^{**}L) - 1}{LS}$$

where, X is the physical measurement (e.g. weight, height, etc.) and L, M and S are the values from the appropriate table corresponding to the age in months of the child. The children were then categorized into three levels of nutritional status, following the cut-off points proposed by Visweswara Rao (1996), which are as follows:

(1) Normal = -2 to + 2 of Z-score
(2) Moderate = -2 to – 3 of Z- score
(3) Severe = Below –3 of Z - score

## BODY COMPOSITION

By "body composition" we mean to the lean body mass (LBM) or fat free mass (FFM) plus adipose tissue (AT) or fat mass (FM). According to Forbes (1987), LBM refers to "body mass minus ether-extractable fat, and hence includes the stroma of adipose tissue." An assessment of body composition is useful in getting a better understanding of the growth and nutritional status of children. In the present study, we have assessed the body composition of the Lotha adolescent children taking into consideration the equations proposed by Durnim and Womersley (1974), which are generally recommended for the adolescent children (Norgan, 1995). Following are the equations used for computing the body composition:

Males: Density (D) = $1.1620 - 0.0630 \times \log_{10}$ (biceps + triceps + subscapular + suprailiac)

Females: Density (D) = $1.1549 - 0.0678 \times \log_{10}$ (biceps + triceps + subscapular + suprailiac)

Percentage fat = $(4.95/D - 4.5) \times 100$

Fat mass (kg) = Percentage fat × body weight (kg)

Fat free mass or lean body mass (kg) = Body weight – fat mass (kg)

## CLINICAL OBSERVATIONS

Clinical observations on lips, eyes, tongue, teeth and gums, skin and skeleton were carried out according to the methods described in Jelliffe (1966) and Latham (1979). Since the observer is not well trained in examining the clinical signs and symptoms of undernutrition, only few selected clinical symptoms and signs that could be easily examined with our naked eyes were taken into consideration. These may be briefly described as follows:

**Eyes**

(i) *Bitot's Spot*: The eyes become dry, greyish, silvery or chalky-white foamy plagues, often triangular or irregularly circular in shape, which is seen usually on the lateral region of the cornea of both eyes. These lesions are associated with vitamin A deficiency in young children.

(ii) *Vascularization of the Cornea*: In this condition the fine capillary blood vessels invade a part or whole of the cornea. This sign is associated with riboflavin deficiency or vitamin B.

**Lips**

(i) *Cheliosis*: Cracks occur on both lips, which may be either red and sore or dry accompanied by swelling and ulceration of the lips other than the angles. The mid-part of the lower lip is commonly affected. It is considered a sign of riboflavin deficiency.

(ii) *Angular Stomatitis*: This refers to lesions associated with fissuring or cracking at the angles of the mouth. It may be shallow or deep, confined to a small area of the angles of the mouth or extending into the buccal cavity and few millimeters into the skin outside. The milder lesions are discerned more easily with the mouth half open. When lesions appear on both the angles of the mouth, it is angular stomatitis and is a sign of riboflavin, niacin and pyridoxine deficiencies.

**Tongue**

(i) *Atrophic Papillae*: The tongue appears extremely smooth due to the absence of filiform papillae mostly around the central or marginal area of the tongue. This is a sign of niacin deficiency.

(ii) *Scarlet and Raw Tongue (Glossitis)*: The tongue is bright red in colour, denuded due to desquamation and it is very painful. This is a deficiency sign of niacin.

### Teeth and Gums

*Spongy and Bleeding Gums*: It is characterized by purplish or red spongy swelling of the inner dental papillae and the gum margins, which usually bleed easily on slight pressure. This is considered a sign of vitamin C deficiency.

### Skin

*Xerosis*: This is generally characterized by dryness with branny desquamation of skin. The causes of xerosis are, of course, varied in nature due to environmental factors such as dirt, lack of washing, a dry, hot windy climate, etc. This condition is often associated with vitamin A deficiency.

### Skeleton

*Knock-Knees and Bow Legs*: Children with rickets develop deformities due to soft, weak characters of the bones. Bow-legs generally occurs because of the deficiency in vitamin D.

## STATISTICAL METHODS

The statistical analyses, which are adopted in the present study, may be briefly described as follows:

**Mean**: The mean is also known as arithmetic average. It is defined as the value, which can be obtained by dividing the total values of various items in a series by the total number of items. It is worked out as under:

Mean ( $\bar{X}$ ) = $\Sigma X_i/N = (x_1 + x_2 + \ldots + x_n)/N$, where x is the value of the i-th item $X_i$, i =1, 2, ..., n, and N stands for the total number of items.

In the case of frequency distribution, the mean is obtained as follows:

Mean ( $\bar{X}$ ) = $\Sigma f_i x_i/f_i N = (f_1 x_1/f_1 + f_2 x_2/f_2 + \ldots + f_n x_n/f_n)/N$, where $f_i x_i$ is the product of the mid value ($x_i$) of i-th class-interval and the frequency ($f_i$) of the i-th item.

**Standard Deviation (SD):** Standard deviation is defined as the square root of the mean of the squares of the deviation of observations from their arithmetic mean. It is computed as follows:

$SD = \sqrt{\{(X_i - \bar{X})^2/N - 1\}}$

Where $X_i$ is the value of the i-th item, $\bar{X}$ stands for the mean, and N is the total number of cases. In the case of frequency distribution, the SD is obtained as follows:

$SD = \sqrt{\{(\Sigma fd^2/N - 1) - (\Sigma fd/N - 1)^2\}} \times C$

Where fd is the product of the deviation from the assumed mean (d) and the frequency (f) of item in the i-th class-interval; while C stands for class interval.

The divisor was taken as (N – 1) but not as N because we did not know the true mean and standard deviation of the population. So the mean and standard deviation were estimated through samples collected for the present study, and in doing so we lost what is known as a degree of freedom (Parker, 1973).

**Standard Error of Mean (SE):** It is calculated as $SD/\sqrt{N}-1$.

**Differences between two means**: In the present study, the numbers of observations in two sample means are almost more than 50. Therefore, the statistical difference between two means is worked out according to standard t-test given as follows:

$$t = (\bar{X}_1 - \bar{X}_2) \div \sqrt{\{(SE_1)^2 + (SE_2)^2\}}$$

Where $\bar{X}_1$ and $SE_1$ are the mean and standard error of a given variable for the first sample, while $\bar{X}_1$ and $SE_2$ are the mean and standard error of the same variable for the second sample of the same population or different populations.

**Differences between proportions:** In the present study, the differences between the proportions were tested by using the chi-square ($\chi^2$). It is obtained as follows:

$$\chi^2 = \Sigma(O_i - E_i)^2/E_i = (O_1 - E_1)^2/E_1 + (O_1 - E_1)^2/E_1 + \ldots + (O_n - E_n)^2/E_n$$

where $O_i$ and $E_i$ are the observed and expected frequencies of the i-th character in each class.

The value obtained is then compared with that given in the Table of Chi-square distribution with (N −1) degree of freedom (d.f.). In the case of 2 × C contingency Table, the number of d.f. is (Row −1)(Column − 1). The expected frequency is calculated as (Row Total)(Column Total)/(Grand Total) OR (Column Total)/(Grand Total) multiplied by Row Total.

**Correlation and Regression Analysis**: Regression analysis has many applications. The main purpose is the regression analysis is to know if Y (dependent variable) does depend on X (independent variable), or to make a prediction of Y from X. In the present study, we are also concerned with the error in Y-variable after adjustments were made for the effects of X-variable. The regression coefficient (b) of Y on X is worked out as follows:

$$b = \Sigma xy/\Sigma x^2$$

where, $\Sigma xy = \Sigma XY - (\Sigma X)(\Sigma Y)/N$

$\Sigma x^2 = \Sigma X^2 - (\Sigma X)^2/N$

The regression of Y on X is expressed as

$\bar{Y} = a + bX$, where $a = \bar{Y} - \bar{X}b$, and $\bar{Y}$ = Estimated value

*Correlation coefficient*(**r**)**:** The correlation coefficient was computed as follows:

$r = \Sigma xy \div \sqrt{\{(\Sigma x^2)(\Sigma y^2)\}}$, where $y^2 = Y^2 - (Y)^2/N$

The correlation coefficient is usually taken when there is no reason to think of one variable as dependent variable and the other as the independent variable. It is taken as a simple measure of the degree of relationship, but not to make out the nature of relationship between two or more variables.

# CHAPTER - III

# GROWTH PATTERN

In this chapter, we shall describe the growth pattern of the Lotha boys and girls taking into consideration the body weight, height, sitting height, subischial length, biacromial diameter, bi-iliac diameter, head circumference, chest circumference, arm circumference, calf circumference, and skinfold thickness at triceps, biceps, subscapular and suprailiac. We shall also describe the growth pattern in body composition derived from the relevant anthropometric measurements.

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## Weight

The means and standard deviations of weight for both boys and girls against their age groups are shown in Table 3.1. It can be observed that both boys and girls are similar in weight at 9 years of age, although the former are heavier than the latter at the age of 10. On the other hand, girls are heavier than boys from 11 to 12 years of age. Thereafter, the boys are heavier than girls, although it is not significant at all ages (Table 3.1).

The mean values given in Table 3.1 were smoothed using PB1 model. It can be observed from Figure 3.1 that both boys and girls are more or less similar in weight from 9 to13 years of age, and thereafter the boys surpassed the girls. The estimated adult weight according to the PB1 model is about 54.02 kg in boys and 52.52 kg in girls. Thus, the estimated adult body weight for boys is about 2.07 kg higher than the observed value at the age of 18 years for boys, while it is about 2.71 kg for girls. This indicates that both boys and girls by and large reach their adult body weight by the age of 18.

**Table 3.1.** Statistical constants of weight for boys and girls

| Age (yrs) | Boys |  |  | Girls |  |  | t-value |
|---|---|---|---|---|---|---|---|
|  | Number | Mean | SD | Number | Mean | SD |  |
| 9 | 36 | 22.47 | 2.67 | 36 | 22.50 | 2.84 | 0.04 |
| 10 | 38 | 24.39 | 3.52 | 37 | 22.92 | 3.86 | 1.73 |
| 11 | 36 | 28.36 | 4.80 | 39 | 29.15 | 3.12 | 0.84 |
| 12 | 36 | 31.33 | 4.95 | 38 | 31.82 | 3.62 | 0.48 |
| 13 | 38 | 36.89 | 6.00 | 38 | 35.97 | 5.41 | 0.70 |
| 14 | 37 | 41.49 | 7.44 | 40 | 40.23 | 5.79 | 0.83 |
| 15 | 36 | 44.78 | 4.14 | 35 | 43.86 | 4.74 | 0.87 |
| 16 | 37 | 49.11 | 4.52 | 37 | 47.51 | 3.94 | 1.62 |
| 17 | 35 | 51.11 | 5.01 | 39 | 49.31 | 4.31 | 1.67 |
| 18 | 37 | 51.95 | 5.75 | 36 | 49.81 | 4.02 | 1.84 |

| Results of PB1 fits | Boys | Girls |
|---|---|---|
| *PB1 parameters* |  |  |
| h0 | 38.7405 | 35.2377 |
| h1 | 54.0196 | 52.5175 |
| s0 | 0.6059 | 0.5106 |
| s1 | 0.0240 | 0.0038 |
| θ | 13.4571 | 12.7753 |
| *Biological parameters* |  |  |
| Adult body weight (kg) | 54.0196 | 52.5175 |
| Age at peak velocity (years) | 13.0400 | 12.9262 |
| Weight at peak velocity (kg) | 36.6912 | 35.8824 |
| Peak weight velocity (kg/year) | 4.2424 | 3.9375 |

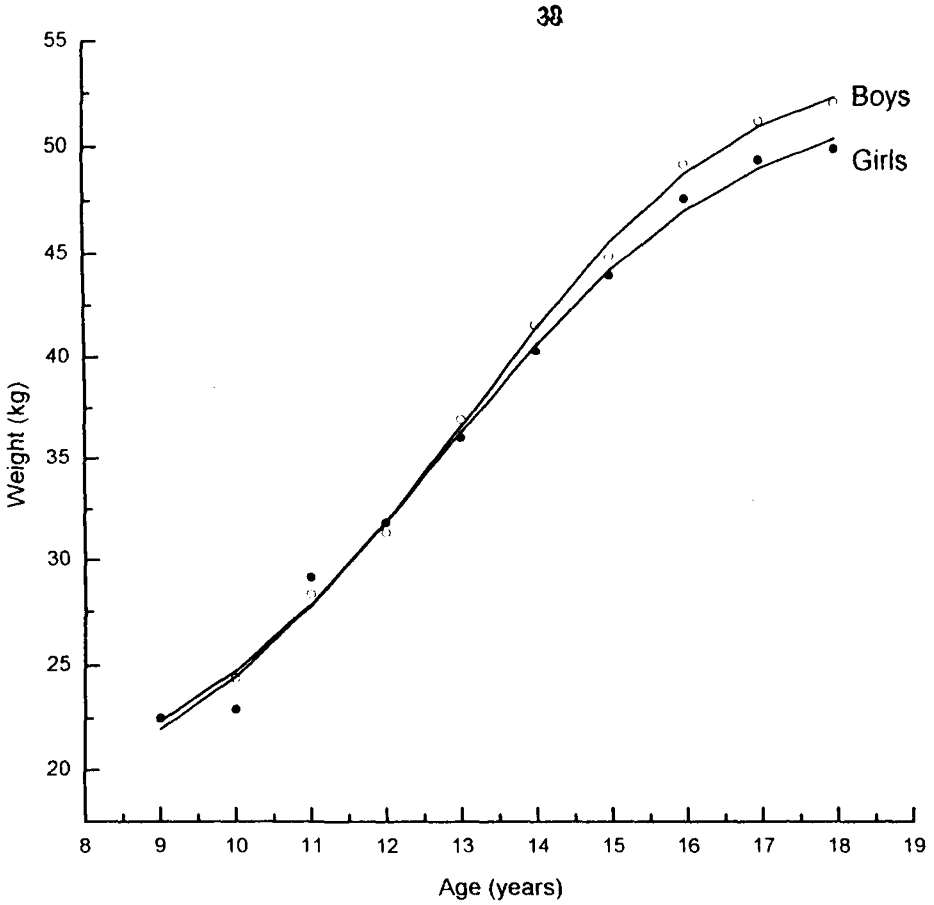


Figure 3.1. Distance curves for weight (Smooth curves are PB1 fits to the means)

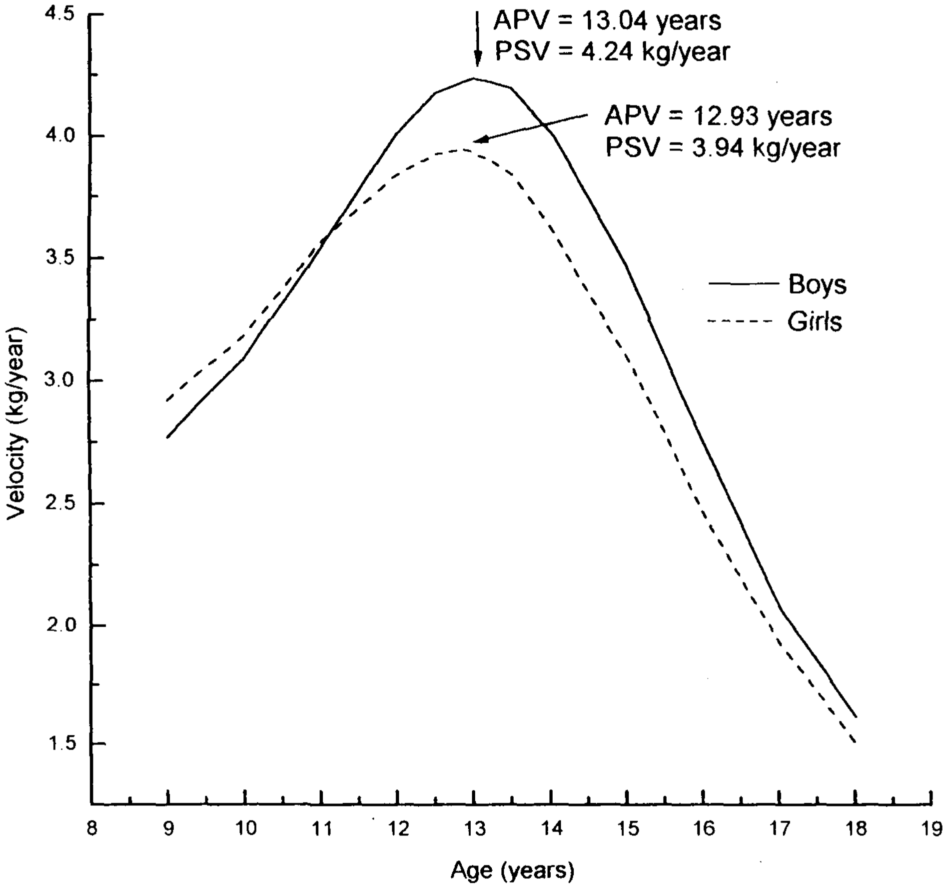


Figure 3.2. Velocity curves for weight (first derivative of PB1 fits) indicating age at peak velocity (APV) and peak size velocity (PSV)

Using the first derivative of the PBI distance curves, the estimated age at peak weight velocity is 13.04 years for boys and 12.93 years for girls with the mean weight of 36.69 kg and 35.88 kg, respectively. Therefore, the adolescent growth spurt in body weight took place little earlier in girls than in boys, although the latter are heavier than the former at the age of peak velocity (Table 3.1). Table 3.1 further shows that the peak weight velocity is slightly higher in boys (4.24 kg/year) than in girls (3.94 kg/year). It is further observed from Figure 3.2 that the weight velocity is more or less same from 9 to 12 years of age, and thereafter it is higher in boys than in girls across ages.

### Height

Table 3.2 gives the statistical constants of height for boys and girls according to age groups. It is seen that both boys and girls are more or less same in height from 9 to 10 years of age, but girls are taller than boys from 11 to 12 years of age, and it is statistically significant at the age of 12 ($t = 2.48$, $P < 0.02$). Thereafter, boys are significantly taller than girls across ages, especially after 13 years of age (Table 3.2).

Using PB1 model, the mean values given in Table 3.3 were smoothed, and it can be observed from Figure 3.3 that girls are taller than boys from 10 to 12 years of age, while the latter are taller than the former from 13 years till the final age of 18 years. At the age of 9 years, the curve is more or less similar for both boys and girls. The estimated adult height according to PB1 model is found to be 163.47 cm for boys, which is about 0.68 cm higher than the observed value at the age of 18 years. On the other hand, the estimated adult height for girls is about 158.68cm, which is about 1.95 cm higher than the observed value at 18 years of age. This indicates that both boys and girls still continue to grow in height, especially in girls.

Using the first derivative of the PBI distance curves, the estimated age at peak height velocity is 13.01 years for boys and 11.00 years for girls (Table 3.2). Therefore, it indicates the earlier achievement of adolescent growth spurt in girls (11 years) than in boys (13 years). Figure 3.4 shows that the velocity (annual increment) is higher in girls from 9 to about 11 years of age, and thereafter it is higher in boys till the age of 17 years. This is perhaps due to the fact that the difference between the estimated adult height and the observed value at the age of 18 is much higher in girls than in boys. It is further observed that the peak height velocity is lower in girls (6.48 cm/year) as compared with boys (6.98 cm/year). Also, the height at peak velocity is much higher in boys (143.90 cm) than in girls (131.86 cm). Therefore, the larger stature in boys when compared with girls could be largely attributed by the differences in growth rate during the adolescent period.

**Table 3.2.** Statistical constants of height for boys and girls

| Age (yrs) | Boys | | | Girls | | | t-value |
|---|---|---|---|---|---|---|---|
| | Number | Mean | SD | Number | Mean | SD | |
| 9 | 36 | 119.49 | 5.93 | 36 | 119.08 | 5.62 | 0.30 |
| 10 | 38 | 124.07 | 6.87 | 37 | 124.75 | 5.29 | 0.48 |
| 11 | 36 | 130.60 | 6.22 | 39 | 132.21 | 5.22 | 1.22 |
| 12 | 36 | 134.84 | 4.96 | 38 | 138.14 | 6.32 | 2.48* |
| 13 | 38 | 145.06 | 5.25 | 38 | 143.81 | 4.84 | 1.08 |
| 14 | 37 | 151.77 | 6.13 | 40 | 148.40 | 4.90 | 2.68* |
| 15 | 36 | 156.43 | 3.81 | 35 | 151.92 | 4.81 | 4.39** |
| 16 | 37 | 160.24 | 4.75 | 37 | 154.61 | 4.11 | 5.45** |
| 17 | 35 | 162.37 | 3.13 | 39 | 156.25 | 4.17 | 7.07** |
| 18 | 37 | 162.79 | 4.43 | 36 | 156.73 | 3.72 | 6.34** |

| Results of PB1 fits | Boys | Girls |
|---|---|---|
| *PB1 parameters* | | |
| h0 | 146.9331 | 143.8074 |
| h1 | 163.4677 | 158.6791 |
| s0 | 0.8472 | 0.5069 |
| s1 | 0.7264 | 0.0357 |
| θ | 13.3609 | 11.4665 |
| *Biological parameters* | | |
| Adult height (cm) | 163.4677 | 158.6791 |
| Age at peak velocity (years) | 13.0092 | 11.0038 |
| Height at peak velocity (cm) | 143.9019 | 131.8627 |
| Peak height velocity (cm/year) | 6.9765 | 6.4798 |

$^{*}P < 0.01$, $^{**}p < 0.000$

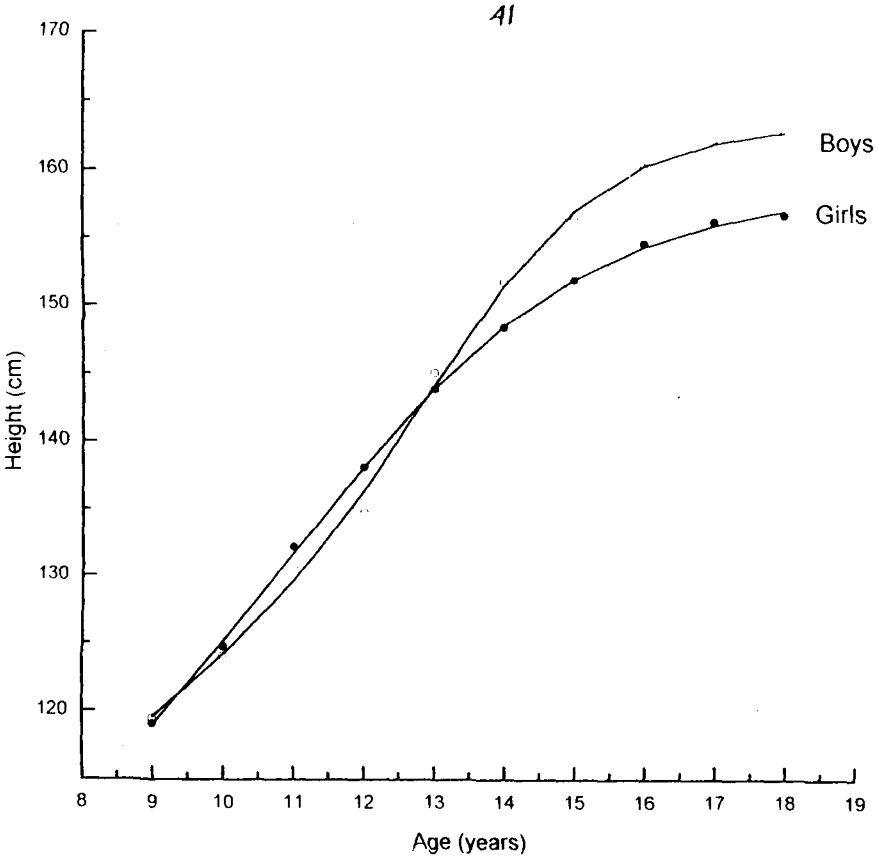


Figure 3.3. Distance curves for height (smooth curves are PB1 fits)

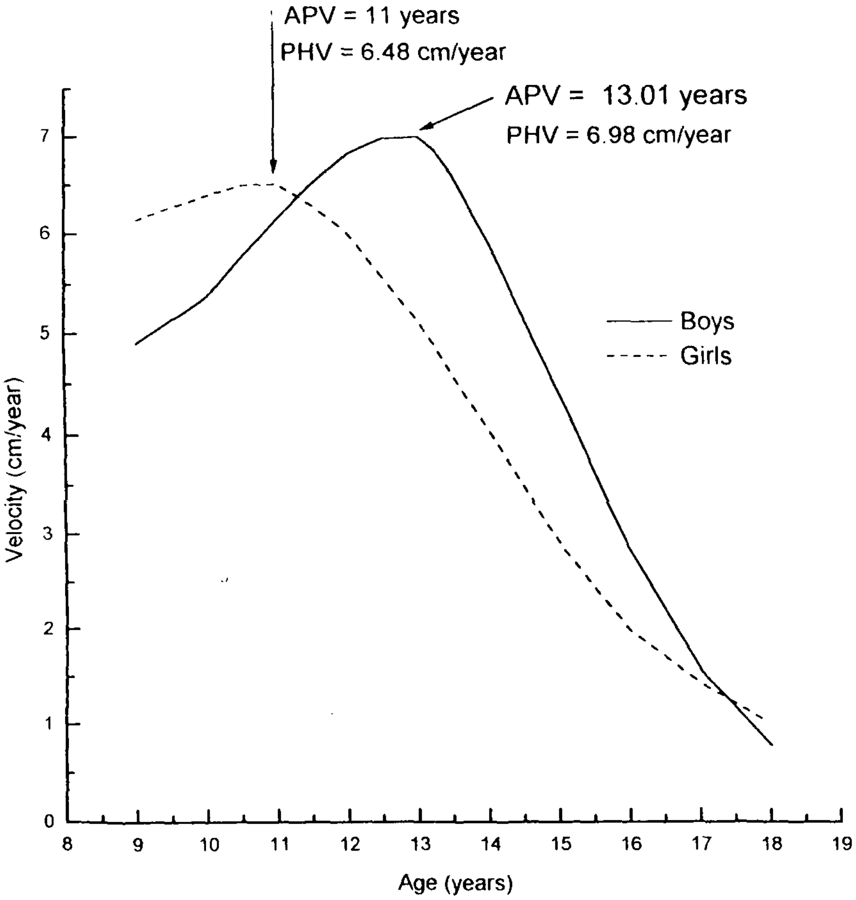


Figure 3.4. Velocity curves for height (first derivative of PB1 fits) indicating age at peak velocity (APV) and peak height velocity (PHV)

## Sitting Height

As for sitting height, the mean values and standard deviations for both the sexes are given in Table 3.3. It is seen from the Table that boys are slightly taller than girls in sitting height from 9 to 10 years of age, and from 13 years till the final age of 18. On the other hand, girls have higher sitting height from 11 to 12 years of age, i.e., during adolescent growth spurt period. The t-test for the differences between the mean values indicate that boys are significantly higher in sitting height from 14 years onwards, that is, the differences between boys and girls are not statistically significant from 9 to 13 years of age.

The differences between boys and girls can also be seen from the distance curves fitted according to PB1 model (Figure 3.5). Figure 3.5 shows that the sitting height is higher in girls from 11 to 12 years of age, while the boys surpassed the girls in all other age groups, and the differences are clearly perceptible from 13 years onwards. The estimated adult size for sitting height is 85.74 cm for boys and 84.79 cm for girls. The differences between the estimated final height and the observed values at the age of 18 are 0.19 cm and 1.34 cm in boys and girls, respectively. It indicates that boys reach their adult sitting height at about 18 years of age, but girls still continue to grow.

Figure 3.6 shows that the velocity or rate of growth derived from the fitted distance curves is higher in girls from 9 to about 11 years of age, thereafter it is higher in boys till the age of 16. The velocity is higher in girls than in boys after 16 till the age of 18 years. Thus, the growth pattern in sitting height is more or less similar to that of height, although the girls surpassed the boys in height velocity from 17 to 18 years of age. Further, it is observed from Table 3.3 and Figure 3.6 that the estimated age at peak velocity is higher in boys (13.03 years) than in girls (11.03 years). The mean size at peak velocity is found to be 75.75 cm in boys and 68.26 cm in girls with the peak velocity of 3.96 cm/year and 3.65 cm/year, respectively. Thus, the present analysis indicates that the adolescent growth spurt occurs earlier in girls as compared with boys, and the higher sitting height in boys at 18 years of age is largely due to their higher growth rate from 11 to 16 years of age. As a matter of fact, like the case of height, the girls outrun the boys in acceleration till their adolescent period, and thereafter it tilted in favour of boys till the age of 16 years.

**Table *3.3.*** Statistical constants of sitting height for boys and girls

| Age (yrs) | Boys | | | Girls | | | t-value |
|---|---|---|---|---|---|---|---|
| | Number | Mean | SD | Number | Mean | SD | |
| 9 | 36 | 61.85 | 5.29 | 36 | 61.24 | 4.64 | 0.52 |
| 10 | 38 | 64.29 | 4.51 | 37 | 63.83 | 4.35 | 0.45 |
| 11 | 36 | 67.43 | 3.82 | 39 | 68.56 | 3.70 | 1.30 |
| 12 | 36 | 70.60 | 3.47 | 38 | 72.17 | 5.14 | 1.54 |
| 13 | 38 | 76.23 | 3.95 | 38 | 74.98 | 4.46 | 1.30 |
| 14 | 37 | 79.92 | 4.16 | 40 | 77.77 | 3.71 | 2.40* |
| 15 | 36 | 82.58 | 2.61 | 35 | 80.29 | 3.32 | 3.24** |
| 16 | 37 | 84.16 | 2.27 | 37 | 82.67 | 3.02 | 2.39* |
| 17 | 35 | 85.22 | 2.65 | 39 | 83.20 | 3.01 | 3.04** |
| 18 | 37 | 85.55 | 3.23 | 36 | 83.45 | 2.78 | 2.98* |

| Results of PB1 fits | Boys | Girls |
|---|---|---|
| *PB1 parameters* | | |
| h0 | 75.6581 | 73.9395 |
| h1 | 85.7371 | 84.7904 |
| s0 | 0.8533 | 0.5562 |
| s1 | 0.0521 | 0.0694 |
| θ | 12.9753 | 12.6091 |
| *Biological parameters* | | |
| Adult sitting height (cm) | 85.7371 | 84.7904 |
| Age at peak velocity (years) | 13.0346 | 11.0292 |
| Size at peak velocity (cm) | 75.7451 | 68.2647 |
| Peak size velocity (cm/year) | 3.9588 | 3.6483 |

$^{*}P < 0.02$, $^{**}p < 0.004$

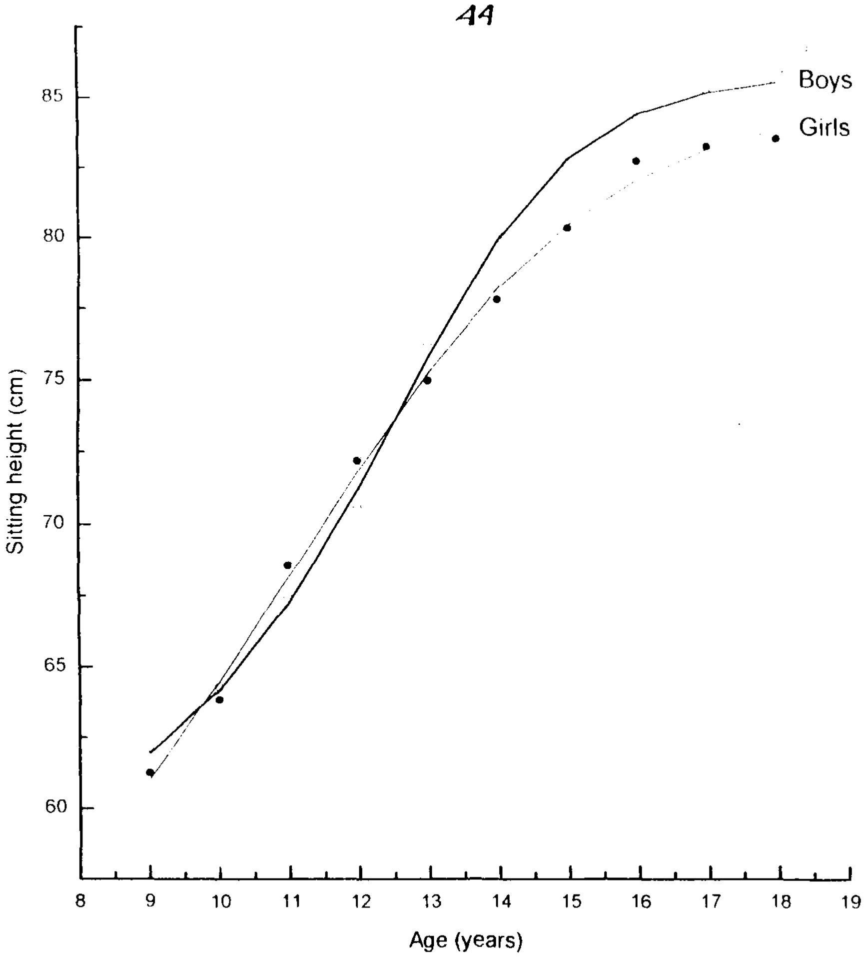


Figure 3.5. Distance curves for sitting height (smooth curves are PB1 fits of means)

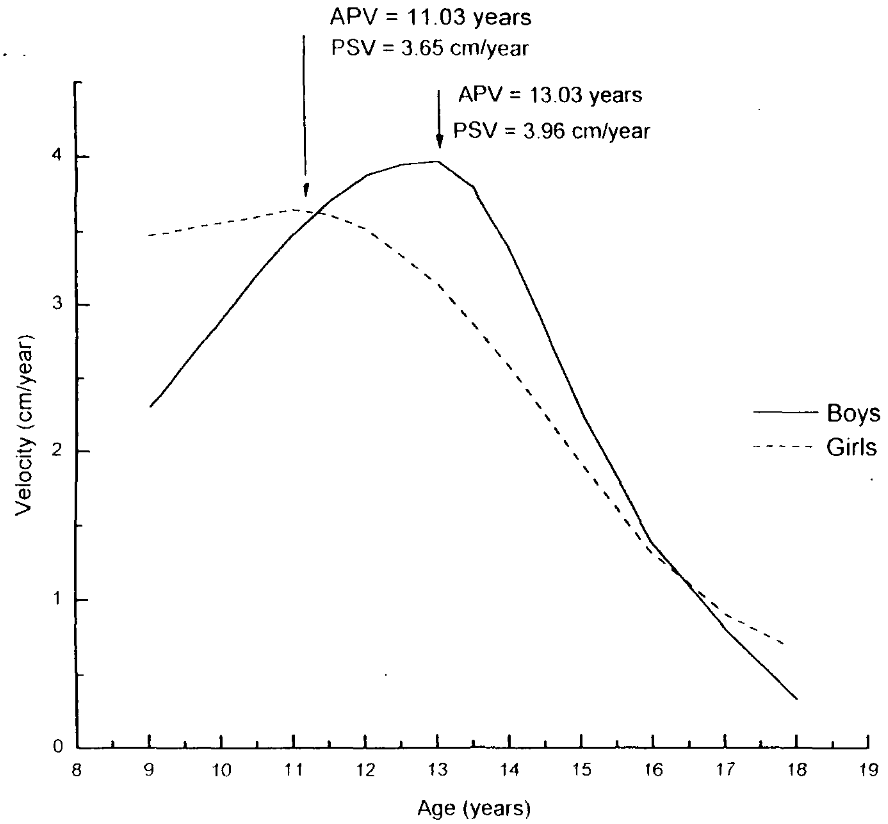


Figure 3.6. Velocity curves for sitting height (first derivative of PB1 fits) indicating age at peak velocity (APV) and peak size velocity (PSV)

**Subischial Length**

The statistical constants of subischial length (stature minus sitting height) for boys and girls at different age groups are given in Table 3.4. It is seen from the Table that girls have higher subischial length than boys from 9 to 12 years, and it is significant only at the age of 12 years. Thereafter, the boys are higher in subischial length till the age of 18, except at age 13 when both boys and girls are similar. The t-test indicates that the higher subischial length in boys is statistically significant from 14 year onwards.

The PB1 fits to the means are shown in Figure 3.7 for both the sexes. The mean curve shows higher subischial length in girls than in boys from 9 to 12 years of age, but the latter surpass the former from 14 till the final age of 18 years. The estimated adult size for subischial length of boys according to the PB1 model is 77.69 cm, which is about 0.45 cm higher than the observed value at the age of 18 years. On the other hand, the estimated adult size for girls is 73.48 cm, which is about 0.20 cm higher than the observed mean value at the age of 18 years. Therefore, both boys and girls attained their adult size of subischial length by and large at the age of 18 years. This also indicates that the lower extremity reached its adult size earlier than the upper extremity as commonly observed in other populations (Tanner, 1978; Dasgupta and Das, 1997).

The first derivative of the PBI model, which indicates the velocity, is shown in Figure 3.8 for both boys and girls. Like in the case of other measurements mentioned so far, the Figure reveals that the estimated age at peak velocity is higher in boys (12.96 years) than in girls (10.04 years). In other words, girls attain their adolescent growth spurt earlier than boys, and the difference in respect of subischial length is much higher, i.e., about 3 years. It is also found that the mean value of subischial length during age at peak velocity is much higher in boys (68.28 cm) than in girls (60.80 cm). Similarly, the peak size velocity is higher in boys (2.98 cm/year) as compared with girls (2.86 cm/year). In fact, Figure 3.8 shows that the velocity is higher in girls from 9 to about 11 years of age, and thereafter, the acceleration is much higher in boys till the age of 18 years. This clearly indicates that the higher subischial length in boys is due to their greater rate of growth from the age of 12 onwards.

**Table 3.4.** Statistical constants of subischial length for boys and girls

| Age (yrs) | Boys | | | Girls | | | t-value |
|---|---|---|---|---|---|---|---|
| | Number | Mean | SD | Number | Mean | SD | |
| 9 | 36 | 57.64 | 2.95 | 36 | 57.84 | 4.09 | 0.24 |
| 10 | 38 | 59.77 | 3.30 | 37 | 60.92 | 2.87 | 1.60 |
| 11 | 36 | 63.17 | 3.01 | 39 | 63.45 | 2.52 | 0.75 |
| 12 | 36 | 64.25 | 3.01 | 38 | 65.96 | 2.20 | 2.81* |
| 13 | 38 | 68.83 | 1.97 | 38 | 68.83 | 2.32 | 0.01 |
| 14 | 37 | 71.85 | 2.97 | 40 | 70.63 | 2.07 | 2.09* |
| 15 | 36 | 73.85 | 1.71 | 35 | 71.63 | 1.94 | 5.11** |
| 16 | 37 | 76.08 | 3.06 | 37 | 71.94 | 1.63 | 7.28** |
| 17 | 35 | 77.15 | 1.79 | 39 | 73.06 | 2.75 | 7.49** |
| 18 | 37 | 77.24 | 4.31 | 36 | 73.28 | 2.51 | 4.79** |

| Results of PB1 fits | Boys | Girls |
|---|---|---|
| *PB1 parameters* | | |
| h0 | 71.4386 | 66.9736 |
| h1 | 77.6870 | 73.4786 |
| s0 | 0.8886 | 0.1043 |
| s1 | 0.0995 | 0.6389 |
| θ | 13.9434 | 12.2678 |
| *Biological parameters* | | |
| Adult size (cm) | 77.6870 | 73.4786 |
| Age at peak velocity (years) | 12.9567 | 10.0392 |
| Size at peak velocity (cm) | 68.2843 | 60.8039 |
| Peak size velocity (cm/year) | 2.9797 | 2.8638 |

$^{*}P < 0.01$, $^{**}p < 0.000$

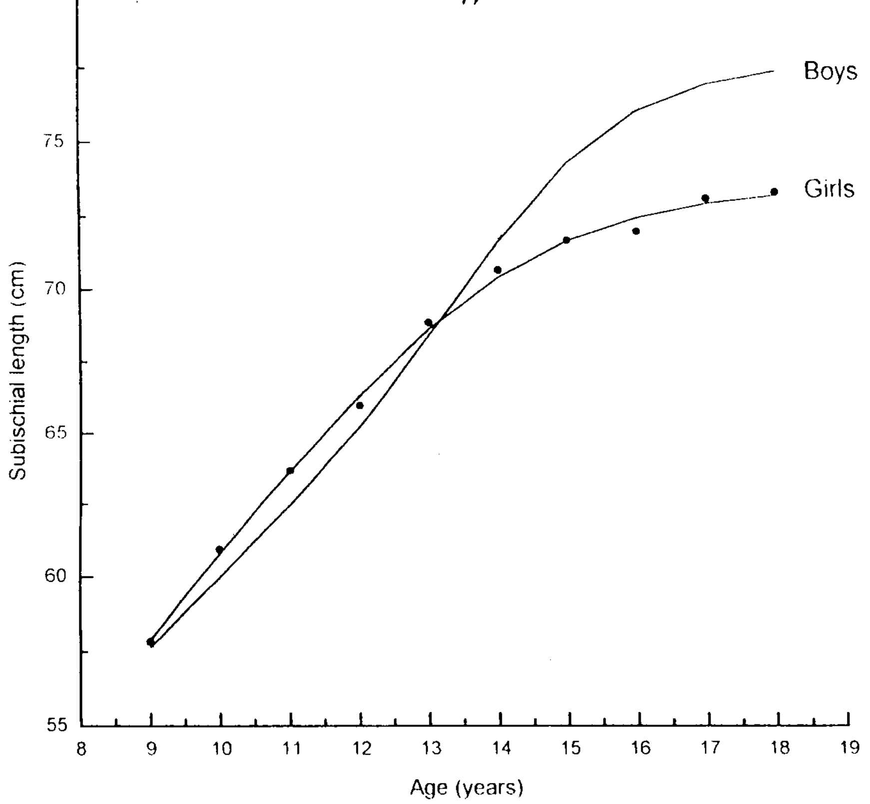
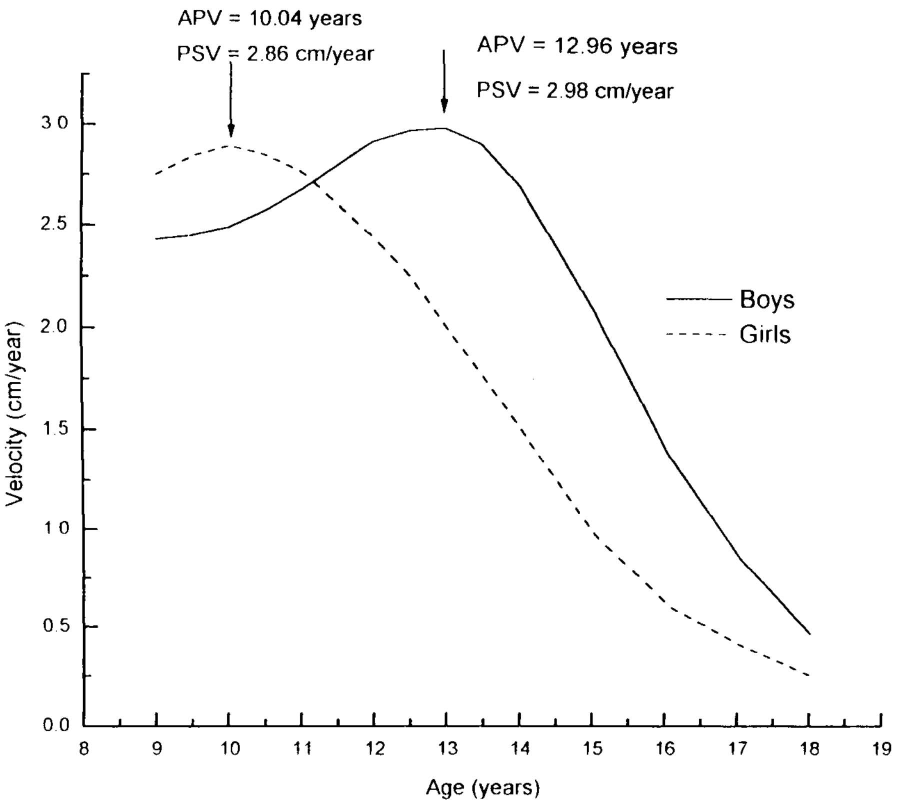


Figure 3.7. Distance curves for subischial length (smooth curves are PB1 fits)


APV = 10.04 years
PSV = 2.86 cm/year

APV = 12.96 years
PSV = 2.98 cm/year

Figure 3.8. Velocity curves (first derivative of PB1 fits) indicating age at peak velocity (APV) and peak size velocity (PSV)

**Bi-acromial Diameter**

The means and standard deviations of biacromial diameter are presented in Table 3.5. The mean values are plotted against age as shown in Figure 3.9. It indicates the gradual increase in biacromial diameter as age advances. The distance curves shows that boys have a broader shoulder from 9 to 10 years of age, and thereafter girls are broader in shoulder up to the age of about 12 years, although it is statistically significant only at the age of 11 years. Nevertheless, the broader shoulder in girls from 11 to 12 years may be associated with their adolescent growth spurt. On the other hand, the boys have a broader shoulder from 13 to18 years. The t-test also indicates that the differences are statistically significant (Table 3.5). The observed mean values at the age of 18 years are 34.56 cm for boys and 32.77 cm for girls, which indicate that boys are about 1.79 cm broader in shoulder as compared with girls at this age. This difference may be mainly associated with the significant difference in growth pattern after the age of 13 years.

**Table 3.5.** Statistical constants of biacromial breadth of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Incre-ment | N | Mean | SD | Incre-ment | |
| 9 | 36 | 24.44 | 1.20 | | 36 | 24.06 | 1.33 | | 1.30 |
| 10 | 38 | 25.17 | 1.47 | 0.73 | 37 | 24.88 | 1.29 | 0.82 | 0.92 |
| 11 | 36 | 26.27 | 1.20 | 1.10 | 39 | 26.88 | 1.27 | 2.00 | 2.14* |
| 12 | 36 | 27.67 | 2.14 | 1.40 | 38 | 28.08 | 1.68 | 1.20 | 0.92 |
| 13 | 38 | 30.16 | 2.71 | 2.49 | 38 | 29.03 | 1.46 | 0.95 | 2.27* |
| 14 | 37 | 31.31 | 1.87 | 1.15 | 40 | 29.90 | 1.75 | 0.87 | 3.42* |
| 15 | 36 | 32.41 | 1.97 | 1.10 | 35 | 30.86 | 1.57 | 0.96 | 3.69** |
| 16 | 37 | 33.12 | 1.27 | 0.71 | 37 | 31.73 | 0.90 | 0.87 | 5.46** |
| 17 | 35 | 34.00 | 1.69 | 0.88 | 39 | 32.37 | 1.26 | 0.64 | 4.76** |
| 18 | 37 | 34.56 | 1.43 | 0.56 | 36 | 32.77 | 1.59 | 0.40 | 5.07** |

$*p<0.04$, $**p<0.000$

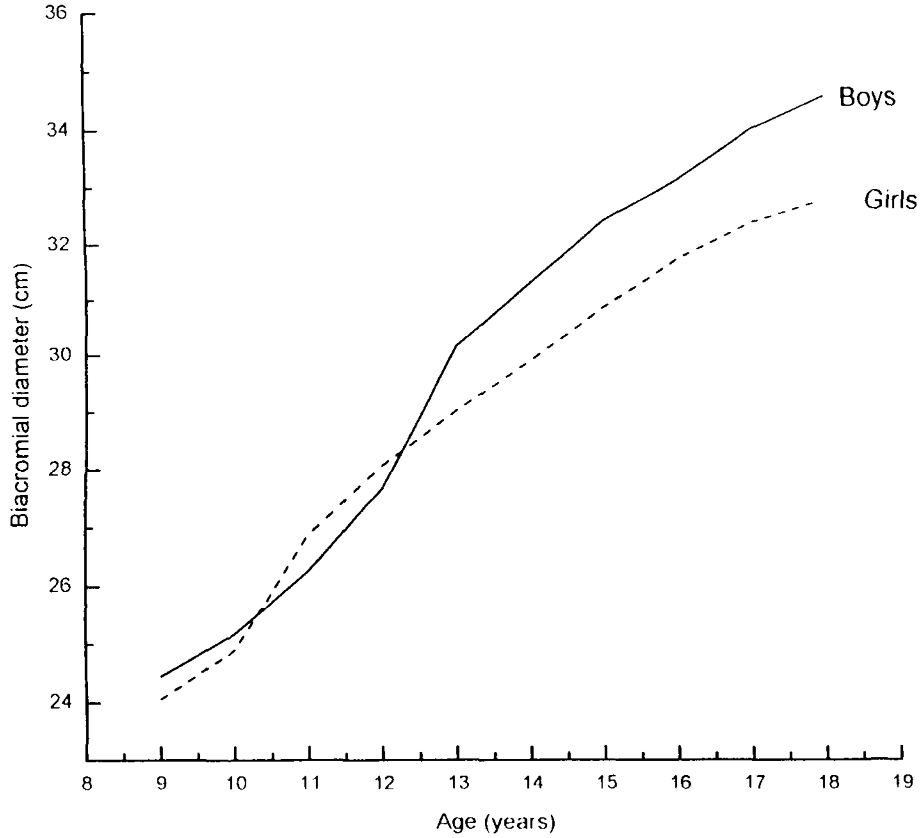


Figure 3.9. Distance curves for biacromial diameter

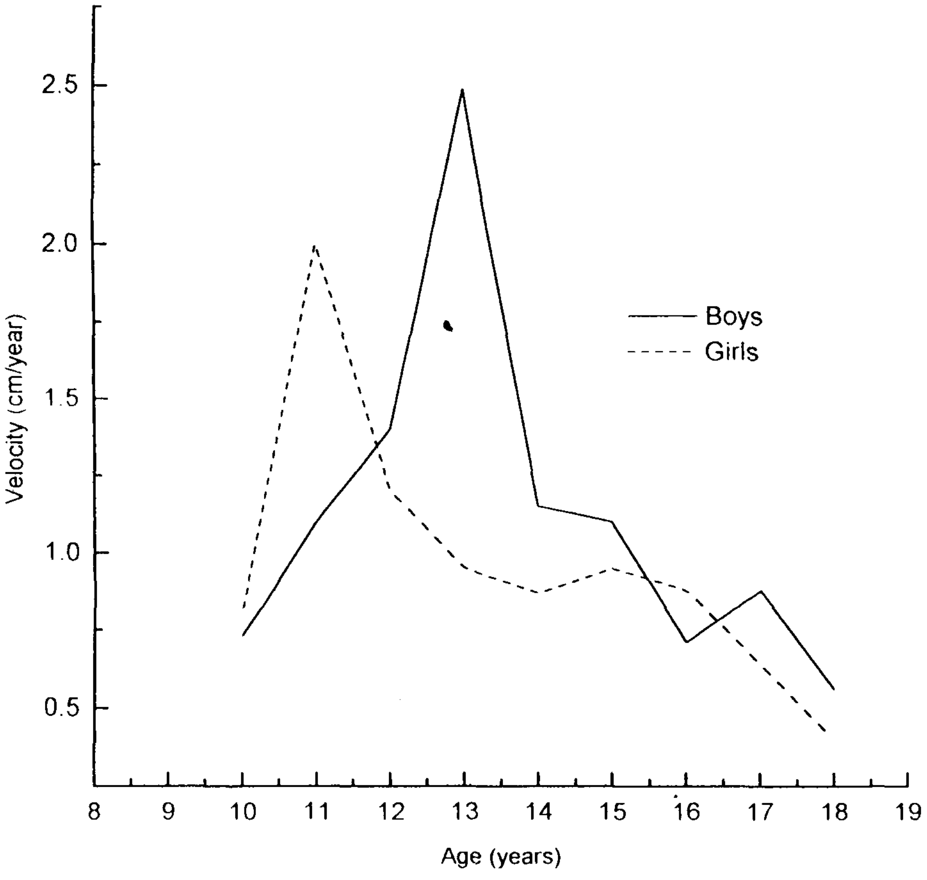


Figure 3.10. Velocity curve for biacromial diameter

The velocity curves (Figure 3.10) shows that the rate of growth is higher in girls than in boys from 10 to 11, and thereafter it is higher in boys especially from 12 to 15 years and from 17 to 18 years. It is found that a total gain from 9 to 18 years of age is 10.12 cm and 8.71 cm in boys and girls, respectively. In boys, the maximum gain of 2.49 cm/year occurs between 12 and 13 years of age (that is, 24.60% of the total gain), whereas in girls the maximum gain of 2.00 cm/year takes place from about 10 to 11 years of age (that is, 22.96% of the total gain). Thus, like in the case of other measurements, adolescent growth spurt takes place at about 11 years in girls and 13 years in boys. In view of the present data on biacromial diameter, it can be concluded that the sex differences are significant during the occurrence of adolescent growth spurt.

**Bi-iliac Diameter**

Table 3.6 shows the means and standard deviations of bi-iliac diameter for both boys and girls. The distance curves based on the mean values against age is shown in Figure 3.11. Like in the case of biacromial diameter, boys have a broader hip from 9 to 10, and thereafter the girls surpassed the boys up to about 12 years of age. Again, boys have a broader hip than girls from 13 years onwards. The t-values (Table 3.6) indicate that the differences between the sexes are significant at 11 and 12 years of age. That is, the bi-iliac diameter is significantly higher in girls than in boys at the age of 11 and 12 years, which may be associated with their adolescent growth spurt. The differences from 13 to 18 years of age are not statistically significant, which indicate that both boys and girls have shown a similar growth pattern in bi-iliac diameter after 13 years of age. This can also be seen from the observed values at the age of 18 years, which are 22.61 cm and 22.00 cm in boys and girls, respectively. That is, the difference between the sexes is about 0.61 cm, or below 1 cm, which is relatively close to each other.

**Table 3.6.** Statistical constants of bi-iliac diameter of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Increment | N | Mean | SD | Increment | |
| 9 | 36 | 16.42 | 1.80 | | 36 | 16.09 | 1.21 | | 0.91 |
| 10 | 38 | 16.69 | 1.36 | 0.27 | 37 | 16.49 | 1.00 | 0.40 | 0.72 |
| 11 | 36 | 17.11 | 1.27 | 0.42 | 39 | 17.91 | 0.84 | 1.42 | 3.23* |
| 12 | 36 | 17.83 | 1.03 | 0.72 | 38 | 18.93 | 1.36 | 1.02 | 3.90** |
| 13 | 38 | 19.61 | 1.86 | 1.78 | 38 | 19.46 | 1.56 | 0.53 | 0.37 |
| 14 | 37 | 20.62 | 1.91 | 1.01 | 40 | 20.27 | 1.15 | 0.81 | 0.99 |
| 15 | 36 | 21.08 | 2.23 | 0.46 | 35 | 20.82 | 1.17 | 0.55 | 0.60 |
| 16 | 37 | 21.72 | 1.94 | 0.64 | 37 | 21.24 | 1.12 | 0.42 | 1.31 |
| 17 | 35 | 22.27 | 1.69 | 0.55 | 39 | 21.67 | 1.40 | 0.43 | 1.65 |
| 18 | 37 | 22.61 | 2.57 | 0.34 | 36 | 22.00 | 2.03 | 0.33 | 1.47 |

*p<0.02, **p<0.000

The rate of growth per annum is plotted against age in Figure 3.12. It is seen that the velocity is higher in girls than in boys from 10 to 12 years of age, while the boys surpassed the girls from 13 years onwards, although the girls accelerate higher from about 14.5 to 15.5 years of age. Nevertheless, it is obvious that girls accelerate more than boys during 10 and 12 years, while the latter moves faster at the age of 13 and 14 years. It indicates that the rate of growth for both the sexes accelerate higher than the other during their adolescent growth spurt period. The total increment of bi-iliac diameter from 9 to 18 years is 6.19 cm in boys and 5.91 cm in girls. The peak velocity in boys is about 1.78 cm/year or 28.76% of the total increment at about 13 years, while the peak velocity of 1.42 cm/year or 24.03% of the total increment in girls is observed at the age of about 11 years. Like the bi-acromial diameter, data on bi-iliac diameter also show that adolescent growth spurt occurs at 11 and 13 years in girls and boys, respectively.

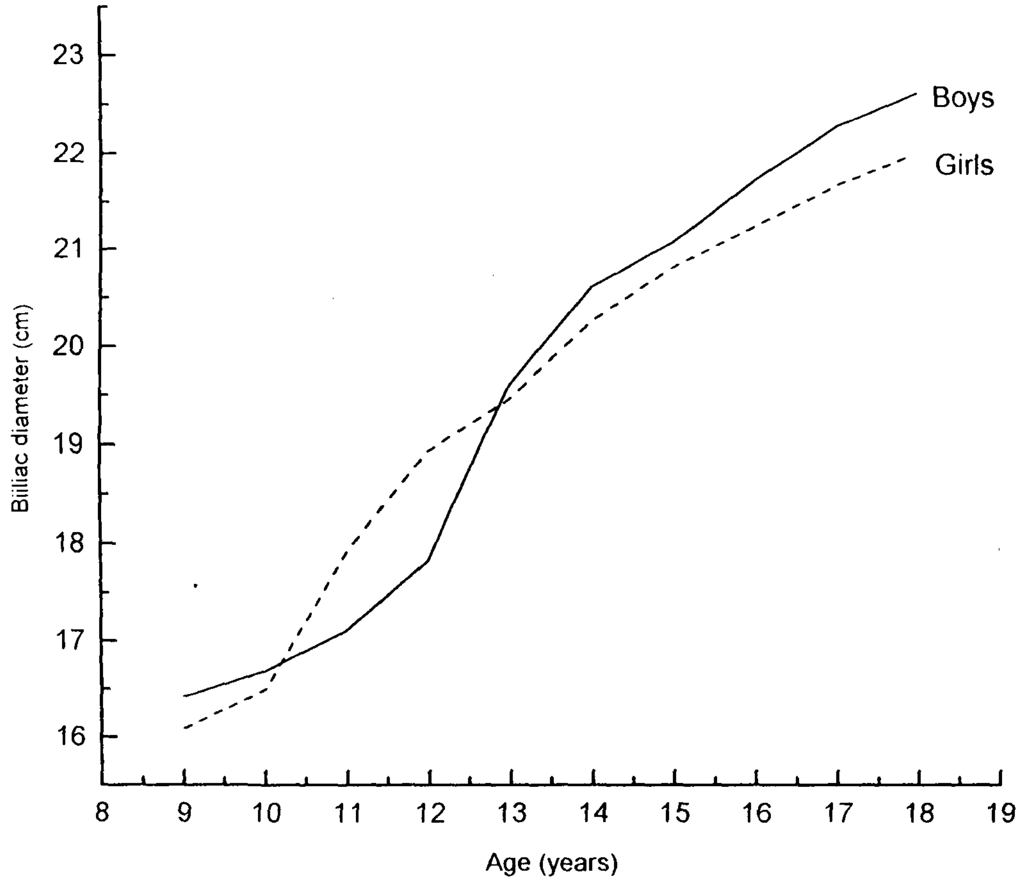


Figure 3.11. Distance curves for bi-iliac diameter

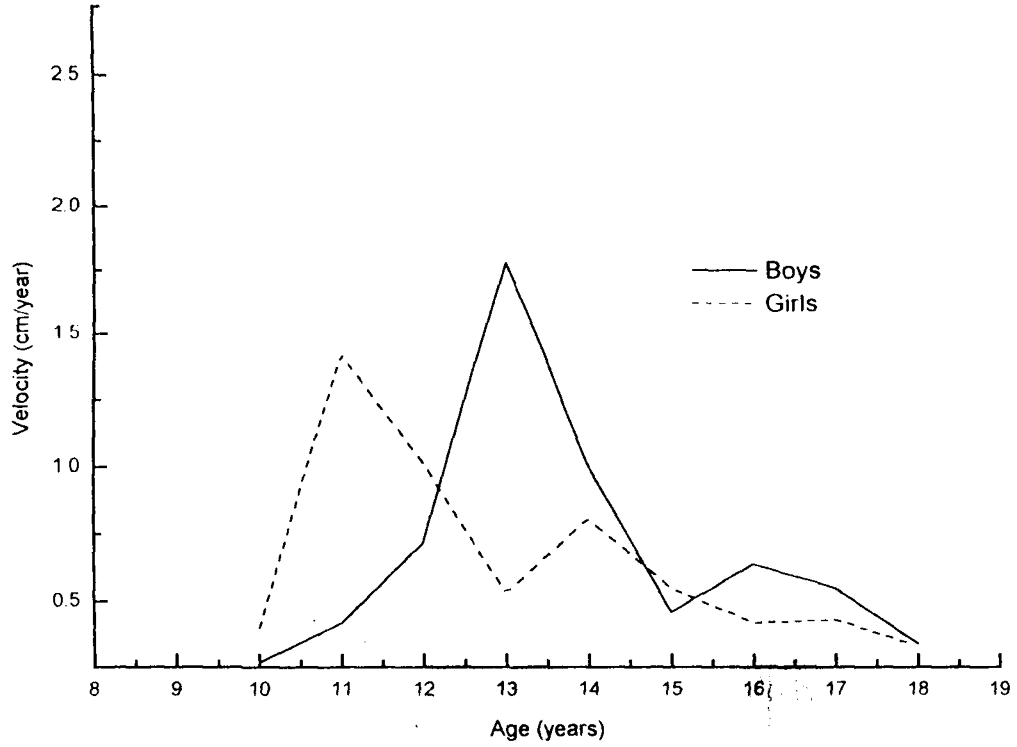


Figure 3.12. Velocity curve for biiliac diameter

## Head Circumference

The statistical constants of the head circumference of both boys and girls are given in Table 3.7, and the means plotted against age are shown in Figure 3.13. It is observed that the head circumference is larger in girls than in boys from 9 to 13 years of age, although the growth pattern is more or less similar at the age of 10 years. The t-test indicates that these differences are significant at the ages of 11 and 12 years (Table 3.7). Thus, it indicates that girls have greater head dimension than boys during the period of adolescent growth spurt. As for the boys, it is observed that they have a broader head circumference from 14 years onwards, although the differences are not statistically significant. As a matter of fact, there is not much difference between the sexes with respect to the observed mean values at the age of 18 years, which is about 54.45 cm in boys and 54.18 cm in girls. Thus, the present findings with regard to head circumference is similar to that observed for bi-iliac diameter.

**Table 3.7.** Statistical constants of head circumference of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Increment | N | Mean | SD | Increment | |
| 9 | 36 | 49.90 | 1.10 | | 36 | 50.14 | 0.94 | | 0.98 |
| 10 | 38 | 50.27 | 0.88 | 0.37 | 37 | 50.29 | 1.56 | 0.15 | 0.99 |
| 11 | 36 | 50.46 | 0.79 | 0.19 | 39 | 51.43 | 1.55 | 1.14 | 3.36* |
| 12 | 36 | 51.18 | 0.89 | 0.72 | 38 | 52.44 | 1.70 | 1.01 | 3.97** |
| 13 | 38 | 52.77 | 1.66 | 1.59 | 38 | 52.86 | 1.59 | 0.42 | 0.24 |
| 14 | 37 | 53.66 | 1.93 | 0.89 | 40 | 53.24 | 0.94 | 0.38 | 1.23 |
| 15 | 36 | 53.79 | 1.95 | 0.13 | 35 | 53.47 | 1.40 | 0.23 | 0.78 |
| 16 | 37 | 53.98 | 1.31 | 0.19 | 37 | 53.75 | 0.79 | 0.28 | 0.94 |
| 17 | 35 | 54.24 | 1.09 | 0.26 | 39 | 53.97 | 0.99 | 0.22 | 1.10 |
| 18 | 37 | 54.45 | 1.02 | 0.21 | 36 | 54.18 | 1.00 | 0.21 | 1.17 |

*p<0.01, **p<0.000

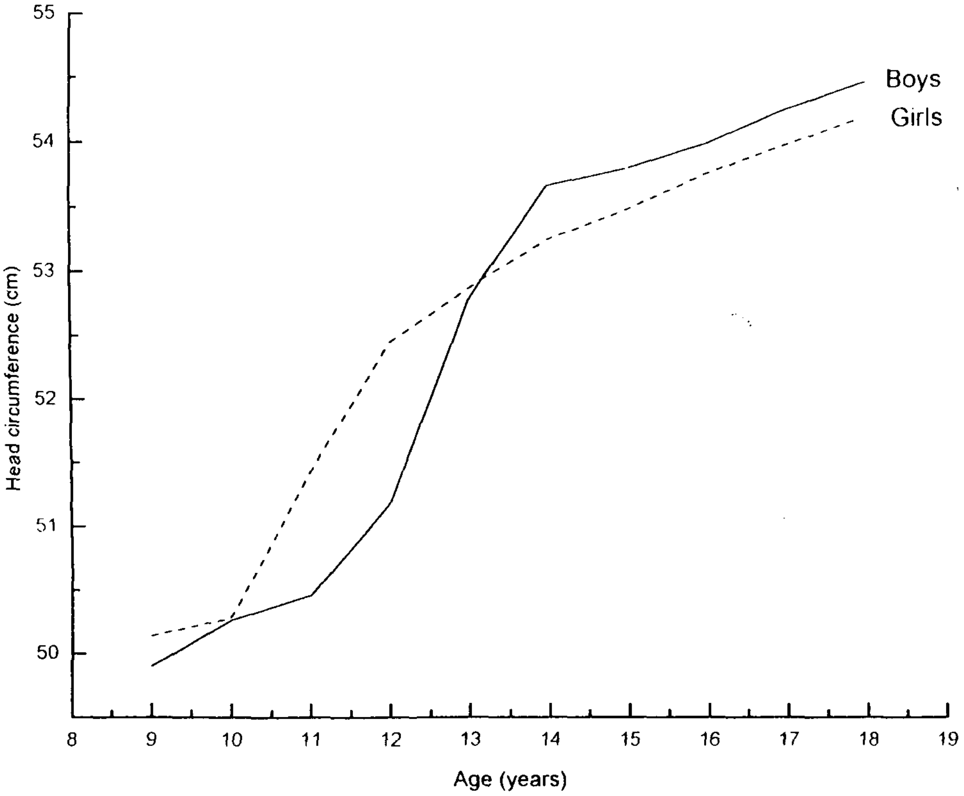


Figure 3.13. Distance curves for head circumference

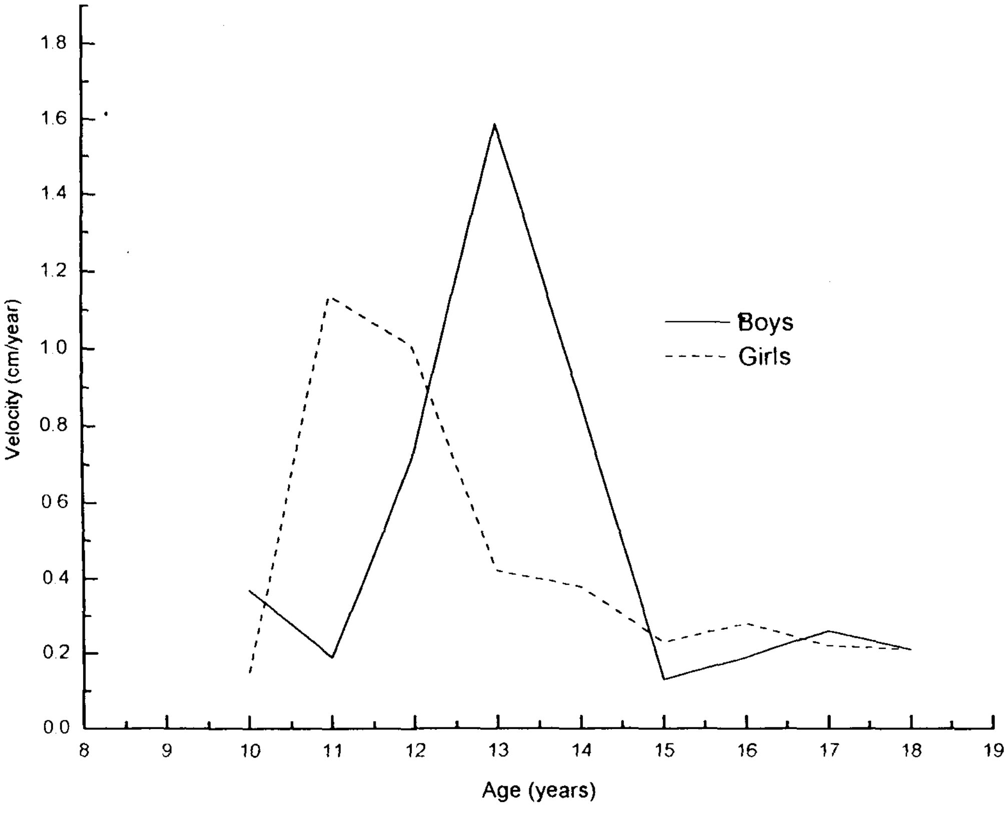


Figure 3.14. Velocity curves for head circumference

As far as the velocity is concerned (Figure 3.14), it indicates that the velocity curves for girls lies above that for boys from 11 to 12 years, and thereafter the curve tilts in favour of boys up to about 14 years of age. Meanwhile, the rate of growth is more or less similar from 15 to 18 years for both boys and girls, although it is slightly higher in boys from 17 to 18 years of age. A total gain from 9 to 18 years of age is 4.55 cm in boys and 4.04 cm in girls. The maximum increment occurs at the age of 11 years in girls with the peak size of 1.14 cm/year (28.22% of the total gain) like in the case of other measurements. On the other hand, the maximum increment in boys takes place at 13 years of age with the peak size of 1.59 cm/year (34.95% of the total gain). Thus, like the other measurements, the adolescent growth spurt with regard to head circumference occurs at 11 years in girls and 13 years in boys.

**Chest Circumference**

The statistical constants of chest circumference (normal) for both boys and girls are given in Table 3.8. The mean values are plotted against age as shown in Figure 3.15. It is observed that there is a gradual increase in chest circumference from 9 to 18 years of age for both boys and girls. The distance curves shows that both boys and girls have a similar chest circumference from 9 to 10 years of age and from 13 to 14 years of age. Like in the case of other measurements, the chest circumference is higher in girls than in boys from 10 to 13 years of age, and the differences are statistically significant at 11 and 12 years of age (Table 3.8). On the other hand, the boys have higher mean values from 14 to 18 years of age. However, the t-test indicates that boys are statistically higher in mean values of chest circumference only at 18 years of age. Nevertheless, the observed values at 18 years of age, which may be considered as accumulations of growth from 14 years onwards, are about 2.78 cm greater in boys (80.44 cm) than in girls (77.66 cm).

**Table 3.8.** Statistical constants of chest circumference of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Increment | N | Mean | SD | Increment | |
| 9 | 36 | 60.55 | 3.08 | | 36 | 60.65 | 3.23 | | 0.14 |
| 10 | 38 | 61.46 | 2.55 | 0.91 | 37 | 61.71 | 4.05 | 1.06 | 0.33 |
| 11 | 36 | 63.46 | 1.77 | 2.00 | 39 | 65.79 | 3.85 | 4.08 | 3.33* |
| 12 | 36 | 65.48 | 2.23 | 2.02 | 38 | 68.40 | 3.06 | 2.61 | 4.66** |
| 13 | 38 | 69.56 | 3.29 | 4.08 | 38 | 69.97 | 3.70 | 1.57 | 0.51 |
| 14 | 37 | 71.74 | 3.87 | 2.18 | 40 | 71.57 | 5.00 | 1.60 | 0.16 |
| 15 | 36 | 74.67 | 2.91 | 2.93 | 35 | 73.51 | 5.26 | 1.94 | 1.16 |
| 16 | 37 | 77.15 | 3.78 | 2.48 | 37 | 75.01 | 6.19 | 1.50 | 1.79 |
| 17 | 35 | 78.86 | 4.71 | 1.71 | 39 | 76.58 | 5.80 | 1.57 | 1.84 |
| 18 | 37 | 80.44 | 3.70 | 1.58 | 36 | 77.66 | 6.32. | 1.08 | 2.30* |

$^*p<0.02$, $^{**}p<0.000$

Figure 3.16 shows the velocities for boys and girls in different age groups. It is observed that the rate of growth is higher in girls than in boys from 10 to 12 years of age. Thereafter, the acceleration is higher in boys than in girls from 13 to 18 years of age. It is found that the total gain from 9 to 18 years is 19.89 cm in boys and 17.01 cm in girls. The maximum gain or peak velocity of 4.08 cm/year (20.51% of the total gain) occurs in boys at the age of 13 years, while in girls it is 4.08 cm/year (23.99% of the total gain) at the age of 11 years.

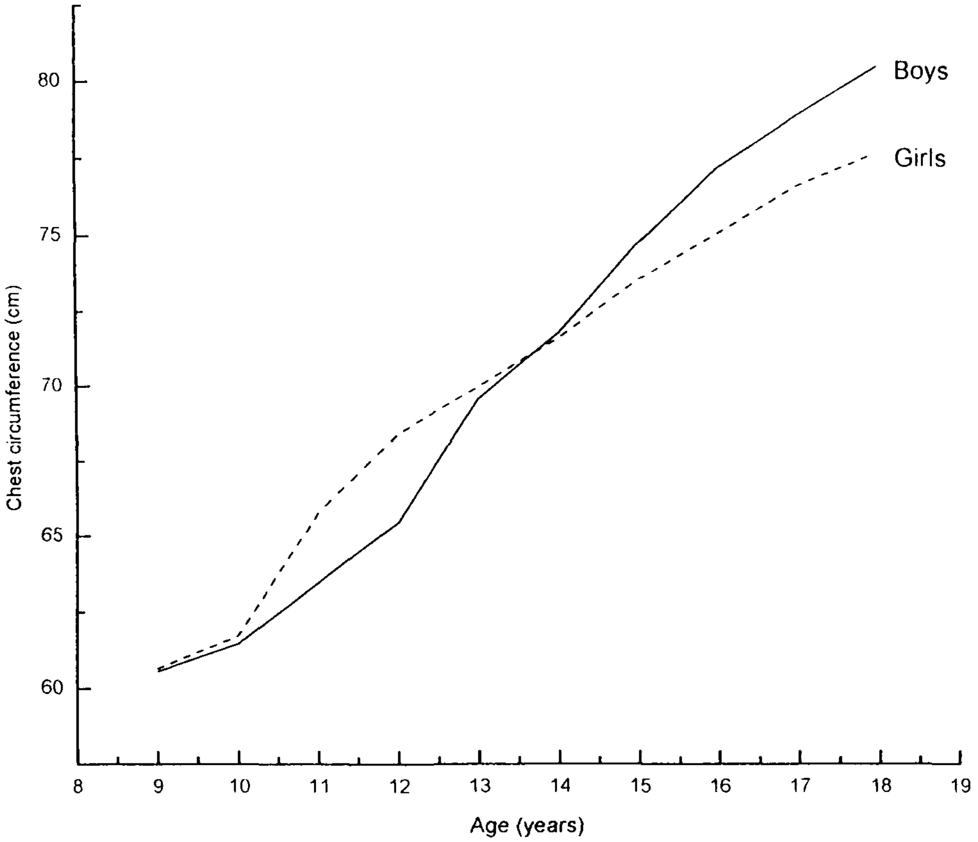


Figure 3.15. Distance curves for chest circumference

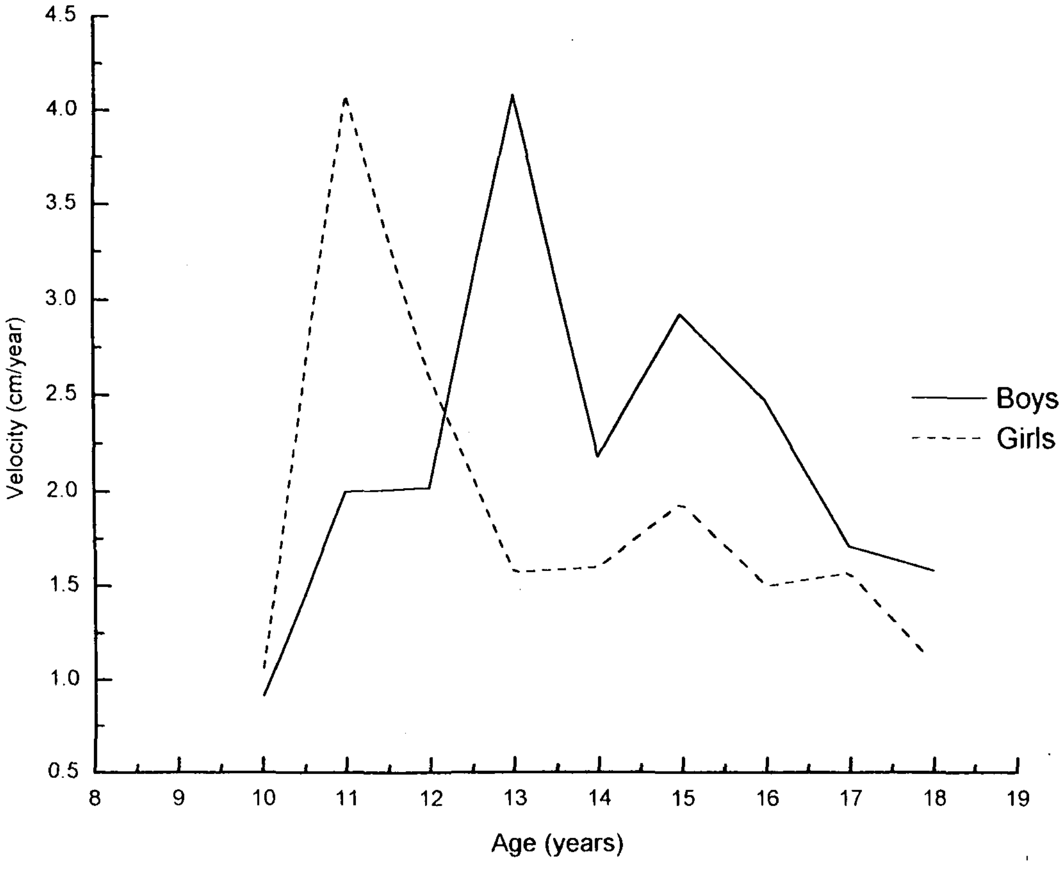


Figure 3.16. Velocity curves for chest circumference

## Upper Arm Circumference

Table 3.9 shows the means and standard deviations of the upper arm circumference for both boys and girls, and the distance curves plotted against means are shown in Figure 3.17. The distance curves shows that boys are slightly higher in upper arm circumference from 9 to 10 years of age, and thereafter girls have higher mean values up to about 13 years of age. Like in the case of chest circumference, the sex differences are statistically significant at 11 and 12 years of age, that is, the upper arm circumference is significantly higher in girls than in boys. On the other hand, the arm circumference is higher in boys than in girls from 14 to 18 years of age, and it is significant at the age of 18 years. The observed mean values at 18 years of age are 23.87 cm in boys and 22.92 cm in girls indicating a difference of 0.95 cm.

**Table 3.9.** Statistical constants of upper arm circumference of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Incre-ment | N | Mean | SD | Incre-ment | |
| 9 | 36 | 16.08 | 1.03 | | 36 | 15.76 | 1.01 | | 1.35 |
| 10 | 38 | 16.28 | 0.96 | 0.20 | 37 | 16.02 | 1.06 | 0.26 | 1.13 |
| 11 | 36 | 16.61 | 0.67 | 0.33 | 39 | 17.64 | 1.08 | 1.62 | 4.94** |
| 12 | 36 | 17.22 | 0.85 | 0.61 | 38 | 18.72 | 1.23 | 1.08 | 6.09** |
| 13 | 38 | 19.58 | 1.54 | 2.36 | 38 | 19.62 | 2.10 | 0.90 | 0.11 |
| 14 | 37 | 20.79 | 2.50 | 1.21 | 40 | 20.40 | 1.79 | 0.78 | 0.79 |
| 15 | 36 | 21.69 | 2.19 | 0.90 | 35 | 21.27 | 1.43 | 0.87 | 0.95 |
| 16 | 37 | 22.49 | 2.37 | 0.80 | 37 | 22.08 | 1.20 | 0.81 | 0.94 |
| 17 | 35 | 23.08 | 1.84 | 0.59 | 39 | 22.78 | 1.10 | 0.70 | 0.87 |
| 18 | 37 | 23.87 | 1.79 | 0.79 | 36 | 22.92 | 1.20 | 0.14 | 2.66* |

*p<0.01, **p<0.000

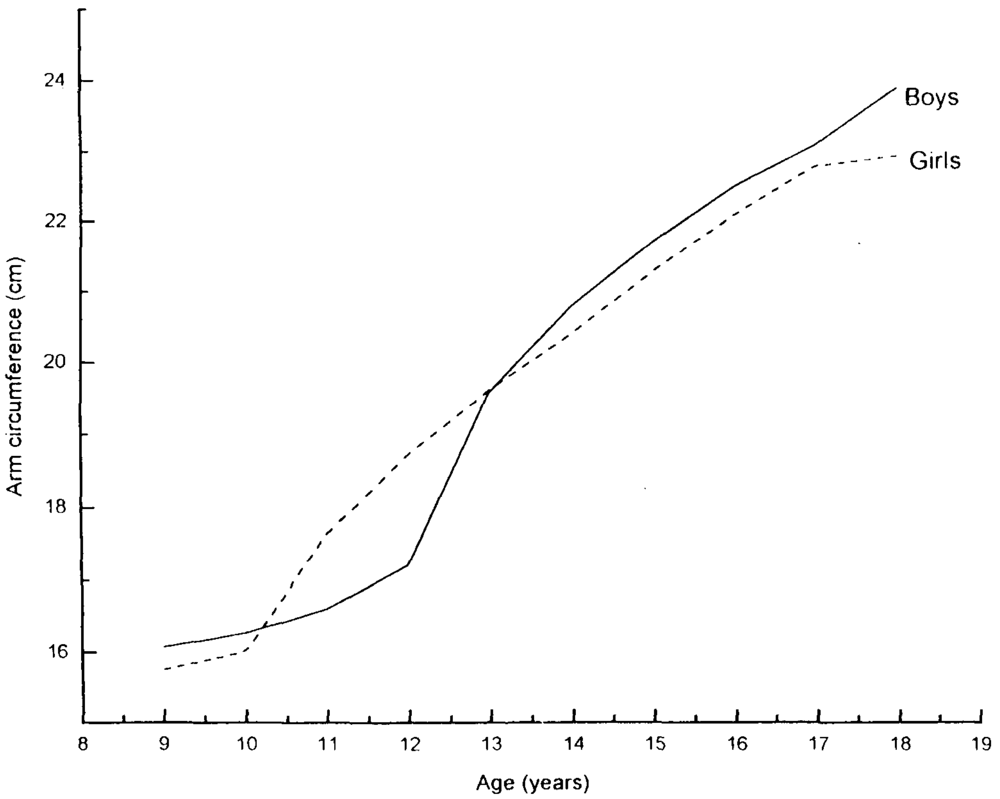


Figure 3.17. Distance curves for arm circumference

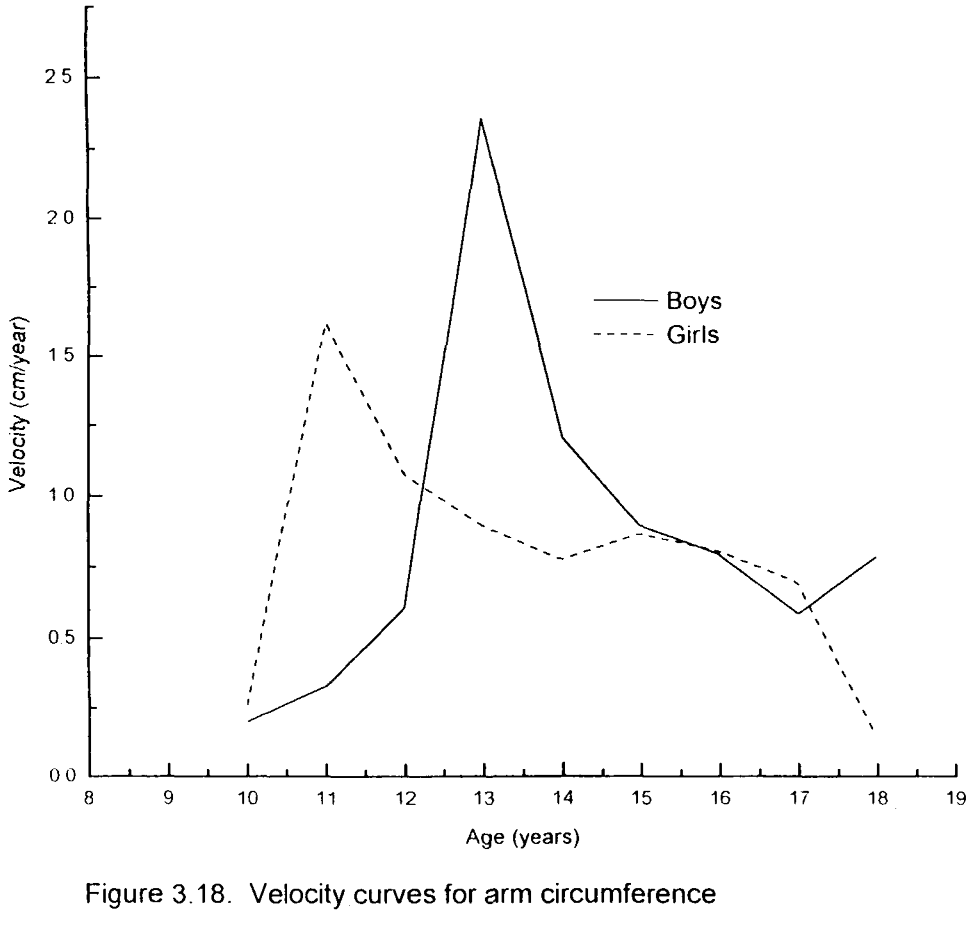


Figure 3.18. Velocity curves for arm circumference

As for the annual increment, Figure 3.18 shows that the acceleration is higher in girls from 10 to 12 years of age, and thereafter it is higher in boys up to about 14 years of age. From 15 to 17 years of age, the velocity is more or less similar for both boys and girls, and thereafter the boys surpassed the girls. The total gain in arm circumference is higher in boys (7.79 cm) than in girls (7.16 cm). In boys, the maximum increment occurs at 13 years (2.36 cm/year), while in girls it takes place at 11 years of age (1.62 cm/year), accounting to about 30.30% and 22.63%, respectively, of the total gain from 9 to 18 years. Thus, like the chest circumference, it is obvious that adolescent spurt occurs at 11 and 13 years in girls and boys, respectively.

### Calf Circumference

Table 3.10 shows the statistical constants of calf circumference for both boys and girls. Unlike in the case of other measurements of circumference, the distance curves (Figure 3.19) depict the larger growth progression in girls than in boys at the age of 9, 11 and 12 years. The t-test also indicates that the difference is statistically significant at the age of 12 years. From 13 years onwards, the growth pattern in calf circumference is much higher in boys than in girls, and the differences are statistically significant from 15 to 18 years of age (Table 3.10). Also, the observed mean values at the age of 18 years are 32.63 cm and 31.28 cm in boys and girls, respectively, indicating that the calf in boys is larger by about 1.35 cm as compared with girls.

The rate of growth per year is plotted in Figure 3.20. The curve indicates that the velocity is higher in boys than in girls from 9 to 10 years of age, and from 13 to 16 years of age. On the other hand, the girls surpass the boys in velocity from 11 to 12 and 17 years of age. It can also be observed that the total increment from 9 to 18 years of age is about 9.59 cm in boys and 8.14 cm in girls. The highest increment in boys occurs at the age of 13 years with a peak size of 2.05 cm/year (i.e., about 21.38% of the total gain), while in girls it takes place at 11 years with a peak size of 1.77 cm/year (i.e., about 21.74% of the total gain). Hence, like in the case of other measurements, adolescent growth spurt takes place earlier in girls (11 years) when compared with boys (13 years).

**Table 3.10.** Statistical constants of calf circumference of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Increment | N | Mean | SD | Increment | |
| 9 | 36 | 23.04 | 1.15 | | 36 | 23.14 | 1.24 | | 0.37 |
| 10 | 38 | 23.73 | 1.47 | 0.69 | 37 | 23.36 | 1.38 | 0.22 | 1.14 |
| 11 | 36 | 24.38 | 1.19 | 0.65 | 39 | 25.13 | 1.99 | 1.77 | 1.95 |
| 12 | 36 | 25.33 | 1.40 | 0.95 | 38 | 26.19 | 1.74 | 1.06 | 2.35* |
| 13 | 38 | 27.38 | 1.84 | 2.05 | 38 | 27.14 | 1.57 | 0.95 | 0.60 |
| 14 | 37 | 28.80 | 1.42 | 1.42 | 40 | 28.03 | 2.41 | 0.89 | 1.69 |
| 15 | 36 | 30.04 | 1.20 | 1.24 | 35 | 28.98 | 1.81 | 0.95 | 2.92** |
| 16 | 37 | 31.25 | 1.40 | 1.21 | 37 | 29.85 | 2.00 | 0.87 | 3.42** |
| 17 | 35 | 31.97 | 1.70 | 0.72 | 39 | 30.62 | 2.01 | 0.77 | 3.12** |
| 18 | 37 | 32.63 | 1.31 | 0.66 | 36 | 31.28 | 1.85 | 0.66 | 3.60** |

$*p<0.02$, $**p<0.005$

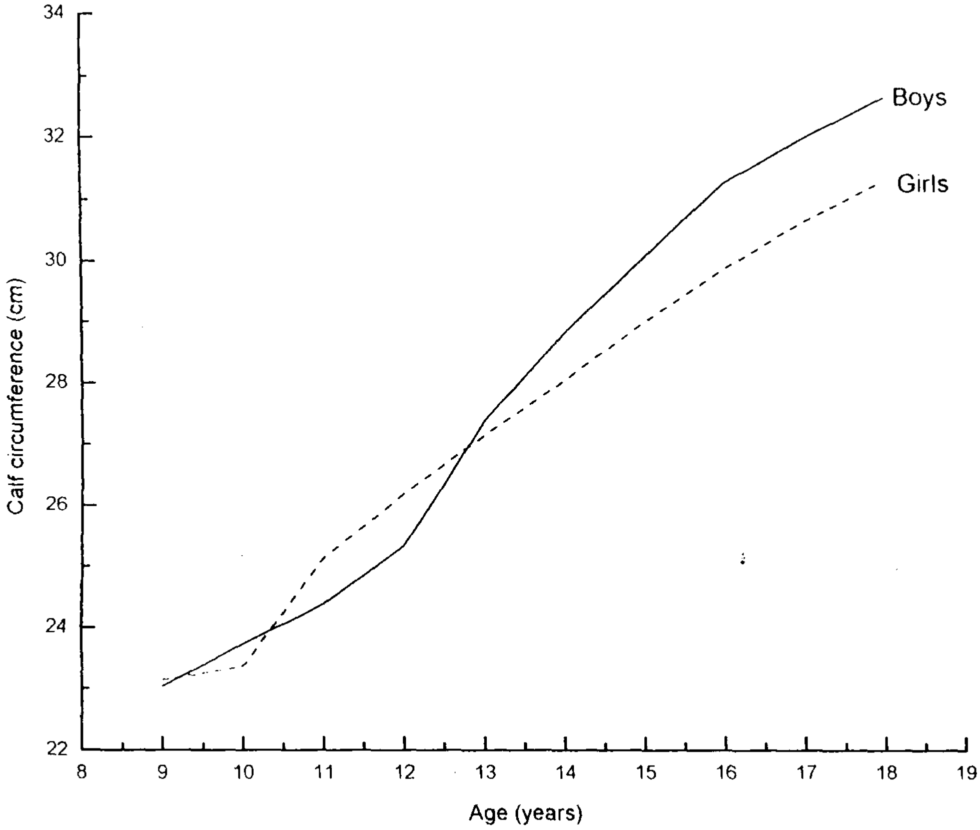


Figure 3.19. Distance curves for calf circumference

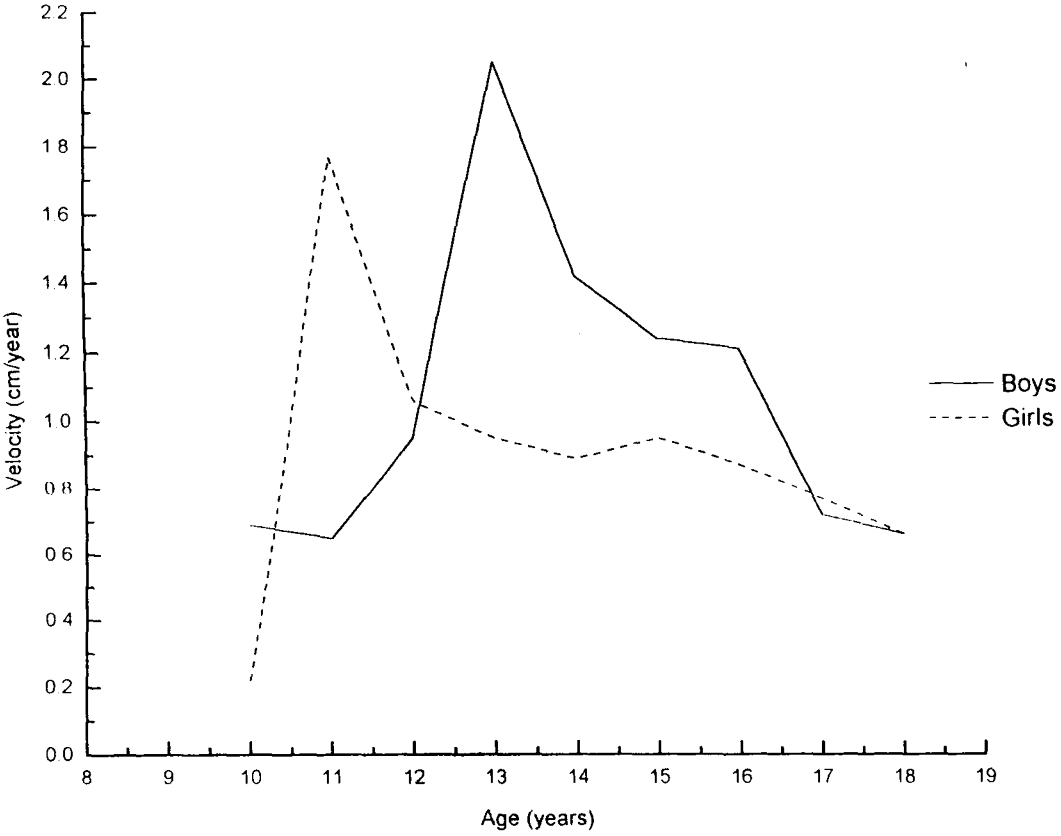


Figure 3.20. Velocity curves for calf circumference

**Triceps**

The statistical constants of the triceps for both boys and girls are given in Table 3.11. The mean values plotted against age are shown in Figure 3.21. Unlike other measurements, it is observed that the fat accumulation at triceps is greater in girls than in boys from the initial age of 9 till the final age of 18 years. It is also found that the sex differences are statistically significant across ages. The final size achieved at 18 years of age is 7.18 mm in boys and 11.22 mm in girls.

**Table 3.11.** Statistical constants of triceps of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Incre-ment | N | Mean | SD | Incre-ment | |
| 9 | 36 | 5.75 | 0.94 | | 36 | 7.15 | 1.11 | | 5.77** |
| 10 | 38 | 5.99 | 1.08 | 0.24 | 37 | 6.92 | 1.17 | -0.23 | 3.56* |
| 11 | 36 | 6.28 | 1.00 | 0.29 | 39 | 7.21 | 1.00 | 0.29 | 3.89* |
| 12 | 36 | 6.60 | 1.37 | 0.32 | 38 | 7.99 | 1.01 | 0.78 | 4.86** |
| 13 | 38 | 6.29 | 1.28 | -0.31 | 38 | 8.29 | 1.19 | 0.30 | 7.05** |
| 14 | 37 | 6.71 | 1.14 | 0.42 | 40 | 10.53 | 0.74 | 2.24 | 17.55** |
| 15 | 36 | 6.76 | 1.49 | 0.05 | 35 | 10.60 | 1.56 | 0.13 | 10.61** |
| 16 | 37 | 6.91 | 1.52 | 0.15 | 37 | 10.94 | 1.18 | 0.26 | 12.74** |
| 17 | 35 | 6.79 | 1.47 | -0.12 | 39 | 10.87 | 1.20 | -0.07 | 13.13** |
| 18 | 37 | 7.18 | 1.56 | 0.39 | 36 | 11.22 | 1.12 | 0.35 | 12.68** |

$^{*}p<0.01$, $^{**}p<0.000$

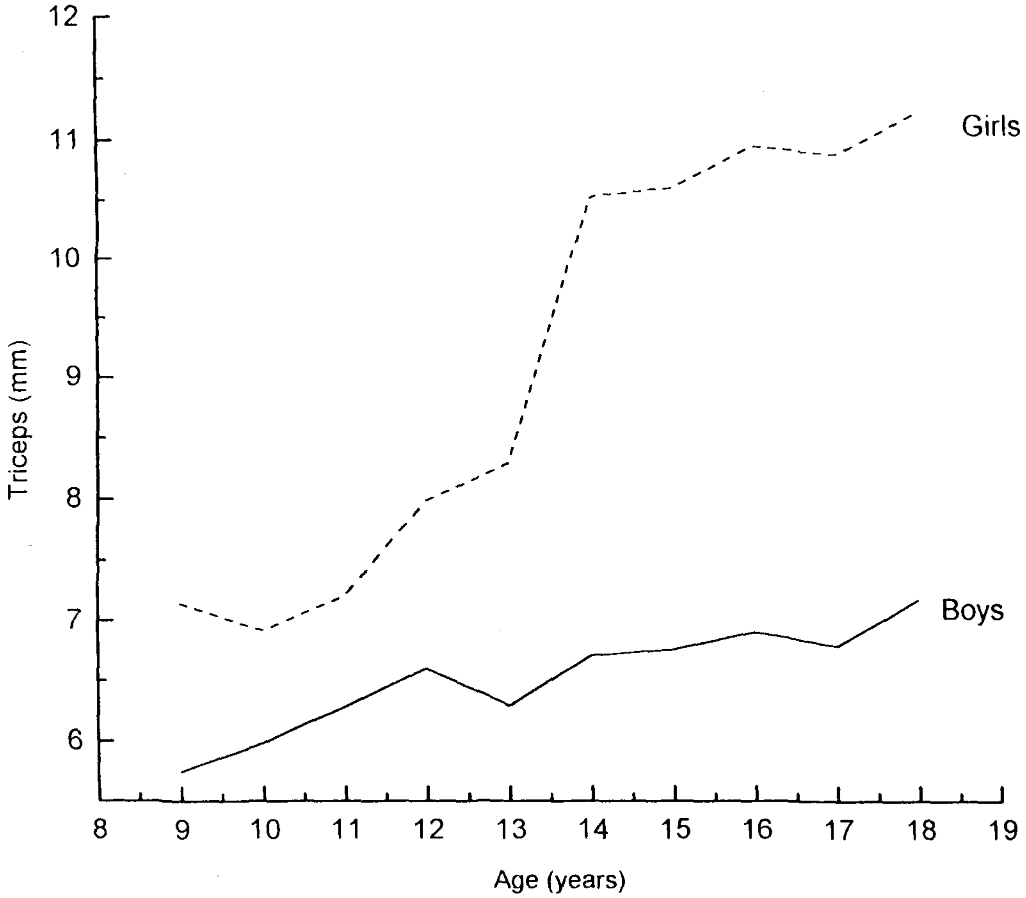


Figure 3.21. Distance curves of triceps skinfold thiickness

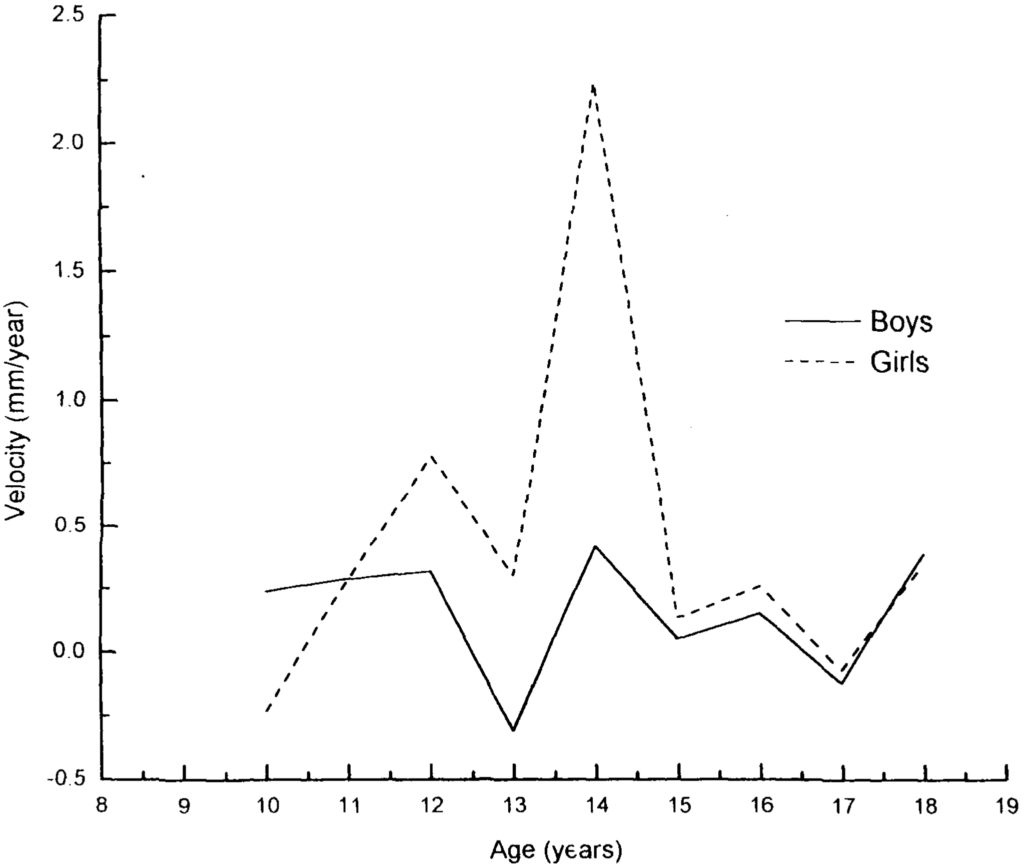


Figure 3.22. Velocity curves for triceps skinfold thickness

The rate of growth per year, as plotted in Figure 3.22, depicts higher acceleration in girls at many age groups, except at the age of 10 and 18 years when the rate is higher in boys than in girls, although both of them shows growth deceleration at the age of 17 years. The Figure further shows that the boys experience deceleration during their adolescent growth spurt for other measurements like height, weight, etc, at the age of 13 years, while in girls deceleration of -0.23 mm takes place at the age of 10 years, that is one year ahead of their adolescent growth spurt with respect to other measurements. Thus, the results on fat fold at triceps are inconsistent when compared with other measurements described so far. In other words, it indicates that the amount of fat deposited at triceps in boys is reduced considerably during the occurrence of adolescent growth spurt with respect to other measurements at the age of 13 years. It can be observed from Figure 3.22 that the peak velocity takes place at about the age of 14 years for both boys and girls, although it is much higher in girls than in boys. It is found that the maximum increment that occurs at 14 years of age is 0.42 mm/year in boys and 2.24 mm/year in girls. Thus, the maximum increment at 14 years of age is about 29.37% of the total gain (1.43 mm) in boys and about 55.04% of the total gain (4.07 mm) in girls.

**Biceps**

The mean values and standard deviations of the skinfold thickness at biceps for boys and girls are shown in Table 3.12. The mean values are plotted against age groups as shown in Figure 3.23. It can be observed that girls exhibit greater biceps skinfold than boys through out ages. The t- test also indicates that the differences between boys and girls are highly significant in all age groups (Table 3.12). The observed mean values at the terminal age of 18 years are found to be 4.90 mm and 7.19 mm in boys and girls, respectively. Thus, the girls experience a greater biceps skinfold thickness of 2.29 mm when compared with the boys at the age of 18 years.

The velocity curves of the boys and girls are plotted in Figure 3.24. The Figure shows that the annual increment is higher in boys than in girls from 9 to about 12 years of age, and thereafter there is a deceleration in boys when the girls surpass the boys till the age of about 16 years. In the case of girls, growth decelerates between 9 and 10 years of age, while at the age of 17 years both boys and girls experience decrease in acceleration. Nevertheless, Figure 3.24 depicts that boys are higher in acceleration at the lower age groups, that is, before the occurrence of adolescent growth spurt with respect to other measurements. Thereafter, the velocity is much higher in girls than in boys although both of them experience deceleration at the age of 17 years. The maximum increment of biceps skinfold occurs at the age of 14 years for both boys (0.49 mm/year) and girls (0.76 mm/year). It is found that the total gain from 9 to 18 years of age is much lower in boys (1.61 mm) than in girls (2.78 mm). The rate of growth at maximum spurt is found to be 30.43% and 27.34% of the total gain in boys and girls, respectively.

**Table 3.12.** Statistical constants of the biceps of boys and girls

| Age | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| yrs | N | Mean | SD | Increment | N | Mean | SD | Increment | |
| 9 | 36 | 3.29 | 0.69 | | 36 | 4.41 | 0.62 | | 7.18** |
| 10 | 38 | 3.44 | 0.64 | 0.15 | 37 | 4.22 | 0.74 | -0.19 | 4.90** |
| 11 | 36 | 3.82 | 1.03 | 0.38 | 39 | 4.48 | 0.86 | 0.26 | 3.21* |
| 12 | 36 | 4.10 | 0.92 | 0.28 | 38 | 4.68 | 0.81 | 0.20 | 2.89* |
| 13 | 38 | 3.78 | 0.88 | -0.32 | 38 | 5.32 | 0.90 | 0.64 | 7.55** |
| 14 | 37 | 4.27 | 0.91 | 0.49 | 40 | 6.08 | 1.26 | 0.76 | 7.20** |
| 15 | 36 | 4.38 | 1.01 | 0.11 | 35 | 6.23 | 0.76 | 0.15 | 8.71** |
| 16 | 37 | 4.55 | 1.13 | 0.17 | 37 | 6.68 | 1.07 | 0.45 | 8.33** |
| 17 | 35 | 4.50 | 0.99 | -0.05 | 39 | 6.59 | 0.98 | -0.09 | 9.10** |
| 18 | 37 | 4.90 | 0.82 | 0.40 | 36 | 7.19 | 1.33 | 0.60 | 8.49 |

*$p<0.01$, **$p<0.000$

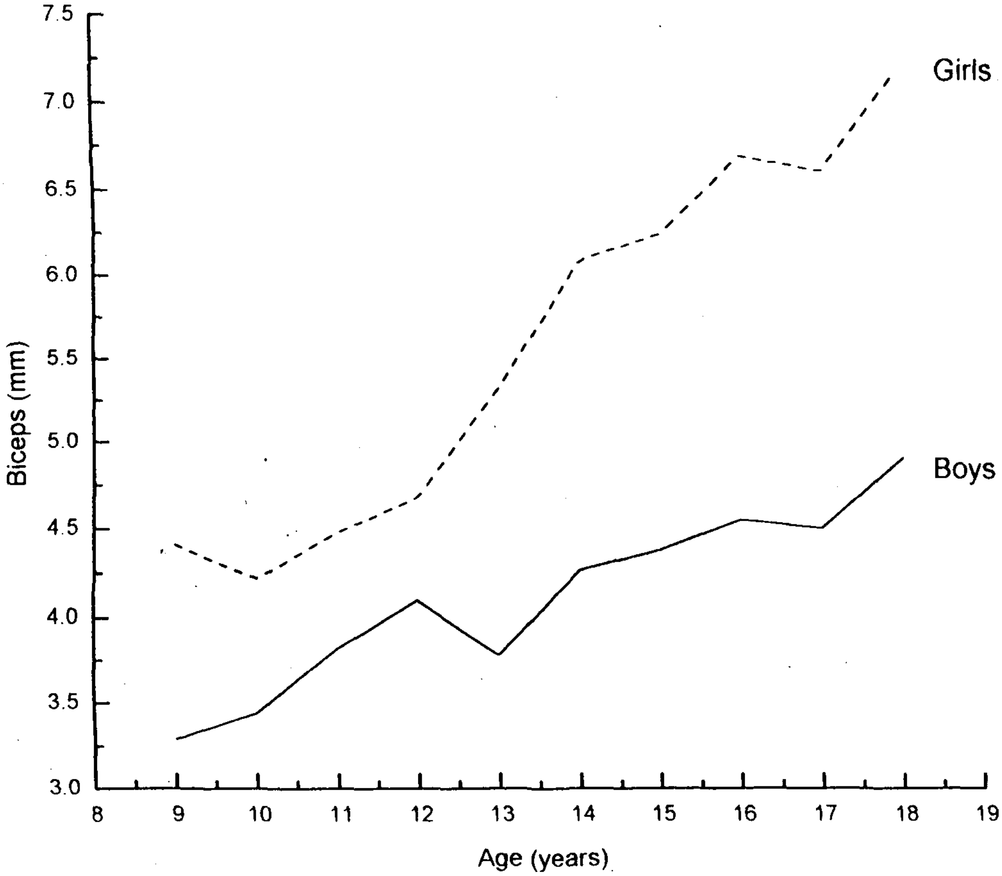


Figure 3.23. Distance curves for biceps skinfold thickness

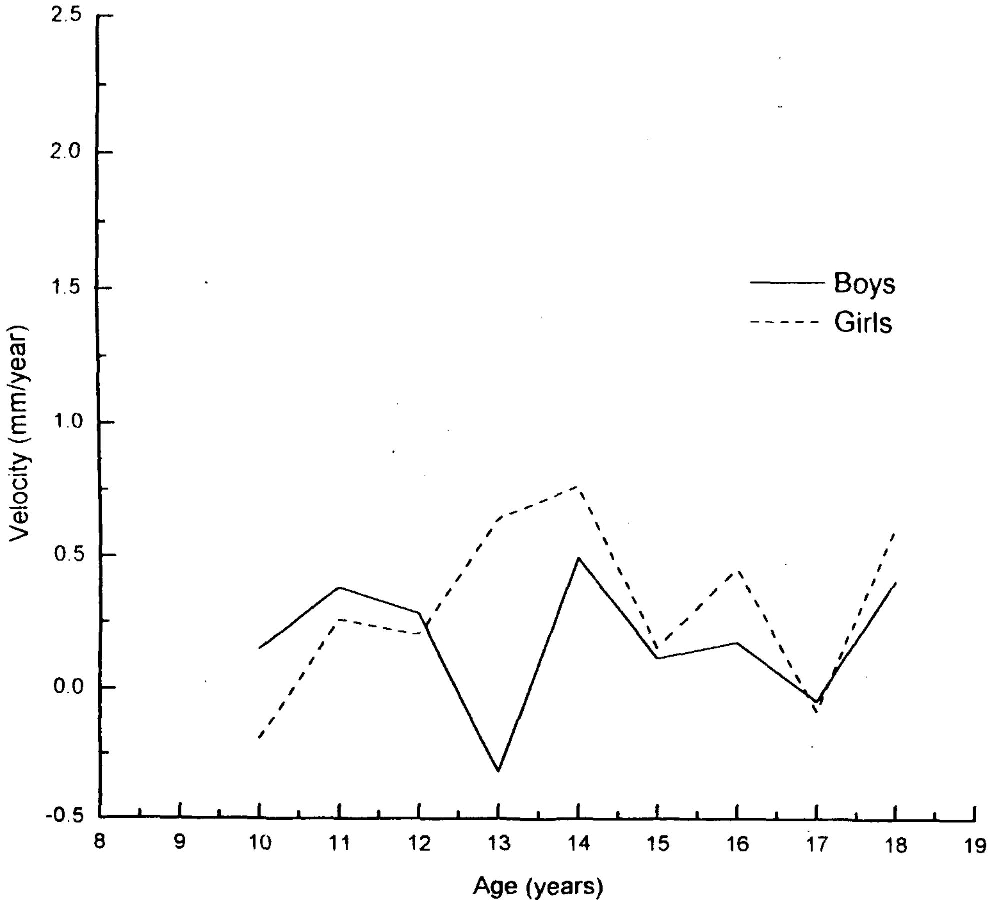


Figure 3.24. Velocity curves for biceps skinfold thickness

**Subscapular**

The statistical constants of the subscapular for both boys and girls are given in Table 3.13. The distance curves (Figure 3.25) depicts that the girls surpass the boys across ages 9 to 18 years. It is also found that the differences between boys and girls in respect of subscapular skinfold thickness is statistically significant in all the age groups. It is seen that the observed values at the age of 18 years are 7.58 mm in boys and 11.10 mm in girls. Thus, girls experience about 3.52 mm higher than boys in fat accumulation at the terminal age of 18 years.

**Table 3.13.** Statistical constants of subscapular of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Increment | N | Mean | SD | Increment | |
| 9 | 36 | 5.57 | 0.85 | | 36 | 6.05 | 1.07 | | 2.13* |
| 10 | 38 | 5.08 | 0.99 | -0.49 | 37 | 5.85 | 0.99 | -0.20 | 3.33* |
| 11 | 36 | 4.92 | 0.50 | -0.16 | 39 | 5.93 | 0.68 | 0.08 | 7.30** |
| 12 | 36 | 5.11 | 0.77 | 0.19 | 38 | 5.89 | 0.68 | -0.04 | 4.61** |
| 13 | 38 | 5.16 | 0.76 | 0.05 | 38 | 6.91 | 1.19 | 1.02 | 7.68** |
| 14 | 37 | 5.80 | 0.93 | 0.64 | 40 | 8.66 | 0.94 | 1.75 | 13.38** |
| 15 | 36 | 6.32 | 1.27 | 0.52 | 35 | 9.54 | 0.86 | 0.88 | 12.43** |
| 16 | 37 | 6.92 | 1.17 | 0.60 | 37 | 9.99 | 1.23 | 0.45 | 10.98** |
| 17 | 35 | 7.14 | 1.29 | 0.22 | 39 | 10.91 | 1.11 | 0.92 | 13.57** |
| 18 | 37 | 7.58 | 1.16 | 0.44 | 36 | 11.10 | 1.99 | 0.19 | 9.26** |

*p<0.01, **p<0.000

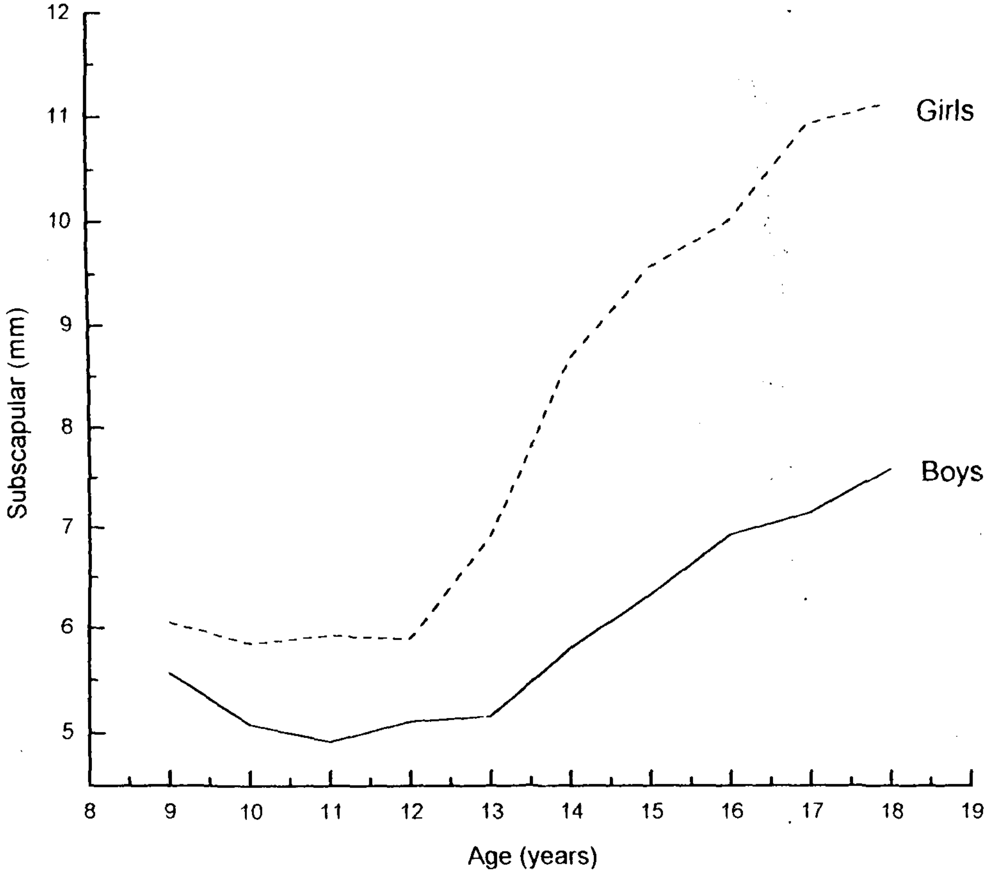


Figure 3.25. Distance curves for subscapular skinfold thickness

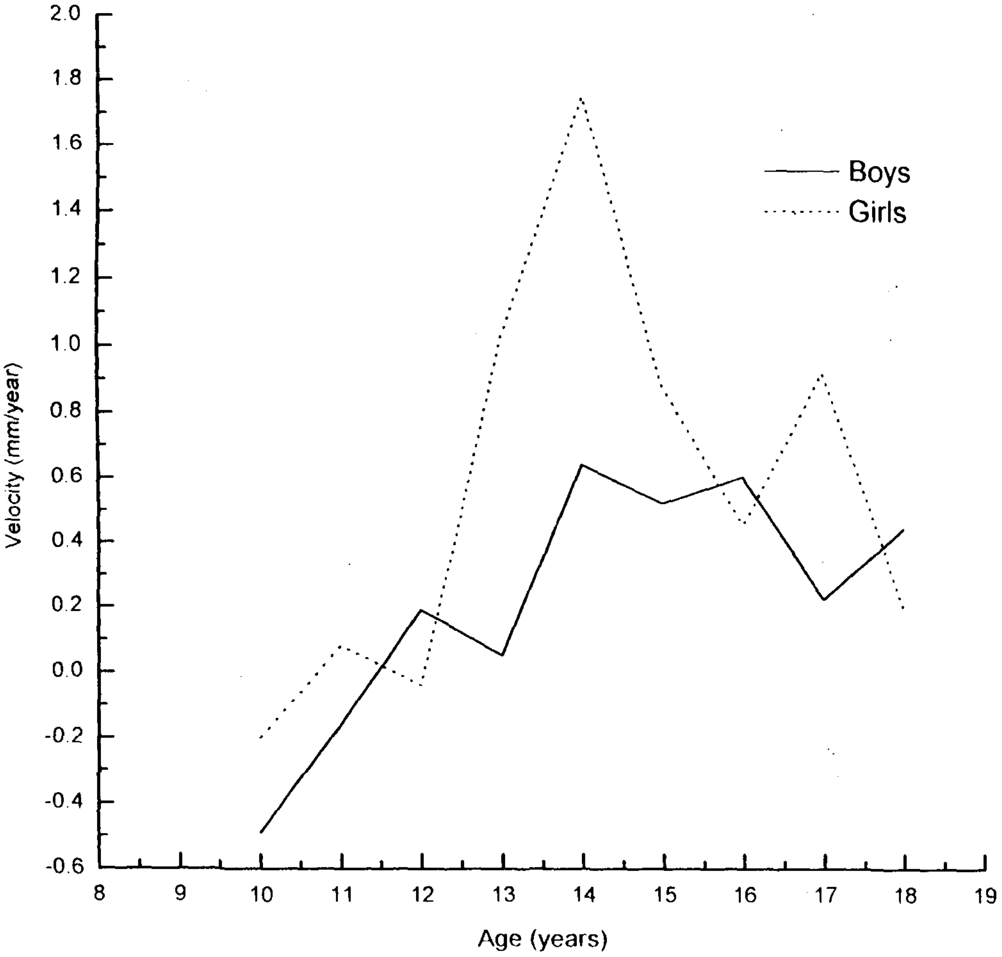


Figure 3.26. Velocity curves for subscapular skinfold thickness

The velocity curves for boys and girls are plotted against age in Figure 3.26. It reveals that the acceleration is higher in girls than in boys in many age groups, except at the ages of 12, 16 and 18 years when the velocities are higher in boys than in girls. Meanwhile, Figure 3.26 shows that there is a growth deceleration between 10 and 11 years in boys, while in girls deceleration takes place between 10 and 12 years of age. A net increment from 9 to 18 years is found to be 2.01 mm and 5.05 mm in boys and girls, respectively. The maximum increment occurs at the age of 14 years for both boys and girls with peak velocities of 0.64 mm/years and 1.75mm/year, respectively, which are about 31.84% and 34.65% of the net increment in boys and girls, respectively.

**Suprailiac**

The statistical constants of suprailiac skinfold thickness for boys and girls are shown in Table 3.14. The mean differences across ages are plotted in Figure 3.27. Like the other skinfold measurements, the amount of fat accumulation is greater in girls than in boys from 9 to18 years. Table 3.14 further shows that the differences between boys and girls in mean values of suprailiac skinfold thickness are highly significant for all age groups. It is seen that the observed value at the terminal age of 18 years is 4.85 mm in boys and 8.64 mm in girls. Thus, girls have a greater suprailiac skinfold thickness of about 3.79 mm than the boys at the age of 18 years.

The rate of fat accumulated per year is plotted against age in Figure 3.28. The Figure depicts a fluctuation of fat in both boys and girls. In boys, there is deceleration of fat accumulation at the ages of 10 and 13 years, while in girls deceleration of fat accumulation takes place at the ages of 11 and 17 years. Nevertheless, it shows that the rate of growth is higher in girls than in boys at the ages of 13, 15-16 and 18 years, while the boys surpass the girls from 11 to 12 years and at the ages of 14 and 17 years. It is found that a total gain from 9 to 18 years is 1.02 mm in boys and 3.74 mm in girls. The maximum velocity of about 0.48 mm/year or about 47.06% of the total gain occurs at 14 years in boys and at 15 years in girls, which is about 1.70 mm/year or about 45.45% of the total gain.

**Table 3.14.** Statistical constants of suprailiac of boys and girls

| Age yrs | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Incre-ment | N | Mean | SD | Incre-ment | |
| 9 | 36 | 3.83 | 0.78 | | 36 | 4.90 | 0.98 | | 5.12** |
| 10 | 38 | 3.22 | 0.54 | -0.61 | 37 | 5.00 | 1.17 | 0.10 | 8.52** |
| 11 | 36 | 3.39 | 0.61 | 0.17 | 39 | 4.88 | 0.93 | -0.12 | 8.13** |
| 12 | 36 | 3.71 | 0.72 | 0.32 | 38 | 5.06 | 1.05 | 0.18 | 6.43** |
| 13 | 38 | 3.68 | 0.66 | -0.03 | 38 | 5.56 | 0.73 | 0.50 | 11.83** |
| 14 | 37 | 4.16 | 0.70 | 0.48 | 40 | 5.75 | 0.81 | 0.19 | 9.18** |
| 15 | 36 | 4.29 | 0.71 | 0.13 | 35 | 7.45 | 1.67 | 1.70 | 10.40** |
| 16 | 37 | 4.62 | 0.99 | 0.33 | 37 | 8.61 | 1.13 | 1.16 | 16.13** |
| 17 | 35 | 4.69 | 0.65 | 00.7 | 39 | 7.87 | 0.97 | -0.74 | 16.43** |
| 18 | 37 | 4.85 | 1.01 | 0.16 | 36 | 8.64 | 1.33 | 0.77 | 13.73** |

**$p<0.000$

In view of the above measurements on skinfold thickness, it is obvious that fat accumulation is fluctuating for both boys and girls, although the peak velocity seems to take place by and large at the age of 14 years for boys and girls. It is also seen that the fat accumulation is much higher in girls than in boys across ages, irrespective of growth deceleration in certain age groups. Nevertheless, the results of skinfold measurement are reverse to those observed for the other measurements in which adolescent growth spurt takes place at the age of 13 years in boys and 11 years in girls. As a matter of fact, it is difficult to explain the adolescent growth spurt with respect to skinfold measurement in the present study, since the age at peak velocity seems to be more or less same for both boys and girls.

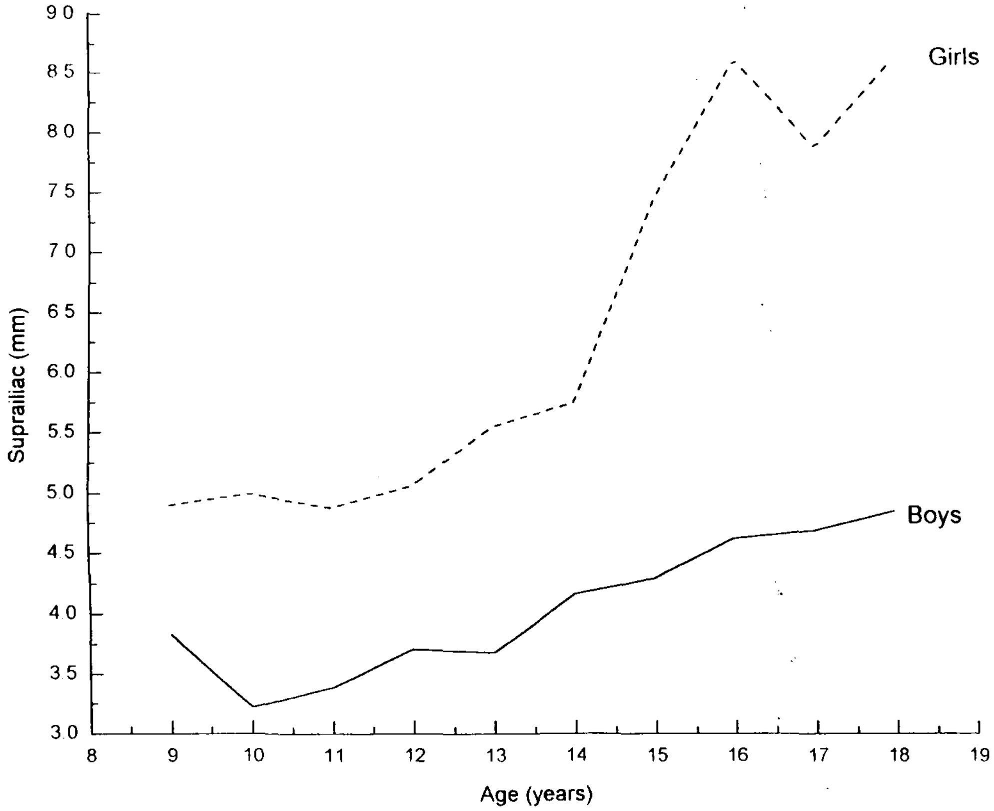


Figure 3.27. Distance curves for suprailiac skinfold thickness

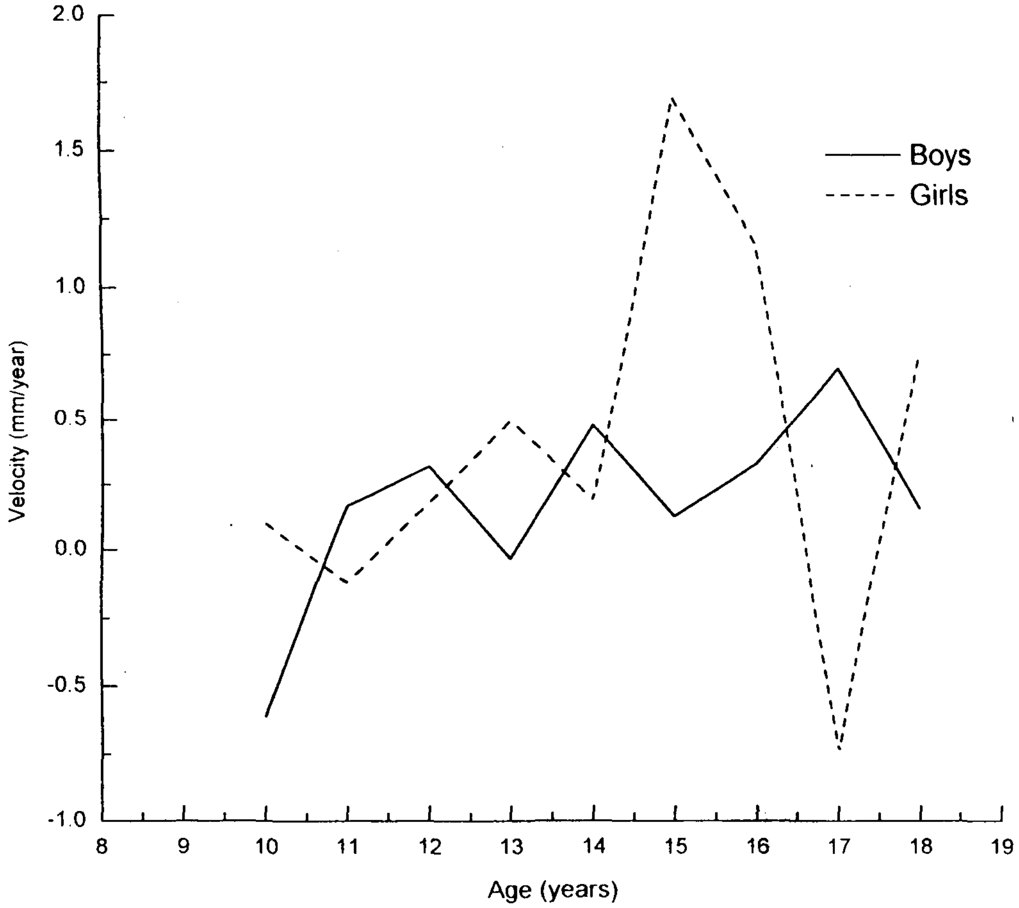


Figure 3.28. Velocity curves for suprailiac skinfold thickness

**Body composition**

By "body composition" we refer to the lean body mass (LBM) or fat free mass (FFM) plus adipose tissue (AT) or fat mass (FM). According to Forbes (1987), LBM refers to "body mass minus ether-extractable fat, and hence includes the stroma of adipose tissue." The measurement of body composition is essential for studying human variation and adaptation, and it is being used increasingly in the assessment of growth and nutritional status, fitness, work capacity, disease and its treatment (Norgan, 1995). Of many methods, anthropometry has been used for many years for measuring body composition, especially in respect of skinfold thicknesses and weight/height indices like body mass index (weight in kg/ height square in meter), although it is subject to certain limitations (Norgan, 1995). In the present study, we have assessed the body composition of the Lotha adolescent children taking into consideration the equations proposed by Durnim and Womersley (1974), which is generally recommended for the adolescent children (Norgan, 1995). In the following, we shall look into the growth pattern of the Lotha children in terms of body composition, which is divided into two major components, namely, FM and LBM.

*Fat Mass*

Table 3.15 shows the means and standard deviations of FM of the boys and girls against age. The distance curves (Figure 3.29) depicts that FM is higher in girls than in boys in all age groups. The t-test indicates that the differences between boys and girls are highly significant for all age groups (Table 3.15).

The velocity curves of FM for boys and girls are plotted in Figure 3.30. It can be observed that there is a deceleration between 9 and 10 years of age in girls, and thereafter the velocity is higher in girls than in boys from 11 to 17 years. The maximum increment occurs at the age of 14 years in both boys (0.84 kg/year) and girls (1.63 kg/year). This maximum spurt is found to be 21.31% and 20.54% of the total gain for girls (7.65 kg) and boys (4.09 kg), respectively.

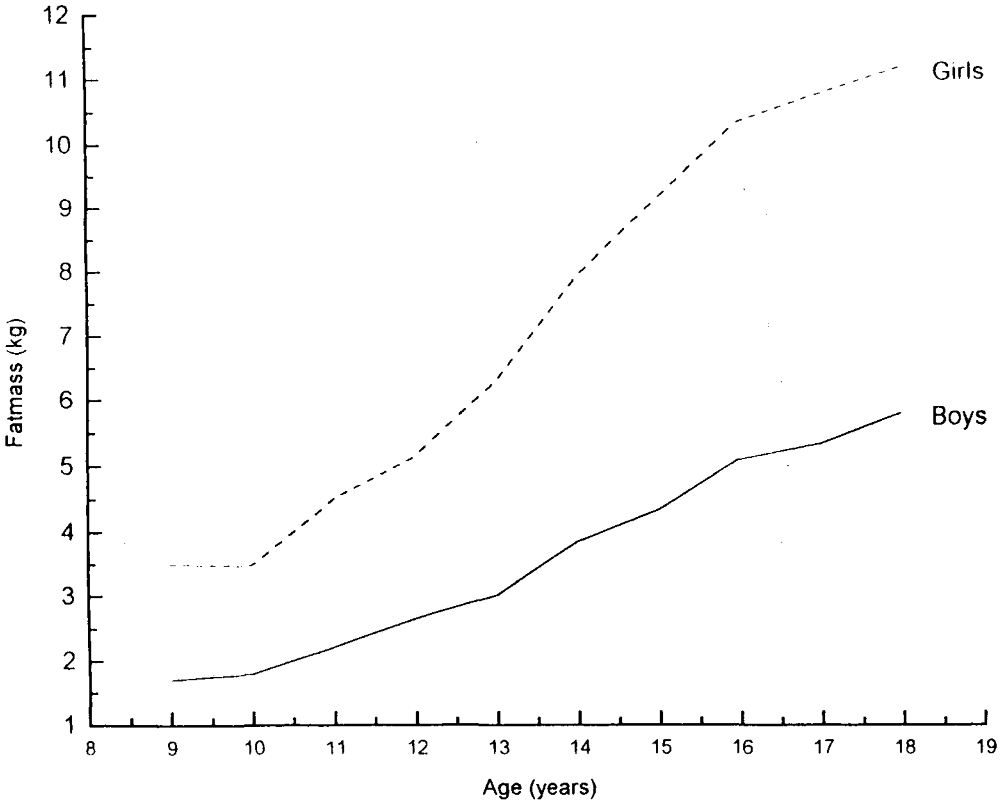


Figure 3.29. Distance curves for fatmass

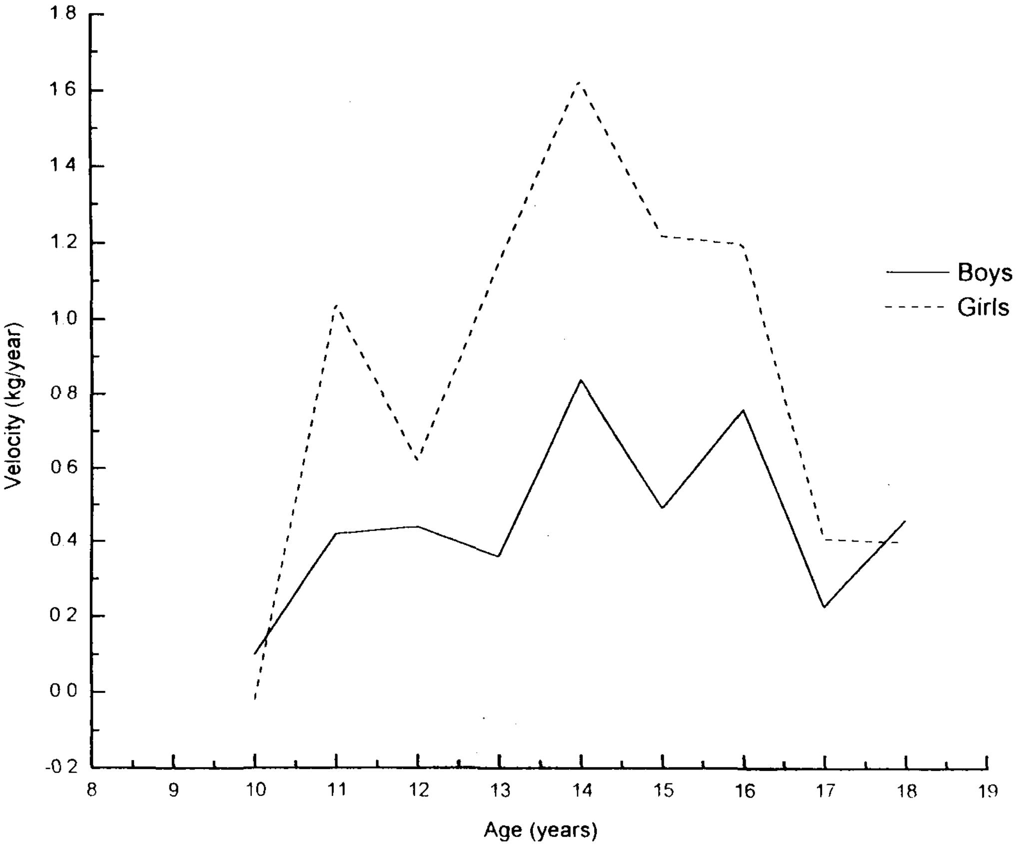


Figure 3.30. Velocity curves for fatmass

**Table 3.15.** Statistical constants of fat mass (kg) of boys and girls.

| Age (years) | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Incre-ment | N | Mean | SD | Incre-ment | |
| 9 | 36 | 1.71 | 0.41 | - | 36 | 3.50 | 0.66 | - | 13.24* |
| 10 | 38 | 1.80 | 0.48 | 0.09 | 37 | 3.48 | 0.76 | -0.02 | 11.58* |
| 11 | 36 | 2.22 | 0.53 | 0.42 | 39 | 4.52 | 0.66 | 1.04 | 16.58* |
| 12 | 36 | 2.66 | 0.73 | 0.44 | 38 | 5.14 | 0.76 | 0.62 | 14.22* |
| 13 | 38 | 3.02 | 0.88 | 0.36 | 38 | 6.29 | 1.29 | 1.15 | 12.89* |
| 14 | 36 | 3.86 | 0.95 | 0.84 | 40 | 7.92 | 1.23 | 1.63 | 16.12* |
| 15 | 37 | 4.35 | 1.01 | 0.49 | 35 | 9.14 | 1.31 | 1.22 | 17.30* |
| 16 | 37 | 5.11 | 1.14 | 0.76 | 39 | 10.34 | 1.13 | 1.20 | 19.77* |
| 17 | 35 | 5.34 | 0.89 | 0.23 | 37 | 10.75 | 1.17 | 0.41 | 22.13* |
| 18 | 37 | 5.80 | 1.19 | 0.46 | 36 | 11.15 | 1.37 | 0.40 | 17.89* |

*P>0.000

*Lean Body Mass or Fat Free Mass*

The lean body mass (LBM) or fat free mass (FFM) is calculated by subtracting body fat from total body weight. The mean values and standard deviations of LBM for boys and girls are presented in Table 3.16. The mean differences against age groups are plotted in Figure 3.31. Unlike the growth pattern of fat mass (FM), LBM is found to be greater in boys than in girls across ages, i.e., from 9 to 18 years. The t-test also indicates that the differences between boys and girls are statistically significant in many of the age groups, except at 11 years of age (Table 3.16). The observed mean values at the age of 18 years are 46.14 kg in boys and 38.65 kg in girls, indicating that the LBM is greater in boys by about 7.49 kg when compared with girls.

Figure 3.32 shows the annual growth increment of boys and girls across ages. It reveals that the annual increment is higher in girls than in boys at the age of 11 years, and thereafter the latter surpasses the former till 18 years of age. The highest growth increment in boys occurs at the age of 13 years with the peak velocity of about 5.21 kg or 20.47% of the total increment (25.45 kg). On the other hand, highest growth increment in girls occurs at the age of 11 years with the peak velocity of about 5.20 or 26.46% of the total increment (19.65kg).

**Table 3.16.** Statistical constant of lean body mass (kg) of boys and girls.

| Age (years) | Boys | | | | Girls | | | | t-value |
|---|---|---|---|---|---|---|---|---|---|
| | N | Mean | SD | Increment | N | Mean | SD | Increment | |
| 9 | 36 | 20.69 | 2.34 | | 36 | 19.00 | 2.29 | | 3.10* |
| 10 | 38 | 22.60 | 3.26 | 1.91 | 37 | 19.43 | 3.24 | 0.43 | 4.22** |
| 11 | 36 | 26.14 | 4.44 | 3.54 | 39 | 24.63 | 2.63 | 5.20 | 1.81 |
| 12 | 36 | 28.67 | 4.48 | 2.53 | 38 | 26.68 | 3.01 | 2.05 | 2.26* |
| 13 | 38 | 33.88 | 5.34 | 5.21 | 38 | 29.68 | 4.26 | 3.00 | 3.79** |
| 14 | 36 | 37.63 | 6.75 | 3.75 | 40 | 32.31 | 4.69 | 2.63 | 4.04** |
| 15 | 37 | 40.43 | 3.71 | 2.80 | 35 | 34.72 | 3.66 | 2.41 | 6.52** |
| 16 | 37 | 44.00 | 3.92 | 3.57 | 39 | 37.17 | 3.01 | 2.45 | 8.40** |
| 17 | 35 | 45.77 | 4.62 | 1.77 | 37 | 38.56 | 3.24 | 1.39 | 7.84** |
| 18 | 37 | 46.14 | 4.97 | 0.37 | 36 | 38.65 | 3.07 | 0.09 | 7.72** |

*P> 0.005; **P> 0.000

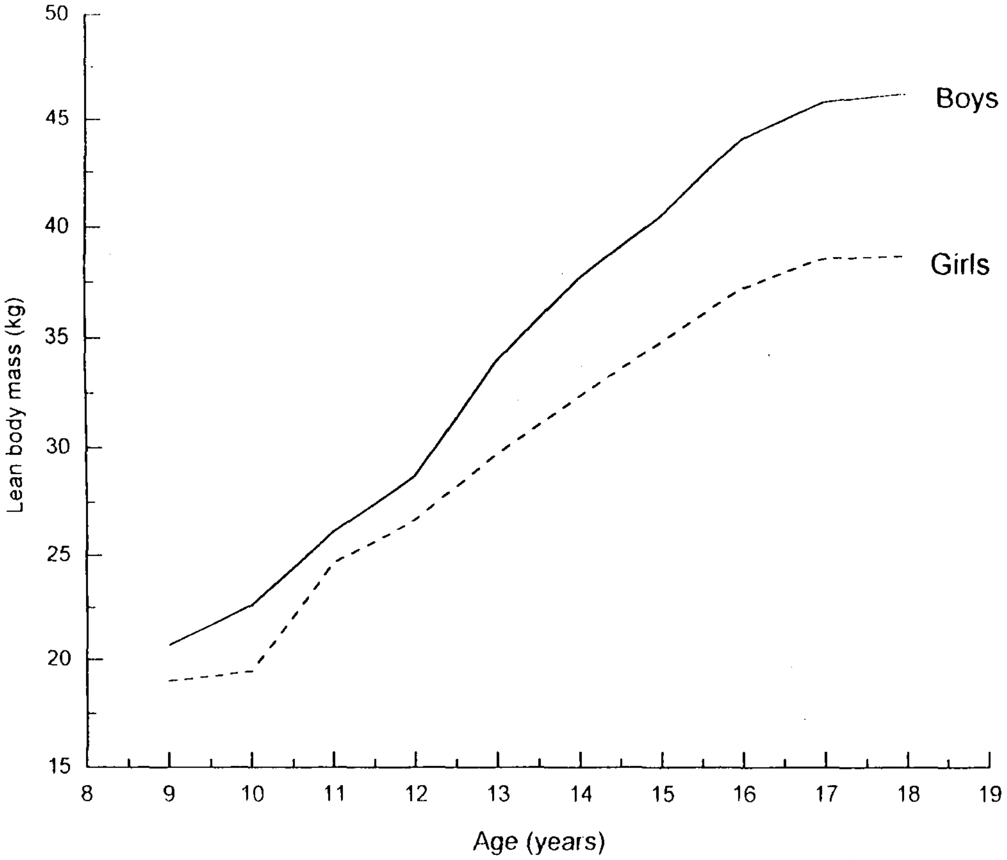


Figure 3.31. Distance curves for lean body mass

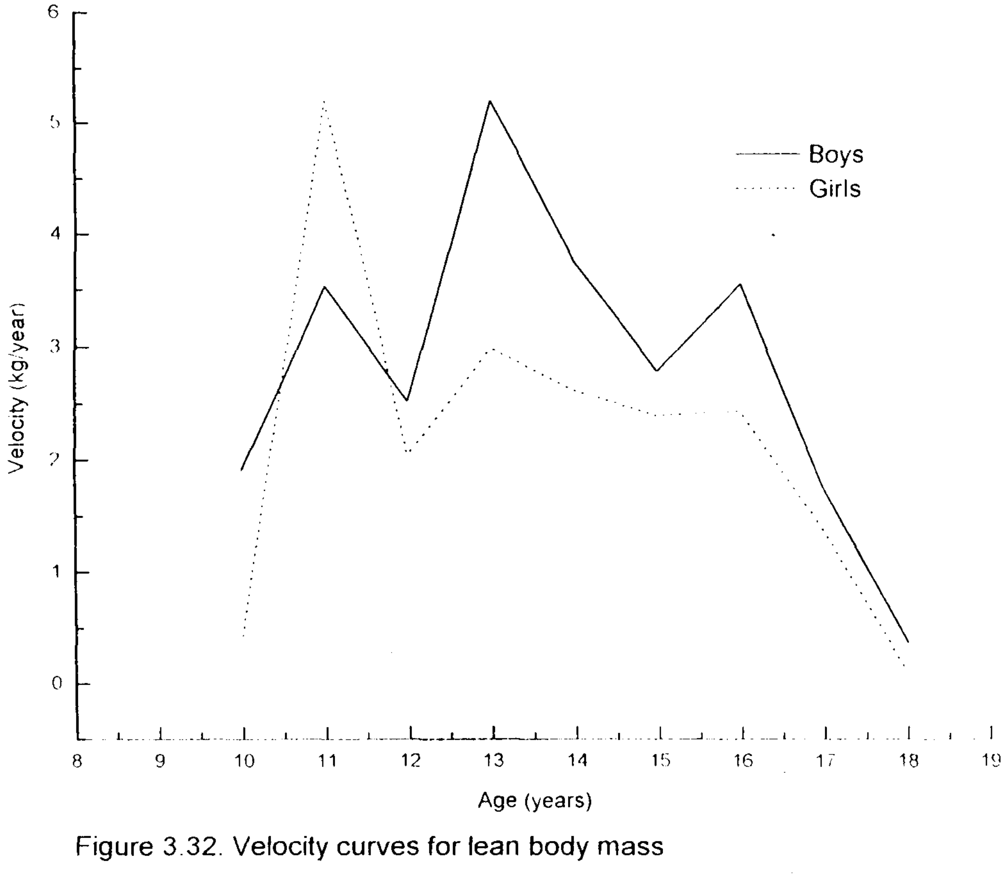


Figure 3.32. Velocity curves for lean body mass

# CHAPTER - IV
# NUTRITIONAL STATUS

In this chapter, we shall deal with the nutritional status of Lotha children taking into consideration some anthropometric indices like weight for age, height for age and body mass index, which are generally used as an indicators of nutritional status. We shall also look into how these anthropometric indices are correlated with body composition in terms of fat mass (FM) and lean body mass (LBM), or fat free mass (FFM). We shall also take into consideration certain clinical signs of undernutrition.

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## NUTRITIONAL STATUS

One of the major health problems in many developing countries is the widespread prevalence of under nutrition and infectious diseases (WHO, 1990). It is generally reported that the basic causes of under nutrition and infections in developing countries are poverty, poor hygienic conditions and little access to preventive and health care (Mitra, 1985; WHO, 1990). Hence, assessment of the nutritional status of population has attracted the attention of not only the nutritionists and other biological scientists, but also the economists and other social scientists with a view to understanding the health and socioeconomic status of the population (Osmani, 1992). Nutritional status is defined as a physical expression of the relationship between the nutrient intakes, or bio-availability of nutrients, and the physiological requirements of an individual (Brown, 1984). This physical expression of the relationship between nutrient intakes and physiological requirements of a person can be measured by a number of methods. Of different methods, anthropometry is one that is generally used for measuring the magnitude of under nutrition at both individual and population levels. Anthropometric measurements and indices like weight, height, mid upper arm circumference, skinfold thickness, weight for age, height for age, weight for height, body mass index, indices of upper arm circumference, etc., (WHO, 1963; Jelliffe, 1966; Frisancho, 1990) are used for assessing the nutritional status of children.

In the present study, we have taken three important anthropometric indices, i.e., weight for age, height for age, and body mass index for assessing the nutritional status of the children. We have also made an attempt to correlate these indices with certain indicators of body composition like fat mass, and LBM. Also, the study has taken into consideration certain clinical signs of undernutrition to support the findings on anthropometric measurements and indices. The findings of the study may be presented briefly as follows:

**Weight for age**

Weight for age, expressed as percentage or Z-score of individual weight to the median or 50th percentile of the international population references (i.e., NCHS growth references) is generally considered as one of the indicators of underweight. The means and standard deviations of the weight for age of children in the present study are given in Table 4.1. It is seen that the mean weight for age is higher in boys than in girls from 9 to 14 years of age, although the differences are not statistically significant except at the age of 10 years. After 14 years of age, the situation is reverse in which the mean values of weight for age are significantly higher in girls than in boys, except at the age of 15 years (Table 4.1).

Using LMS methods of Z-score (Kuczmarski *et al.*, 2000), the different grades of nutritional status according to weight for age is shown in Table 4.2 for both boys and girls. The cut-off points for the three different grades of nutritional status were followed according to those proposed by Visweswara Rao (1996). Table 4.2 shows that about 77.59% of boys and 83.47% of girls for all age groups are in the normal category (-2 to + 2 of Z-scores) of nutritional status. On the other hand, the prevalence of moderate (-2 to – 3 of Z-scores) and severe (below –3 of Z-scores) forms of undernutrition among boys is 18.58% and 3.83%, respectively. In the case of girls, these frequencies are found to be 13.60% and 2.93%, respectively. Considering the cut-off point of - 2 to + 2 Z-score, the estimated odds ratio (OR) is found to be 1.46 with 95% confidence interval (CI) of 1.01

and 2.11, which indicates that boys are likely to be 1.46 times underweight when compared with girls in this age group. This odds ratio is found to be significant at 5% level ($\text{Log}_e$ OR ± SE = 0.3784 ± 0.1872, $P < 0.05$), although the chi-square test does not reveal any significant difference between the two sexes for all age groups ($\chi^2 = 4.09$, DF = 2, $P>0.05$).

**Table 4.1.** Statistical constants of weight for age (% of NCHS references) for boys and Girls

| Age | Boys | | | Girls | | | |
|---|---|---|---|---|---|---|---|
| (yrs) | Number | Mean | SD | Number | Mean | SD | t-value |
| 9 | 36 | 82.74 | 9.82 | 36 | 82.18 | 10.39 | 0.24 |
| 10 | 38 | 80.48 | 11.62 | 37 | 73.84 | 12.44 | 2.39* |
| 11 | 36 | 83.42 | 14.12 | 39 | 82.85 | 8.88 | 0.21 |
| 12 | 36 | 81.83 | 12.92 | 38 | 80.32 | 9.13 | 0.58 |
| 13 | 38 | 85.44 | 13.89 | 38 | 81.83 | 12.30 | 1.20 |
| 14 | 37 | 85.52 | 15.33 | 40 | 84.10 | 12.11 | 0.45 |
| 15 | 36 | 83.06 | 7.68 | 35 | 86.13 | 9.30 | 1.52 |
| 16 | 37 | 83.38 | 7.67 | 39 | 89.43 | 7.43 | 3.45** |
| 17 | 35 | 81.10 | 7.95 | 37 | 90.29 | 7.89 | 4.99*** |
| 18 | 37 | 78.59 | 8.70 | 36 | 89.42 | 7.23 | 5.78*** |

**P 0.02, **P 0.001, ***P 0.000*

Table 4.2 also shows the percentage distribution of undernourished children according to three arbitrary age groups. In the age group 12 years and below, it is found that about 26.03% and 4.79% of boys, and 18.67% and 4.67% of girls are in the categories of moderate and severe forms of underweight, respectively. Thus, it indicates that the prevalence of undernutrition is higher in boys than in girls in this age group, despite the absence of statistical significance ($\chi^2 = 2.37$, DF = 2, $P>0.05$). Also, the OR is 1.46 (95% CI = 0.84-2.45), which indicates a marked difference in the prevalence of underweight of boys when compared with girls, although it is not statistically significant ($P > 0.05$). In the second age group, i.e., 13-15 years, the Table shows that none of the boys has suffered from severe form of underweight, but about 13.51% of them are moderately underweight. On the other hand, about 14.16% and 3.54% of girls are in the categories of moderate and severe forms of underweight. Therefore, the prevalence of underweight in this age group is higher in girls than in boys, although the difference is not statistically significant ($\chi^2 = 0.74$, DF = 1, $P>0.05$). The same is true with respect to OR which is about 1.38 with 95% CI of 0.67 and 2.86 ($P > 0.05$). In the last age group. i.e., 16-18 years, it can be observed from the Table that about 13.76% and 6.42% of boys are in the moderate and severe categories of underweight, respectively. Whereas in girls, there is no case of severe grade of underweight, although about 6.25% of them are moderately undernourished. Thus, unlike in the age group 13-15 years, the prevalence of undernutrition in the age group 16-18 years is higher in boys than in girls, and the difference is statistically significant ($\chi^2 = 9.41$, DF = 1, $P< 0.002$). Also, the estimated OR is found to be quite high, that is, boys are likely to be about 3.79 (95% CI = 1.55 - 9.29) times higher in the prevalence of underweight when compared with girls, which is highly significant ($\text{Log}_e\text{OR} \pm \text{SE} = 1.33 \pm 0.4575$, $P < 0.01$).

Besides sex variation in the distribution of low weight for age mentioned above, Table 4.2 further shows that the frequencies of underweight (i.e., moderate plus severe forms) in boys for the age groups $\leq 12$, 13-15 and 16-18 years are 30.82%, 13.51% and 20.18%, respectively. While in the case of girls, these frequencies are 23.34%, 17.70% and 6.25%, respectively. Thus, it indicates that the prevalence of underweight is higher in the lower age groups especially in the case of girls. In other words, the nutritional status seems to be better in the higher age groups as compared with the lower age groups. The Pearson correlation coefficient (r) between age and weight Z-score is found to be 0.309, $P < 0.01$ in girls and 0.173, $P < 0.05$ in boys. The chi-square test also indicates that the differences in the distribution of undernourished individuals between age groups are highly significant in both boys ($\chi^2=11.31$, DF = 2, $P<0.003$) and girls ($\chi^2=13.72$, DF = 2, $P<0.001$).

**Table 4.2.** Nutritional status according to weight for age (based on NCHS references)

| Nutritional status | Boys (N =366) | | Girls (N = 375) | |
|---|---|---|---|---|
| | Number | Percent | Number | Per cent |
| *≤ 12 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 101 | 69.18 | 115 | 76.66 |
| Moderate (-2 to -3 Z-score) | 38 | 26.03 | 28 | 18.67 |
| Severe (< -3 Z-score) | 7 | 4.79 | 7 | 4.67 |
| Total | 146 | 100.00 | 150 | 100.00 |
| $\chi^2 = 2.37$, DF = 2, $P > 0.05$, OR (95% CI) = 1.46 (0.84-2.45) | | | | |
| *13 to 15 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 96 | 86.49 | 93 | 82.30 |
| Moderate (-2 to -3 Z-score) | 15 | 13.51 | 16 | 14.16 |
| Severe (< -3 Z-score) | 0 | 0.00 | 4 | 3.54 |
| Total | 114 | 100.00 | 113 | 100.00 |
| $\chi^2 = 0.74$, DF = 1, $P > 0.05$ OR (95% CI) = 1.38 (0.67-2.86) | | | | |
| *16 to 18 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 87 | 79.82 | 105 | 93.75 |
| Moderate (-2 to -3 Z-score) | 15 | 13.76 | 7 | 6.25 |
| Severe (< -3 Z-score) | 7 | 6.42 | 0 | 0.00 |
| Total | 109 | 100.00 | 112 | 100.00 |
| $\chi^2 = 9.41$, DF = 1, $P < 0.002$, OR (95% CI) = 3.79 (1.55-9.29)** | | | | |
| *9 to 18 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 284 | 77.59 | 313 | 83.47 |
| Moderate (-2 to -3 Z-score) | 68 | 18.58 | 51 | 13.60 |
| Severe (< -3 Z-score) | 14 | 3.83 | 11 | 2.93 |
| Total | 366 | 100.00 | 375 | 100.00 |
| $\chi^2 = 4.09$, DF = 2, $P > 0.05$, OR (95% CI) = 1.46 (1.01-2.11)* | | | | |

* $P < 0.05$, **$P < 0.01$ OR = Odds ratio, CI = 95% confidential interval

Therefore, the present findings on the percentage distribution of underweight children indicate that the differences between the sexes are not significant, except in the age groups 10 and 16-18 years which indicates that the prevalence of undernutrition is more in girls than in boys. With respect to age, it indicates that the prevalence of undernutrition is much higher in the lower age groups, and the differences are highly significant for both boys and girls.

### Height for age

In the present study, height for age is expressed as percentage and Z-score of individual height to the median or 50th percentile of the NCHS population references. This index is considered as one of the best indicators of stunting or short stature of individuals due to undernutrition. The means and standard deviations of height for age (%) of both boys and girls are presented in Table 4.3. It reveals that the mean values are more or less similar at the age of 9 years for both boys and girls. Thereafter, girls are higher in mean values as compared with boys from 10 to 12 and from 15 to 18 years of age. However, the t-test indicates that girls are significantly higher in mean values only from 16 to 18 years (Table 4.3). As for the boys, Table 4.3 shows that they are significantly higher than girls at the age of 13 years. Nevertheless, it is obvious from Table 4.3 that girls are by and large better than boys in respect of height for age especially after the age of 14 years.

Table 4.4 shows the nutritional status of both boys and girls according to height for age, following the cut-off levels proposed by Visweswara Roa (1996). It is seen that the proportions of boys with normal, moderate, and severe forms of growth retardation are 81.69%, 17.49% and 0.82%, respectively. In the case of girls, these frequencies are found to be 75.47%, 20.53% and 4%, respectively. Thus, it indicates that the overall prevalence of undernutrition for all age groups is higher in girls than in boys, and it is statistically significant ($\chi^2 = 9.53$, DF =2, $P<0.05$). The estimated OR is found to be 1.45 (95% CI = 1.02-2.08), which is also significant at 5% level ($\text{Log}_e\text{OR} \pm \text{SE} = 0.372 \pm 0.181$, $P < 0.05$).

**Table 4.3.** Statistical constants of height for age (% of NCHS references) for boys and Girls

| Age | Boys | | | Girls | | | |
|---|---|---|---|---|---|---|---|
| (yrs) | Number | Mean | SD | Number | Mean | SD | t-value |
| 9 | 36 | 91.22 | 4.53 | 36 | 91.12 | 4.30 | 0.10 |
| 10 | 38 | 91.00 | 5.04 | 37 | 91.97 | 3.90 | 0.93 |
| 11 | 36 | 92.46 | 4.41 | 39 | 93.74 | 3.70 | 1.37 |
| 12 | 36 | 92.13 | 3.39 | 38 | 93.44 | 4.27 | 1.45 |
| 13 | 38 | 95.02 | 3.44 | 38 | 92.93 | 3.13 | 2.78* |
| 14 | 37 | 94.66 | 3.82 | 40 | 93.21 | 3.08 | 1.83 |
| 15 | 36 | 93.41 | 2.28 | 35 | 94.17 | 2.98 | 1.20 |
| 16 | 37 | 93.08 | 2.76 | 39 | 95.27 | 2.53 | 3.55** |
| 17 | 35 | 92.98 | 1.79 | 37 | 95.99 | 2.56 | 5.81*** |
| 18 | 37 | 92.59 | 2.52 | 36 | 96.13 | 2.28 | 6.30*** |

*P < 0.007; **P < 0.001; ***P < 0.000

Table 4.4 further shows the percentage distribution of growth retardation in boys and girls according to three age groups arbitrarily classified as in the case of weight for age. In the first age group (i.e., ≤ 12 years), the frequencies of moderate and severe forms of stunting/growth retardation in boys are about 14.38% and 2.05%, respectively, whereas in girls these frequencies are found to be about 27.34% and 7.33%, respectively. Thus, the prevalence of stunting in this age group is significantly higher in girls than in boys ($\chi^2$ =13.60, DF =2, P<0.05). Also, the estimated OR (2.70, 95% CI = 1.55 - 4.66) is found to be highly significant ($\text{Log}_e\text{OR} \pm \text{SE} = 0.992 \pm 0.282$, P < 0.001). In the second age group (i.e., 13-15 years), Table 4.4 shows that none of the boys has suffered from severe form of stunting, but about 9.91% of them are moderately short in stature. In the case of girls, the frequencies of moderate and severe forms of stunting are about 23.89% and 2.65%, respectively. Accordingly, like the case of the first age group, the frequency of low height for age is significantly higher in girls than in boys in this age group

($\chi^2$ = 10.37, DF = 1, P< 0.001). The estimated OR shows that the prevalence of low height for age in girls are about three times higher than boys in this age group with 95% CI of 1.55 and 6.96 ($Log_e$OR ± SE = 1.189 ± 0.383, P < 0.002). Also, there is no case of severe form of stunting in boys aged 16-18 years, but about 29.36% of them are found to be moderately undernourished. With regard to girls, the moderate and severe forms of stunting are found to be about 8.04% and 0.89%, respectively. Thus, unlike in the other age groups, the frequency of low height for age in the age group 16-18 years is significantly higher in boys than in girls ($\chi^2$ = 14.98, DF = 1, P< 0.000). The calculated OR (4.24, 95% CI = 1.97 - 9.12) is also found to be highly significant ($Log_e$OR ± SE = 1.444 ± 0.393, P < 0.002). It may be noted here that this finding seems to be consistent with those results presented in Table 4.3, which indicate that the girls are by and large better in height for age when compared with the boys after the age of 14 years.

With regard to the age group differences for each sex, it is found that about 16.42%, 9.91% and 29.36% of boys in the age groups ≤ 12, 13-15 and 16-18 years, respectively, are low in height for age (i.e., moderate plus severe forms of undernutrition). In girls, these frequencies are found to be 34.66%, 26.54% and 8.93% respectively. Thus, it indicates that the prevalence of undernutrition is more in the lower age groups in girls, which is similar to that observed with respect to weight for age. The situation is, however, different in the case of boys, which shows that the percentage distribution of boys with low height for age is higher in the age group 16-18 years when compared with the lower age groups. The Pearson correlation coefficient (r) between age and height Z-score is also positively significant in the case of girls (r = 0.311, P < 0.01) and negatively significant in the case of boys (r = -0.493, P < 0.01). It may be noted that the chi-square test also indicates the significant differences between age groups for boys ($\chi^2$ = 14.48, DF = 2, P < 0.001) and girls ($\chi^2$ = 23.30, DF = 2, P < 0.000). Thus, it is obvious that girls in the lower age groups are higher in the frequency of low height for age as compared with those in higher age groups, but the situation is reverse in the case of boys. In other words, the frequency of higher Z-scores of height for age increases with age in girls, but it decreases as age advances in the case of boys.

**Table 4.4.** Nutritional status according to height for age (based on NCHS references)

| | Boys (N =366) | | Girls (N = 375) | |
|---|---|---|---|---|
| Nutritional status | Number | Per cent | Number | Per cent |
| *≤ 12 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 122 | 83.56 | 98 | 65.34 |
| Moderate (-2 to -3 Z-score) | 21 | 14.38 | 41 | 27.33 |
| Severe (< -3 Z-score) | 3 | 2.05 | 11 | 7.33 |
| Total | 146 | 99.99 | 150 | 100.00 |
| $\chi^2 = 13.6$, DF = 2, $P < 0.05$ OR (95% CI) = 2.70 (1.55-4.66)*** | | | | |
| *13 to 15 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 100 | 90.09 | 83 | 73.45 |
| Moderate (-2 to -3 Z-score) | 11 | 9.91 | 27 | 23.89 |
| Severe (< -3 Z-score) | 0 | 0.00 | 3 | 2.65 |
| Total | 111 | 100.00 | 113 | 99.99 |
| $\chi^2 = 10.37$, DF = 1, $P < 0.001$ OR (95% CI) = 3.29 (1.55-6.96)** | | | | |
| *16 to 18 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 77 | 70.64 | 102 | 91.07 |
| Moderate (-2 to -3 Z-score) | 32 | 29.36 | 9 | 8.04 |
| Severe (< -3 Z-score) | 0 | 0.00 | 1 | 0.89 |
| Total | 109 | 100.00 | 112 | 100.00 |
| $\chi^2 = 14.98$, DF = 1, $P < 0.000$ OR (95% CI) = 4.24 (1.97-9.12)* | | | | |
| *9 to 18 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 299 | 81.69 | 283 | 75.47 |
| Moderate (-2 to -3 Z-score) | 64 | 17.49 | 77 | 20.53 |
| Severe (< -3 Z-score) | 3 | 0.82 | 15 | 4.00 |
| Total | 366 | 100.00 | 375 | 100.00 |
| $\chi^2 = 9.53$, DF = 2, $P < 0.05$ OR (95% CI) = 1.45 (1.02-2.08)* | | | | |

*$P < 0.05$, **$P < 0.002$, ***$P < 0.001$

## Body mass index

Body mass index (BMI) is generally considered as the best indicator of body fat mass, or thinness due to chronic energy deficiency (Ferro-Luzi *et al.*, 1992; WHO, 1995). This anthropometric index is expressed as weight in kilogram divided by height-square in meter, and it is independent of age. In the present study, Table 4.5 shows the means and standard deviations of the BMI for age (percentage of BMI to the median of NCHS growth references) for both boys and girls. It indicates that boys are higher in mean values from 9 to 13 years of age, and thereafter the mean values are higher in girls till the age of 18 years. However, the t-test indicates that boys are significantly higher in BMI only at the ages of 10 and 12 years. On the other hand, the mean values of BMI for age are significantly higher in girls than in boys from the age of 16 onwards (Table 4.5).

**Table 4.5.** Statistical constants of body mass index (% of NCHS references) for boys and girls

| Age | Boys | | | Girls | | | |
|---|---|---|---|---|---|---|---|
| (yrs) | Number | Mean | SD | Number | Mean | SD | t-value |
| 9 | 36 | 98.66 | 9.87 | 36 | 98.54 | 7.02 | 0.06 |
| 10 | 38 | 96.25 | 7.14 | 37 | 88.35 | 9.86 | 3.98**** |
| 11 | 36 | 97.79 | 10.91 | 39 | 97.17 | 9.00 | 0.27 |
| 12 | 36 | 98.33 | 14.02 | 38 | 93.51 | 5.23 | 1.98* |
| 13 | 38 | 96.31 | 12.01 | 38 | 93.96 | 9.89 | 0.93 |
| 14 | 36 | 95.29 | 13.03 | 40 | 95.51 | 9.74 | 0.08 |
| 15 | 37 | 93.73 | 6.95 | 35 | 96.47 | 6.62 | 1.70 |
| 16 | 37 | 94.55 | 6.68 | 39 | 98.24 | 4.69 | 2.75** |
| 17 | 35 | 92.73 | 8.40 | 37 | 97.49 | 5.92 | 2.85** |
| 18 | 37 | 90.80 | 8.77 | 36 | 95.94 | 4.29 | 3.17*** |

*$P < 0.05$; **$P$ 0.007; ***$P < 0.002$; ****$P < 0.000$

The nutritional status of both boys and girls according to BMI Z-score of the NCHS growth references is given in Table 4.6. The cut-off levels taken are followed as proposed by Visweswara Rao (1996). Considering all age groups, the Table shows that about 91.80% of boys and 94.93% of girls are in the normal grade of nutritional status. In other words, the frequencies of moderate and severe grades of CED in boys are about 6.56% and 1.64%, respectively. While in girls, these frequencies are about 3.73% and 1.34%, respectively. Thus, the prevalence of CED is higher in boys (8.20%) than in girls (5.07%), although it is statistically insignificant ($\chi^2$ = 3.19, DF = 2, P>0.05). The estimated OR is also not statistically significant ($\mathrm{Log_e OR} \pm \mathrm{SE} = 0.512 \pm 0.486$, P > 0.05), although it indicates that boys are likely to be about 1.67 (95% CI = 1.03-2.71) times higher in the prevalence of CED when compared with girls.

Table 4.6 also shows the percentage distribution of undernutrition in boys and girls according to three age groups classified arbitrarily. In the first age group (i.e., ≤ 12 years), the Table shows that no boys has suffered from the severe grade of CED, but about 6.85% of them are in the moderate form of CED. However, the prevalence of moderate and severe grades of CED in girls is about 5.33% and 2.67%, respectively. So, the prevalence of CED is higher in girls (8%) than in boys (6.85%), despite the absence of statistical significance ($\chi^2$ = 0.14, DF = 1,P>0.05). As for the second age group (13-15 years), about 4.42% and 0.88% of girls and about 8.11% and 1.80% of boys have suffered from moderate and severe grades of CED, respectively. Thus, unlike in the first age group, it indicates that the prevalence of CED is higher in boys than in girls in this age group, although the differences are not statistically significant ($\chi^2$ = 1.69, DF = 1, P> 0.05). In the third age group (16-18 years), the Table shows that in the case of boys the frequencies of moderate and severe forms of CED are about 4.59% and 3.67%, respectively. On the other hand, none of the girls has suffered from the severe form of CED, but about 0.89% of them are in moderate grade of CED. Thus, in this age group also, the prevalence of CED is higher in boys than in girls, and it is statistically significant ($\chi^2$ = 6.93, DF = 1, P<0.01). With regard to the estimated OR, Table 4.6 shows that it is not statistically significant for all the age groups, although the chi-square test indicates that the difference between the sexes is significant in the age group 16-18 years.

It may also be noted that like in the case of height for age, the prevalence of CED in boys is higher in the higher age groups. It is found to be 6.85%, 9.91% and 8.26%, respectively for the age groups ≤ 12, 13-15 and 16-18 years. On the contrary, the girls in the lower age groups are found to have higher frequencies of CED, that is, about 8.0%, 5.31% and 0.89% of them suffered from CED in the age groups ≤ 12, 13-15 and 16-18 years, respectively. The differences between age groups are significant in the case of girls ($\chi^2 = 6.76$, DF = 2, $P < 0.05$), but it is not significant in boys ($\chi^2 = 0.79$, DF = 2, $P > 0.05$). The Pearson correlation coefficient between age and BMI Z-score is also positively significant in the case of girls ($r = 0.188$, $P < 0.01$) and negatively significant in the case of boys ($r = -0.156$, $P < 0.01$). Thus, it indicates that the number of individuals with higher Z-scores of BMI increases with age in girls, but tends to decrease with age in the case of boys.

In view of the results presented above, it is obvious that there are certain differences between sexes and age groups in respect of the prevalence of undernutrition based on weight, height and BMI for age. With regard to index weight for age, it is observed that the prevalence of underweight is about 1.46 times higher in boys (22.41%) than in girls (16.53%) and such a difference is statistically significant. It is found that this sex difference in weight for age is mainly attributed by the differences in the age group 16-18 years. In other words, the differences between the sexes in respect of the prevalence of underweight are not statistically significant in the lower age groups ≤ 12 and 13-15 years. With respect to differences between age groups within sex, the present findings indicate that the nutritional status according to weight for age is better in the higher age groups as compared with the lower age groups. This is true for both boys and girls.

**Table 4.6.** Nutritional status according to BMI for age (based on NCHS references)

| Nutritional status | Boys (N =366) | | Girls (N = 375) | |
|---|---|---|---|---|
| | Number | Per cent | Number | Per cent |
| *≤ 12 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 136 | 93.15 | 138 | 92.0 |
| Moderate (-2 to -3 Z-score) | 10 | 6.85 | 8 | 5.33 |
| Severe (< -3 Z-score) | 0 | 0.00 | 4 | 2.67 |
| Total | 146 | 100.00 | 150 | 100.00 |
| $\chi^2 = 0.14$, DF = 1, $P > 0.05$, OR (95% CI) = 1.18 (0.62-2.23) | | | | |
| *13 to 15 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 100 | 90.09 | 107 | 94.69 |
| Moderate (-2 to -3 Z-score) | 9 | 8.11 | 5 | 4.42 |
| Severe (< -3 Z-score) | 2 | 1.80 | 1 | 0.88 |
| Total | 111 | 100.00 | 113 | 99.99 |
| $\chi^2 = 1.69$, DF = 1, $P > 0.05$, OR (95% CI) = 1.96 (1.22-4.67) | | | | |
| *16 to 18 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 100 | 91.74 | 111 | 99.11 |
| Moderate (-2 to -3 Z-score) | 5 | 4.59 | 1 | 0.89 |
| Severe (< -3 Z-score) | 4 | 3.67 | 0 | 0 |
| Total | 109 | 100.00 | 112 | 100.00 |
| $\chi^2 = 6.93$, DF = 1, $P < 0.008$, OR (95% CI) = 9.99 (1.37-72.95) | | | | |
| *9 to 18 years* | | | | |
| Normal (≤ -2 to +2 Z-score) | 336 | 91.80 | 356 | 94.93 |
| Moderate (-2 to -3 Z-score) | 24 | 6.56 | 14 | 3.73 |
| Severe (< -3 Z-score) | 6 | 1.64 | 5 | 1.33 |
| Total | 366 | 100.00 | 375 | 99.99 |
| $\chi^2 = 3.19$, DF = 2, $P > 0.05$, OR (95% CI) = 1.67 (1.03-2.71) | | | | |

The findings with respect to height for age is somewhat different from those on weight for age as mentioned above. It is observed that the prevalence of low height for age is higher significantly in girls (24.53%) than in boys (18.31%). The estimated OR for all age groups indicates that girls are about 1.45 times higher than boys in the prevalence of low Z-score of height for age. This higher frequency of low Z-score in girls is found to be statistically significant in the lower age groups (≤ 12 and 13-15 years), but in the age group 16-18 years the prevalence is significantly higher in boys than in girls. Moreover, it is also observed that the prevalence of low height for age in girls is similar to low weight for age, that is, it is higher in the lower age groups, but the situation is reverse in the case of boys. As regards BMI, which is indicator of CED, there is no significant difference between boys (8.20%) and girls (5.06%), and the nutritional status is also better than that indicated by weight for age and height for age. In the case of girls, it is found that the frequency of higher Z-score for BMI is positively correlated with age, while in boys it is negatively correlated.

To sum up our description of the anthropometric indices of nutrition, it is found that the prevalence of undernutrition in both boys and girls for all age groups is higher in weight for age (19.43%) and height for age (21.46%) when compared with that indicated by BMI (6.61%). It is also seen that the prevalence of low height for age or stunting is higher in girls than in boys, especially in the lower age groups. These problems will be discussed in the next Chapter. But it seems that the present population is moderate in terms of the severity of undernutrition, according to the classificatory criteria proposed by Gorstein *et al.*, (1994), which are given in Table 4.7.

**Table 4.7.** Criteria for assessing severity of undernutrition in a population*

| Indicator | Prevalence (%) | | | |
|---|---|---|---|---|
| | Low | Moderate | High | Very high |
| Underweight | < 10 | 10.0 – 19.9 | 20.0 - 29.9 | ≥ 30.0 |
| Stunting | < 20 | 20.0 – 29.9 | 30.0 - 39.9 | ≥ 40.0 |
| Wasting | < 5 | 5.0 – 9.9 | 10.0 – 14.9 | ≥ 15.0 |

* As proposed by Gorstein *et al.*, (1994)

## CLINICAL OBSERVATIONS

Clinical observation and/or examination of the symptoms/signs of various nutrient deficiencies is one of the important methods for the assessment of the nutritional status of an individual, or a population (Kaul and Nyamongo, 1990). Clinical observations on lips, eyes, tongue, teeth and gums, skin and skeleton were carried out according to the methods described in Jelliffe (1966) and Latham (1979). Since the observer is not well trained in examining the clinical signs and symptoms of undernutrition, only few selected clinical symptoms and signs that could be easily examined with our naked eyes were taken into consideration. The results of the present study may be presented as follows:

### Clinical symptoms of vitamin A deficiency

Children exposed with the signs of Bitot's spot and skin xerosis has been considered as clinical signs of vitamin A deficiency. It is found that all two types of clinical signs of vitamin A deficiency are significantly higher in boys than in girls (Table 4.7). The most common sign of vitamin A deficiency is that of skin xerosis, which is characterized by general dryness of skin with branny desquamation. Of course, this skin xerosis is difficult to examine since it is also associated with other environmental factors like dirt, lack of washing, dry, hot and windy climatic conditions (Jelliffe, 1966), so our report here may not reflect the true prevalence.

**Table 4.8.** Clinical signs of vitamin A deficiency in boys and girls.

| Deficiency symptoms. | Boys (N = 366) | | Girls (N = 375) | | $\chi^2$-value |
|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | |
| Bitot's spot | 33 | 9.02 | 18 | 4.80 | 5.14, $P < 0.05$ |
| Skin xerosis | 156 | 42.62 | 118 | 31.47 | 9.89, $P < 0.002$ |

**Clinical signs of other nutrient deficiencies**

The clinical signs like angular stomatitis (sodden and excoriated lesions associated with fissuring at the angles of the mouth), cheilosis (a lesion characterized by vertical fissuring, later complicated by redness, swelling and ulceration of lips) and vascularization of the cornea (characterized by invasions of all quadrants or the whole of the periphery of the cornea by fine capillary blood vessels) is a condition due to the lack of riboflavin, a component of vitamin B. Scarlet and raw tongue, which is characterized by bright red in colour of tongue, usually with slight atrophic, denuded and very painful, is due to the lack of riboflavin, niacin, folic acid and vitamin $B_{12}$. Atrophic papillae (characterized by disappearance of filiform papillae, giving the tongue an extremely smooth appearance) is present due to inadequacy of the component of riboflavin, niacin and iron. Thus, in the present study, clinical symptoms like angular stomatitis, cheilosis, vascularization of the cornea, scarlet and raw tongue, and atrophic papillae were considered to be associated with vitamin B deficiency.

It is seen from Table 4.8 that the prevalence of cheilosis is about 17.76% in boys and 13.07% in girls, while angular stomatitis occurs in about 12.84% of boys and 7.73% of girls. Atrophic papillae is present in about 6.56% of boys and 4.8% of girls, while the prevalence of scarlet and raw tongue is about 3.55% of boys and 3.47% of girls. On the other hand, the frequency of the vascularization of the cornea is about 3.55% in boys and 3.20% in girls. Although the prevalence of these different signs of vitamin B deficiency is higher in boys than in girls, the chi-square test indicates that the sex difference is statistically significant only in respect of angular stomatitis.

**Table 4.9.** Percentage distribution of children with clinical signs of mineral, niacin and other vitamin deficiencies.

| Deficiency symptoms | Boys (N = 366) | | Girls (N = 375) | | $\chi^2$-value |
|---|---|---|---|---|---|
| | Number | Percent | Number | Percent | |
| Cheilosis | 65 | 17.76 | 49 | 13.07 | 3.13, P > 0.05 |
| Angular Stomatitis | 47 | 12.84 | 29 | 7.73 | 5.25, P < 0.02 |
| Atrophic Papillae | 24 | 6.56 | 18 | 4.8 | 1.07, P > 0.05 |
| Scarlet and RT* | 13 | 3.55 | 13 | 3.47 | 0.004, P > 0.05 |
| Vasc. of Cornea** | 13 | 3.55 | 12 | 3.2 | 0.07, P > 0.05 |
| Spongy & Bleeding Gum | 47 | 12.84 | 18 | 4.80 | 14.96, P < 0.000 |
| Bow legs | 10 | 2.73 | 7 | 1.87 | 0.62, P > 0.05 |

* Raw tongue
**Vascularization of the cornea

Table 4.8 also shows that the prevalence of spongy and bleeding gum is about 12.84% in boys and 4.8% in girls. Like the other nutrient deficiencies, the occurrence of this sign of vitamin C deficiency is more in boys than in girls, and it is highly significant ($\chi^2$ = 14.96, P < 0.000). Another clinical signs considered in the present study are those of knock-knees and bow-legs, which are classified as the signs of vitamin D deficiency. This is also known as rickets. Table 4.8 further shows that the prevalence of bow-legs is in about 2.73°% in boys and 1.87% in girls.

With regard to the findings given in the present Chapter, it is obvious that the prevalence of stunting is more than that of wasting. In other words, the prevalence of undernutrition according to height for age is higher than that according to BMI for age, although the present population is moderate in degree of severe undernutrition. It is also found that the prevalence of stunting is higher in girls than in boys especially in the lower age groups. On the other hand, the prevalence of clinical signs of nutrient deficiencies seems to be higher in boys than in girls. We shall discuss these problems in the next Chapter.

# CHAPTER - V

# DISCUSSION

In this chapter, we shall discuss the present findings on the growth and nutritional status of the Lotha boys and girls in relation to some populations in Northeast India like the Khasi of Meghalaya, Meitei of Manipur and Assamese Muslims of Assam. We shall also take into consideration National growth standards of the Indian Council of Medical Research (ICMR) and the International growth references of the U.S. National Center for Health Statistics (NCHS).

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## GROWTH PATTERN

In Chapter III, we have presented our findings on growth pattern of the Lotha adolescent children in respect of some selected anthropometric measurements keeping in view the sex and age variation in growth pattern. In discussing the growth pattern, or growth characteristics of the Lotha children, we shall restrict to linear measurements particularly to lower and upper extremities as has been generally done in other populations for comparative purposes (Tanner, 1978; Dasgupta *et al.*, 1997; Begum and Choudhury, 1999, Khongsdier and Mukherjee, 2003).

It is observed that there are no significant differences between boys and girls in respect of body weight, although the boys are heavier especially after the age of 13 years. The estimated adult weight according to the PB1 model was about 54.02 kg in boys and 52.52 kg in girls, which was about 81.71% and 94.27% respectively of the $50^{th}$ percentile of the NCHS growth references (Kuczmarski *et al.*, 2000) at the age of 18 years. Thus, although the estimated adult body weight is about 1.50 kg heavier in boys than in girls, the former are much lighter than the latter at the age of 18. Nevertheless, the present findings indicate that there are no significant differences between sexes with regard to body weight. Also, the estimated age at peak weight velocity was more or less similar in boys (13.04 years) and in girls (12.93 years) with the peak weight velocity of 4.24 kg/year and 3.94 kg/year, respectively.

With respect to height, it is found that both boys and girls are more or less same in height from 9 to 10 years of age, but girls are significantly taller than boys from 11 to 12 years of age, thereafter boys are significantly taller than girls across ages (Table 3.2). The estimated adult height according to PB1 model is about 163.47 cm for boys, which is about 0.68 cm taller than the observed value at the age of 18 years. On the other hand, the estimated adult height for the girls is about 158.68 cm, which is 1.95 cm taller than the observed value at 18 years of age. This indicates that both boys and girls still continue to grow in height, especially in girls. The present findings among the Lotha children are, therefore, different from those observed among the Assamese children (Begum and Choudhury, 1999) and Khasi boys (Khongsdier and Mukherjee, 2003), which showed that adult size had been reached by the age of 18 years. Of course, human growth does not cease around the age of 18 years, but it may continue for about a decade or more. Garn (1980) has suggested that there may be a gain in stature of as much as 8 cm from 18 to 28 years of age. Tanner (1978) is of the opinion that the vertebral column continues to grow until about 30 years of age, leading to an increase of 3 to 5 mm in height on average and for practical purposes, the defined age of growth cessation should be about 98% of the estimated adult height. Thus, from this point of view, we may conclude that, for practical purposes, the Lotha boys and girls reached their adult height by the age of 18 years, although growth in height may still continue at a lesser rate.

The estimated age at peak height velocity is 13.01 years for boys and 11.00 years for girls with mean height of 143.90 cm and 131.86 cm, respectively (Table 3.2). Therefore, the adolescent growth spurt occurs about 2 years earlier in girls than in boys.

It is observed that the velocity (annual increment) is higher in girls from 9 to about 11 years of age with a peak velocity of 6.48 cm/year, and thereafter it is higher in boys till the age of 17 years with a peak velocity of 6.98 cm/year. Thus, the larger stature in boys when compared with girls could be largely attributed by the greater rate of growth in the former during the adolescence, that is, from 11 years onwards. Begum and Choudhury (1999) have reported that the age at peak velocity for height derived from the PB1 fits was 13.4 years for boys and 11.4 years for girls among the Assamese Muslims. Thus, the Lotha children are more or less similar in age at peak velocity for height to the Assamese Muslim children of Assam.

In the case of the upper extremity or sitting height, it is found that the sex difference is by and large similar to that for height. It is shown, in Chapter III, that the differences between boys and girls are not statistically significant from 9 to 13 years of age, but boys are significantly taller in sitting height from 14 years onwards. The estimated adult size, according to the PB1 model, is 85.74 cm for boys and 84.79 cm for girls. It is found that boys have reached their adult sitting height at about 18 years of age, but girls might still continue to grow. Like in the case of height, the estimated age at peak velocity is higher in boys (13.03 years) than in girls (11.03 years). Thus, the present analysis indicates that the adolescent growth spurt occurs earlier in girls as compared with boys, and the higher sitting height in boys at 18 years of age is largely due to their higher growth rate from 11 to 16 years of age. It is reported that among the Assamese children, the peak velocity was about 13.9 years for boys and 11.6 years for girls (Begum and Choudhury, 1999), whereas among the Khasi girls it is reported to be 13.01 years (Mukherjee, 2002). Thus, it indicates that the peak velocity for both boys and girls of the present population is comparable to that reported for the Assamese boys and girls.

Like in the case of trunk height or sitting height, the lower extremity or subischial length (stature minus sitting height) is significantly higher in boys from 14 years onwards, although girls are significantly higher at the age of 12 years. It is shown in Chapter III that both boys and girls attained their adult size of subischial length by and large at the age of 18 years. This also indicates that the lower extremity reached its adult size earlier than the upper extremity as commonly observed in other populations (Tanner, 1978; Dasgupta and Das, 1997; Begum and Choudhury, 1999). With regard to age at peak velocity, it is found that it is similar to height and sitting height in the case of boys (12.96 years). But girls (10.04 years) experienced about 3 years earlier than boys. It is also observed that the velocity is higher in girls from 9 to about 11 years of age, and thereafter it is much higher in boys till the age of 18 years. Thus, the higher subischial length in boys is due to their greater velocity from the age of 12 onwards.

## GROWTH STATUS IN RELATION TO OTHER POPULATIONS

In the present study, by "growth status" we mean the growth pattern of children in relation to their coevals at a given age in other populations, or in relation to the recommended growth references and/or standards. In Chapter I, we have pointed out that growth is a good indicator of nutritional status, which is greatly influenced by socioeconomic factors of a population, although it is also influenced by genetic factors. In other words, growth of children can also be regarded as a good indicator of socioeconomic status of a given population since socioeconomic factors play a very important role in regulating human nutrition, which is very important for normal growth and development (WHO Working Group, 1986). Thus, in this section of the present Chapter, we shall look into the growth status of the Lotha children with a view to understand the population variation, which may reflect the socioeconomic conditions of the study population. In this regard, we shall take into consideration only some important anthropometric variables like weight, height, head circumference, upper arm circumference, etc., which are also reported for other populations especially for the populations in Northeast India.

It may be noted here that in India we do not have the recommended growth references and/or standards. Although the data collected by the Indian Council of Medical Research (ICMR, 1972) are old and lack representation of all sections of the Indian population, its use in the present study is but to understand the growth status of the

Lotha boys, but not as a target or standard of growth that one should assess the children's growth in the present study. As a matter of fact, we have used the U.S. NCHS growth references (Kuczmarski *et al.*, 2000) for the assessment of the nutritional status of the children in the present study as generally recommended.

**Weight**

Figure 5.1 shows the mean weight of Lotha boys in comparison with the ICMR and NCHS growth references. It can be observed that the Lotha boys are much above the 50th percentile of the ICMR growth references from 9 to 18 years of age. In comparison with the NCHS growth references, the Lotha boys are below the 10th percentile from 9 to 10 years of age, and thereafter they are above the 10th percentile and below the 25th percentile of the NCHS growth references till the age of about 17 years. But they are below the 10th percentile of the NCHS growth references from 17 to 18 years of age. Nevertheless, it indicates that the Lotha boys of the present study have better growth status of weight when compared with the Indian boys of the ICMR. In comparison with their counterparts reported from some populations of Northeast India, the Lotha boys are found to be comparable to the Meitei (Talwar and Singh, 1995), Khasi (Khongsdier and Mukherjee. 2003) and Assamese Muslim (Begum and Choudhury, 1999) boys from 9 to 18 years of age. Figure 5.2 shows that the Lotha boys are by and large heavier than the Meitei. Khasi and Assamese Muslim boys from the age of 11 onwards. They are similar to the Assamese Muslims at 9, 12 and 15 years of age, but they are lighter than the Meitei boys of Manipur from 17 to 18 years of age. Thus, in view of these comparisons, the Lotha boys seem to be better in growth status of weight when compared with the Indian boys of the ICMR and those reported for some populations in Northeast India.

With regard to girls, Figure 5.3 shows that the Lotha girls are below the 50th percentile of the ICMR growth references at 10 years of age, and thereafter the curve lies much higher than the ICMR growth curve. In comparison with the NCHS growth references. Figure 5.3 shows that the Lotha girls are more or less comparable to the 10th percentile from 11 to about 13 years of age, and thereafter they are much higher than the 10th percentile and move towards the 25th percentile of the international (NCHS) growth references. especially from the age of 16 onwards. From this point of view, the Lotha girls are better than their male counterparts whose curve tends to lie below the 10th percentile of the NCHS growth references after the age of 16 years. In comparison with the Khasi and Meitei girls of Northeast India, Figure 5.4 shows that curve for the Lotha girls is below that of the Khasi girls from 9 to about 11 years of age, and thereafter the curve for the Lotha girls lies much above that of the Khasi girls till the terminal age of 18 years. The Lotha girls of the present study are also heavier than the Meitei girls of Manipur from 11 to 13 years and from 16 to 18 years, although the Meitei girls are heavier from 14 to 15 years of age. In comparison with the Assamese Muslim girls, the Lotha girls are lighter from 9 to about 14 years of age, and thereafter they are much heavier than the Assamese Muslim girls. Nevertheless, Figures 5.3 and 5.4 show that the Lotha girls are heavier than the ICMR Indian girls and other Indian girls like the Khasi and Meitei of Northeast India.

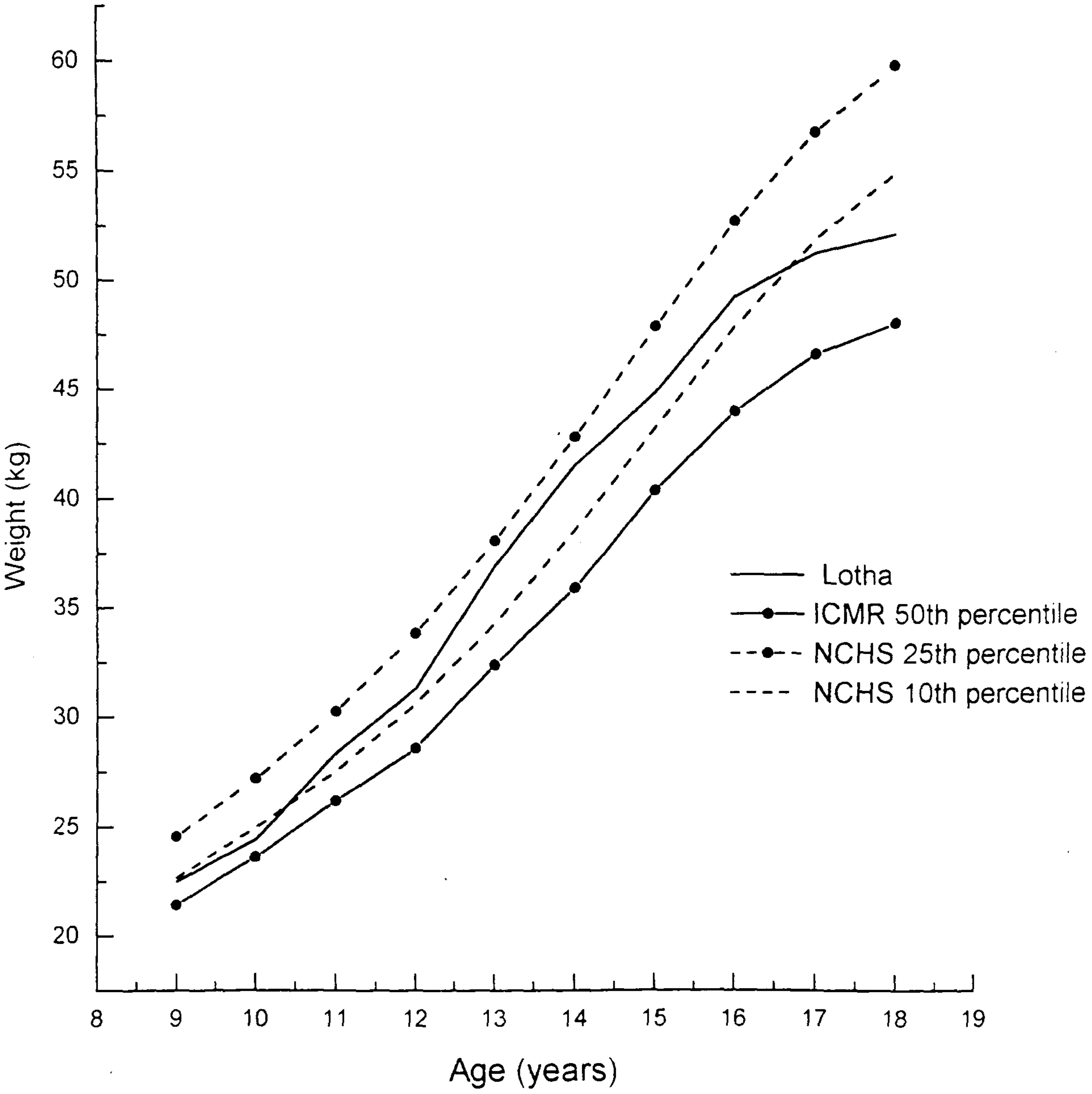

Figure 5.1. Mean weight (kg) of Lotha boys in comparison with ICMR and NCHS references

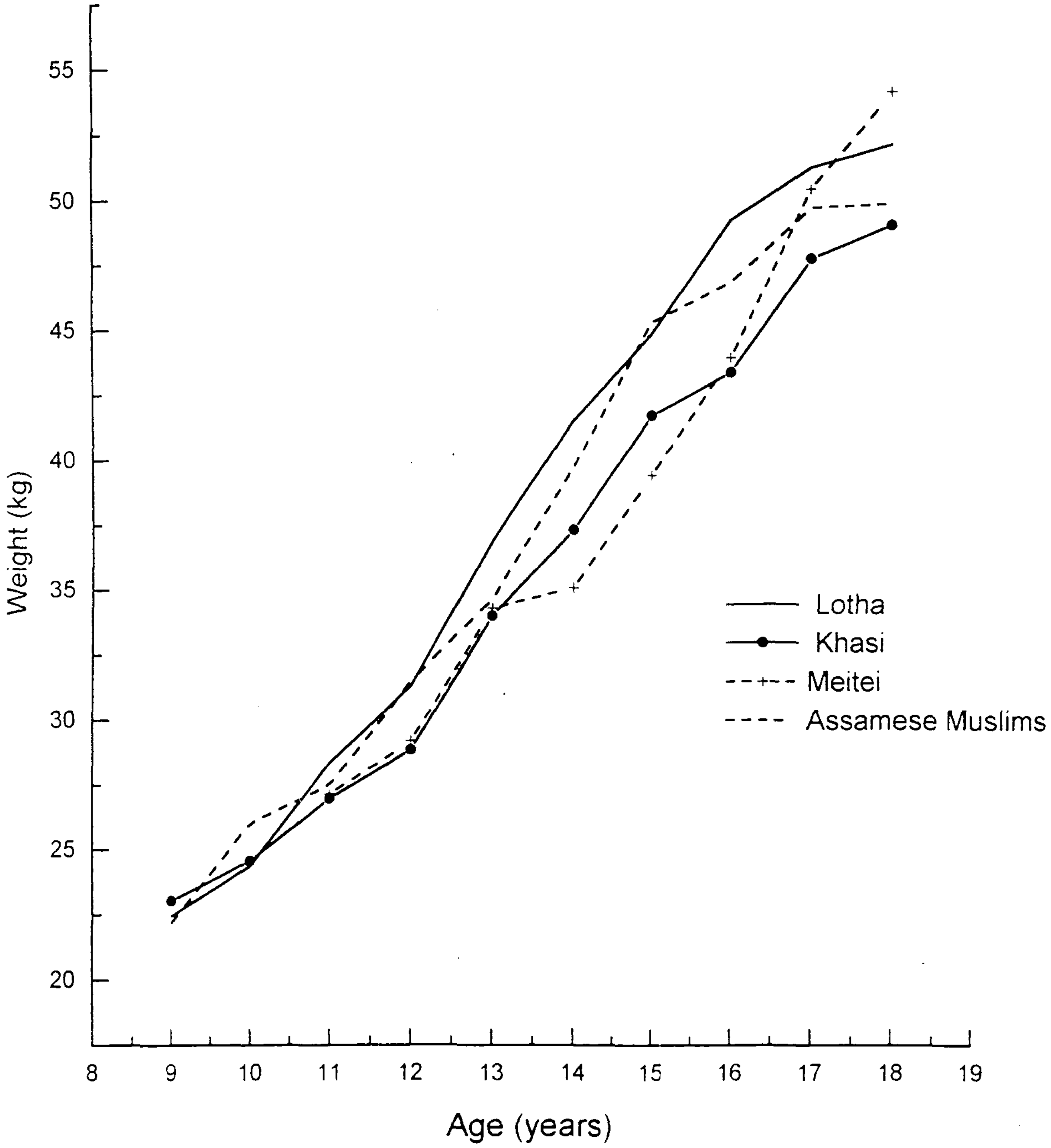

Figure 5.2. Mean weight (kg) of Lotha boys and their counterparts in other populations

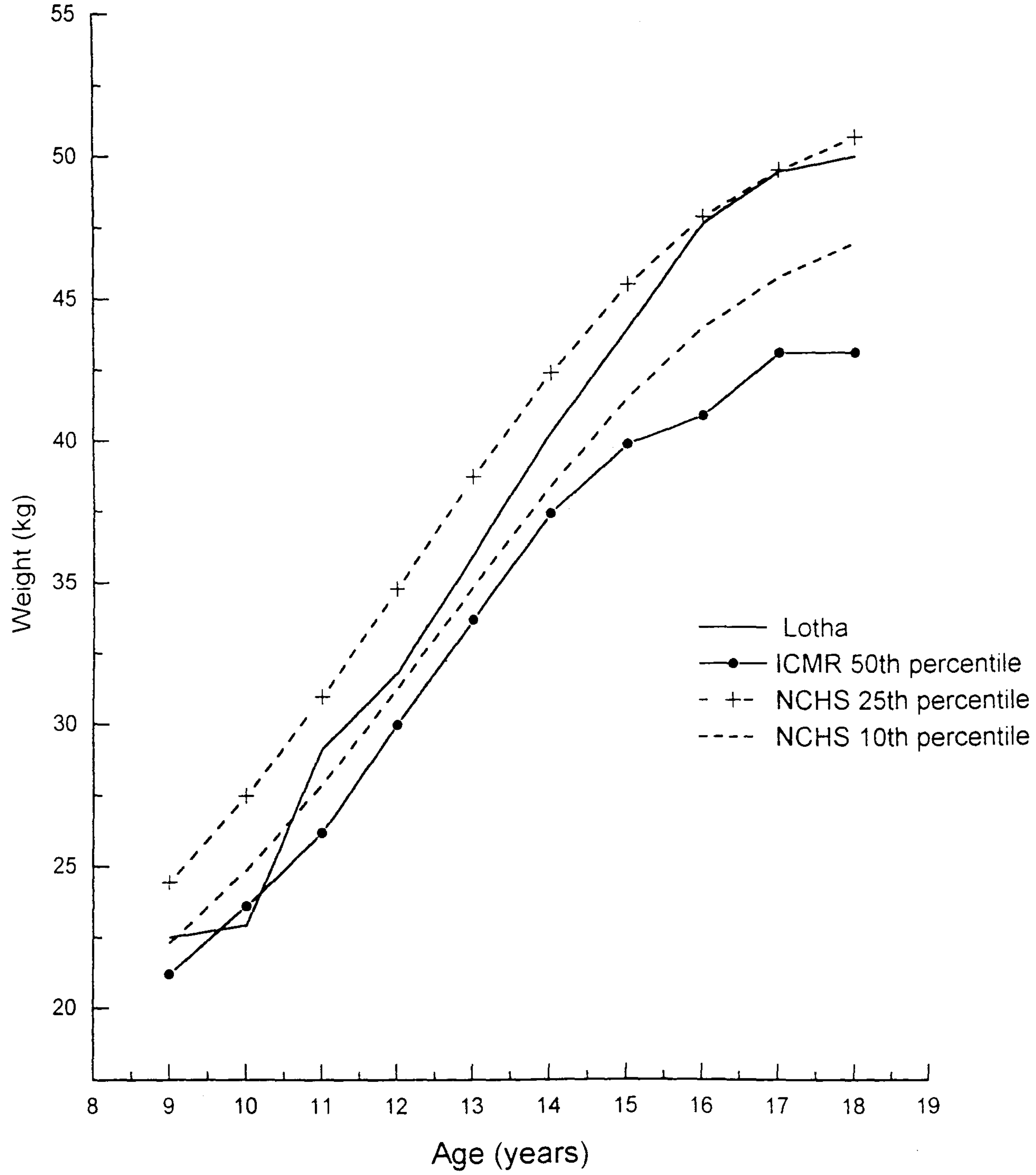

Figure 5.3. Mean weight (kg) of Lotha girls in comparison with ICMR and NCHS references

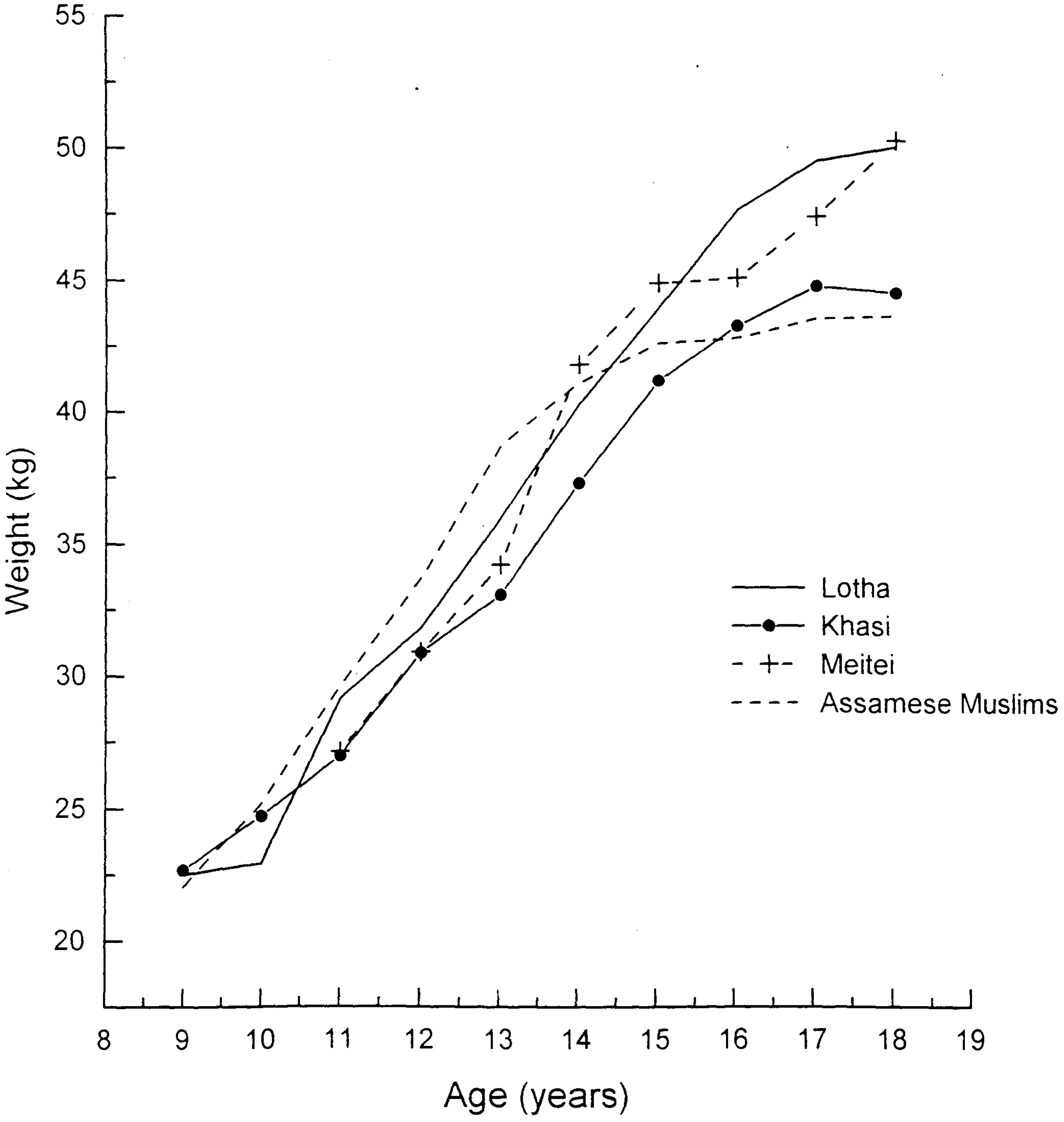

Figure 5.4. Mean weight (kg) of Lotha girls and their counterparts in other populations

**Height**

In Figure 5.5, an attempt has been made to show the mean height of the Lotha boys in comparison with the ICMR and NCHS growth references. It can be observed that the curve for the Lotha boys lies below the 50th percentile of the ICMR growth references from 9 to about 13 years of age, and below the10th percentile of the NCHS growth references from 9 to about 12.5 years. However, the curve for the Lotha boys lies above the 50th and 10th percentiles of the ICMR and NCHS growth references, respectively, from 13 to about 15 years of age. After 15 years of age, the curve is similar to that of ICMR growth references, but much below the 10th percentile of the NCHS growth references. Figure 5.6 shows that the Lotha boys are similar in height to the Assamese Muslim boys at the age of 13 years and from 16 onwards, although the latter are much taller in other age groups. If we are to consider the 5th percentile of the NCHS references as a cut-off point for categorizing growth retardation, the present Lotha boys are below the 5th percentile from 17 to 18 years, but similar to this percentile from 11 to 12 years of age. In short, the Figure shows that the Lotha boys are much taller than the Meitei and Khasi boys of Northeast India, and they are similar to the 50th percentile of the ICMR growth references.

As for girls, Figure 5.7 shows that the curve lies below the 5th percentile of the NCHS growth references from 9 to 10 years of age, and thereafter it tends to move along the 10th percentile up to about 12 years of age. From 12 years of age, the curve lies along the 5th percentile of the NCHS references up to about 14 years of age when it started moving upward and crossing above the 10th percentile from the age of 16 onwards. In comparison with the ICMR growth references, the curve for the Lotha girls lies below the 50th percentile from 9 to about 13 years of age, and thereafter it is similar to the Indian girls up to 14 years of age. From 14 years of age, they are much taller than the Indian girls of the ICMR. Compared with other populations in Northeast India, the Lotha girls are shorter than the Assamese Muslim girls from 9 to about 14 years of age, but thereafter the former are taller than the latter (Figure 5.8). However, Figure 5.8 shows that the Lotha girls are much taller than the Meitei and Khasi girls.

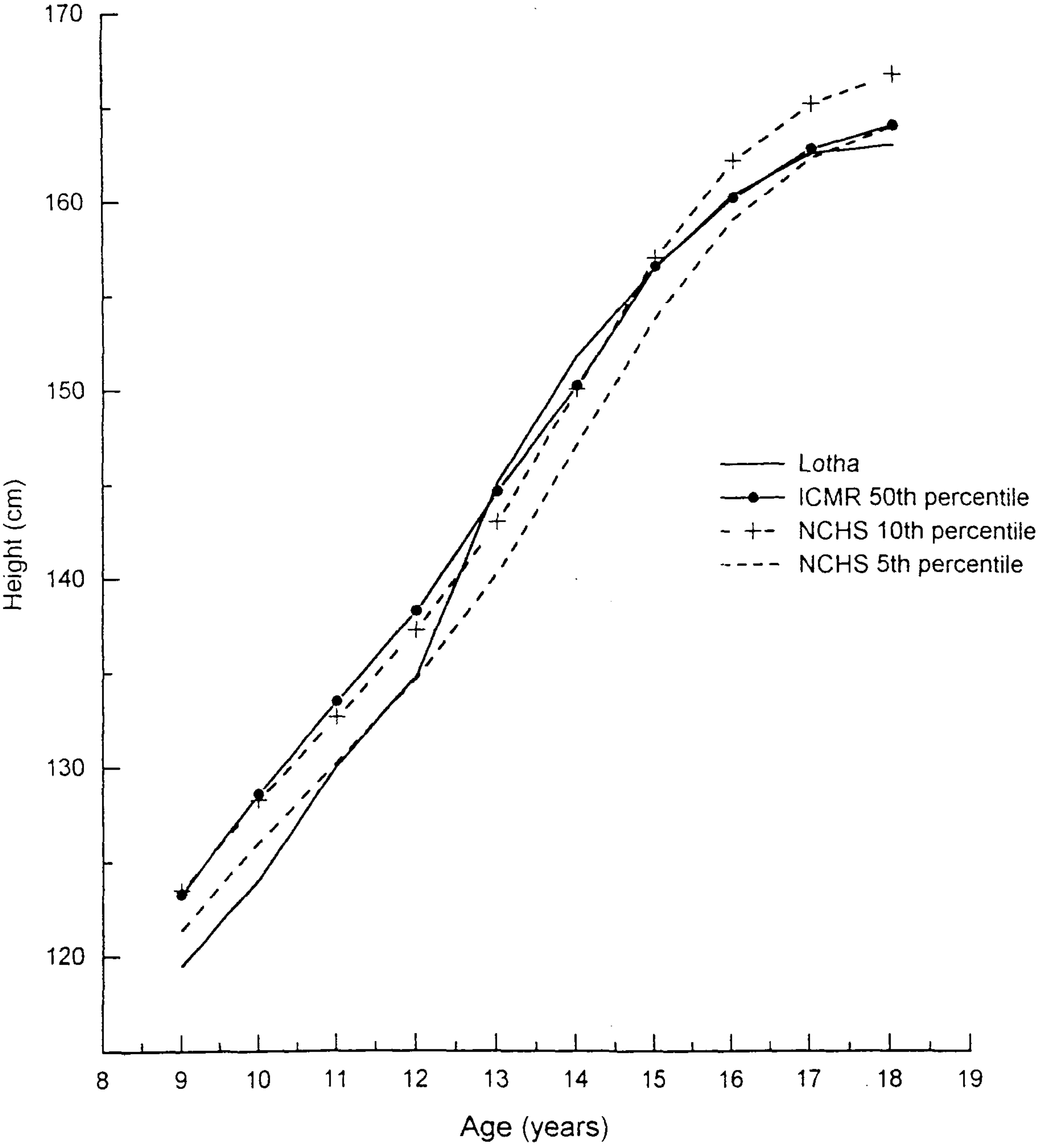

Fig 5.5. Mean height (cm) of Lotha boys in comparison with ICMR and NCHS references

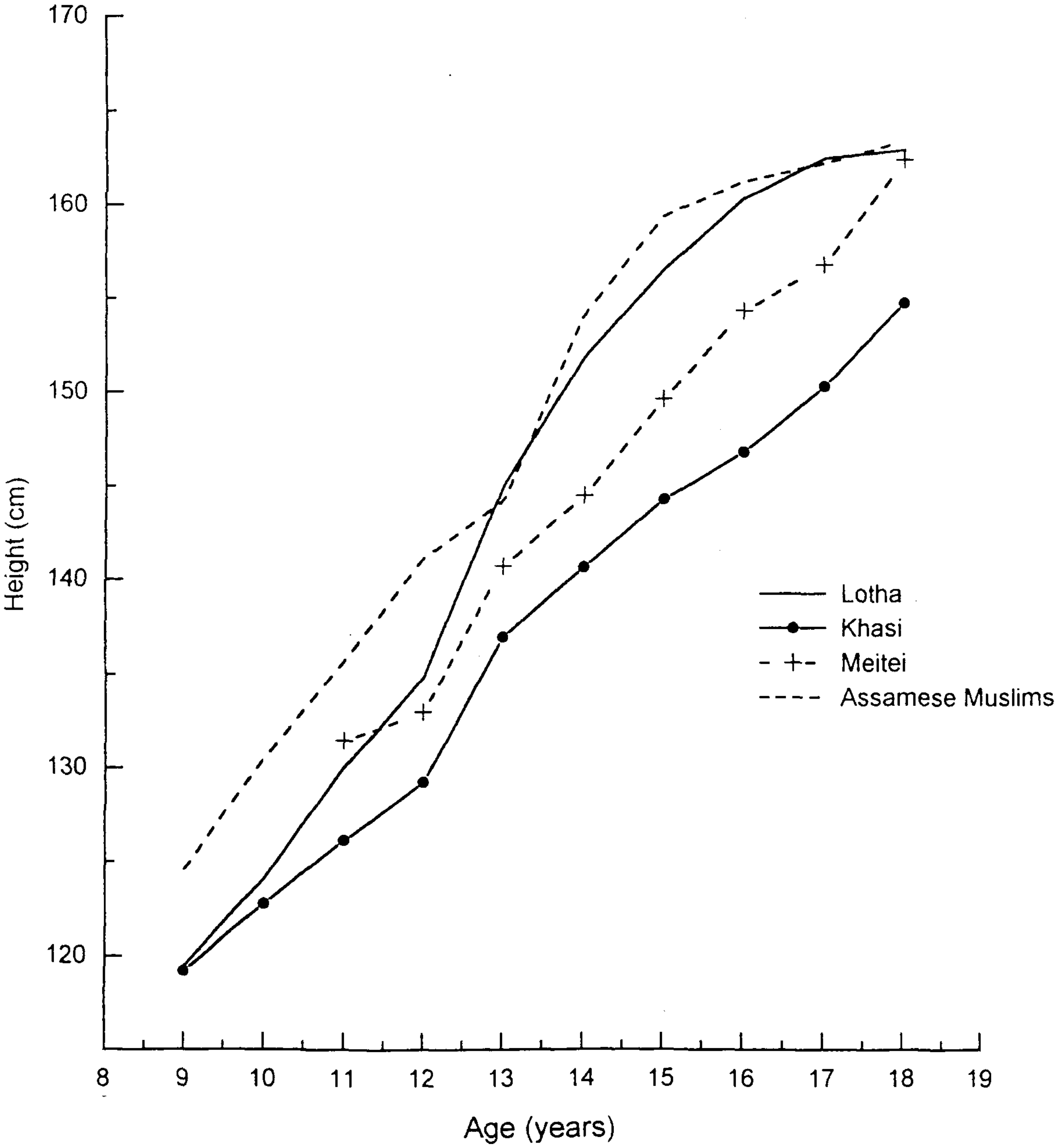

Figure 5.6. Mean height (cm) of Lotha boys and their counterparts in other populations

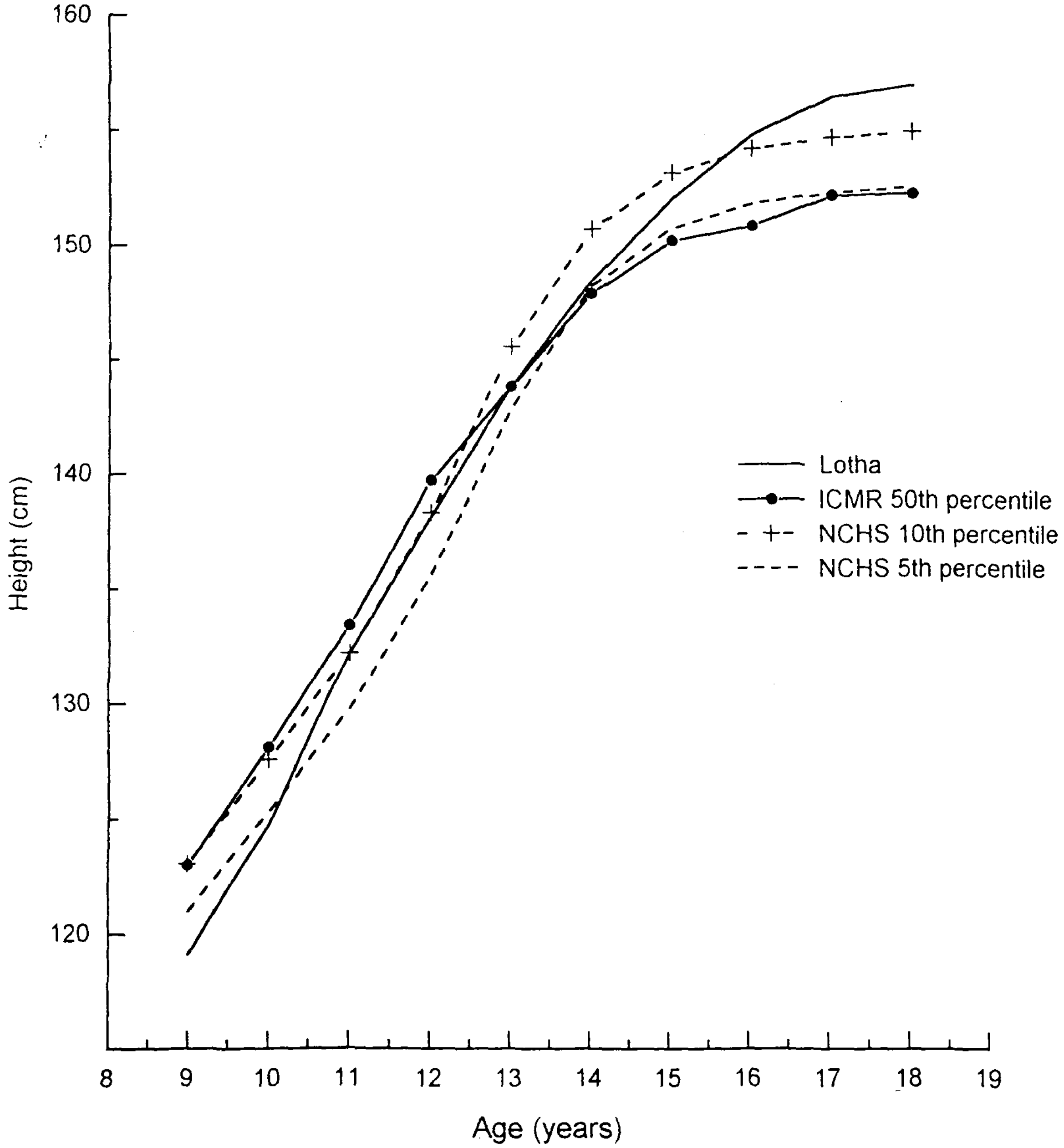

Fig 5.7. Mean height (cm) of Lotha girls in comparison with ICMR and NCHS references

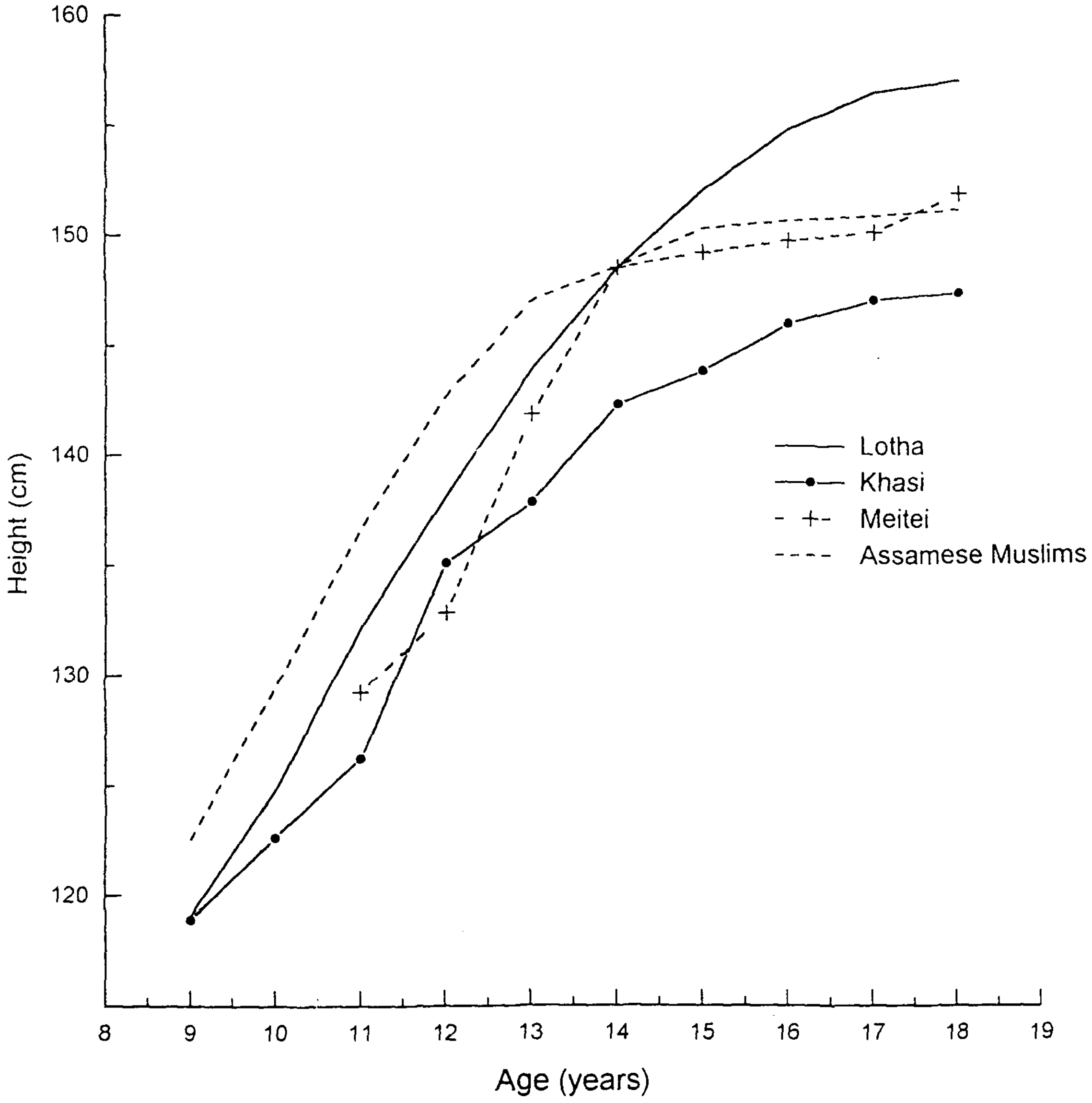

Fig 5.8. Mean height (cm) of Lotha girls and their counterparts in other populations

## Sitting Height

With respect to sitting height, Figure 5.9 shows that the Lotha boys have higher sitting height than any population under comparison from about the age of 12 onwards. However, they are lower in sitting height from 9 to 12 years of age when compared with the Assamese Muslim boys of Assam, but higher than the 50th percentile of the ICMR growth references and the observed mean values among the Khasi and Meitei boys.

In the case of girls, Figure 5.10 shows that the curve for the Lotha girls lies above that of other populations from the age of 14 onwards. The sitting height of Lotha girls is similar to the 50th percentile of the ICMR growth references from 11 to about 13 years of age. But the curve is below that of the Assamese Muslim girls from 9 to 13.5 years of age. The Lotha girls are also similar in sitting height to the Khasi and Meitei girls at the age of 10, 11 and 14 years, respectively, although the sitting height is higher among the Lotha girls across other age groups.

## Head Circumference

The growth status of Lotha boys in respect of head circumference is shown in Figure 5.11. It can be observed from the Figure that the curve for the Lotha boys is below the 50th percentile of the ICMR growth references from 9 to 11 years of age, and thereafter the curve is much higher in the former till the age of 18 years. On the other hand, the head circumference among the Lotha boys is lower when compared with the Assamese Muslim boys, except from 13 to 15 and 17 to 18 years of age, which shows that it is higher in the former than in the latter. In comparison with the Khasi boys, Figure 5.11 shows that the Lotha boys are lower than the Khasi boys in head circumference from 9 to about 11 years of age, but they are similar in growth curve from 11 to 12 years of age. On the other hand, the Lotha boys are much higher in head circumference from the age of 12 to 18 years.

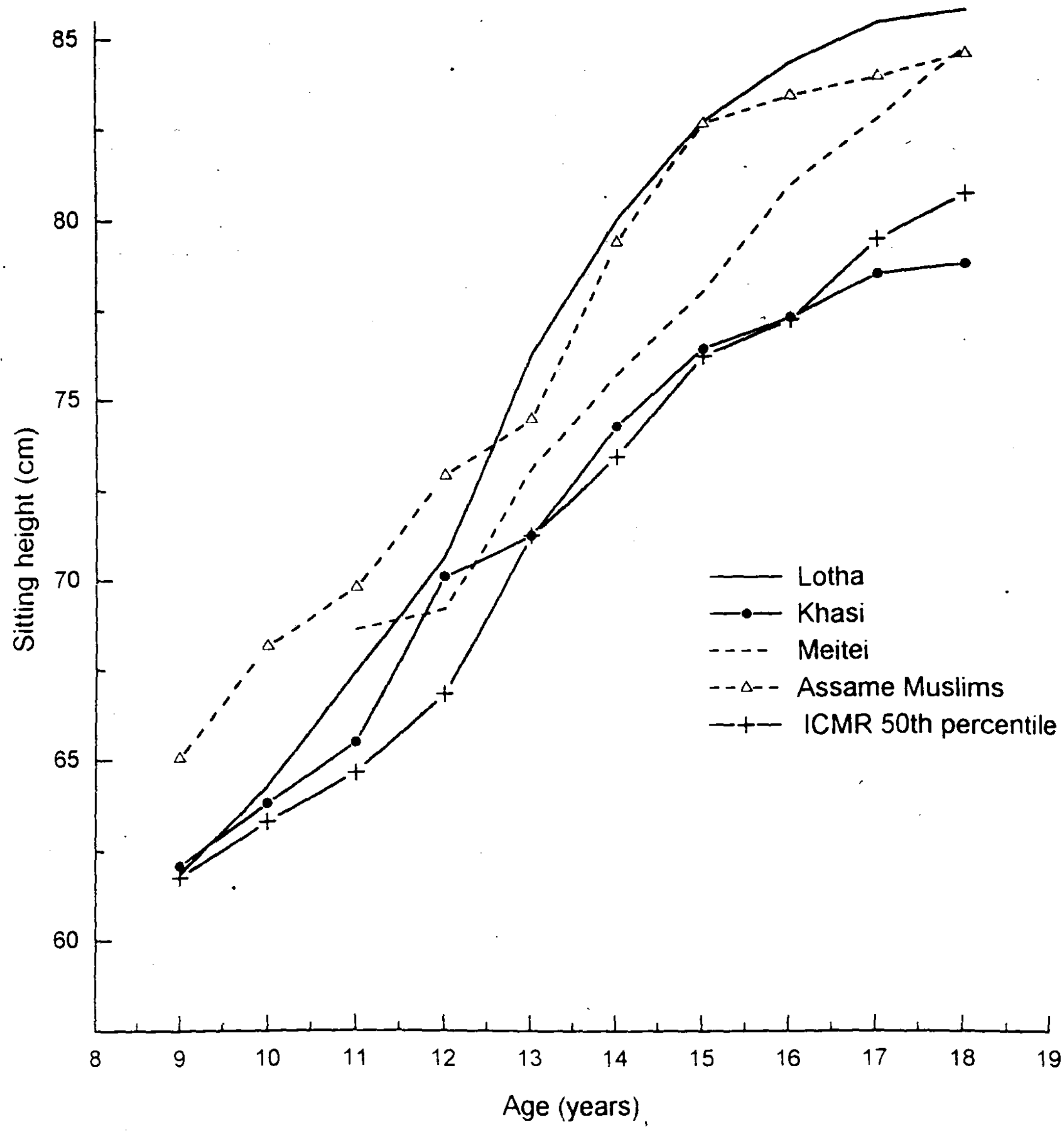

Figure 5.9. Mean sitting height (cm) of Lotha boys and their counterparts in other populations

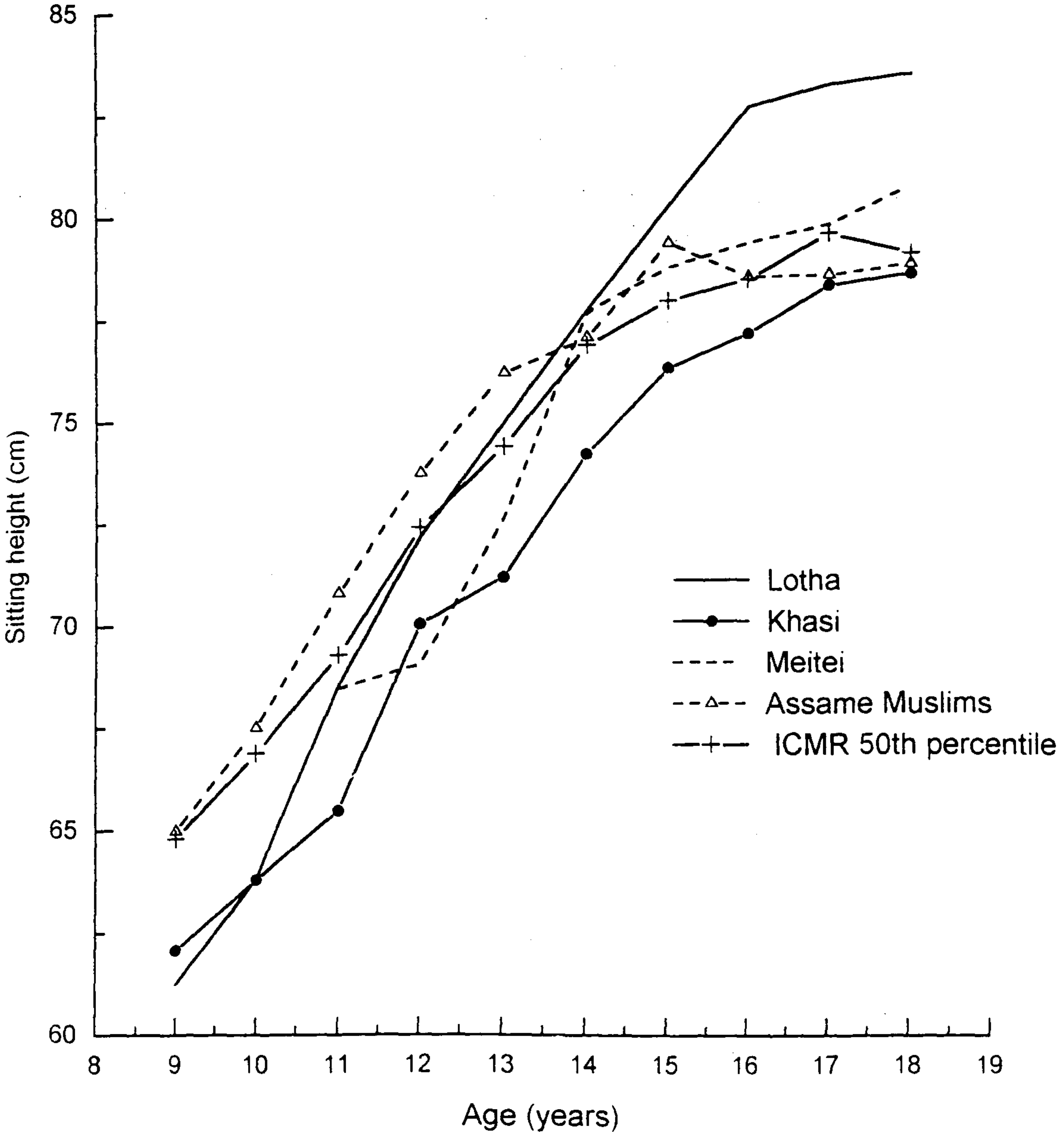

Figure 5.10. Mean sitting height (cm) of Lotha girls and their counterparts in other populations

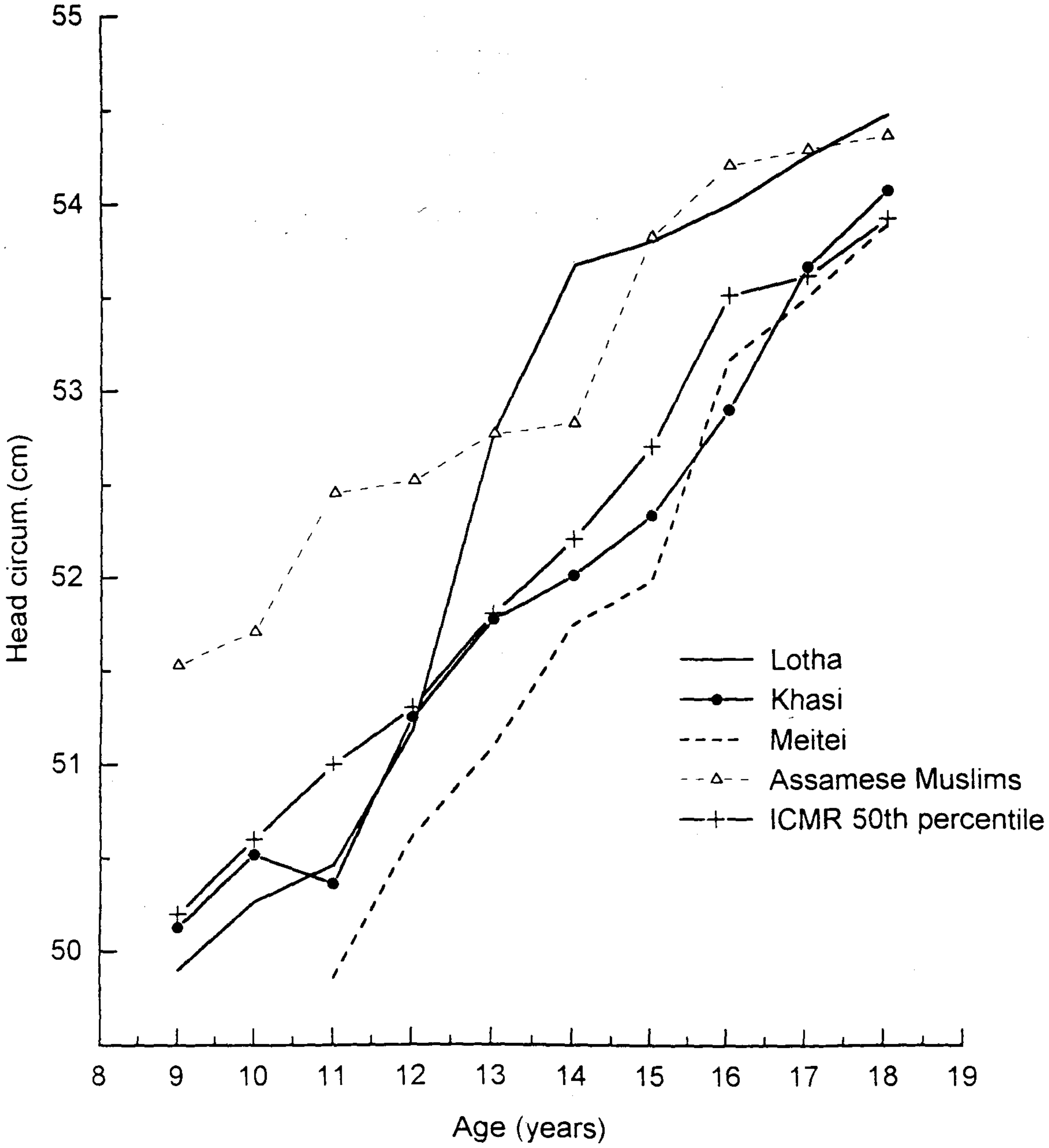

Figure 5.11. Head circumference of Lotha boys and other populations

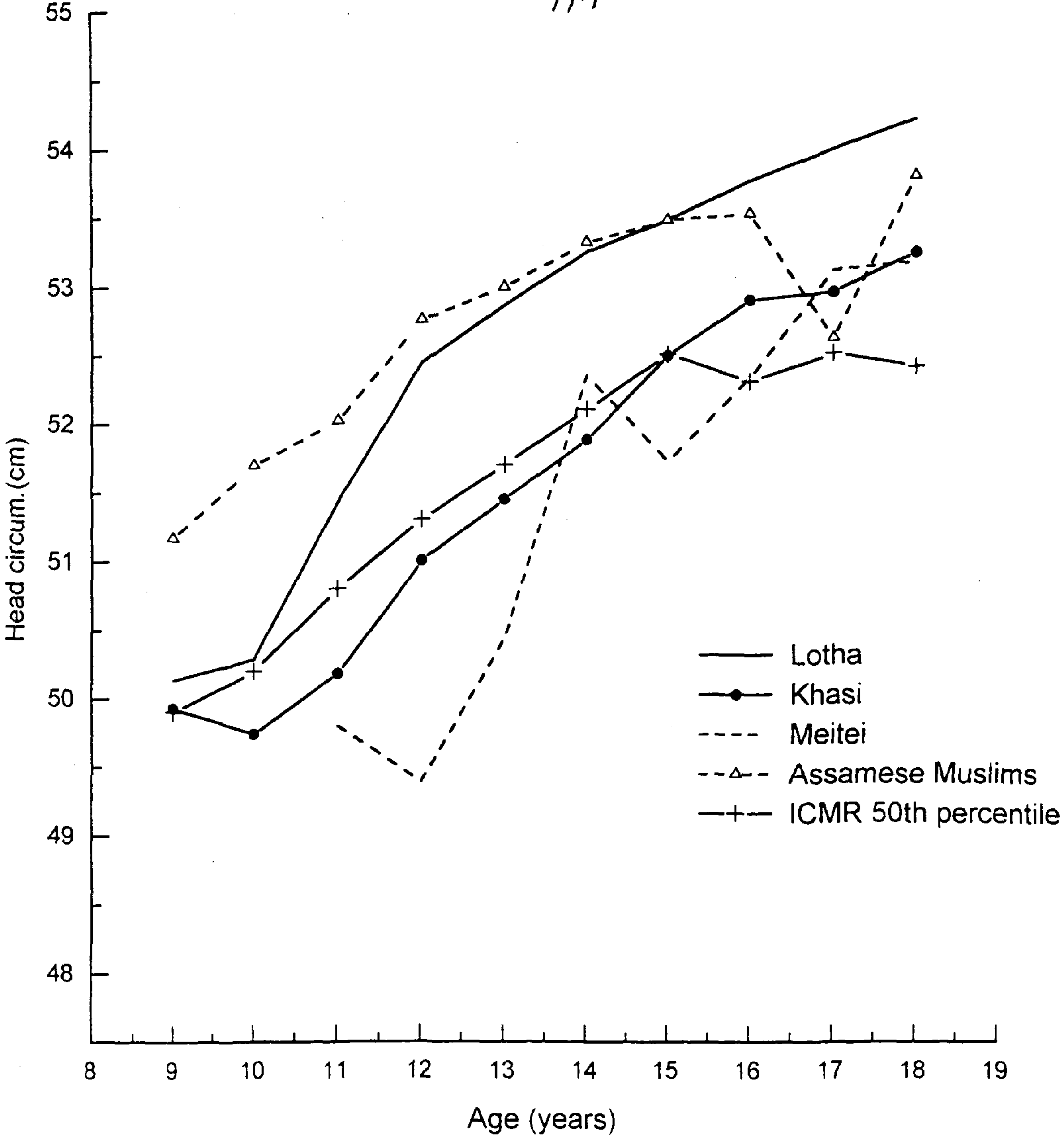

Figure 5.12. Head circumference of Lotha girls and other populations

In the case of girls, Figure 5.12 shows that the curve for the Lotha girls lies above that of the 50th percentile of the ICMR growth references and that among the Khasi and Meitei girls. The Lotha girls are also higher than the Assamese Muslim girls from 15 to 18 years of age, but they are similar from 14 to 15 years of age. On the other hand, they are far below the Assamese Muslim girls from 9 to about 13 years of age. Thus, it indicates that the Lotha girls have a broader head than the Indian girls of the ICMR and the Khasi and Meitei girls of Northeast India, although they are below the Assamese Muslim girls from 9 to about 13 years of age.

### Chest Circumference

As regards the chest circumference, Figure 5.13 shows that the curve for the Lotha boys is much above the 50th percentile of the ICMR growth references and that for the observed mean values among the Meitei boys across age groups. However, the Lotha boys are lower in chest circumference when compared with the Khasi and Assamese Muslim boys across age groups. In short, it indicates that the Lotha boys are in between the Indian boys of the ICMR and the Khasi or Assamese Muslim boys in respect of chest circumference. This can also be observed in the case of girls as shown in Figure 5.14, although the Lotha girls are slightly above the Assamese Muslim girls at 9 years of age, and similar to the Khasi girls at 13 years of age.

### Upper Arm Circumference

Figure 5.15 shows the mean upper arm circumference of the Lotha boys in comparison with their counterparts in other populations of Northeast India. The Figure shows that the Lotha boys are lower in arm circumference when compared with the Assamese Muslim, Khasi and Meitei boys from 9 to about 12 years of age. From 12 years of age, the curve for the Lotha boys is above that of the Khasi and Meitei boys, but below the Assamese Muslim boys. It may be noted that data on the Indian children of the ICMR are not available for the upper arm circumference. So, comparison was limited to the populations

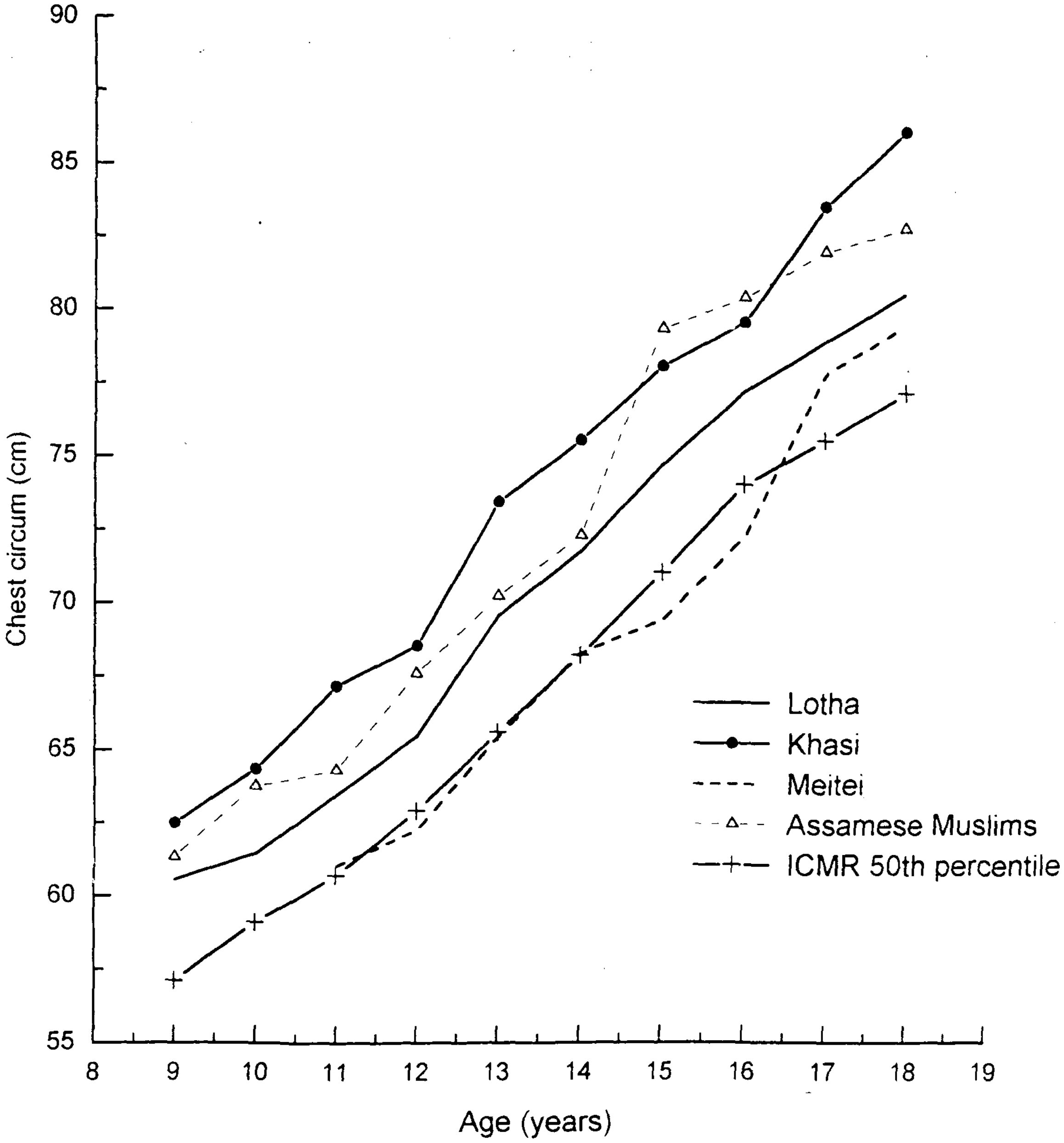

Figure 5.13. Chest circumference of Lotha boys and other populations

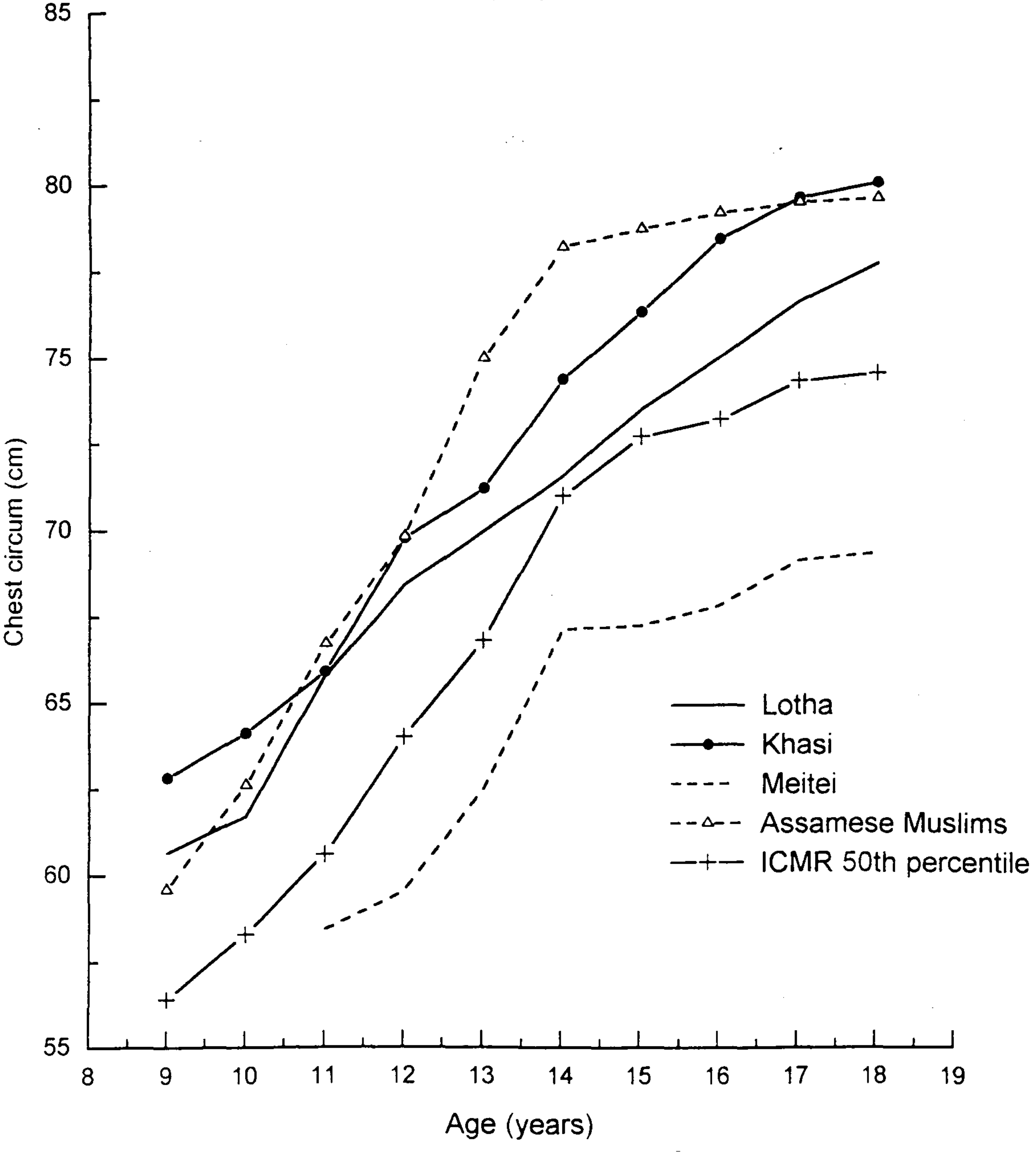

Figure 5.14. Chest circumference of Lotha girls and other populations

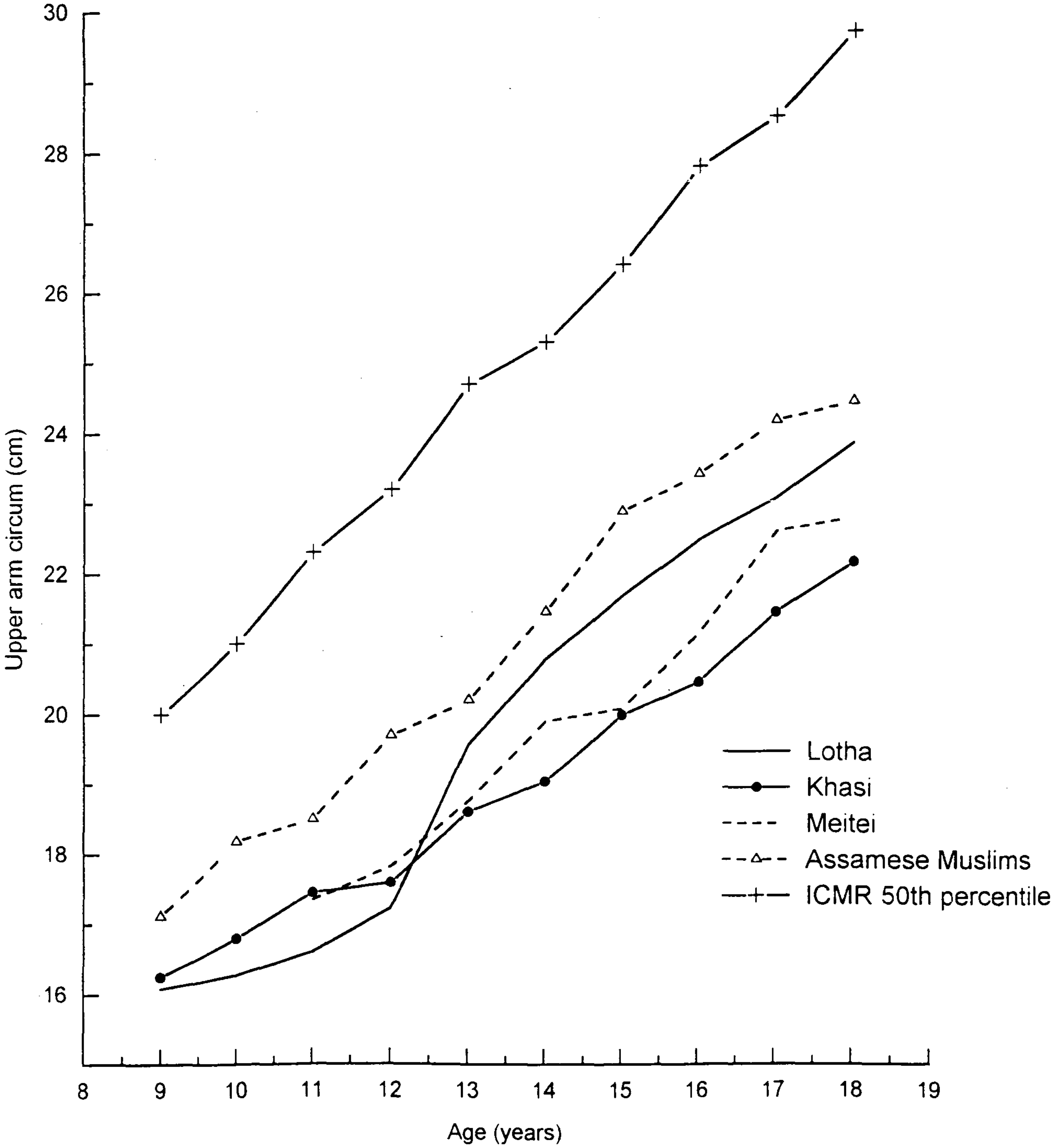

Figure 5.15. Upper arm circumference of Lotha boys and other populations

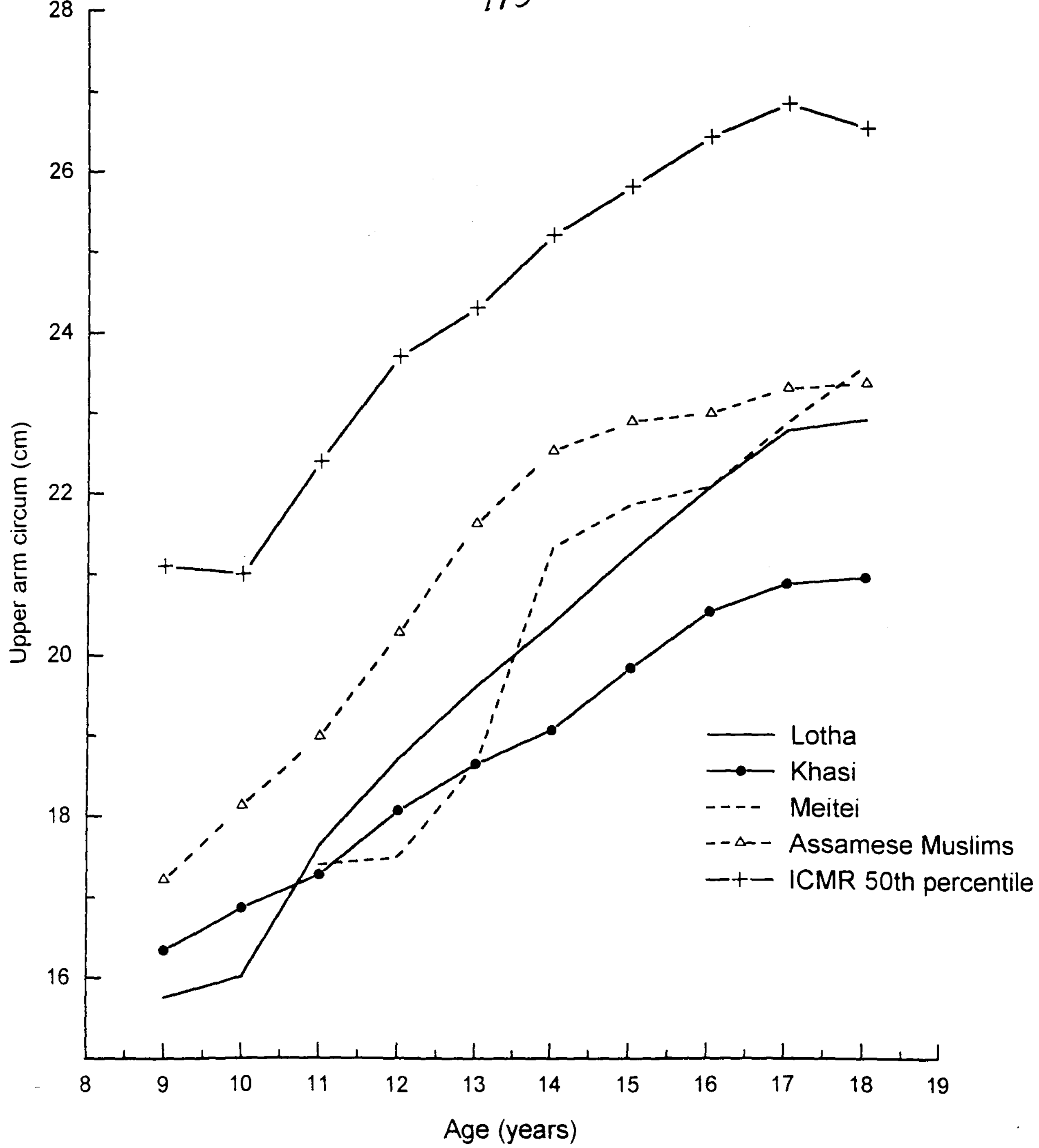

Figure 5.16. Upper arm circumference of Lotha girls and other populations

of Northeast India only. Like the Lotha boys, the Lotha girls are also much lower in upper arm circumference when compared with the Assamese Muslim children across age groups (Figure 5.16). They are also below the Khasi girls from 9 to 11 years of age, and thereafter the Lotha girls are much higher in upper arm circumference up to the age of 18. In comparison with the Meitei girls, the upper arm circumference is higher in the Lotha girls from 11 to about 13.5 years and thereafter it is higher in the Meitei girls up to about 15 years of age. Both Lotha and Meitei girls are similar in arm circumference from 16 to about 17 years of age, although the latter surpass the later from 17 years onwards.

In view of the present comparison, it is obvious that the growth status of Lotha children is, on average, comparable to Indian children of the ICMR, but they are bigger than the Khasi and Meitei children. They are by and large comparable to the 10th and 25th percentiles of the NCHS growth references in respect of weight and to the 5th and 10th percentiles in respect of height.

## NUTRITIONAL STATUS

In the previous Chapter, we have described the findings of the present study relating to the nutritional status of the Lotha children. We have taken three important anthropometric indices, namely, weight for age, height for age and BMI for age, as generally recommended (WHO, 1983; WHO Working Group, 1986). As mentioned, weight for age is considered as a measure of underweight, whereas height for age is taken as an indicator of growth retardation or stunting in relation to the international growth references given by the U.S. National Center for Health Statistics (NCHS). On the other hand, BMI for age is considered as a good indicator of fatness, or thinness and/or wasting due to chronic energy deficiency (CED).

With respect to the prevalence of underweight, it is shown in Chapter IV that the proportion for all age groups is about 1.46 times higher in boys (22.41%) than in girls (16.53%) and such a difference is statistically significant (95% confidence interval = 1.01 to 2.11, $P < 0.05$). It is found that this sex difference in weight for age is mainly attributed by the differences in the age group 16-18 years. With respect to differences between age groups within sex, the present findings indicate that the nutritional status according to weight for age seems to be better in the higher age groups as compared with the lower age groups. This is true for both boys and girls. When compared with related data on children of Northeast India the prevalence of underweight in this population is much lower than that among the Khasi children (Khongsdier and Mukherjee, 2003). As already mentioned, to the best of our knowledge, there is no published data on growth and nutritional status of children, especially among the Lotha children. The National Family Health Survey (NFHS, 1998-99) has, of course, taken into consideration the nutritional status of the children below 4 years of age. It is reported that the prevalence of underweight in Nagaland is about 24.1%, which is the lowest in comparison with the states of Arunachal Pradesh, Assam, Manipur, Mizoram and Meghalaya. Thus, the prevalence of underweight among the Lotha children (19.43% when the sexes are combined) is comparable to the finding of the NFHS, although it is lower in the present study. Also, the NFHS data was based on state level but not on population level as in the case of the present study.

The prevalence of growth retardation or stunting as per height for age is found to be 21.46% which is higher than that for underweight (19.43%). Also, unlike weight for age, the prevalence of growth retardation is higher significantly in girls (24.53%) than in boys (18.31%). The estimated OR for all age groups indicates that the girls are about 1.45 times higher than boys in the prevalence of growth retardation, i.e., low Z-scores of height for age (95% confidence interval = 1.02-2.08, $P < 0.05$). This higher frequency of growth retardation in girls is found to be statistically significant in the lower age groups ($\leq$ 12 and 13-15 years), but in the age group 16-18 years the prevalence is significantly higher in boys than in girls. Moreover, it is also observed that the prevalence of growth retardation in girls is similar to low weight for age, that is, it is higher in the lower age groups, but the situation is reverse in the case of boys. The Pearson correlation coefficient ($r$) is also found to be positively significant in the case of girls ($r = 0.311$, $P < 0.01$) and negatively significant in the case of boys ($r = -0.493$, $P < 0.01$). Thus, it is obvious from the present findings that the girls in the lower age groups are higher in the frequency of low height for age as compared with the higher age groups, but the situation is reverse in the case of boys. In other words, the frequency of higher Z-scores of height for age increases with age in girls, but it decreases as age advances in the case of boys. Nevertheless, the prevalence of growth retardation in the Lotha children of the present study (21.46%) is found to be lower than that for the state of Nagaland (33%) as reported by the NFHS (1998-99). It is also lower than that reported for the Khasi children (Khongsdier and Mukherjee, 2003). In short, it indicates that the Lotha children are better in height for age as compared with the available data on populations in Northeast India. This can also be seen from the findings of the NFHS for all the states in Northeast India, which shows that nutritional status in children of Nagaland is better than other states including Mizoram.

With respect to the prevalence of chronic energy deficiency, it is found that the Lotha children are much better than the Khasi children (Khongsdier and Mukherjee, 2003; Mukherjee, 2002). It is found that the prevalence of CED is about 6.61 % for the children of all age groups. It is also found that there is no significant difference between boys (8.20%) and girls (5.07%) in respect of the prevalence of CED according to BMI for age as shown in the last Chapter. In the case of girls, it is found that the frequency of higher Z-scores for BMI is positively correlated with age ($r = 0.188$, $P < 0.01$), and negatively significant in the case of boys ($r = -0.156$, $P < 0.01$). Thus, the number of individuals with higher Z-scores of BMI increases with age in girls, but tends to decrease with age in the case of boys. Nevertheless, the nutritional status of children according to BMI for age is better than that indicated by weight for age and height for age. Figure 5.17 shows that the curve for the Lotha boys lies between the 25th and 50th percentile of the NCHS growth references. This is also true in the case of girls (Figure 5.18), despite the deceleration from 9 to 10 years of age. In short, it shows that the nutritional status of the present population, as indicated by BMI, is better than many Indian populations (Visweswara Roa *et al.*, 1994; Bandyopadhyay and Saha, 1999; Khongsdier and Mukherjee, 2003), although the BMI for age is below the 50th percentile of the NCHS growth references.

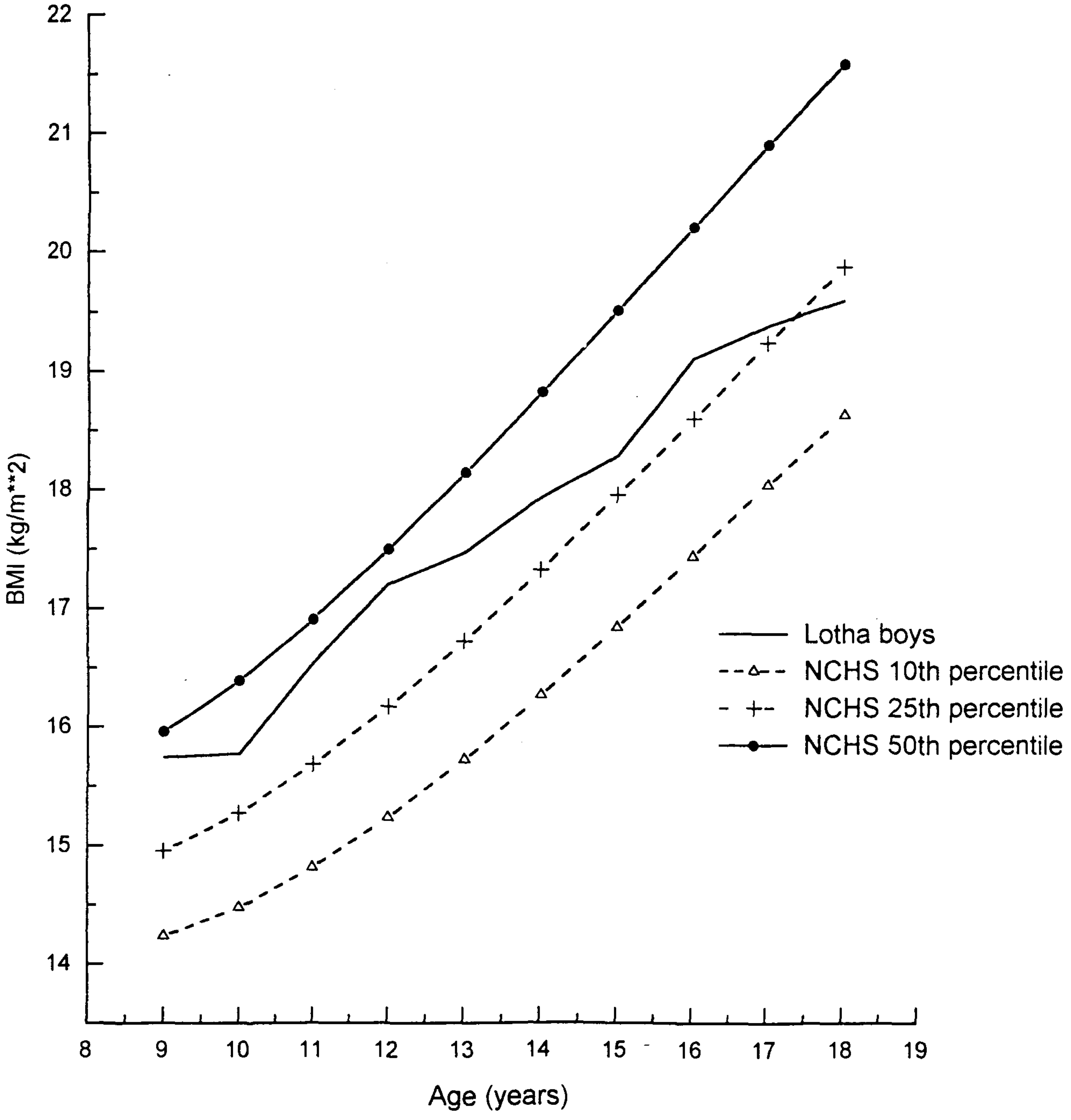

Figure 5.17. BMI of Lotha boys in comparison with NCHS growth references

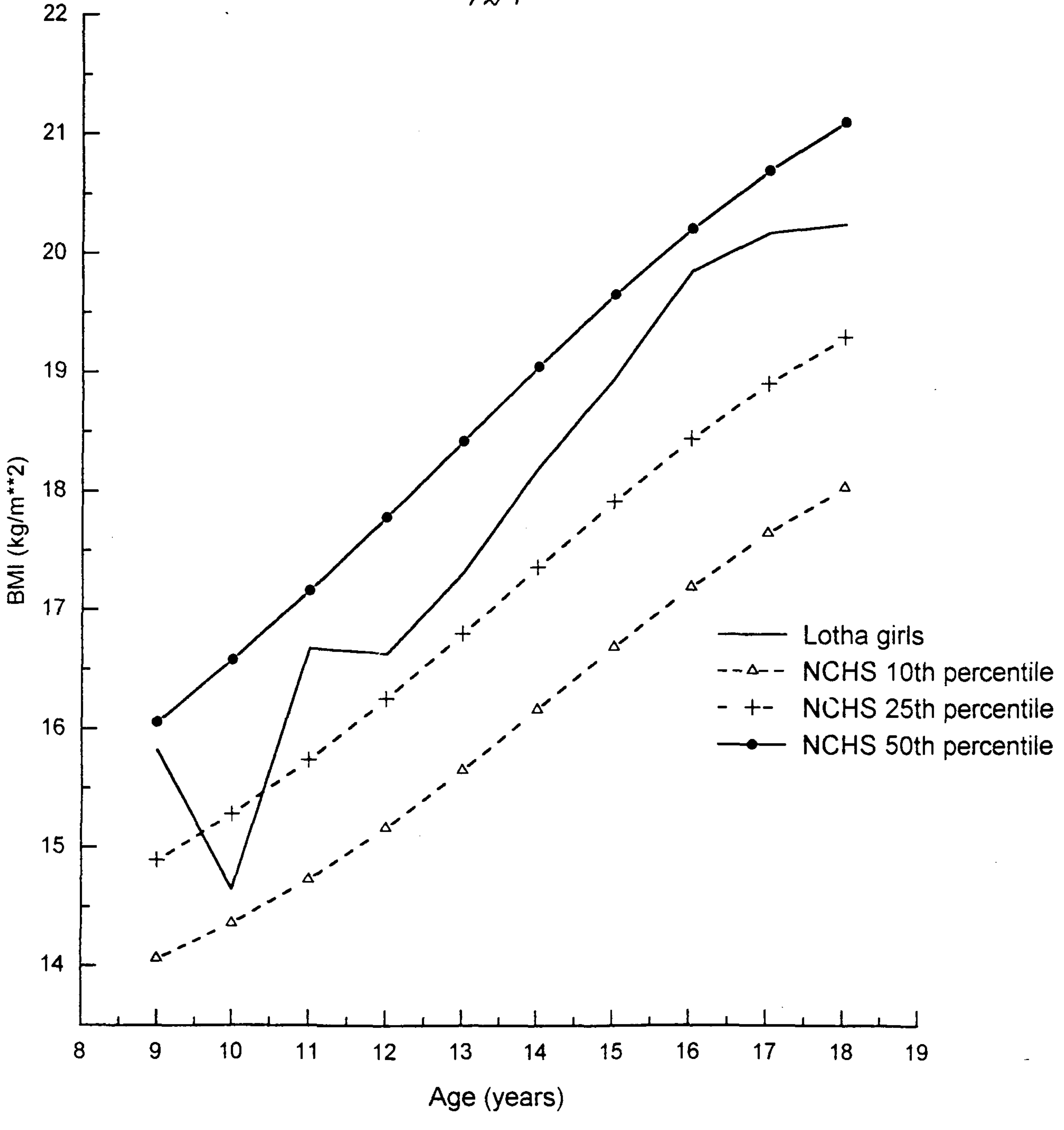

Figure 5.18. BMI of Lotha girls in comparison with NCHS growth references

In view of the present findings on anthropometric indicators of the nutritional status of population, one may argue that the prevalence of undernutrition in the Lotha children is not as high as that observed in other children of some Indian populations. Of course, the prevalence of undernutrition is higher in terms of weight for age and height for age as compared with BMI for age. In this connection, it may be noted that weight for age is also dependent on height, although it is used as good indicator of underweight when the value of Z-score in relation to the growth references is below - 2. In the present study, it is found that the correlation coefficient between Z-scores of weight for age and height is positively significant for both boys ($r = 0.239$, $P < 0.01$) and girls ($r = 0.544$, $P < 0.01$). Therefore, weight for age is not independent of height, rather it is significantly correlated with height in the present population. As a matter of fact, weight for age is a composite index of both height for age and BMI for age and "fails to distinguish tall, thin children from those who are short with adequate weight" (Gorstein *et al.*, 1994). This is due to the fact that weight for age does not take into account the height of an individual at a given age. However, weight for age is generally used for assessing the current nutritional status of the population, and it is important when compared with the recommended growth references like that of the NCHS taken for the present study. According to the WHO Working Group (1986), its use along with height for age may be helpful in getting an overview of the nutritional problems in a community, or in understanding the "direction of change" that is, to find out whether the intervention activities in a population should first be directed towards resolving the causes of stunting or wasting.

We have mentioned that the height for age Z-score of below – 2 in relation to the growth references is indicative of growth retardation or stunting due to slow skeletal growth. In fact, height for age is considered to indicate the present and past history of the growth status of a child. The WHO Working Group (1986) has recommended that the use of height for age is essential to know the "accumulated consequences of retarded growth" for it is also associated with poor economic condition, high frequency of infections and inadequate nutrient intake. Its use for assessing the nutritional status of adolescent children, like in the present study, is however subject to controversy because of the variable timing of growth spurt (Cameron, 1993). Nevertheless, the use of height for age along with BMI for age is important in understanding the nutritional and socioeconomic conditions of the study population. It may be noted that BMI is used instead of weight for height in the present study because BMI is generally considered as good indicator of fatness or thinness and/or wasting. This may be one of the reasons why the U.S. National Center for Health Statistics has recently used BMI for age instead of weight for height, which is commonly used as indicator of wasting (Kuczmarski *et al.*, 2000). In the present study also, BMI for age is considered to represent the current status of wasting, fatness or thinness due to CED. It is also believed to be associated with socioeconomic condition and morbidity of a population (Nubé *et al.*, 1998; Khongsdier, 2002).

In view of the above circumstances, we may conclude that the nutritional problem in the present population is related mainly to the problem of stunting, but not to that of wasting. The prevalence of stunting for both boys and girls of all ages is about three times (21.46%) the prevalence of wasting/thinness (6.61%) as indicated by BMI Z-score. Although the present study lack data on socioeconomic conditions of the study population, it is likely that stunting is associated with low socioeconomic status as generally observed in different populations of the world (WHO Working Group, 1986; Gorstein *et al.*, 1994; Norgan, 2000). It may be suggested that efforts to improve food availability, dietary quality, hygiene, adequate supply of safe-drinking water, and prevention and treatment of infectious diseases are likely to improve the nutritional status of the Lotha population over time. It may be noted that growth retardation is not only because of low socioeconomic condition, but it has also economic consequences for the individual as well as for the population. For the individual, earning capacity may be low, and health and welfare compromised. Consequently, increased costs and expenditure for the individual and population follow because of the increased morbidity and mortality (Norgan, 2000). Earlier studies in India have indicated that growth retardation among adolescent children also influenced earning capacity (Satyanarayana *et al.*, 1980, 1989). In short, although the nutritional status in the present population is by and large moderate, efforts should be made to improve the socioeconomic condition so as to improve the overall health and nutritional status of the population. Special efforts should be also made to pay more attention in resolving the problem of stunting in girls. The problem of stunting is higher in girls, especially in the lower age groups. On the contrary, the frequency of the clinical signs of nutrient deficiencies is higher in boys than in girls. One possible explanation of such a higher frequency of clinical signs of nutrient deficiencies in boys may be related to the fact that the prevalence of wasting, or CED is higher in boys (8.20%) than in girls (5.06%), despite the absence of statistical significance. As for the question of higher prevalence of stunting in girls, it is difficult to give a proper explanation as it is also related to past history of growth status. Whether this reflects the patrilineal system of the society is the question to be answered by future studies. With the present set of data, we are not in a position to argue that there exists a sex bias in dietary intakes among the Lotha population. We hope that future studies, which are concerned with both growth and socioeconomic data, will shed much more light on the relationship between nutritional status and socioeconomic status of the present population.

## NUTRITIONAL STATUS IN RELATION TO BODY COMPOSITION

In Chapter III, we have seen that the mean values of fat mass (FM) are significantly higher in girls than in boys across age groups. On the other hand, the lean body mass (LBM) is significantly higher in boys than in girls in almost all age groups. This clearly shows that fat content is more in girls than in boys whereas muscle mass is higher in the latter as observed in other populations (Forbes, 1987). However, it is not clear whether body composition in terms of FM and LBM is associated with nutritional status of the children in the present study. Before going on further discussion, we shall look into the mean values of FM and LBM according to the nutritional status of the Lotha children as mentioned above in terms of three anthropometric indices.

It is seen from Table 5.1 and 5.2 that the mean values of FM and LBM, respectively, are significantly higher in children with higher Z-score (≥ 2 Z-score) when compared to those children with lower Z-score (< 2 Z-score) for weight for age, height for age and BMI for age. It is true for both adjusted and unadjusted means for age groups. This observation seems to confirm those earlier observations that the undernourished children have lower FM and LBM when compared with the nourished children (Norgan, 2000). Of course, in the present study, there is no statistical difference between girls of higher and lower BMI Z-scores in respect of FM and LBM after adjusted for age, which is opposite to the general observation that BMI is highly correlated with FM and LBM (Rolland-Cachera, 1993; Norgan, 1994). It is found that, in the case of girls, the partial correlation coefficient (r) between BMI Z-score and FM after adjusting for age is 0.074, while the correlation coefficient with LBM is 0.076 (Table 5.3). This indicates that the relationship between BMI and these two estimates of body composition in the Lotha girls is not significant after adjusting for age. In the case of boys, it is found that there is a significant correlation between BMI Z-score and FM ($r = 0.522$, $P < 0.000$) and LBM ($r= 0.763$, $P < 0.000$), that is, after removing the effect of age. Thus, considering the case of boys and the findings in other populations, we may conclude that the mean values of FM and LBM in the present population are, on average, significantly lower in the children of poor nutritional status, i.e., children who are below -2 Z-score of height for age, weight for and BMI for age.

**Table 5.1.** Mean values (± SE) of fat mass (FM) according to Z-scores of weight, height and BMI for age

| Parameters | Boys | | Girls | |
|---|---|---|---|---|
| | Unadjusted | Adjusted[a] | Unadjusted | Adjusted[a] |
| **Weight for age** | | | | |
| ≥ 2 Z-score | 3.85 ± 0.095 | 3.78 ± 0.480 | 7.73 ± 0.159 | 7.45 ± 0.059 |
| < 2 Z-score | 2.70 ± 0.175 | 2.93 ± 0.088 | 4.63 ± 0.358 | 6.04 ± 0.135 |
| Difference ± SE | 1.15 ± 0.199 | 0.86 ± 0.101 | 3.10 ± 0.392 | 1.41 ± 0.148 |
| 95% CI | 0.761- 1.545 | 0.658- 1.053 | 2.325-3.866 | 1.112-1.169 |
| t-value | 5.79*** | 8.47*** | 7.90*** | 9.48*** |
| **Height for age** | | | | |
| ≥ - 2 Z-score | 3.56 ± 0.096 | 3.69 ± 0.050 | 7.89 ± 0.167 | 7.45 ± 0.065 |
| < - 2 Z-score | 3.81 ± 0.208 | 3.16 ± 0.109 | 5.14 ± 0.293 | 6.48 ± 0.116 |
| Difference ± SE | -0.25 ± 0.229 | 0.63 ± 0.120 | 2.75 ± 0.337 | 0.97 ± 0.135 |
| 95% CI | -0.705-0.196 | 0.292-0.766 | 2.090-3.415 | 0.709-1.240 |
| t-value | 1.11 | 4.41*** | 8.18*** | 7.22*** |
| **BMI for age** | | | | |
| ≥ - 2 Z-score | 3.64 ± 0.091 | 3.66 ± 0.046 | 7.32 ± 0.159 | 7.22 ± 0.061 |
| < - 2 Z-score | 3.00 ± 0.303 | 2.82 ± 0.155 | 5.07 ± 0.690 | 7.01 ± 0.268 |
| Difference ± SE | 0.64 ± 0.316 | 0.84 ± 0.162 | 2.25 ± 0.708 | 0.21 ± 0.275 |
| 95% CI | 0.013-1.260 | 0.521-1.157 | 0.862-3.646 | -0.329-0.752 |
| t-value | 2.01* | 5.18*** | 3.18** | 0.48 |

[a] =Adjusted for age

CI = Confidence intervals

*P < 0.05, ** P < 0.002, *** P < 0.000

**Table 5.2.** Mean values (± SE) of lean body mass (LBM) according to Z-scores of weight, height and BMI for age

| Parameters | Boys | | Girls | |
|---|---|---|---|---|
| | Unadjusted | Adjusted[a] | Unadjusted | Adjusted[a] |
| **Weight for age** | | | | |
| ≥ 2 Z-score | 36.64 ± 0.561 | 36.21 ± 0.211 | 31.76 ± 0.386 | 31.10 ± 0.159 |
| < 2 Z-score | 27.49 ± 1.035 | 28.94 ± 0.390 | 21.64 ± 0.867 | 25.00 ± 0.363 |
| Difference ± SE | 9.15 ± 1.177 | 7.27 ± 0.444 | 10.12 ± 0.949 | 6.10 ± 0.399 |
| 95% CI | 6.835- 11.466 | 6.393-8.141 | 8.253-11.985 | 5.317-6.887 |
| t-value | 7.77*** | 16.37*** | 10.66*** | 15.29*** |
| **Height for age** | | | | |
| ≥ - 2 Z-score | 34.59 ± 0.588 | 35.49 ± 0.250 | 32.18 ± 0.408 | 31.15 ± 0.185 |
| < - 2 Z-score | 34.85 ± 1.272 | 30.68 ± 0.548 | 23.65 ± 0.716 | 26.83 ± 0.332 |
| Difference ± SE | -0.24 ± 1.401 | 4.81 ± 0.606 | 8.54 ± 0.825 | 4.32 ± 0.386 |
| 95% CI | -3.004- 2.508 | 3.621- 6.005 | 6.917-10.161 | 3.563-5.080 |
| t-value | 0.17 | 7.94*** | 10.35*** | 11.19*** |
| **BMI for age** | | | | |
| ≥ - 2 Z-score | 35.01 ± 0.550 | 35.11 ± 0.550 | 30.41 ± 0.407 | 30.16 ± 0.188 |
| < - 2 Z-score | 29.56 ± 1.839 | 28.36 ± 0.789 | 24.03 ± 1.760 | 28.78 ± 0.825 |
| Difference ± SE | 5.45 ± 1.920 | 6.75 ± 0.817 | 6.38 ± 1.806 | 1.38 ± 0.847 |
| 95% CI | 1.670- 9.220 | 5.143- 8.358 | 2.832- 9.934 | -0.283- 3.048 |
| t-value | 2.84* | 8.26*** | 3.53* | 1.63 |

[a] = Adjusted for age

CI = Confidence intervals

*P < 0.05, *** P < 0.000

In view of the results presented in Tables 5.1 and 5.2, the question may also arise whether there is any difference between the anthropometric indices (namely, weight for age, height for age and BMI for age) in respect of their correlation with FM and LBM for both boys and girls? In the case of BMI Z-score, we have already pointed out that it is more correlated with LBM ($r = 0.763$, $P < 0.000$) than with FM ($r = 0.522$, $P < 0.000$) in boys, although it is not perceptible in girls. Of course, BMI is as much a measure of leanness and/or wasting as of fatness (Norgan, 1994). With respect to weight for age, we have already mentioned that it is a composite measure of both wasting and stunting. Table 5.3 shows that, after adjusting for age, the weight for age Z-score in boys is more correlated with LBM ($r = 0.931$, $P < 0.000$) than with FM ($r = 0.927$, $P < 0.000$). The same is true in the case of girls ($r = 0.927$, $P < 0.000$ and 0.758, $P < 0.000$, respectively). Similarly, the height for age Z-score is more correlated with LBM for both boys and girls (Table 5.3). Nevertheless, it indicates that BMI for age and weight for age are better indicators of body composition in terms of FM and LBM of the children in the present study when compared with height for age. However, as mentioned earlier weight for age does not take into account the height of individual at a given age. Similarly, height for age does not take into account the weight of individual for a given age, although it is highly correlated with LBM. As a matter of fact, LBM is a function of height for all ages (Forbes, 1987), thus, height for age is considered to be a good indicator of growth retardation or stunting. Therefore, many human biologists and anthropologists have used BMI as indicator of body composition, which is more sensitive to chronic energy deficiency (Ferro-Luzi, *et al.*, 1992).

To sum up our brief discussion on the relationship between body composition and anthropometric indices, it is obvious that the children with lower Z-scores of weight for age, height for age and BMI for age are also lower in body composition when compared with those children of higher Z-scores, which is consistent with the earlier findings on other populations. The present study also reveals that three anthropometric indices used for assessing the nutritional status are more correlated with LBM than with FM. Although weight for age Z-score is more correlated with FM and LBM in the present study, BMI for age may still be considered a better indicator of body composition because it takes into account the weight and height of an individual, whereas weight for age fails to do so. This is also as observed in other populations.

**Table 5.3.** Partial correlation coefficients (r) between body composition and Z-scores of BMI, weight and height for age.

| Indices | Boys | | Girls | |
|---|---|---|---|---|
| | FM | LBM | FM | LBM |
| BMI for age Z-score | 0.522* | 0.763* | 0.074 | 0.076 |
| Weight for age Z-score | 0.556* | 0.931* | 0.758* | 0.927* |
| Height for age Z-score | 0.333* | 0.499* | 0.503* | 0.683* |

* $P < 0.000$

## CONCLUDING REMARKS

The present study has revealed that there are significant differences between boys and girls in respect of growth pattern. This is as generally observed and expected especially in adolescent boys and girls because of the inter- and intra-individual timing of growth spurt. We have observed that the sex variation is much greater in respect of body composition, despite of the absence of statistical differences between boys and girls in body weight for all age groups. The study indicates that the mean FM is greater in girls than in boys, while the mean LBM is higher in the latter. This implies that the total body mass or body weight of boys is mainly composed of muscle mass, while fat mass has mainly contributed to the total body mass of girls. In other words, the fat composition of the total body weight is much higher in girls than in boys, whereas the muscle mass is higher in the latter. Thus, the present findings seem to confirm the earlier observations on other populations (Forbes, 1987; Rolland-Cachera, 1995). Whether this is associated with genetic factors is a matter of interpretation. Of course, the sex differences in age at peak velocity, adult size and peak size velocities are also likely to be more associated with genetic factors. It is observed that in the present study the sex differences in linear measurements like height, sitting height and subischial length are largely contributed by the differences in growth rate during the occurrence of adolescent growth spurt. This may have certain implications with the general observation that growth during childhood is more sensitive to environmental factors, while growth during adolescence is determined more by genetics (Hauspie and Sussane, 1998; Bogin, 1999).

Further, although the common nutritional problem among the Lotha children is stunting but not that of wasting, the present study reveals that the prevalence of wasting is higher in boys than in girls. This may also imply that girls are better "buffered" than boys against environmental factors like inadequate dietary intakes (Stinson, 1985; Bogin, 1999), which may be associated with genetic factors. The higher prevalence of the clinical signs of nutrient deficiencies in boys than in girls is likely to support such a "buffering hypothesis" which states that girls are less likely to be "knocked-off-track" by poor environmental conditions including inadequate nutrition. Little is known about this problem in Indian populations, thereby warranting more studies.

As for the question of higher prevalence of stunting in girls, it is difficult to give a proper explanation as it is also related to past history of growth status. Whether this reflects the patrilineal system of the society is the question to be answered by future studies. With the present set of data, we are not in a position to argue that there exists a sex bias in dietary intakes among the Lotha population. We hope that future studies - which are concerned with both growth and socioeconomic data - will shed much more light on the relationship between nutritional status and socioeconomic status of the present population.

On average, the Lotha children of the present study are comparable to the Indian children of the ICMR, but are bigger than the Khasi and Meitei children. They are by and large comparable with the 10th and 25th percentiles of the NCHS growth references in respect of weight and with the 5th and 10th percentiles in respect of height. The nutritional status of the Lotha children is also, on average, moderate in comparison with some other populations. Such a better growth and nutritional status reflects the better dietary intakes of the Lotha population. Although, the present study is short of data on socioeconomic condition of the study population, better dietary intakes may be associated with better socioeconomic status, although it may not be so in hunting and agricultural community where human labour is entirely related to food consumption. It may be noted that in the present population, agriculture is the mainstay of the people as described in Chapter I. Individual's earning is mostly not in terms of cash but in terms of kind, that is, either in terms of the exchange of food grains or agricultural labour. As such, it is very difficult to assess the per capita income of the Lotha people. But what it is to be noted here is that most of the agricultural work is for household consumption but not for marketing the agricultural produce. So self-sufficiency in food production depends on labour and the availability of land for cultivation, which is mostly under the control of the clan. We hope that future studies will shed more light on the relationship between nutritional and socioeconomic condition of the Lotha population.

Last but not least, the present study has also certain policy implications. Although the nutritional status is moderate in the present population, the nutritional problem is related mainly to that of stunting or growth retardation. Growth retardation is not only because of poor socioeconomic condition, but it has a vicious circle. It may affect the socioeconomic condition of an individual, or a population as well, because of the poor earning capacity due to poor health status. It may be suggested that efforts to improve agricultural activity or food availability, dietary quality, hygiene, supply of safe-drinking water, and prevention and treatment of infectious diseases are likely to improve the health and nutritional status of the Lotha population over time.

# CHAPTER - VI

# SUMMARY

## INTRODUCTION

Growth and development are ubiquitous to all living organisms including human beings. Growth and development are the two distinct biological processes that occur simultaneously from the beginning to the end of the life of individual. **Growth** is defined as a regular process of quantitative increase in size or mass of different tissues and organs of the body especially from conception to adulthood.

Nowadays, the study of physical growth of children has become the major interest not only among the auxologists, but also among the biologists, anthropologists, nutritionists and other social and behavioural scientists with different interests and objectives of study. As for anthropology, the study of human growth has been an essential part of anthropological research since the birth of the discipline itself. Early anthropologists, especially Franz Boas are well known for their contribution to growth studies. One of the main reasons for such an interest in growth studies is that human growth serves as a mirror that "reflects the biocultural evolution of our species" (Bogin, 1999). Of course, the basic objective of anthropology is to understand the biological and cultural evolution of human population. Human growth may be considered the product of the interplay between the biology of our species, the physical and the socioeconomic environment where we live. Therefore, the pattern of human growth and development reflects the biological and socio-cultural aspects of our society as well as the evolutionary history of our species. According to Tanner (1988), "The study of growth is important in elucidating the mechanism of evolution, for the evolution of morphological characters necessarily comes about through alteration in the inherited pattern of growth and development. Growth also occupies an important place in the study of individual differences in form and function of man, for many of these also arise through differential rates of growth of particular parts of the body relative to others."

Besides, the study of human growth is also essential to understand not only the health and nutritional status of a population, but also the interaction between biology and culture. For example, the pattern of human growth is indirectly influenced by several economic and socio-cultural factors through their direct influence on nutrition and infection. Several studies have revealed that children belonging to different socio economic groups have shown differences in their growth pattern (Frisancho, 1978; Eveleth and Tanner, 1990; Hauspie *et al.*, 1992; Misuraca *et al.*, 1995; Edward *et al.*, 1996; Milani *et al.*, 1999; Reddy and Rao, 2000; and many others). Further, Eveleth and Tanner (1990) have also observed, "A Child's growth rate reflects, perhaps better than any other single index, his state of health and nutrition; and often indeed his psychological situation also. Similarly the average values of children's height and weight reflect accurately the state of a nation's public health and the average nutritional status of its citizens, when appropriate allowance is made for differences, if any, in genetic potential. This is especially so in developing and disintegrating countries". Therefore, a well-designed growth study is a very important tool for assessing the health status of the population concerned. Since human growth and development is also largely influenced by socio-environmental factors like nutrition, infection, occupation, income and religion, it is very vital for understanding the biocultural variation and evolution of human populations (Tanner, 1988; Eveleth and Tanner, 1990; etc.).

In the light of the above circumstances, physical growth is not only helpful in understanding the process of human evolution and variation, but also reflects the health and economic condition of a population. In India, the large sample growth study was first carried out by the Indian Council of Medical Research between 1956 and 1965 and reported in 1972, although stray researches began since 1930s by workers like Aykroyd and Rajgopal (1936), Narinder Singh (1939), and others. However, growth studies in India are still limited in number especially those which are concerned with the assessment of health and nutritional status of different ethnic groups in the country (Sharma, 1992). Therefore, it is essential to conduct more researches on physical growth and development of children with a view of understanding the nutritional status and economic conditions of the different populations in different parts of the country.

## OBJECTIVES OF STUDY

It may be worthwhile to mention here that in the Northeast India, only few growth studies have so far been published (Khongsdier and Ghosh, 1998; Chelleng and Mahanta, 1998; Begum and Choudhury, 1999). Moreover, most growth studies in Northeast India have been carried out among some populations of Assam only. Very few studies have been carried out in other states of Northeast India (Singh and Singh, 2000; Gaur and Singh, 1995; Talwar and Singh, 1995; Khongsdier, 1996, 1999, 2001) especially in the state of Nagaland. Moreover, the growth studies carried out in Northeast India were mainly concerned with the assessment of growth patterns only. Very few studies are also concerned with the assessment of the nutritional status of children. Therefore, the present study was carried out among the Lotha children of rural areas in Wokha district of Nagaland taking into consideration the following objectives:

1. To describe the growth pattern of Lotha adolescent children aged 9 to 18 years in terms of anthropometric variables.
2. To assess the nutritional status of these children, using certain anthropometric indices.
3. To find out the frequency of some common nutritional deficiency signs.
4. To compare the physical growth and nutritional status of Lotha children with those children reported for other populations, especially in Northeast India.

## MATERIALS AND METHODS

The present study was conducted among the Lotha children in rural areas of Wokha district of Nagaland. The fieldwork was carried out during the period from January 1998 to August 1999. No statistical sampling technique was applied for the selection of villages or individuals covered under study. However, an attempt was made to include in our sample almost all villages, which are located within a radius of 20 km from Wokha town, keeping in view that distance from town might have influenced the socioeconomic and nutritional status of the population. The villages included in our study are Changsu, Chukitong, Elumyo, Humtso, Koio, Longsa, Longsachung, Niroyo, Nru-Longidang, Phiro, Pongitong, Sankiton, Shaki, Wokha-yan, Yanthamo, Yikhum and Yimkha. The total number of individual samples is 741 of which 366 are boys and 375 are girls, who are aged 9 to 18 years. As hinted above, these boys and girls were selected not on the basis of statistical sampling because of operational difficulties in the field. However, efforts were made to include in our sample all those boys and girls who were willing to co-operate to the present study with the help of school teachers and parents.

**Data on Growth of Children:** A cross-sectional method of study was followed for collection of data on physical growth of 741 children aged 9 to 18 years (Eveleth and Tanner, 1990), taking into consideration some selected anthropometric measurements like weight, height, sitting height, subischial length, biacromial diameter, upper arm circumference, skinfold thickness, etc.

Standard techniques of measurements described in Hooton (1946), Weiner and Lourie (1981) and Sen (1994) were followed while taking the anthropometric measurements of children. The age of children was based on the school registers and the date of birth given by the parents. The date of birth for every individual was converted into decimal age following the method of decimal age calendar given by Tanner (cited in Weiner and Lourie, 1981). For example, the age group 9 years includes all the children whose decimal age falls between 8.500 to 9.499 years.

### Preece-Baines Model 1 (PB1)

In the present study, we have used the mathematical model proposed by Preece and Baines (1978), referred to herein as PB1 model. This model was adopted for fitting the means of weight and some important linear measurements (Precee and Baines, 1978), using Levenberg-Marquardt method through SPSS (version 10.0) and Origin Software (Version 7.0) for Windows. The model is expressed as follows:

$Y = h_1 - [2(h_1 - h_0)]/[\exp\{s_0(t-\theta)\}+\exp(s_1(t-\theta)\}]$

Where, $Y$ = anthropometric measurement, $t$ = age (years), $s_1$ and $s_0$ = rate constants, $\theta$ = time constant, $h_1$ = final size of a measurement, $h_0$ = measurement at $t = 0$.

Although PB1 model is primarily meant for fitting individual-longitudinal data, its use in the present study was but to estimate graphically some biological parameters (like adult size, age at maximum increment, or peak velocity, and peak size velocity) with a view to understand the nature of variation in growth pattern. Of course, the application of this model to cross-sectional data has also been revealed by many studies (Cameron *et al.*, 1982; Lindgren and Hauspie, 1989; Milani 2000; Ward *et al.*, 2001).

### Anthropometric Assessments of Nutritional Status

For assessing the nutritional status of children, we have adopted three anthropometric indices, namely, weight for age, height for age and body mass index (i.e., weight in kg/height$^2$ in mts) for age, which are considered as good indicators of nutritional status. These indices were derived both as Z-scores and percentages of the international standards or references, i.e., the growth references of the U.S. National Center for Health Statistics (NCHS) recently revised (Kuczmarski *et al.*, 2000). For classifying the children into different grades of nutritional status, we have calculated the Z-score of individuals in relation to the NCHS growth references, using LMS method (Kuczmarski *et al.*, 2000). This method was based on the median (M), the standard deviation (S), and the power in the Box-Cox transformation (L). In order to obtain the Z-score (Z) for a given measurement, we used the following equation:

$$Z = \frac{((X/M)**L) - 1}{LS}$$

Where, X is the physical measurement (e.g. weight, height, etc.) and L, M and S are the values from the appropriate table corresponding to the age of the child. The children were then categorized into three levels of nutritional status, following the cut-off points proposed by Visweswara Rao (1996), which are as follows:

(1) Normal = -2 to + 2 of Z-score
(2) Moderate = -2 to – 3 of Z- score
(3) Severe = Below –3 of Z - score

**Body composition**

By "body composition" we mean to the lean body mass (LBM) or fat free mass (FFM) plus adipose tissue (AT) or fat mass (FM). According to Forbes (1987), LBM refers to "body mass minus ether-extractable fat, and hence includes the stroma of adipose tissue." An assessment of body composition is useful in getting a better understanding of the growth and nutritional status of children. In the present study, we have assessed the body composition of the Lotha adolescent children taking into consideration the equations proposed by Durnim and Womersley (1974), which are generally recommended for the adolescent children (Norgan, 1995). Following are the equations used for computing the body composition:

Males: Density (D) = $1.1620 - 0.0630 \times \log_{10}$ (biceps + triceps + subscapular +suprailiac)

Females: Density (D) = $1.1549 - 0.0678 \times \log_{10}$ (biceps + triceps + subscapular + suprailiac)

Percentage fat = $(4.95/D - 4.5) \times 100$

Fat mass (kg) = Percentage fat × body weight (kg)

Fat free mass or lean body mass (kg) = Body weight – fat mass (kg)

### Clinical Observations

Clinical observations relating to certain signs of nutrient were carried out according to the methods described in Jelliffe (1966) and Latham (1979). Since the observer is not well trained in examining the clinical signs and symptoms of undernutrition, only few selected clinical signs that could be easily examined with our naked eyes were taken into consideration. The selected clinical signs include bitot's spot, vascularization of the cornea (characterized by invasions of all quadrants or the whole of the periphery of the cornea by fine capillary blood vessels), skin xerosis, angular stomatitis (sodden and excoriated lesions associated with fissuring at the angles of the mouth), cheilosis (a lesion characterized by vertical fissuring, later complicated by redness, swelling and ulceration of lips), scarlet and raw tongue (characterized by bright red in colour of tongue, usually with slight atrophic, denuded and very painful), and atrophic papillae (characterized by disappearance of filiform papillae, giving the tongue an extremely smooth appearance).

## FINDINGS OF THE PRESENT STUDY

The present thesis consists of six chapters. The first chapter deals with the introduction and review of related literature, including a brief description of the area and population of study. In the second chapter, we have described the materials and methods of data collection adopted in the present study. The findings of the study relating to growth pattern and nutritional status are presented in chapter III and IV, respectively. The discussion and implication of the findings are given in chapter V, while the summary of the study is given in chapter VI. The findings of the present study may be briefly presented as follows:

**Growth Pattern**: The growth pattern of the Lotha children in the present study are described in terms of fourteen anthropometric measurements. In this presentation, we shall restrict to weight and some important linear measurements like height, sitting and subischial length, which are generally used as important anthropometric variables for assessing the growth patterns of children.

### Weight

It is observed that there are no statistical differences between boys and girls in respect of weight, although the former are heavier than the latter especially after 12 years of age. Using Preece-Baines model 1(PB1) model, the mean values were smoothed in order to estimate the adult body mass and maximum age at peak velocity. It is found that both boys and girls are more or less similar in weight from 9 to13 years of age, and thereafter the boys surpassed the girls. The estimated adult weight according to the PB1 model was about 54.02 kg in boys and 52.52 kg in girls. The estimated adult body weight was about 2.07 kg higher than the observed value at the age of 18 years for boys, while it was about 2.71 kg for girls. Thus, it indicates that both boys and girls reach their adult body weight by and large at the age of 18.

Using the first derivative of the PBI distance curves, the estimated age at peak weight velocity was 13.04 years for boys and 12.93 years for girls with the mean weight of 36.69 kg and 35.88 kg, respectively. Therefore, the adolescent growth spurt in body weight took place little earlier in girls than in boys, although the latter are heavier than the former at the age of peak velocity. It is further observed that the peak weight velocity is slightly higher in boys (4.24 kg/year) than in girls (3.94 kg/year).

### Height

It is found that both boys and girls are more or less same in height from 9 to 10 years of age, but girls are significantly taller than boys from 11 to 12 years of age, thereafter boys are significantly taller than girls across ages. The estimated adult height according to PB1 model is found to be 163.47 cm for boys, which is about 0.68 cm higher than the observed value at the age of 18 years. On the other hand, the estimated adult height for girls is about 158.68 cm, which is 1.95 cm higher than the observed value at 18 years of age. This indicates that both boys and girls still continue to grow in height, especially in girls. The present findings among the Lotha children are, therefore, different from those observed among the Assamese children (Begum and Choudhury, 1999) and Khasi boys (Khongsdier and Mukherjee, 2003), which showed that adult size had been reached by the age of 18 years. Of course, human growth does not cease around the age of 18 years, but it may continue for about a decade or more. Garn (1980) has suggested that there may be a gain in stature as much as 8 cm from 18 to 28 years of age. Tanner (1978) is of the opinion that the vertebral column continues to grow until about 30 years of age, leading to an increase of 3 to 5 mm in height on the average, and for practical purposes, the defined age of growth cessation should be about 98% of the estimated adult height. Thus, from this point of view, we may conclude that, for practical purposes, the Lotha boys and girls reach their adult height by the age of 18 years, although the growth in height may still continue at a lesser rate.

The estimated age at peak height velocity is 13.01 years for boys and 11.00 years for girls with the mean height of 143.90 cm and 131.86 cm, respectively. Therefore, the adolescent growth spurt occurs about 2 years earlier in girls than in boys. It is observed that the velocity (annual increment) is higher in girls from 9 to about 11 years of age with the peak velocity of 6.48 cm/year, and thereafter it is higher in boys till the age of 17 years with the peak velocity of (6.98 cm/year). Thus, the larger stature in boys when compared with girls could be largely attributed by the greater growth rates in the former during adolescence, that is, from 11 years onwards. Begum and Choudhury (1999) have reported that the age at peak velocity for height derived from the PB1 fits was 13.4 years for boys and 11.4 years for girls among the Assamese Muslims. Thus, the Lotha children are more or less similar in age at peak velocity for height to the Assamese Muslim children of Assam.

### Sitting height

In the case of the upper extremity or sitting height, it is found that the sex differences are by and large similar to that for height. It is observed that the differences between boys and girls are not statistically significant from 9 to 13 years of age, but boys are significantly higher in sitting height from 14 years onwards. The estimated adult size, according to the PB1 model, is 85.74 cm for boys and 84.79 cm for girls. It is found that boys had reached their adult sitting height at about 18 years of age, but girls might still continue to grow. Like in the case of height, the estimated age at peak velocity is higher in boys (13.03 years) than in girls (11.03 years). Thus, the present analysis indicates that the adolescent growth spurt occurs earlier in girls as compared with boys, and the higher sitting height in boys at 18 years of age is largely due to their higher growth rate from 11 to 16 years of age. It is reported that among the Assamese children, the peak velocity was about 13.9 years for boys and 11.6 years for girls (Begum and Choudhury, 1999), whereas among the Khasi girls it was about 13.01 years (Mukherjee, 2002). Thus, it indicates that the peak velocity for both boys and girls of the present population is comparable to that reported for the Assamese boys and girls.

### Subischial length

Like in the case of trunk height or sitting height, the lower extremity or subischial length (stature minus sitting height) is significantly higher in boys from 14 years onwards, although the girls are significantly higher at the age of 12 years. It is observed that both boys and girls attained their adult size of subischial length by and large at the age of 18 years. This also indicates that the lower extremity reach its adult size earlier than the upper extremity as commonly observed in other populations (Tanner, 1978; Dasgupta and Das, 1997; Begum and Choudhury, 1999). With regard to age at peak velocity, it is found that it is similar to height and sitting height in the case of boys (12.96 years). But girls (10.04 years) experienced about 3 years earlier than boys. It is also observed that the velocity is higher in girls only from 9 to about 11 years of age, and thereafter it is much higher in boys till the age of 18 years. Thus, the higher subischial length in boys is due to their greater growth rate from the age of 12 onwards.

## COMPARISON WITH OTHER POPULATIONS

### Weight

It is observed that the Lotha boys are much above the 50th percentile of the ICMR growth references from 9 to 18 years of age. In comparison with the NCHS growth references, the Lotha boys are below the 10th percentile from 9 to 10 years of age, and thereafter they are above the 10th percentile and below the 25th percentile of the NCHS growth references till the age of about 17 years. But they are below the 10th percentile of the NCHS growth references from 17 to 18 years of age. Nevertheless, it indicates that the Lotha boys of the present study are better in growth status of weight when compared with the Indian boys of the ICMR. In comparison with their counterparts reported from some populations of Northeast India, the Lotha boys are found to be comparable to the Meitei (Talwar and Singh, 1995), Khasi (Khongsdier and Mukherjee, 2003; Mukherjee, 2002) and Assamese Muslim (Begum and Choudhury, 1999) boys from 9 to 18 years of age. It is observed that the Lotha boys are by and large heavier than the Meitei, Khasi and Assamese Muslim boys from the age of 11 onwards. They are similar to the Assamese Muslims at 9, 12 and 15 years of age, but they are lighter than the Meitei boys of Manipur from 17 to 18 years of age. Thus, in view of these comparisons, the Lotha boys seem to have a better growth status in weight when compared with the Indian boys of the ICMR and those reported for some populations in Northeast India.

As for girls, it is found that the Lotha girls are below the 50th percentile of the ICMR growth references at 10 years of age, and thereafter the curve lies much higher than the ICMR growth curve. In comparison with the NCHS growth references, the Lotha girls are more or less comparable to the 10th percentile from 11 to about 13 years of age, and thereafter they are much higher than the 10th percentile and move towards the 25th percentile of the international (NCHS) growth references, especially from the age of 16 onwards. From this point of view, the Lotha girls are better than their male counterparts whose curve tends to lie below the 10th percentile of the NCHS growth references after the age of 16 years. In comparison with the Khasi and Meitei girls of Northeast India, it is found that curve for the Lotha girls is below that of the Khasi girls from 9 to about 11 years of age, and thereafter the curve for the Lotha girls lies much above that of the Khasi girls till the terminal age of 18 years. The Lotha girls are also heavier than the Meitei girls of Manipur from 11 to 13 years and from 16 to 18 years, although the Meitei girls are heavier from 14 to 15 years of age. In comparison with the Assamese Muslim girls, the Lotha girls are lighter from 9 to about 14 years of age, and thereafter they are much heavier than the Assamese Muslim girls. In short, the present findings indicate that the Lotha girls are heavier than the ICMR Indian girls and other Indian girls like the Khasi and Meitei of Northeast India.

**Height**

With respect to height, it is observed that the curve for the Lotha boys lies below the 50th percentile of the ICMR growth references from 9 to about 13 years of age, and below the10th percentile of the NCHS growth references from 9 to about 12.5 years. However, the curve for the Lotha boys lies above the 50th and 10th percentiles of the ICMR and NCHS growth references, respectively, from 13 to about 15 years of age. After 15 years of age, the curve is similar to that of ICMR growth references, but much below the 10th percentile of the NCHS growth references.

The Lotha boys are similar in height to the Assamese Muslim boys at the age of 13 years and from 16 onwards, although the latter are much taller in other age groups. If we are to consider the 5th percentile of the NCHS references as a cut-off point for categorizing growth retardation, the present Lotha boys are below the 5th percentile from 17 to 18 years, but similar to this percentile from 11 to 12 years of age. Nevertheless, the present findings show that the Lotha boys are much taller than the Meitei and Khasi boys of Northeast India, and they are similar to the 50th percentile of the ICMR growth references.

In the case of girls, it is found that the curve lies below the 5th percentile of the NCHS growth references from 9 to 10 years of age, and thereafter it tends to move along the 10th percentile up to about 12 years of age. From 12 years of age, the curve lies along the 5th percentile of the NCHS references up to about 14 years of age when it started moving upward and crossing above the 10th percentile from the age of 16 onwards. In comparison with the ICMR growth references, the curve for the Lotha girls lies below the 50th percentile from 9 to about 13 years of age, and thereafter it is similar to the Indian girls up to 14 years of age. From 14 years of age, they are much taller than the Indian girls of the ICMR. Compared with other populations in Northeast India, the Lotha girls are shorter than the Assamese Muslim girls from 9 to about 14 years of age, but thereafter the former are taller than the latter. However, the Lotha girls are much taller than the Meitei and Khasi girls.

**Sitting height**

With respect to sitting height, it is found that the Lotha boys have higher sitting height than any population under comparison from about the age of 12 onwards. However, they are lower in sitting height from 9 to 12 years of age when compared with the Assamese Muslim boys of Assam, but higher than the 50th percentile of the ICMR growth references and the observed mean values among the Khasi and Meitei boys.

In the case of girls, the curve for the Lotha girls lies above that of other populations from the age of 14 onwards. The sitting height of Lotha girls is similar to the 50th percentile of the ICMR growth references from 11 to about 13 years of age. But the curve is below that of the Assamese Muslim girls from 9 to 13.5 years of age. The Lotha girls are also similar in sitting height to the Khasi and Meitei girls at the age of 10, 11 and 14 years, respectively, although the sitting height is higher among the Lotha girls across other age groups.

In view of the present comparison, it is obvious that the growth status of Lotha children is on the average comparable to the Indian children of the ICMR, but they are bigger than the Khasi and Meitei children. They are by and large comparable with the 10th and 25th percentiles of the NCHS growth references in respect of weight and with the 5th and 10th percentiles in respect of height.

## NUTRITIONAL STATUS

Nutritional status is defined as the physical expression of the relationship between the nutrient intakes, or bio-availability of nutrients, and the physiological requirements of an individual (Brown, 1984). This physical expression of the relationship between nutrient intakes and physiological requirements of a person can be measured by a number of methods. Of different methods, anthropometry is one that is generally used for measuring the magnitude of under nutrition at both individual and population levels. In the present study, we have taken three important anthropometric indices, i.e., weight for age, height for age, and body mass index for assessing the nutritional status of the children. We have also made an attempt to correlate these indices with certain indicators of body composition like fat mass, and LBM. Also, the study has taken into consideration certain clinical signs of undernutrition to support the findings on anthropometric measurements and indices. The findings of the study may be presented briefly as follows:

**Weight for age**

Weight for age, expressed as percentage or Z-score of individual weight to the median or 50th percentile of the international population reference (i.e., NCHS growth references) is generally considered as one of the indicators of underweight. It is found that the mean weight for age is higher in boys than in girls from 9 to 14 years of age, although the differences are not statistically significant except at the age of 10 years. After 14 years of age, the situation is reverse in which the mean values are significantly higher in girls than in boys except at the age of 15 years.

Using LMS methods of Z-score (Kuczmarski *et al.*, 2000), it is found that about 77.59% of boys and 83.47% of girls for all age groups are in the normal category (-2 to + 2 of Z-scores) of nutritional status. On the other hand, the prevalence of moderate (-2 to – 3 of Z-scores) and severe (below –3 of Z-scores) forms of underweight among boys is 18.58% and 3.83%, respectively. In the case of girls, these frequencies are found to be 13.60% and 2.93%, respectively. Considering the cut-off point of -2 to + 2 Z-score, the estimated odds ratio (OR) is found to be 1.46 with 95% confidence interval (CI) of 1.01 and 2.11, which indicates that boys are likely to be 1.46 times underweight when compared with girls in this age group. This odds ratio is found to be significant at 5% level ($\text{Log}_e$ OR ± SE = 0.3784 ± 0.1872, $P < 0.05$), although the chi-square test does not reveal any significant difference between the two sexes for all age groups ($\chi^2 = 4.09$, DF = 2, $P>0.05$).

Besides sex variation in the distribution of low weight for age mentioned above, it is found that the frequencies of underweight (i.e., moderate plus severe forms) in boys for the age groups ≤ 12, 13-15 and 16-18 years are 30.82%, 13.51% and 20.18%, respectively. In the case of girls, these frequencies are 23.34%, 17.70% and 6.25%, respectively. Thus, it indicates that the prevalence of underweight is higher in the lower age groups especially in girls. In other words, the nutritional status seems to be better in the higher age groups as compared with that in the lower age groups. The Pearson correlation coefficient (r) between age and weight Z-score is found to be 0.309, $P < 0.01$ in girls and 0.173, $P < 0.05$ in boys. The chi-square test also indicates that the differences in the distribution of undernourished individuals between age groups are highly significant in both boys ($\chi^2 = 11.31$, DF = 2, $P<0.003$) and girls ($\chi^2 = 13.72$, DF = 2, $P<0.001$).

When compared with related data on children of Northeast India, the prevalence of underweight in this population is much lower than that among the Khasi children (Khongsdier and Mukherjee, 2003). As already mentioned, to the best of our knowledge. there is no published data on growth and nutritional status of children, especially among the Lotha children. The National Family Health Survey (NFHS, 1998-99) has, of course, taken into consideration the nutritional status of the children below 4 years of age. It is reported that the prevalence of underweight in Nagaland is about 24.1%, which is the lowest in comparison with the states of Arunachal Pradesh, Assam, Manipur, Mizoram and Meghalaya. Thus, the prevalence of underweight among the Lotha children (19.43% when both the sexes are combined) is comparable to the finding of the NFHS, although it is lower in the present study. Also, the NFHS data was based on state level but not on population level as in the case of the present study.

### Height for age

In the present study, height for age is expressed as percentage and Z-score of individual height to the median or 50th percentile of the NCHS population references. This index is considered as one of the best indicators of stunting or growth retardation due to undernutrition. It is found that the mean values of height for age (%) are more or less similar at the age of 9 years for both boys and girls. Thereafter, girls are higher in mean values as compared with boys from 10 to 12 and 15 to 18 years of age. However, the t-test indicates that girls are significantly higher in mean values only from 16 to 18 years.

With respect to levels of nutritional status, it is found that the proportions of boys with normal, moderate, and severe forms of undernutrition are 81.69%, 17.49% and 0.82%, respectively. In the case of girls, these frequencies are about 75.47%, 20.53% and 4%, respectively. Thus, unlike weight for age, it indicates that the overall prevalence of undernutrition for all age groups is higher in girls (24.53%) than in boys (18.31%), and it is statistically significant ($\chi^2 = 9.53$, DF =2, $P<0.05$). The estimated OR is found to be 1.45 (95% CI = 1.02-2.08), which is also significant at 5% level ($Log_eOR \pm SE = 0.372 \pm 0.181$, $P < 0.05$). This higher frequency of growth retardation in girls is found to be statistically significant in the lower age groups (≤ 12 and 13-15 years), but in the age group 16-18 years the prevalence is significantly higher in boys than in girls. Moreover, it is also observed that the prevalence of growth retardation in girls is similar to low weight for age, that is, it is higher in the lower age groups, but the situation is reverse in the case of boys. The Pearson correlation coefficient (r) between age and height for age Z-score is also positively significant in the case of girls ($r = 0.311$, $P < 0.01$) and negatively significant in the case of boys ($r = -0.493$, $P < 0.01$). Thus, the present findings indicate that girls in the lower age groups are higher in the frequency of low height for age as compared with the higher age groups, but the situation is reverse in the case of boys. In other words, the frequency of higher Z-scores of height for age increases with age in girls, but it decreases as age advances in the case of boys.

The prevalence of growth retardation in Lotha children of the present study (21.47%) is found to be lower than that for the state of Nagaland (33%) as reported by the NFHS (1998-99). It is also lower than that reported for the Khasi children (Khongsdier and Mukherjee, 2003). In short, it indicates that the Lotha children are better in height for age when compared with the available data on populations in Northeast India. This can also be seen from the findings of the NFHS for all the states in Northeast India, which shows that nutritional status in children of Nagaland is better than other states including Mizoram.

### Body mass index

Body mass index (BMI) is generally considered as the best indicator of body fat mass, or thinness due to chronic energy deficiency (Ferro-Luzi *et al.*, 1992; WHO, 1995). This anthropometric index is expressed as weight in kilogram divided by height-square in meter, and it is independent of age. In the present study, it is found that boys are higher in mean values from 9 to 13 years of age, and thereafter the mean values are higher in girls till the age of 18 years. However, the t-test indicates that the boys are significantly higher in BMI only at the ages of 10 and 12 years. On the other hand, the mean values of BMI for age are significantly higher in girls than in boys from the age of 16 onwards.

It is observed that the nutritional status of children according to BMI for age is better than that indicated by weight for age and height for age. It is found that about 91.80% of boys and 94.93% of girls are in the normal grade of nutritional status. In other words, the frequencies of moderate and severe grades of CED in boys are about 6.56% and 1.64%, respectively. While in girls, these frequencies are about 3.73% and 1.33%, respectively. Thus, the prevalence of CED is higher in boys (8.20%) than in girls (5.07%), although it is statistically insignificant ($\chi^2$ = 2.94, DF = 1, P>0.05). The estimated OR is also not statistically significant ($Log_e$OR ± SE = 0.512 ± 0.486, P > 0.05), although it indicates that boys are about 1.67 (95% CI = 1.03-2.71) times higher in the prevalence of CED when compared with girls.

The percentage distribution of undernutrition in boys and girls are also analysed according to three arbitrarily age groups. In the first age group (i.e., ≤ 12 years), no boys has suffered from the severe grade of CED, but about 6.85% of them are in the moderate form of CED. However, the prevalence of moderate and severe grades of CED in girls is about 5.33% and 2.67%, respectively. So, the prevalence of CED is higher in girls (8%) than in boys (6.85%), despite of the absence of statistical significance ($\chi^2$ = 0.13, DF = 1,P>0.05). As for the second age group (13-15 years), about 4.42% and 0.88% of girls and about 8.11% and 1.80% of boys have suffered from moderate and severe grades of CED, respectively. Thus, unlike in the first age group, the prevalence of CED is higher in boys than in girls in this age group, although the differences are not statistically significant ($\chi^2 = 1.67$, DF = 2, P> 0.05). In the third age group (16-18 years), it is found that in the case of boys the frequencies of moderate and severe forms of CED are about 4.59% and 3.67%, respectively. On the other hand, none of the girls has suffered from the severe form of CED, but about 0.89% of them are in moderate grade of CED. Thus, in this age group also, the prevalence of CED is higher in boys than in girls, and it is statistically significant ($\chi^2 = 6.93$, DF = 1, P<0.008), although the estimated OR is not statistically significant for all the age groups.

It may also be noted that like in the case of height for age, the prevalence of CED in boys is higher in the higher age groups. It is found to be 6.85%, 9.91% and 8.26%, respectively for the age groups ≤ 12, 13-15 and 16-18 years. On the contrary, girls in the lower age groups are found to have higher frequencies of CED, that is, about 8.0%, 5.31% and 0.89% of them have suffered from CED in the age groups ≤12, 13-15 and 16-18 years, respectively. The differences between age groups are significant in the case of girls ($\chi^2 = 6.76$, DF = 2, P< 0.05), but it is not significant in boys ($\chi^2 = 0.79$, DF = 2, P> 0.05). The Pearson correlation coefficient between age and BMI Z-score is also found to be positively significant in the case of girls ($r = 0.188$, $P < 0.01$) and negatively significant in the case of boys ($r = -0.156$, $P < 0.01$). Thus, it indicates that the number of individuals with higher Z-scores of BMI increases with age in girls, but tends to decrease with age in the case of boys.

With respect to the prevalence of chronic energy deficiency, it is found that the Lotha children are much better than the Khasi children (Khongsdier and Mukherjee, 2003). It is also better than many Indian populations (Visweswara Roa *et al.*, 1994; Bandyopadhyay and Saha, 1999; Khongsdier and Mukherjee, 2003), although the BMI for age is below the 50th percentile of the NCHS growth references.

In view of the present findings on anthropometric indicators of the nutritional status of population, one may argue that the prevalence of undernutrition in the Lotha children is not as high as that observed in other children of some Indian populations. Of course, the prevalence of undernutrition is higher in terms of weight for age and height for age as compared with BMI for age. In this connection, it may be noted that weight for age is also dependent on height, although it is used as good indicator of underweight when the value of Z-score in relation to the growth references is below - 2. In the present study, it is found that the correlation coefficient between Z-scores of weight for age and height is positively significant for both boys and girls. Therefore, weight for age is not independent of height rather it is significantly correlated with height in the present population. As a matter of fact, weight for age is a composite index of both height for age and BMI for age and "fails to distinguish tall, thin children from those who are short with adequate weight" (Gorstein *et al.*, 1994). This is due to the fact that weight for age does not take into account the height of individual at a given age. However, weight for age is generally used for assessing the current nutritional status of the population, and it is important when compared with the recommended growth references like that of the NCHS taken for the present study. According to the WHO Working Group (1986), its use along with height for age may be helpful in getting an overview of the nutritional problems in a community, or in understanding the "direction of change" that is, to find out whether the intervention activities in a population should first be directed towards resolving the causes of stunting or wasting.

We have mentioned that the height for age Z-score of below – 2 in relation to the growth references is indicative of growth retardation or stunting due to slow skeletal growth. In fact, height for age is considered to be indicative of the present and past history of the growth status of a child. The WHO Working Group (1986) has recommended that the use of height for age is essential to know the "accumulated consequences of retarded growth" for it is also associated with poor economic condition, high frequency of infections and inadequate nutrient intake. Its use for assessing the nutritional status of adolescent children, like in the present study, is however subject to controversy because of the variable timing of growth spurt (Cameron, 1993). Nevertheless, the use of height for age along with BMI for age is important in understanding the nutritional and socioeconomic conditions of the study population. It may be noted that BMI is used instead of weight for height in the present study because BMI is generally considered as good indicator of fatness or thinness and/or wasting. This may be one of the reasons why the U.S. National Center for Health Statistics has recently used BMI for age instead of weight for height, which is commonly used as indicator of wasting (Kuczmarski *et al.*, 2000). In the present study also, BMI for age is considered to represent the current status of wasting, fatness or thinness due to CED. It is also believed to be associated with socioeconomic condition and morbidity of a population (Nubé *et al.*, 1998; Khongsdier, 2002).

### Clinical symptoms of vitamin A deficiency

Children exposed with the signs of bitot's spot and skin xerosis were considered as clinical signs of vitamin A deficiency. It is found that the two types of clinical signs of vitamin A deficiency are significantly higher in boys than in girls. The most common sign of vitamin A deficiency is that of skin xerosis, which is characterized by general dryness of skin with branny desquamation. Of course, this skin xerosis is difficult to examine since it is also associated with other environmental factors like dirt, lack of washing, dry, hot and windy climatic conditions (Jelliffe, 1966). So our report here may not reflect the true prevalence.

### Clinical signs of other nutrient deficiencies

It is found that the prevalence of cheilosis is about 17.76% in boys and 13.07% in girls, while angular stomatitis occurs in about 12.84% of boys and 7.73% of girls. Atrophic papillae is present in about 6.56% of boys and 4.8% of girls, while the prevalence of scarlet and raw tongue is about 3.55% of boys and 3.47% of girls. On the other hand, the frequency of the vascularization of the cornea is about 3.55% of boys and 3.20% of girls. Although the prevalence of these different signs of vitamin B deficiency is higher in boys than in girls, the chi-square test indicates that the sex difference is significant only in respect of angular stomatitis.

In view of the above circumstances, we may conclude that the nutritional problem in the present population is related mainly to the problem of stunting, but not to that of wasting. The prevalence of stunting for both boys and girls of all ages is about three times (21.46%) the prevalence of wasting/thinness (6.61%) as indicated by BMI Z-score.

Although the present study lacks data on socioeconomic conditions of the study population, it is likely that stunting is associated with low socioeconomic status as generally observed in different populations of the world (WHO Working Group, 1986; Gorstein *et al.*, 1994; Norgan, 2000). It may be suggested that efforts to improve food availability, dietary quality, hygiene, adequate supply of safe-drinking water, and prevention and treatment of infectious diseases are likely to improve the nutritional status of the Lotha population over time. It may be noted that growth retardation is not only because of low socioeconomic condition, but it has also economic consequences for the individual as well as for the population. For the individual, earning capacity may be low, and health and welfare compromised. Consequently, increased costs and expenditure for the individual and population follow because of the increased morbidity and mortality (Norgan, 2000). Earlier studies in India have indicated that growth retardation among adolescent children also influenced earning capacity (Satyanarayana *et al.*, 1980, 1989). In short, although the nutritional status in the present population is by and large moderate, efforts should be made to improve the socioeconomic condition so as to improve the overall health and nutritional status of the population. Special efforts should be also made to pay more attention to resolving the problem of stunting in girls. The problem of stunting is higher in girls, especially in the lower age groups. On the contrary, the frequency of the clinical signs of nutrient deficiencies is higher in boys than in girls. One possible explanation of such a higher frequency of clinical signs of nutrient deficiencies in boys may be related to the fact that the prevalence of wasting, or CED is higher in boys (8.20%) than in girls (5.07%), despite the absence of statistical significance. As for the question of higher prevalence of stunting in girls, it is difficult to give a proper explanation as it is also related to past history of growth status. Whether this reflects the patrilineal system of the society is the question to be answered by future studies. With the present set of data, we are not in a position to argue that there exists a sex bias in dietary intakes among the Lotha population. We hope that future studies, which are concerned with both growth and socioeconomic data, will shed much more light on the relationship between nutritional status and socioeconomic status of the present population.

## NUTRITIONAL STATUS IN RELATION TO BODY COMPOSITION

In the present study, it is observed that the mean values of fat mass (FM) are significantly higher in girls than in boys across age groups. On the other hand, the lean body mass (LBM) is significantly higher in boys than in girls across age groups. Thus, it shows that fat content is more in girls than in boys whereas muscle mass is higher in the latter as observed in other populations (Forbes, 1987). However, it is not clear whether body composition in terms of FM and LBM is associated with nutritional status of the children in the present study.

It is observed that the mean values of FM and LBM are significantly higher in children with higher Z-score (≥ 2 Z-score) when compared to those children with lower Z-score (< 2 Z-score) for weight for age, height for age and BMI for age. It is true for both adjusted and unadjusted means for age groups. This observation seems to confirm those earlier observations that the undernourished children have lower FM and LBM when compared with the nourished children (Norgan, 2000). Of course, there is no statistical difference between girls of higher and lower BMI Z-scores in respect of FM and LBM after adjusted for age, which is opposite to the general observation that BMI is highly correlated with FM and LBM (Rolland-Cachera, 1993; Norgan, 1994). It is found that, in the case of girls, the partial correlation coefficient (r) between BMI Z-score and FM after adjusting for age is 0.074, while the correlation coefficient with LBM is 0.076. This indicates that the relationship between BMI and these two estimates of body composition in the Lotha girls is not significant after removing the effect of age. In the case of boys, it is found that there is a significant correlation between BMI Z-score and FM ($r = 0.522$, $P < 0.000$) and LBM ($r = 0.763$, $P < 0.000$), that is, after removing the effect of age. Thus, considering the case of boys and the findings in other populations, we may conclude that the mean values of FM and LBM in the present population are, on average, significantly lower in the children of poor nutritional status.

In short, we may conclude that the children with lower Z-scores of weight for age, height for age and BMI for age are also lower in body composition when compared with those children with higher Z-scores, which is consistent with the earlier findings on other populations. The present study also reveals that the three anthropometric indices used for assessing the nutritional status are more correlated with LBM than with FM. Although weight for age Z-score is more correlated with FM and LBM in the present study, BMI for age may still be considered a better indicator of body composition because it takes into account the weight and height of an individual, whereas weight for age fails to do so.

## CONCLUDING REMARKS

The present study has revealed that there are significant differences between boys and girls in respect of growth patterns. This is as generally observed and expected especially in adolescent boys and girls because of the inter- and intra-individual timing of growth spurt. We have observed that the sex variation is much greater in respect of body composition, despite the absence of statistical differences between boys and girls in body weight for all age groups. The study indicates that the mean FM is greater in girls than in boys, while the mean LBM is higher in the latter. This implies that the total body mass or body weight of boys is mainly composed of muscle mass, while fat mass has mainly contributed to the total body mass of girls. In other words, the fat composition of the total body weight is much higher in girls than in boys, whereas the muscle mass is higher in the latter. Thus, the present findings seem to confirm the earlier observations on other populations (Forbes, 1987; Rolland-Cachera, 1995). Whether this is associated with genetic factors is a matter of interpretation. Of course, the sex differences in age at peak velocity, adult size and peak size velocities are also likely to be more associated with genetic factors. It is observed that in the present study the sex differences in linear measurements like height, sitting height and subischial length are largely contributed by the differences in growth rates during the occurrence of adolescent growth spurt. This may have certain implications with the general observation that growth during childhood is more sensitive to environmental factors, while growth during adolescence is to a great extent determined more by genetics (Hauspie and Sussane, 1998; Bogin, 1999).

Further, although the common nutritional problem among the Lotha children is stunting but not that of wasting, the present study reveals that the prevalence of wasting is higher in boys than in girls. This may also imply that girls are better "buffered" than boys against environmental factors like inadequate dietary intakes (Stinson, 1985; Bogin, 1999), which may be associated with genetic factors. The higher prevalence of the clinical signs of nutrient deficiencies in boys than in girls is likely to support such a "buffering hypothesis" which states that girls are less likely to be "knocked-off-track" by poor environmental conditions including inadequate nutrition. Little is known about this problem in Indian populations, thereby warranting more studies.

As for the question of higher prevalence of stunting in girls, it is difficult to give a proper explanation as it is also related to past history of growth status. Whether this reflects the patrilineal system of the society is the question to be answered by future studies. With the present set of data, we are not in a position to argue that there exists a sex bias in dietary intakes among the Lotha population. We hope that future studies - which are concerned with both growth and socioeconomic data - will shed much more light on the relationship between nutritional status and socioeconomic status of the present population.

On average, the Lotha children of the present study are comparable to the Indian children of the ICMR, but are bigger than the Khasi and Meitei children. They are by and large comparable with the 10th and 25th percentiles of the NCHS growth references in respect of weight and with the 5th and 10th percentiles in respect of height. The nutritional status of the Lotha children is also, on average, moderate in comparison with some other populations. Such a better growth and nutritional status reflects the better dietary intakes of the Lotha population. Although, the present study is short of data on socioeconomic condition of the study population, it may be argued that better dietary intakes are often associated with better socioeconomic status of a population. Of course, it may not be so in hunting and agricultural community where human labour is entirely related to food consumption. It may be noted that in the present population, agriculture is the mainstay of the people. Individual's earning is mostly not in terms of cash but in terms of kind, that is, either in terms of the exchange of food grains or agricultural labour. As such, it is very difficult to assess the per capita income of the Lotha people. But what it is to be noted here is that most of the agricultural work is for household consumption but not for marketing the agricultural produce. So self-sufficiency in food production depends on labour and the availability of land for cultivation, which is mostly under the control of the clan. We hope that future studies will shed more light on the relationship between nutritional and socioeconomic condition of the Lotha population.

Last but not least, the present study has also certain policy implications. Although the nutritional status is moderate in the present population, the nutritional problem is related mainly to that of stunting or growth retardation. Growth retardation is not only because of poor socioeconomic condition, but it has a vicious circle. It may affect the socioeconomic condition of an individual, or a population as well, because of the poor earning capacity due to poor health status. It may be suggested that efforts to improve agricultural activity or food availability, dietary quality, hygiene, supply of safe-drinking water, and prevention and treatment of infectious diseases are likely to improve the health and nutritional status of the Lotha population over time.

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