GROWTH AND NUTRITIONAL STATUS OF KHASI CHILDREN IN WEST KHASI HILLS DISTRICT OF MEGHALAYA

BY

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DEPARTMENT OF ANTHROPOLOGY

THESIS SUBMITTED

TO

THE NORTH EASTERN HILL UNIVERSITY

FOR PARTIAL FULFILLMENT OF THE DEGREE OF DOCTOR OF PHILOSOPHY

IN

ANTHROPOLOGY

NORTH EASTERN HILL UNIVERSITY

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DECLARATION

I Barikor.C.Warjri hereby declare that the subject matter of this thesis entitled "Growth and Nutritional Status of Khasi Children in West Khasi Hills District of Meghalaya" is the record of work done by me, that the contents of this thesis did not form basis of the award of any pervious 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 Hills University for the degree of Doctor of Philosophy in Anthropology.

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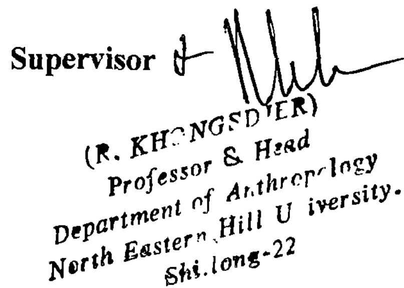

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ACKNOWLEDGEMENT

I wish to express my deep heartfelt gratitude to my supervisor Dr.R. Khongsdier, Head department of Anthropology, NEHU for his valuable suggestion and untiring guidance with constant encouragement throughout the study, without which this work could have not been brought into its present form .

I specially wish to express my gratefulness to MrA.nongrum and M.chyne for their interest and sustained help through out my study period and Dr.N.Hassan who helped me with the proof reading.

In the field I am grateful to all my friends in the study area who had co-operated with me to make this study a success

Last but not the least ,I am very grateful to all my family members particularly my mother for her constant interest and encouragement to this study. I owe my special gratitude to my father and my husband without whose help and encouragement this assignment could not have been completed. And overall my thanks go to God almighty for his manifold blessing who enable me to complete my work.

Balkor.c.warjri

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CHAPTER I
INTRODUCTION

This thesis is concerned with the growth and nutritional status of Khasi children in West Khasi Hills district of Meghalaya. By the term growth we mean a regular process of quantitative increase in size or mass of different tissues and organs of the body especially from conception to adulthood (Bogin, 1999). Nutritional status, on the other hand, 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 the different methods, anthropometry is one that is generally used for measuring the nutritional status 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.

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 Bc 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 used "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 Stoller (1703-1780) in 1729. According to Tanner (1998), Stoller 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. Nevertheless, 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 Stoller. 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 a 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 labour 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, especially to understand the interaction between growth and culture.

As for the study of human growth in anthropology, one may argue that 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 and 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 between the sexes, intra-population variation and other health implications. In addition, 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 (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).

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 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).

In the light of the above backdrop, 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 understanding 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). Such differences are attributable to both genetic and environmental factors. However, it is believed that the growth patterns of under-five children all over the world 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 (Habitch et al., 1974; Waterlow, 1988; Gopalan, 1990; Neumann and Harrison, 1994). 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 reliable growth references. For example, the

U.S. National Center for Health Statistics (NCHS) growth references, now known as the Centers for Disease Control (CDC) growth references(Kuczmarski *et al.*, 2000), and that of the WHO (2007) growth references are used widely used for the assessment of growth and nutritional status of children. 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 peoples 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 CDC 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, there are considerable population

differences in growth and development that need further studies to have a better understanding of the problems, especially in populations of developing countries like India.

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(*author's italic*)*. 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 is 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 curve 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; Jelicoeur et al., 1992; Karlber, 1998; Hauspie, 1998). Also, since growth is a continuous process, the cessation and default of growth in man raised some problems, 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 value of the function parameters that minimize the sum of square deviation 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 give 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 be 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 for certain anthropometric variable (Preece 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).

Sex dimorphism

One of the focuses of growth studies is sexual dimorphism. Differences between the sexes in growth pattern have long been the major interest in the study of human growth and development since the19th century (Garn, 1980). Many of the sex differences in adult body size and form are believed to be due to the differential growth pattern 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 two years earlier" (Tanner,

1998). Several authors have suggested that this feature of difference between boys and girls is a consequence of the timing variation, a positive value for the growth spurt and intensity of the adolescent spurt (Tanner, 1978; Bogin, 1999). Tanner (1998) has also suggested that the differences between the sexes in height during adulthood are mainly due to the longer period of male growth. The differences in pre-pubertal 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 pre-pubescent period of male growth, because the legs are growing faster than the trunk at this time. 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 differential number of X-chromosomes, which are two in females and one on 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 times and in varied magnitudes. According to Bogin (1999), the adolescent growth spurt must have its own intrinsic evolution values, 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 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 under nutrition and over nutrition 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 malnutrition 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 scientist, but also the economists and other social scientists with a view of understanding the health and socioeconomic status of the population (Gopaldas 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 requirement of an individual (Brown, 1984). The physical expression of the relationship between nutrient intake and physiological requirement 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, skin fold thickness, weight for age, height for age, weight for height, body mass Index, indices of upper arm circumference, etc. (Jelliffe, 1996; 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, 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, thereafter the increments in height of 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 indicates 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 socioeconomic condition of populations (Lindgren, 1976; Smith *et al.*, 1980; Garn *et al.*, 1984; Johnston, 1986; Lasker and Mascie-Taylor, 1989; Visweswara Roa *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 socioeconomic 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 are heavier and taller than their counterparts belonging to the poor socio-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 socioeconomic status. Similarly Vijayaraghavan *et al.* (1974) and Visweswara Rao *et al.* (1980) reported that the arm 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 (Roa and Sastry, 1977; Satyanarayana *et al.*, 1980; National Nutrition Monitoring Bureau 1980; Bharati and Basu 1990).

In Northeast India, most of the growth studies were carried out in order to understand the population variation in growth patterns of children (Khongsdier and Ghosh, 1998). Very few growth studies have been carried out with a view to assessing the health and nutritional status of a population, especially in the state of Meghalaya (Khongsdier, 1996; Mukherjee, 2002). In addition, there are still limited studies on the role of socio-economic factors in influencing growth. It may be mentioned that growth studies in Northeast India were initiated by the late Priya Bala of Gauhati University. Das (1973, 1974) initiated the biocultural studies of growth by taking into consideration the caste hierarchy as a social factor that may influence the growth status of children. Choudhury (1979) studied the growth of Rabha boys of Assam aged 4 to 18 years and compared his findings with the Assamese caste boys. He found that the Rabha boys were taller and heavier than the Assamese caste boys during the early stages of growth. On the

hand, the adult Rabhas were found to be the shorter than the caste and other population groups. Choudhury suggested that the population differences during the early stages of growth were mainly due to culture and food intake. The findings of this study are very interesting because other studies also indicated that children, not only from Northeast India (Begum and Choudhury, 1999; Mukherjee and Khongsdier, 2003a, 2003b) but also from other developing countries, are somewhat comparable to the 5th or 10th percentile of the international growth references, especially in the lower age groups. The implication is that growth retardation during the early stages of growth is mainly due to nutritional deprivation, or a failure in the expression of the genetic potential for growth (Gopalan, 1992).

Recently, the National Family Health Surveys (NFHS-2 and NFHS-3) (IIPS & Macro International, 2000, 2009) have revealed that Assam and Meghalaya are the two states with the highest prevalence of undernutrition in Northeast India, i.e., as indicated by anthropometric measurements and indices of the growth of children under 3 years of age. In Meghalaya, the high prevalence of undernutrition was also observed even in urban area for children aged 3-18 years (Mukherjee, 2002). It is likely that the prevalence of undernutrition will be higher in rural areas. Therefore, we propose to undertake a study on growth and nutritional status of Khasi children aged 2-18 years in rural areas of the West Khasi Hills district, Meghalaya, in order to find out certain socioeconomic factors responsible for the growth failure and malnutrition, if any.

OBJECTIVES OF STUDY

In view of the short review given above, we propose to undertake the study on "Growth and Nutritional Status of Khasi Children in the West Khasi Hills District of Meghalaya" taking into consideration the following objectives:

1. To describe the growth pattern of Khasi children aged 3 to 18 years in terms of anthropometric variables.
2. To assess the nutritional status of these children, using certain anthropometric indices relative to the recommended growth references.
3. To analyze the effects of demographic and socio-economic factors such as age, sex, birth order, family size, occupation of parents, household income and educational level of parents on growth and nutritional status of children.

AREA OF STUDY

Location and Topography

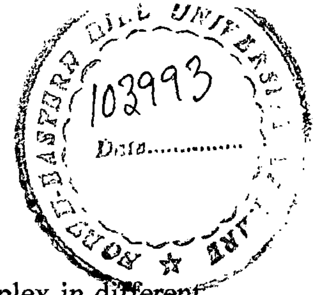
Meghalaya is essentially a small tribal state in the north eastern region of India. It lies between 25° 47' and 26° 10' N latitude and 89° 47' and 92° 87' E longitude. The state covers an area of about 22, 429 km. It is bounded by Assam on the north, east and north west, and by Bangladesh on the south and south west.

Initially, Meghalaya was a part of Assam, which was composed of only two districts, namely, the united Khasi and Jaintia Hills district and Garo Hills district. It was bifurcated from Assam as an autonomous state on April 2, 1970, and subsequently a full-fledged Statehood was given on January 21, 1972. The Khasi Hills district was itself bifurcated on 12th October 1976 into two districts known as East Khasi Hills district with its headquarters in Shillong and the West Khasi Hills Districts with its headquarters at Nongstoin.

Several hills in the Khasi Hills district have a firm place in mythology and traditions of the Khasi people. For example, Shillong peak (Lum Shillong) is the highest peak (1964m) in the Khasi Hills. It associated with the legends of the Khasi with *U 'Lei Shillong* (*Lei* being the abbreviated form of *Blei* meaning God), the titular deity of the old kingdom of Shillong and progenitor of the royal family, *Ka Pah Syntiew*. The base of the peak is the source of four important rivers – the Umngot, Um-Iew, Um-Jasai (important tributaries of the Um-Iam or Barapani) and Um-Khen, from which the water supply of Shillong is obtained.

Geological Composition

Meghalaya may be broadly divided into five Geological formations, namely Archean Gneisses complex, Shillong group of Rocks, Lower Gonduana Rocks, Cretaceous Tertiary Sediments and sylhet Traps (Bhakta, 1992). Shillong Group of Rocks is exposed in the central parts of the Khasi hills comprising mostly quartzite. Rocks of this group rest un-conformably over the gneissic rocks with basal thick bed of conglomerate in the western part. The mildly folded sediments have suffered low grade metamorphism and are dissected by numerous faults. These rocks are intruded by ultra basic and acidic sills and dykes. The granite intrusive along the axial region of the Shillong group of rocks around Mylliem is termed as Mylliem granite. Several



other granite bases such as Kyllang Plateau are intrusive into the gneissic complex in different parts of the region.

The Khasi hills area is endowed with a number of economically important minerals, the major ones being limestone, coal, uranium, sillimanite and clay.

Climate

Because of the considerable variations in altitude and exposure, differences in climatic condition do exist within the Khasi hills. Shillong is situated about 1500 m above sea level. Its climate is pleasant, neither extremely cold nor hot. The temperature rises above 24° C – 34° C in the summer and falling below 4° C in winter. The average temperature and annual rainfall vary from one region to another. But Cherrapunji and Mawsynram areas receive the heaviest rainfall in the world (1270 cm).

Flora and Fauna

The vegetation of Khasi hills may be broadly classified into two major types, viz., the Tropical and warm temperate types. The forest of Mehglaya is the rich source of timber. The important timber-yielding free species are Khasi pine (*Pinus Khasiya*), sal (*Shore robustra*), teak (*Tectana grandis*) gamari (*Gmelina or borea*) etc. Different types of bamboo also grow in abundance.

Major crops of this state are paddy, maize, millet, pulses, potato, and ginger, turmeric, black pepper, sugarcane and oil seeds Among the vegetables, cabbage, cauliflower, bean, radish, chilly, onion, lady's finger, carrot, peas and brinjal are extensively cultivated. The cultivated fruits include guava, orange, lemon, banana, naspati (*Pyrus senensis*), papaya (*Carica papaya*) black berry (*Prunus nepulems*), etc.

About 250 species of orchids have been reported form this region, which include species ranging from tiny ones to tall one or more meters high (Gazetteer of India, 1991) Ferns are also found in abundance. The above mentioned flora of Khasi hills are mostly found in Shillong area.

The fauna of Meghalaya include a unique assemblage of Indo-Chines elements of Oriental and Palaearctic fauna (Gazetteer of India, 1991). The tropical and subtropical evergreen forests ensure the survival of rich mammals and also other groups of animal life. Of

mammals, the Khasi hills possess some interesting animals like the hillock (*aibcon*), the only ape in India (*Hylobates*), the golden cent (*Felies temminckei*), the leopard (*Felids bengalensis veer*), the jungle cat (*Felis chaus*), the Himalayan black bear (*Selenarctos thebethanus*), the banking deer (*Muntiacus muntjak*) and the Panglen (*Manis pentadaetyla*).

Different types of birds are also found in East Khasi hills of Meghalaya. Snakes and lizards are also abundance. Besides, the Khasi Hills also reveal a number of interesting amphibians and fish species. Insects of the region present an interesting assemblage of fauna in the state. It may however be noted that most bird and animal species tend to decrease in number due to increasing deforestation.

THE PEOPLE

According to 2001 census, the total population in 2306069 of which 1167840 are males and 1138229 females. In East Khasi Hills, the total population is 6, 60, 994 of which 3,33,187 are males and 327807 females. The sex ratio is 984 females per 1000 males with a literacy rate of 76.98%.

The people of Meghalaya are mostly tribals, among which the Khasis and Garos are the most dominate tribal groups. The other tribal populations like the Hajongs, Nagas, Mizos, etc. along with some non-tribal populations like Bengalis, Assamese, Nepalis, Biharis, Panjabis, etc. have also settled in Shillong.

The Khasi tribe consists of five major sub-groups, namely, the Wars, Khynriams (Upland Khasis), Jaintias (Pnars or Syntengs), Bhois and Lyngngams. The Khynriams are mostly found in upland region of the East Khasi and West Khasi districts of the State. The Jaintia Hills district is dominated by the Jaintias. The Bhois predominantly live in the Ri-Bhoi district on northern parts of the Khasi Hills. The Lyngngams are mainly confined to the southern and western parts of the West Khasi Hills district.

Physical Characteristics and Affinity

From the anthropological point of view, the Khasis (or Khynriams, Pnar, Bhois, Wars and Lyngngams) belong to the Indo-Mongoloid of the Mongoloid racial stock (Das, 1981). Das (1987) has described that the "Khasis have brown skin color. Their head hair is dark brown with a reddish tinge in color, straight or flat, wavy in form and coarse in texture. They have scanty

beard and moustache. The colour of eye is brown to dark brown. The eye slit is mostly oblique and palpebral fissure is medium. Eye fold is present in most of the cases. They are short in stature. Their head is mosocephalic and nose in mesorrhine". Regarding the four sub-groups of the Khasis, Das (1978) says that these four divisions (i.e., Khynriams, Pnars, Bhois and Wars) do not deviate much from the average Khasis in relation to stature and trunk height. He, however, points out that the "Pnars and the Bhois show most often deviation in higher magnitude and that these two populations are standing porpoise to one another in relation to average Khasis". It may be mentioned that the people have so far treated the Khynriams, Pnars, Bhois, Wars and Lyngngams as one and the same ethnic group. Marwein (1987) says that the Khasis are known sometimes by different names at different places. The names are either confined to a particular Syiemship or state or a particular geographical region". All these sub-groups claim to have descended from the same origin, i.e., *U Hynniew Trep Hynniew Skum* (Seven Huts). Recently, the government of Meghalaya has published one volume of Meghalaya (DIPR, 1991). In this volume, it is clearly stated that these Khasi groups are of the same ethnic origin. They share common traditions and customs, though there may be some variations, owing to different geographical conditions and admixture with other communities.

All the sub-groups of the Khasis follow the matrilineal system of the society and linguistically they speak a different dialect of the Monkhmer language, which belongs to the Austric (Austro-Asiatic) group. So far as the Austric language in concerned, it is believed to be spoken by the earliest inhabitants of the country, particularly the Australians and their descendants (Ghosh and Khongsdier, 1997). At present, besides the Khasis, other peoples like the Kols, Mundas, Nicobarese of Nicobar islands, etc., are the Austric speakers in India. Das (1987) has reported that the Wanchoo of Arunachal Pradesh also use some Austric words in their language.

With regard to the position of the Khasi, Dixon (1922) says "the Khasis in spite of their linguistic isolation among the peoples of Assam, are racially closely related to the majority of the Burmese tribes. With them they represent a very old western drift of south-western Asia peoples unlike their neighbors. However, they have succeeded in retaining their old speech". Haddon (1924) has also tentatively suggested the presence of ancient dolichocephalic platyrrhine (Pre-Dravidian) type among the Khasis. Linguistically, Chatterjee (1951) was of the

opinion that "In Burma Indo-China lived speakers of Austric language, who are largely of Proto-Australoid race from India". Accordingly, Das (1978) has proposed that the "Khasi is an Australoid population speaking the Austric language. Their physical features were modified by a strong intrusive Mongoloid strain. They have retained their language but have undergone remarkable changes in physique".

The other possibility is that the Khasis are a Mongoloid people, who came from south-east Asia as suggested by many scholars like Gurdon (1907), Chatterjee (1951), Bareh (1967), Das (1979), and others. According to Gurdon (1907), "The Khasis are an offshoot of the Mon people of Further India in the light of historical fact." Chatterjee (1951) says, "They would appear to be a Mongoloid people who have adopted the language of the earlier race, the Austrics (or Proto-Australoids), after they have come down from south Tibeto-Burman area of dispersion. They may have changed their speech to the Austric (Mon khmer) Khasi even while they were in Burma." He has also pointed out that the admixture of proto-Australoids and Mongoloids "in very early times in Burma and Indo-China is very likely, this mixture producing the ancient Rmen or Mon people of central and southern Burma, the Palaungs and Was of upper Burma, as well as the Khmers, the Chams, the Stings, the Bahnars and other Austric or Austro-Asiatic speakers of Saim and Indo-China". It may be mentioned here that the Proto-Australians are known by different names like Pre-Dravidians, Australoids, Veddids and Nishadas. The Proto-Australoids are similar to Caucasoids in respect of many characteristics. Sometimes, they are also considered a sub-division of the Caucasoids known as Archaic Caucasoids (Das, 1970). In view of the above suggestions, it appears that the Khasi are a Mongoloid people, who might have learned their language form the Australoids (or Proto-Asutraloids) on their way to India or they might be one of those peoples resulting from the admixture between the Mongoloids and Proto-Austraoids (Australoids), somewhere in Burma or Indo-China. Some scholars (like Gurdon, 1907; Bareh, 1967; Das, 1970; and others) have also supported this view on the basis of cultural evidence. It may however, be noted that there are also some cultural similarities between the Khasi and the Kolarian tribes of Central India.

Occupation

The community was basically a land owning community, the land belonging to the individual proprietress. Along with the advent of Christianity, drastic economic changes also came about in this area. Previously, jhuming (shifting) was the chief mode of cultivation besides the dry land cultivation of rice. The forest resources were immense and the supply of wood, bamboo and cane was another lucrative business. However, after independence and the opening up of greater opportunities there was a rapid rate of urbanization with the result that people got attracted toward towns. Those who were educated got white-collar jobs. The young are usually attracted by vehicles and take up driving as a profession. The men take up job as laborers at various construction sites. Some people are also engaged in business and services. Traditional industries were never important as occupations (Syiemlieh, 1994). The main occupations today are jobs in offices, teaching, contractor and the professional services where there are a large number of Khasis as university and college teachers, engineers, doctors, etc. There is no bonded labor, child labor exists but not in disturbing proportions and there has been little change in the occupational pattern, as industrialization has made no important in terms of the employment.

Religion

The majority of the Khynriam Khasis of Shillong have embraced Christianity, while next to Christian group are the Niam Khasis- believers of Khasi traditional religion (Ka Niam Khasi). There are also a few Khasi Muslims in Shilling, i.e., those Khasis who have converted to Islam through marital alliance with the Muslims who migrated from Bangladesh and other parts of India.

Among the Khasis, Christianity dates back to about 150 years when Krishna Chandra Pal converted two Khasi people in a village, called Pandua (Pyrdiwah) on the border of the Khasi hills and Sylhet District (Bhat, 1975)

But the number of converts to Christianity among the tribal was few, until Thomas Jones of the Wales Presbyterian Mission in 1841 propagated the use of the Latin alphabet to write the tribal dialect. At present there are different Christian denominations like Presbyterian, Roman Catholics, Church of God, Church of Christ, Seven day Adventist, United Pentecostals church, etc. In the present study, data on various denominations were not taken into consideration. By 'Christians' we mean only those Khasis who believe in Christianity. The spread of Christianity

in the Khasi and Jaintia Hills has brought about tremendous change in the field of education (Nag, 1965; Das Gupta, 1984). Nag (1965) has shown that the Christian Khasi have better education standard and economic condition that their non-Christian counterparts. "The spread of education is perhaps the most significant effect of Christianity among the Khasi" (Nag, 1965).

The people, who are still following their traditional religion, are monotheistic, though others are of the opinion that the Khasi religion is animism (Gurdon, 1907; Bareh, 1967, Bhowmik, 1971) and demon worship (Natarajan, 1977) and so on. This is due to the fact that the others have a vague understanding of the Khasi religion as said by Gurdon (1907), "The Khasi have a vague belief in God, the Creator". They believe in one Supreme God, the Creator and Master of Universe (*U Blei Nongbuh Nongthaw*). They also believe in life after death and the presence of God and evil spirit (Marwein, 1987). The breaking of eggs and sacrifice of birds and animals like fowl, pig, cow, goat etc., are their important religious rites and ceremonies. The priest locally known as *U Nongknia or Nongshat Nongkhein* performs these religious rites either for the individual cause or for that of the community as a whole. They do not have any religious scripture, or any common place of worship. "To a khasi, religion is a personal contract between man and God," (Hipshon Roy, 1990). It may also be mentioned here that the movement for revivalism of the traditional religion (Ka Niam Khasi) has also been started under the leadership of the *Seng Khasi Organization*, established first on August 23, 1899.

As already mentioned, some Khasis have also embraced Islam through the marital relationship mainly between the Khasi females and other Muslim males who migrated from Bangladesh and other parts of India like Assam, Uttar Pradesh and Bihar. Historically, the Khasi are also believed to have trade relationship with the Mughal emperors through their viceroys at Murshidabad during the 17th century (Irshad Ali, 1992). So, the Khasis came into contact with the Muslims mainly through trade and commerce. Some of them also visited the Khasi hills as wonderers and hunters. As a result, a good number of them have settled in the Khasi hills and, in course of time, these Muslims adopted the Khasi customs (Irshad Ali, 1992). Gradually, they have settled down in the area and accepted the local women as spouses. This group so mainly confined within the state capital of Meghalaya. No specific census work has ever been attempted amongst them. Hence even rough estimate of the number of individuals is not available. Unlike the Muslims of the other states, the Khasi Muslims do not share a common dialect. The dialect varies from household to household (Roy, 1994). The Khasi Muslims are

non-vegetarians, beef-eaters, but they abstain from taking pork. The staple food is rice. They regularly consume available vegetables and fruits. After marriage, most of the women adopt the elaborate style of cooking as praised by the Muslims, especially on festive occasions. Due to religious sentiments, they try to abstain from alcoholic beverages (Roy, 1994). The marriage is performed according to Islamic rules (Roy, 1994). In fact, the Khasi mothers, who get converted to Islam and her children, are known as Muslims. "But for all practical purposes they are treated as Khasis". (Irshad Ali, 1992). Nowadays, it has been reported that among these Muslim Khasi there is a compromise between Islam and matrilineal system of society with regard to patterns of Kinship, residence, inheritance, etc (Mathur 1975, Irshad Ali , 1992).

Food Habits

The food habits of the Khasis are simple. Rice is their staple food. The Khasis are non-vegetarians and take pork, beef, chicken and fish, depending upon their economic status. They are rice eater, but have also taken wheat flour as snack. The principal pulse taken taken by the people is lentil, which is available in local market. In the case of vegetables, potatoes, sweet potatoes, pumpkin, tomato, onion and various kinds of green leafy vegetables are some of their favorites. Besides a variety of mushroom, which is found in abundance in this hilly regions, form a part of their regular diet. Milk is not a part of their regular diet. Instead, tea without milk is a beverage which is continuously taken during the day. Traditionally, rice bear or Ka-kiad used to be fermented in each house for daily consumption. With the increased urbanization, rice beer has been replaced by distilled liquor and other spirits bought from the market. Seasonal fruits, available locally, are consumed by the Khasis. They have also the habit of taking betel nut leaf and lime.

In the next chapter, we shall describe the materials and methods used for the present study.

CHAPTER – II

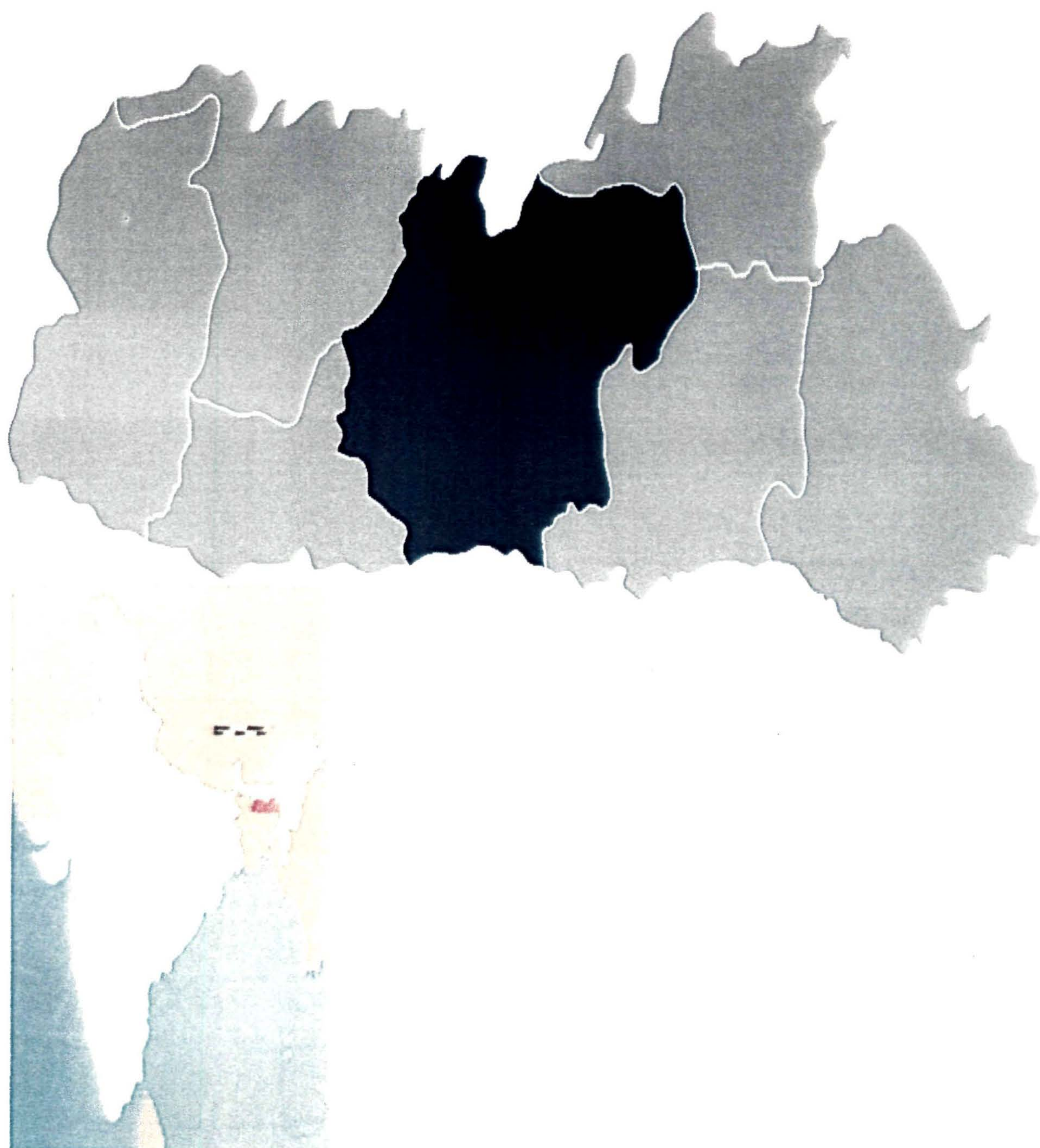
MATERIAL AND METHOD

In this Chapter we shall describe the maternal and method adopted for collecting and analyzing the data in the present study.

Selection of samples

The present study was conducted on West Khasi Hills District of the State of Meghalaya, which is predominantly inhabited by the Khyriam Khasis (i.e. about 473 villages). In the present study the term 'Khasis' is used to refer to the Khynriam Khasis inhabited in the West Khasi hills district of Meghalaya. It has recently been reported that the ban of timber commercial has greatly affected the economic condition of the Khasi people in the West Khasi hills district (Lipok Sungla, 2000). However, it is not clear whether the impact of timber commercialization can also be observed in the growth and nutritional status of children. It is expected that the present study will provide information not only about the nutritional status of children but also how the nutritional status of children is influenced by the socioeconomic conditions of the population.

The study was conducted during the months of January to March, 2004. Sixteen villages were selected by means of simple sampling process. According to this sampling method, a list of villages consisting of more than 150 households was prepared on the basis of the latest report given by the Directorate of Social Welfare, Government of Meghalaya. (DSW, 2003). Four administrative blocks were identified, namely, Nongstoin (125 villages), Mawthadraishan (94 villages), Mawkyrwat (109 villages) and Mairang (145 villages) Development Blocks. Five villages were selected each from Nongstoin and Mairang administrative blocks and three from each of the remaining administrative blocks by means of simple random sampling, using the random numbers given in Snedecor and Cochran (1967).



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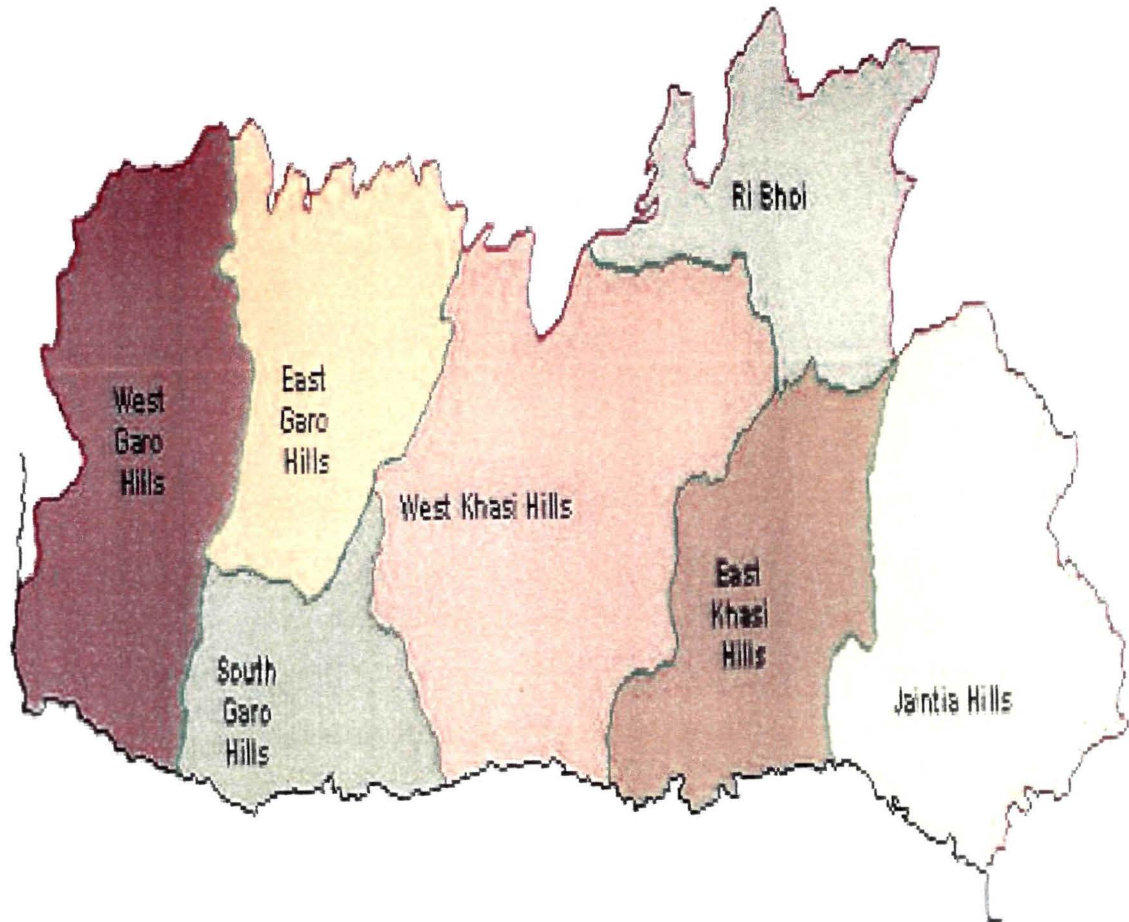

Keeping in view the operation difficulties in getting enough sample size for growth studies, no statistical sampling of households and individuals will be applied for collection of data from each selected sampling unit (i.e., village). Instead, in each selected village, an attempt will be made to include in our sample all those children (aged 3 to 18 years) who were willing to co-operate in carrying out the present work.

ANTHROPOMETRY (CHILDREN)

The present study of physical group was based on a cross sectional sample of Lois boys and girls aged between 3-7 years. Since the exact dates of births were not available for some children, the age grouping of children is done according to the method suggested by Sen (1994), that is 5 year age group includes children of 4.50 (i.e., 4 years 6 months) to 5.49 (i.e., 5 years 5 months 29 days) years of age, where 30 days = 1 month, and 12 months = 1 year. Following are the anthropometric measurements taken on 495 girls and 557 boys:

1. Weight (Kg)
2. Height vertex (cm)
3. Sitting height vertex (cm)
4. Mid upper arm circumference (Left arm) (cm)
5. Chest circumference (cm)

METHODS OF TAKING MEASUREMENTS

Standard techniques of measurements described by Hooton (1946) Weiner and Lourie (1981) and Sen (1994) were followed while taking the anthropometric measurements of children. These 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 on flat wooden chair, or at the end of 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 flattered but concave from behind. The sliding sleeve was then lowered down to touch the vertex lightly.

Sub-ischial Length

Subischial lengths or lower extremity was obtained by substracting stature by sitting height.

Head Circumference

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

Chest circumference

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

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.

ASSESSMENT OF NUTRITIONAL STATUS

For assessing the nutritional status children, we have adopted three anthropometric indices, that is, weight-for-age, height-for-age and body mass index (BMI)-for-age, which ones considered as good indicators of nutritional status.

For classifying the children into different grades of nutritional status, we have calculated the Z – Scores of the individuals relative to the CDC revised growth references (Kuczmarski *et al.*, 2000). In this revised growth reference, the growth charts are smoothed using the Lambda-mu-sigma (LMS) method (Cole 1990). The tables contain the L (power in the Box-Cox transformation), M (median) and S (standard deviation) parameters for deriving the exact percentiles and Z-scores. The formula for obtaining the Z-score for a given measurement relative to CDC growth references is given as:

$$Z = \frac{\left(\frac{X}{M}\right)^{L} - 1}{L \times S}$$

where, X is the anthropometric measurement (e.g. weight, height, etc.) and L, M and S are the reference values corresponding to a given sex and age in months. For example, according to the WHO growth reference 2007, the L, M and S values for the height of girls aged 9.0 years are 1.0, 132.49 and 0.046, respectively. If the height of a 9.0 years old girl in our study population is 125.24 cm, the height-for-age Z-score of the girl will be as follows:

$$Z = \frac{\left(\frac{125.24}{132.49}\right)^{1} - 1}{1 \times 0.046} = -1.19$$

The Z-score of - 2 was considered as the cut-off point for screening the individuals who are likely to be malnourished. On the basis of Z-scores for weight-for-age, height-for-age and BMI-for-age, the nutritional status of children was categorized as follows:

Z-score	**Nutritional status**
≥ + 2 score	Above normal
≤ -2 to +2 Z-score	Normal
-2 to -3 Z-score	Moderate
< -3 Z-score	Severe

STATISTICAL ANALYSES

Preece-Baines Model 1 (PB1)

In the present study, we have used the mathematical model proposed by Preece and Baines (1978), which is referred here as PB1 model. This model was adopted for fitting the means of weight and some important linear measurements (Preece and Baines 1978), using Levenberg-Marquardt method through SPSS (version 17.0) and Origin Software (Version 8.0) 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, θ = 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 the maximum increment, or peak velocity, and peak size velocity) with a view to understanding the nature of variation in growth patterns. 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; Dasgupta and Das 1997; Milani, 2000; Ward *et al.*, 2001).

All data were managed and analyzed using SPSS/PC Software, version 15, in which the level of significance was set at 15%. The analysis will be carried out to present the basic descriptive statistics of anthropometric variables viz., height, weight, sitting height, etc. according to sex and age groups.

SOCIO-ECONOMIC CATEGORIES

In the present study, three important socio-economic variables were taken into consideration. These include religion, monthly income of the households and educational

level. These socio-economic variables were classified arbitrarily into different groups and/or categories with a view to understanding their influence on demographic characteristics, growth, health and nutritional status of the study population. Our classification may be briefly described as follows:

Income groups: Data on household income were collected directly from the heads of the households and they were cross-checked taking into consideration some aspects of socio-economic conditions like housing condition, types of occupation, land holding, and monthly expenditure. The per capita monthly income of the households was classified as follows:

Above 75th percentile (Rs.500) = High income group (HIG)
50th to 75th percentile (Rs.333-500) = Middle income group (MIG)
Below 50th percentile (Rs. 333) = Low income group (LIG)

Educational Level: Data on educational attainment of individuals in the present study were arbitrarily classified as follows: The category **illiterate** includes those individuals who were unable to read and write and those who had no education but could read or write their names. The individuals who attended school up to standard VII were grouped into **Primary** level of education. The individuals with educational level from VIII and above were grouped into **Secondary level** of education.

Family Size: The family size was classified into three categories. The individuals who lived in a household with less than 5 family members were considered as having a **Small Family Size.** The **Average/Medium Family Size** includes those individuals who lived in a household with 5-6 family members. The individuals who lived in a household with more than 6 family members were grouped in the category of **Large Family Size.**

STATISTICAL METHODS

Statistical Analyses

The data collected for the present study were quantified and analysed statistically, using SPSS Window software. The data were presented in terms of means, standard deviation, standard error and proportions or percentages. The differences between two means were tested by using t-student test, and the differences between proportions were tested by using

the chi-square test. Logistic regression analysis was used for analyzing the effects of socioeconomic factors on the nutritional status of children in which the odd ratios (OR) with 95% confidence were derived from the regression coefficients.

. Some of these 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 ($\bar{X}$) = $\Sigma X_i/N$ = ($x_1 + x_1 + \ldots + x_n$)/N, where 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 number 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 proportions were tested by using the chi-square (χ^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.

Logistic regression: Logistic regression is useful for situations in which you want to be able to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables. It is similar to a linear regression model but is suited to models where the dependent variable is dichotomous, or a binary response. Logistic regression coefficients can be used to estimate odds ratios for each of the independent variables in the model by exponentiating the regression coefficient (B).

In linear regression, the expected value of a response variable, *y*, is modeled as a linear function of the explanatory variables by assuming the response variable as having a normal distribution with a constant variance:

$$y = \beta_o + \beta_1 x_1 + \ldots + \beta_k x_k$$

In the case of a binary response with the values 0 and 1 (died and survivied, yes and no, true or false, etc.), the expected value is simply the probability, *p*, that the variable takes the value one, i.e., the probability of survival.

The observed values do not follow a normal distribution with mean *p*, rather it follows a *Bernoulli distribution* (Everitt, 2002). Consequently, the *log-odds* of survival is modeled as a linear function of the explanatory variables in the case of binary response. In terms of *p*, the logistic regression model can be written as

$$p = \exp(\beta_o + \beta_1 x_1 + \ldots + \beta_k x_k)/[1 + \exp(\beta_o + \beta_1 x_1 + \ldots + \beta_k x_k)]$$

In the present study, we have used logistic regression method for analyzing the relationship between undernutrition and socioeconomic factors, using SPSS 15 for Windows. The individuals who were below – Z score of the anthropometric indices were categorized as undernourished (coded as 1) and those with a Z score of – 2 and above were considered as not undernourished (coded as 0).The odds ratio (OR) with 95% confidence interval (CI) was derived as an exponent of the regression coefficient.

CHAPTER III

GROWTH PATTERN

In this chapter, we shall describe the growth pattern of the Khasi both boys and girls taking into consideration the body weight, height, sitting height, sub-ischial length, arm circumference and chest circumference. By growth pattern, we mean the dimensional characteristics of growth in respect of the above mentioned anthropometric measurements at different points of time that are categorized into one year intervals from 3 to 18 years of age.

Sample Size

Table 3.1 shows the sample size for each sex and age group from 3 to 18 years of age. The sample size is the same for all the anthropometric measurements taken in the present study.

Table 3.1. Sample size for all anthropometric measurements taken for the present study

Age (yrs)	Boys	Girls
3	30	30
4	31	33
5	30	26
6	28	31
7	28	30
8	30	33
9	31	34
10	30	49
11	33	42
12	28	42
13	31	38
14	40	42
15	34	36
16	31	31
17	30	30
18	30	30

Table 3.2. Statistical constants of weight (kg) for boys and girls

Age	Boys			Girls			t-value
(yrs)	Mean	SD	Increment	Mean	SD	Increment	
3	11.93	2.16		12.97	1.81		2.01*
4	14.32	1.60	2.39	14.45	1.44	1.49	1.52
5	16.43	1.43	2.11	15.23	1.77	0.78	2.81**
6	18.79	2.70	2.35	16.97	0.87	1.74	3.55***
7	19.54	2.22	0.75	19.73	2.33	2.77	0.33
8	22.17	2.39	2.63	21.18	2.17	1.45	1.71
9	21.87	3.83	-0.30	22.82	2.94	1.64	1.13
10	25.17	2.91	3.30	25.63	2.47	2.81	0.76
11	27.30	4.05	2.14	27.57	3.22	1.94	0.32
12	30.18	2.45	2.88	32.25	3.76	4.68	2.57**
13	38.77	5.25	8.60	35.92	4.15	3.67	2.52**
14	44.98	4.04	6.20	42.31	3.95	6.39	3.02***
15	46.32	3.51	1.35	44.33	6.87	2.02	1.51
16	48.77	3.58	2.45	46.10	3.02	1.76	3.19***
17	50.90	3.95	2.13	47.77	3.78	1.67	3.14***
18	52.30	3.26	1.40	47.07	3.83	-0.70	5.70***

*$p < 0.05$, **$P < 0.01$, $p < 0.001$

Weight

Table 3.2 shows the mean and standard deviation of the body weight for both boys and girls. The mean values are plotted against age in Figure 3.1. The distance curve shows that there is a gradual increase in average weight for both boys and girls from 3 years onwards. Girls are heavier than boys at 3 and 4 years of age and it is significant at 3 years of age ($t = 2.01$, $p < 0.05$). On the other hand, boys are significantly heavier than girls from 5 to 6 years of age, and there are no significant differences between the sexes at 7 and 8 years of age. However, girls are heavier than boys from 9 to 12 years, and the differences are significant at 12 years of age. This may be associated with the adolescent growth spurt in girls at 12 years of age. It is further observed that boys are significantly heavier than girls after 12 years of age, and the differences are statistically significant, except at 15 years of age.

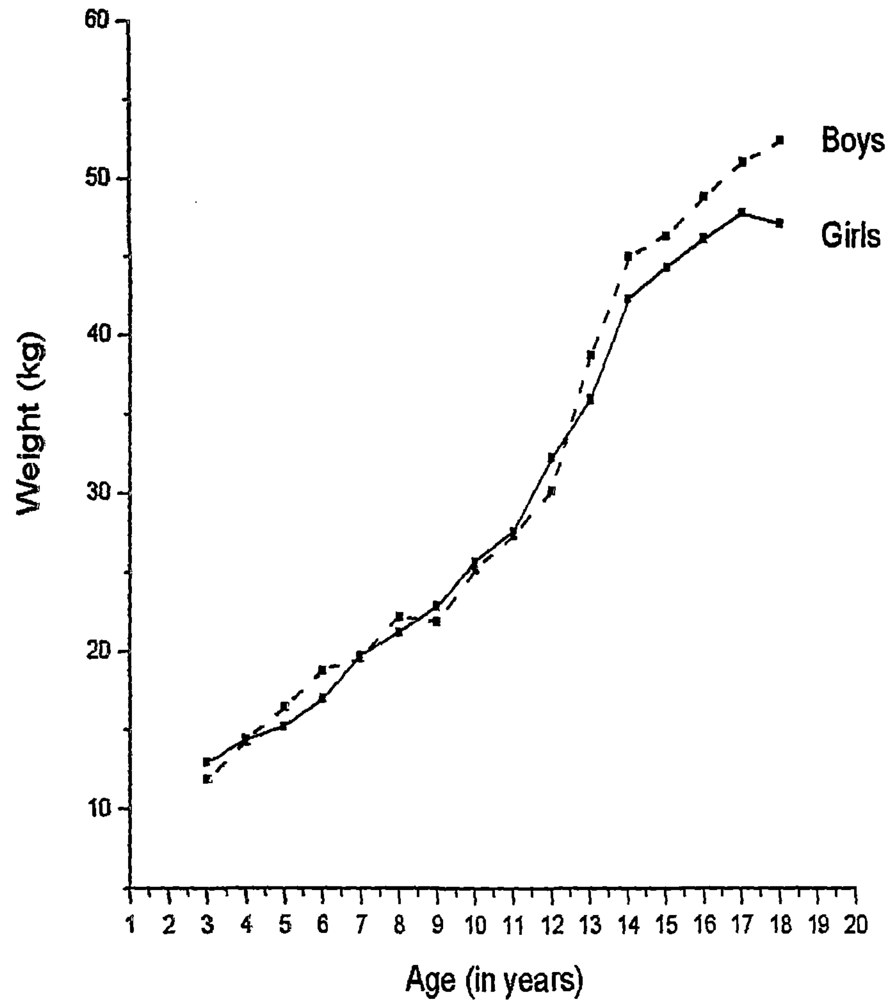

Figure 3.1. Distance curve for weight of boys and girls

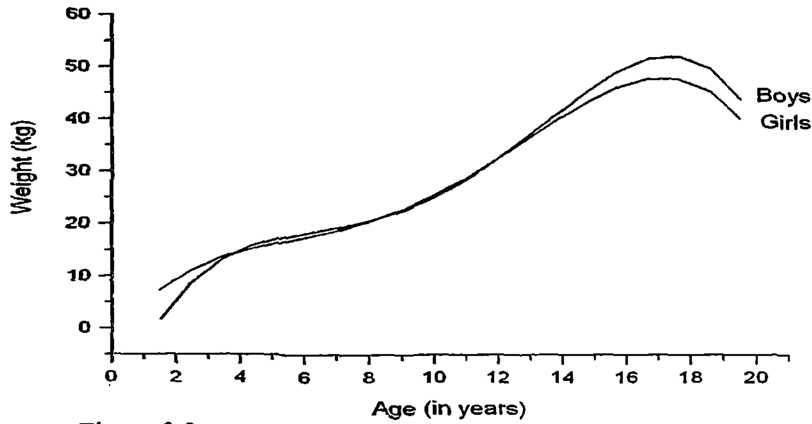

Figure 3.2 **Smooth distance curves for weight according to 4th degree polynomial model**

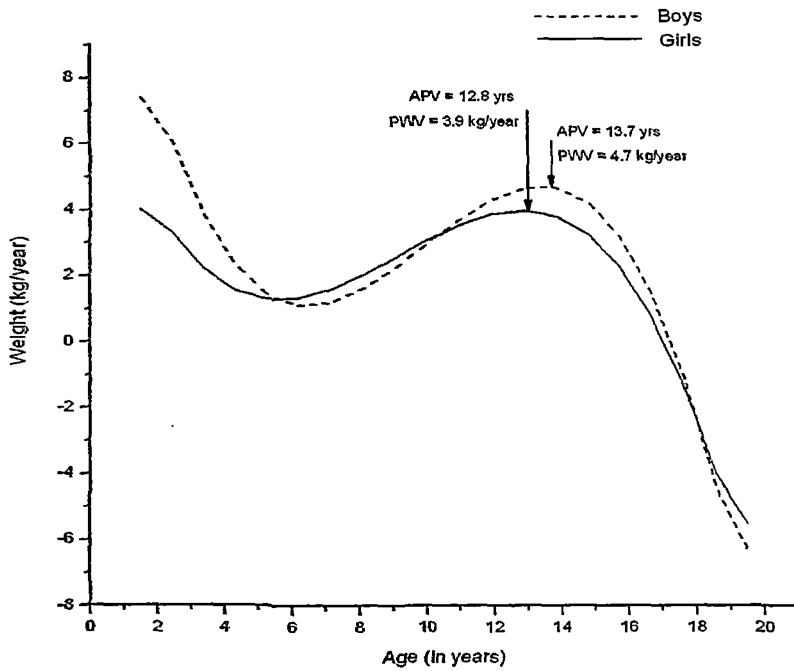

Figure 3.3 **Velocity curves (first derivatives of the fitted function) indicating age at peak velocity (APV) and peak weight velocity (PWV)**

Since the growth curve in weight is somewhat irregular from 3 to 12 years of age, an attempt has been made to fit the weight data as shown in Figure 3.2, following the fourth degree polynomial model. The smooth curve (Figure 3.2) indicates the fitting of weight which is equal to $-16.87361+16.03985(\text{age}) - 2.79182(\text{age})^2 + 0.2151(\text{age})^3 - 0.00543(\text{age})^4$ kg for boys and to $-2.78983+8.71186(\text{age}) -1.56743(\text{age})^2 + 0.13437(\text{age})^3 - 0.00365(\text{age})^4$ for girls. Despite the limitation of polynomial model (Hauspie, 1998), the smooth curve also helps us interpret that both boys and girls are by and large similar in weight from 7 to 12 years of age. Thereafter, boys are taller than girls at all ages.

The growth rate or velocity curve based on the first derivatives of the fitted polynomial model is plotted against age in Figure 3.2. It is seen that the velocity is higher in boys than in girls from 3 to about 5 years of age, and thereafter it is higher in girls up to about 11 years of age. The estimated age at peak velocity is 12.8 years for girls and 13.7 years for boys with the peak weight velocity of 3.9 kg and 4.7 kg, respectively.

Height

Table 3.2 shows the statistical constants for the height of boys and girls. It indicates that boys are in general taller than girls across ages, except during the adolescence from 11 to 12 years when girls are taller than boys. Following the Preece-Baines model I (PBI), the means are smoothed as shown in Figure 3.4. Unlike the raw data, girls are slightly taller than boys up to about 9 years of age. The growth curve is by and large similar in both boys and girls up to about 12 years of age, and thereafter it is greater in boys.

The estimated values for adult height are 157.5 cm for males and 152.0 cm for females. This indicates that both boys and girls have reached their adult height by the age of 18, although the boys may continue to grow. The present observation seems to confirm the earlier observation among the urban Khasis (Khongsdier and Mukherjee, 2003) and that observed among the girls of Assamese Muslims in Assam (Begum and Choudhury, 1999). The differences between the sexes in respect of the biological parameters are statistically significant as expected.

Table 3.3. Statistical constants of height (cm) for boys and girls

Age (yrs)	Boys Mean	Boys SD	Boys Increment	Girls Mean	Girls SD	Girls Increment	t-value
3	87.14	3.54	-	86.05	4.35	-	1.06
4	93.67	4.50	6.54	93.59	4.83	7.54	1.32
5	100.90	4.20	7.23	99.23	6.57	5.64	1.15
6	106.06	5.07	5.16	104.97	5.28	5.74	0.80
7	111.52	6.34	5.46	110.40	4.52	5.43	0.78
8	116.90	4.73	5.38	115.12	4.34	4.72	1.56
9	121.42	6.50	4.52	120.88	5.16	5.76	0.37
10	125.62	4.05	4.20	124.86	4.55	3.98	0.74
11	129.43	6.30	3.81	130.10	5.17	5.23	0.50
12	135.38	4.55	5.95	137.34	4.06	7.25	1.89
13	143.26	6.50	7.88	141.49	5.80	4.15	1.19
14	148.79	5.29	5.53	144.53	4.07	3.04	4.10*
15	152.71	4.62	3.92	147.51	3.22	2.98	5.49*
16	154.64	4.46	1.93	148.93	4.05	1.41	5.28*
17	155.60	5.31	0.96	150.00	4.19	1.07	4.53*
18	157.37	4.25	1.77	150.64	4.26	0.64	6.12*

Parameter estimates according to PB1 model

Sex	h1±SE	h0±SE	s1±SE	s0±SE	θ±SE
Boys	157.48±0.91	144.46±0.83	0.09±0.01	0.80±0.10	13.29±0.20
Girls	151.96±1.02	134.81±1.74	0.07±0.01	0.54±0.07	11.60±0.37
Difference ± SE	5.52±1.37*	9.65±1.93*	0.02±0.01*	0.34±0.12*	1.69±0.42*

Biological variables	Boys	Girls
Age at peak velocity (years)	12.2	11.1
Height at peak velocity (cm)	137.4	131.7
Peak height velocity (cm/year)	5.4	5.6
Final height (cm)	157.5	152.0

$*p < 0.05$

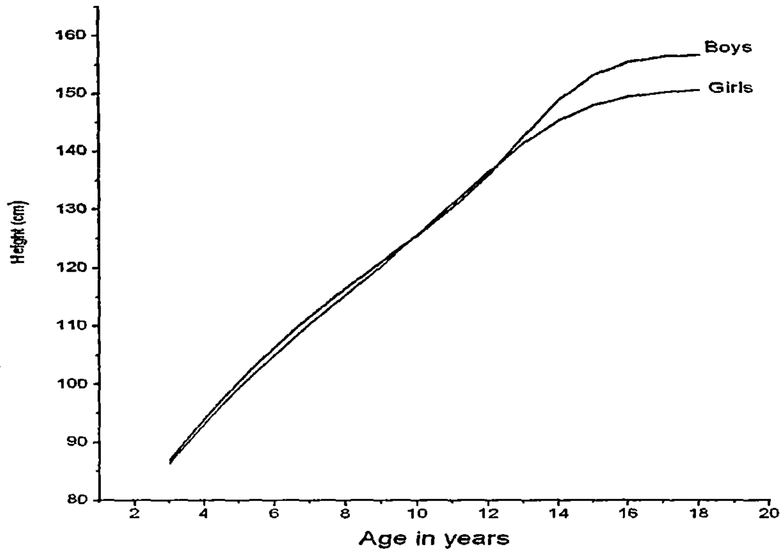

Figure 3.4 Smooth distance curves according PBI model

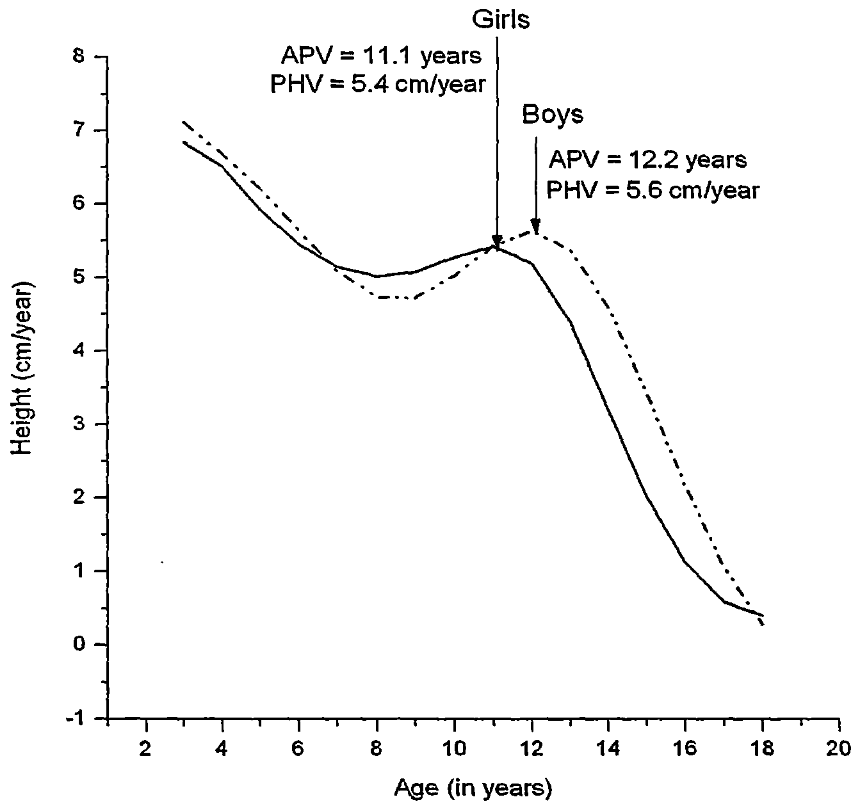

Figure 3.5 Velocity curves (first derivatives of the fitted function) indicating age at peak velocity (APV) and peak height velocity (PHV)

Figure 3.5 shows the velocity curve based on the first derivatives of the PBI model. The estimated age at maximum increment, presumably considered as age at peak height velocity, was 11.1 years for girls and 12.2 years for boys with the approximate height of 131.7 cm and 137.4 cm, respectively. Thus, it indicates that the adolescent growth spurt in height occurs about 1 year earlier in girls as compared to boys, although the peak height velocity is by and large similar in both boys (5.6 cm/year) and girls (5.4 cm/year). The figure shows that the velocity is higher in boys from 3 to about 7 years of age, and thereafter it is higher in girls till about the age of 11 years. These differences may be attributed to the adolescent growth spurt which occurs in girls from 11 to 12 years of age. Overall, the boys are higher in growth rates across ages, especially after 11 years of age.

Sitting Height

The statistical constants for sitting height of both boys and girls are given in Table 3.3. On average, the raw data (Table 3.4) show that boys are slightly greater in sitting as compared to girls. However, girls have greater sitting height than boys at 5 and 12 years of age, and the difference is statistically significant at 12 years of age ($t = 2.01$, $p < 0.05$). The higher mean values of sitting height in boys are statistically significant from 15 to 18 years of age. This can also be observed from the distance curve (Figure 3.6) fitted to the mean values for both boys and girls. The figure indicates that both boys and girls are similar in sitting height from 3 to about 12 years of age. According to PBI, both boys and girls have reached their adult sitting height by the age of 18 (Table 3.3), and the adult sitting height in boys are significantly higher than in girls (difference ± SE = 3.22±0.85, $p < 0.001$).

The velocity curve (Figure 3.7), derived from the fitted PBI function, shows that both the sexes gained their sitting height continuously from 3 to 18 years of age. It is observed that the velocity rate is higher in boys than in girls in many age groups, although it is higher in the latter than in the former from about 7-11 years of age. In other words, the figure shows that the velocity is higher in boys from 3 to about 7 years of age, and thereafter it is higher in girls till about the age of 11 years. These differences may be attributed to the adolescent growth spurt which occurs in girls from 11 to 12 years of age. The estimated age at peak height velocity was 11.2 years for girls and 12.5 years for boys with the approximate height of 67.1cm and 70.9 cm, respectively. Like in the case of

height, the adolescent growth spurt in sitting height occurs about 1 year earlier in girls as compared to boys, although the peak height velocity is by and large similar in both boys (2.8 cm/year) and girls (2.6 cm/year).

Table 3.4. Statistical constants of sitting height (cm) for boys and girls

Age	Boys			Girls			
(yrs)	Mean	SD	Increment	Mean	SD	Increment	t-value
3	46.93	1.76	-	46.48	2.19	-	0.88
4	49.57	2.83	2.64	50.05	2.45	3.57	0.79
5	52.57	2.62	2.99	53.07	4.13	3.02	0.55
6	54.73	3.20	2.17	55.74	4.92	2.68	0.92
7	57.80	4.81	3.06	57.43	4.22	1.69	0.31
8	59.73	3.54	1.94	59.10	5.22	1.67	0.56
9	61.61	3.80	1.88	60.56	4.41	1.46	1.03
10	63.93	3.34	2.32	63.37	3.33	2.81	0.73
11	66.22	2.89	2.28	66.75	3.22	3.39	0.75
12	69.04	2.87	2.82	70.50	3.05	3.75	2.01*
13	72.87	3.46	3.84	72.31	3.39	1.81	0.68
14	75.27	3.87	2.40	74.13	2.87	1.82	1.52
15	77.71	3.32	2.44	75.66	3.25	1.54	2.60*
16	79.42	3.65	1.71	76.95	1.99	1.28	3.31**
17	80.10	3.41	0.68	77.93	3.18	0.99	2.55*
18	81.73	2.84	1.63	78.83	4.10	0.90	3.19**

Parameter estimates according to PB1 model

Sex	h1±SE	h0±SE	s1±SE	s0±SE	θ±SE
Boys	81.78±0.46	74.97±0.36	0.09±0.01	0.75±0.08	13.89±0.18
Girls	78.56±0.72	72.22±0.72	0.09±0.01	0.72±0.15	13.03±0.38
Difference ± SE	3.22±0.85**	2.75±0.80*	0.0±0.01	0.03±0.17	0.86±0.42*

Biological variables	Boys	Girls
Age at peak velocity (years)	12.5	11.2
Height at peak velocity (cm)	70.9	67.1
Peak height velocity (cm/year)	2.8	2.6
Final height (cm)	81.9	78.6

*p < 0.05, **p < 0.01

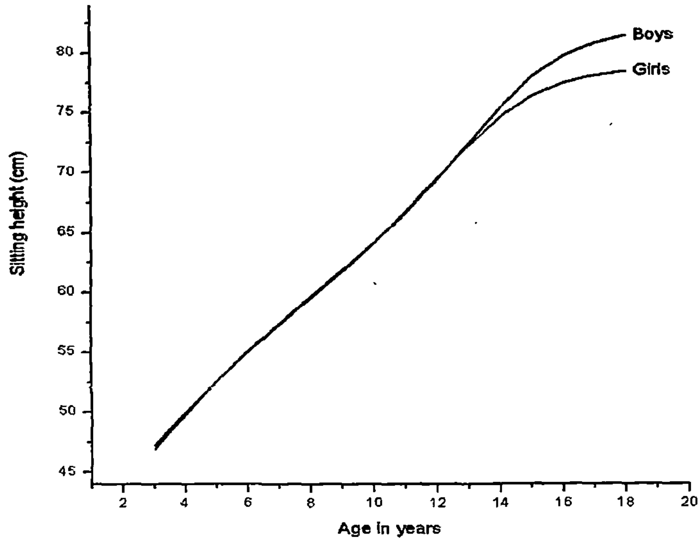

Figure 3.6 5.6. Smooth distance curves for sitting height according to PB1 model

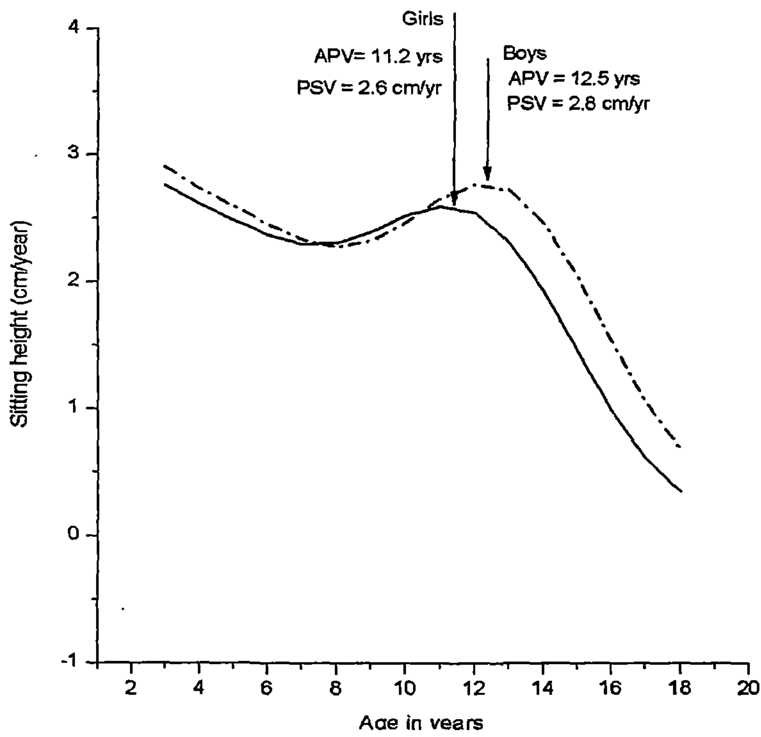

Figure 3.7. Velocity curves (first derivatives of the fitted function) indicating age at peak velocity (APV) and peak size velocity (PSV)

Table 3.5. Statistical constants of subischial length (cm) for boys and girls

Age (yrs)	Boys			Girls			t-value
	Mean	SD	Increment	Mean	SD	Increment	
3	40.20	2.94	-	40.57	2.81	-	0.85
4	44.10	2.62	3.90	43.54	3.04	3.97	1.77
5	48.33	2.68	4.23	46.17	3.88	2.62	2.46*
6	51.33	3.25	2.99	49.23	4.39	3.07	2.06*
7	53.72	2.72	2.40	52.97	2.65	3.73	1.07
8	57.17	2.55	3.45	56.02	2.42	3.05	1.84
9	59.81	3.41	2.64	60.32	2.53	4.31	0.70
10	61.68	1.93	1.88	61.50	2.69	1.17	0.33
11	63.21	4.51	1.53	63.34	2.68	1.85	0.16
12	66.34	2.12	3.13	66.84	2.72	3.50	0.82
13	70.38	4.04	4.04	69.18	4.75	2.34	1.12
14	73.52	4.24	3.14	70.40	3.45	1.22	3.67**
15	75.01	3.35	1.48	71.85	2.96	1.45	4.18**
16	75.23	3.53	0.22	71.98	2.63	0.13	4.10**
17	75.50	2.54	0.27	72.07	2.23	0.09	2.56*
18	75.63	2.97	0.13	71.81	2.90	-0.26	5.06**

Parameter estimates according to PB1 model

Sex	h1±SE	h0±SE	s1±SE	s0±SE	θ±SE
Boys	75.50±0.19	70.75±0.18	0.13±0.01	1.55±0.16	13.12±0.09
Girls	72.61±0.64	66.21±1.41	0.11±0.02	0.62±0.16	11.68±0.67
Difference ± SE	2.89±0.64	4.54±0.64	0.02±0.64	0.93±0.64	1.44±0.64

Biological variables	Boys	Girls
Age at peak velocity (years)	12.0	11.5
Height at peak velocity (cm)	66.5	65.8
Peak height velocity (cm/year)	2.8	2.6
Final height (cm)	75.5	72.6

*p < 0.05

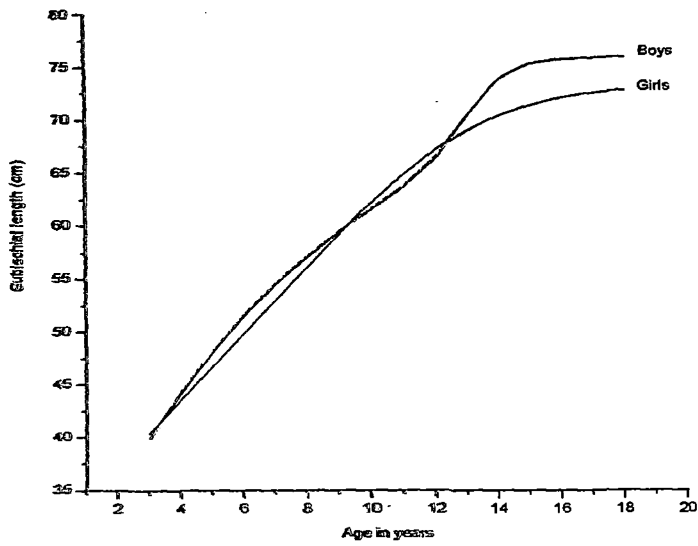

Figure 3.8 **Smooth distance curves for subischial length according to PBl model**

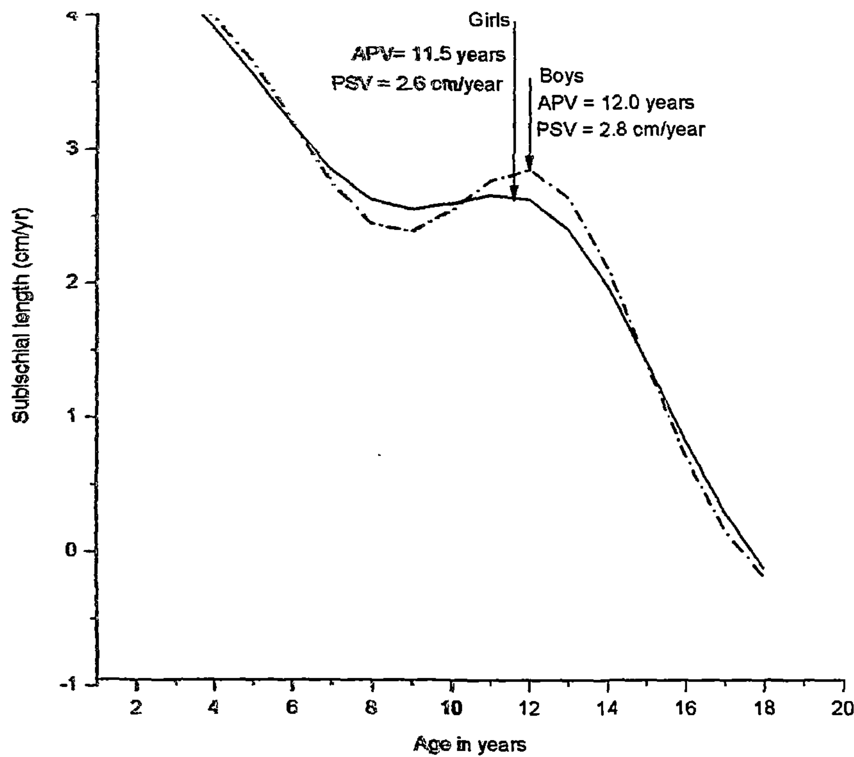

Figure 3.9. Velocity curves (first derivatives of the fitted function) indicating age at peak velocity (APV) and peak size velocity

Subischial Length

The statistical constants for subischial length (height minus sitting height) of both boys and girls are given in Table 3.5. It is seen that boys are significantly greater in subischial length at 5, 6, and across ages from 14 years onwards. The distance curve (Figure 3.8) fitted according to PBI model indicates that boys have a greater subischial length than girls from about 3 to 9 years, and thereafter the latter surpassed the former up to about 12 years of age. However, boys are greater in subischial length from the age of 13 onwards. The higher subischial length in girls from 10 to 12 years of age may be attributed to adolescent growth spurt as in the case of sitting height. According to PBI model, both boys and girls have by and large reached their adult subischial length by the age of 18. It can be observed from Table 3.4 that the difference between the observed and the estimated adult subischial length for boys and girls are 0.13 and 0.79 cm, respectively. Thus, it indicates that both boys and girls have reached their adult size by the age of 18, although girls may still continue to grow. The sex difference in adult size is statistically significant (difference ± SE = 2.89±0.64, $p < 0.01$).

The velocity curve (Figure 3.9) shows that both the sexes gained their sitting height continuously from 3 to 18 years of age. It is observed that the velocity is slightly higher in boys from 3 to 5 and 11 to 14 years of age. On the other hand, girls have a higher velocity from about 7 to 10 and 15 years onwards. These differences may be attributed to the adolescent growth spurt which occurs in girls from 11 to 12 years of age. The estimated age at peak velocity in subischial length was 11.5 years for girls and 12.0 years for boys with the approximate height of 66.5cm and 65.8 cm, respectively. Unlike the case of sitting height, the adolescent growth spurt in subischial length occurs about 0.5 year earlier in girls as compared to boys, although the peak velocity is by and large similar in both boys (2.8 cm/year) and girls (2.6 cm/year).

Upper Arm Circumference

Table 3.6 shows the means and standard deviations of the upper arm circumference for both boys and girls, and the distance and velocity curves are shown in Figures 5.10 and 5.11, respectively. The distance curve shows that mean values of arm circumference are more or less similar for both sexes from 3 to 5, 10 to 11 and 13 to 15 years of age, and thereafter the boys had higher mid upper arm circumference (Figure 3.10). The girls are greater in arm circumference from about 11 to 13 years of age, and it is statistically significant at 12 years ($t = 2.00$, $p < 0.05$). Overall, the boys are

greater in mean arm circumference than girls in many age groups, although the differences are not statistically significant (Table 3.6).

Table 3.6. Statistical constants of upper arm circumference (cm) for boys and girls

Age	Boys			Girls			
(yrs)	Mean	SD	Increment	Mean	SD	Increment	t-value
3	14.98	0.85	-	15.29	0.99	-	1.34
4	15.48	1.16	0.50	15.36	1.18	0.08	0.13
5	15.93	1.07	0.46	15.75	0.99	0.39	0.66
6	16.63	1.27	0.70	16.52	2.07	0.77	0.25
7	17.01	1.47	0.38	16.70	1.26	0.18	0.86
8	17.88	1.82	0.87	17.16	1.58	0.46	1.69
9	18.31	2.31	0.42	17.37	2.06	0.21	1.73
10	18.70	1.82	0.39	18.89	1.84	1.52	0.44
11	19.56	2.36	0.86	19.29	2.08	0.40	0.54
12	20.21	2.30	0.65	21.32	2.23	2.03	2.00*
13	22.03	2.69	1.82	22.09	1.81	0.77	0.11
14	22.88	2.43	0.85	22.68	2.07	0.59	0.40
15	23.26	2.40	0.38	23.32	2.08	0.64	0.12
16	23.99	1.90	0.74	23.68	1.66	0.36	0.70
17	24.37	1.99	0.37	23.80	1.94	0.12	1.12
18	24.90	2.17	0.53	23.47	1.99	-0.33	2.66**

*P < 0.05, **P < 0.01

As for the annual growth rate, Figure 3.11 shows that the velocity rate is fluctuating with no clear sex differences. Nevertheless, boys seem have a higher growth rate than the girls from 7 to 9 years and after 16 years of age. On the other hand, girls are higher in growth rate from about 9 to 10 and 11 to 12 years of age. The total gain in arm circumference from 3 to 18 years of age is more in boys (9.92 cm) than in girls (8.18 cm). In boys, the maximum gain occurs at 13 years, while in girls it takes place at the age of 12 years, accounting to about 18.35% and 24.82% of the total gain from 3 to 18 years for boys and girls, respectively. Thus, it is obvious that adolescent spurt occurs at 12 and 13 years in girls and boys, respectively.

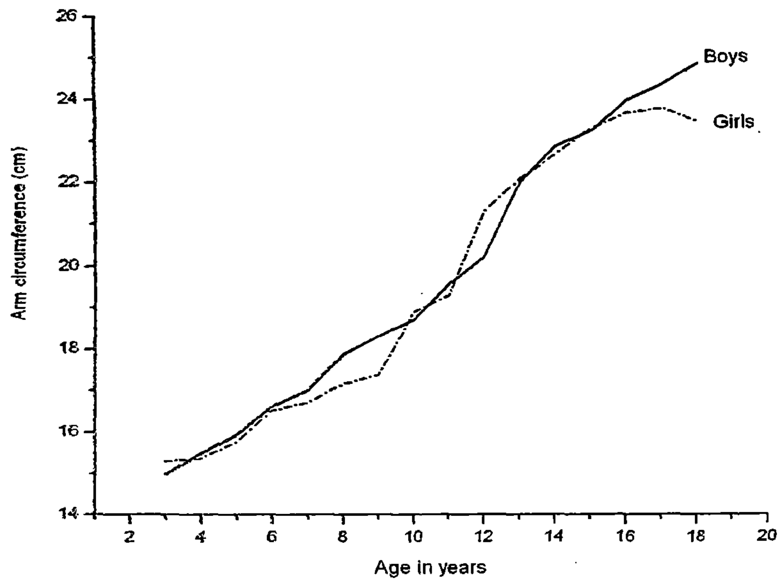

Figure3.10 Distance curves for mid upper arm circumference of boys and girls

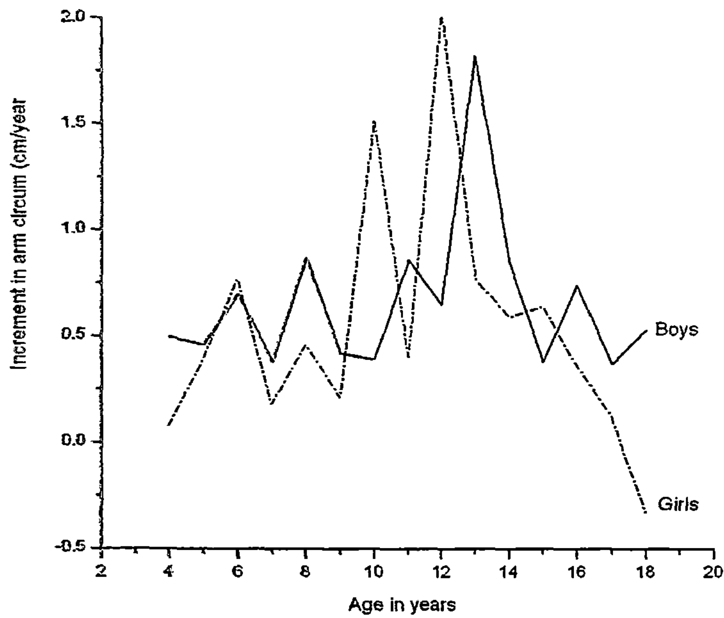

Figure 3.11 I. Velocity curves for mid upper arm circumference of boys and girls

Table 3.7. Statistical constants of chest circumference for boys and girls

Age	Boys			Girls			
(yrs)	Mean	SD	Increment	Mean	SD	Increment	t-value
3	51.30	2.87	-	51.32	2.76	-	0.02
4	52.68	2.69	1.38	52.61	1.59	1.29	0.13
5	54.57	3.40	1.89	54.35	2.61	1.74	0.30
6	55.81	2.59	1.24	55.61	4.19	1.27	0.22
7	57.73	2.07	1.92	56.57	5.45	0.95	1.06
8	59.97	2.54	2.24	59.21	4.23	2.64	0.86
9	61.48	3.34	1.51	62.00	4.42	2.79	0.53
10	63.70	2.91	2.22	64.05	2.84	2.05	0.53
11	65.89	4.63	2.19	65.92	2.25	1.87	0.03
12	68.00	4.38	2.11	69.42	4.18	3.51	1.37
13	72.98	4.58	4.98	72.78	3.41	3.35	0.22
14	75.89	3.90	2.90	74.02	2.34	1.25	2.63
15	77.39	2.84	1.50	76.11	3.00	2.09	1.82
16	78.97	4.16	1.59	78.06	2.85	1.95	1.00
17	80.57	3.49	1.60	79.60	3.10	1.54	1.14
18	82.37	2.77	1.80	80.35	2.15	0.75	3.14*

$^*P < 0.003$

Chest Circumference

The statistical constants for chest circumference of both boys and girls are given in Table 3.7. The mean values are plotted against age as shown in Figure 3.12. It is observed that there is a gradual increase in chest girth from 3 to 18 years of age for both boys and girls. The distance curve shows that the chest girth is higher in boys than in girls from 6 to 8, and after 13 years of age. On the other hand, the girls are higher in mean values from 11 to 11 years of age. However, these differences between boys and girls in respect of chest girth are not statistically significant except at 18 years of age. Nevertheless, it indicates that the boys have higher chest girth in many age groups, especially after 13 years of age.

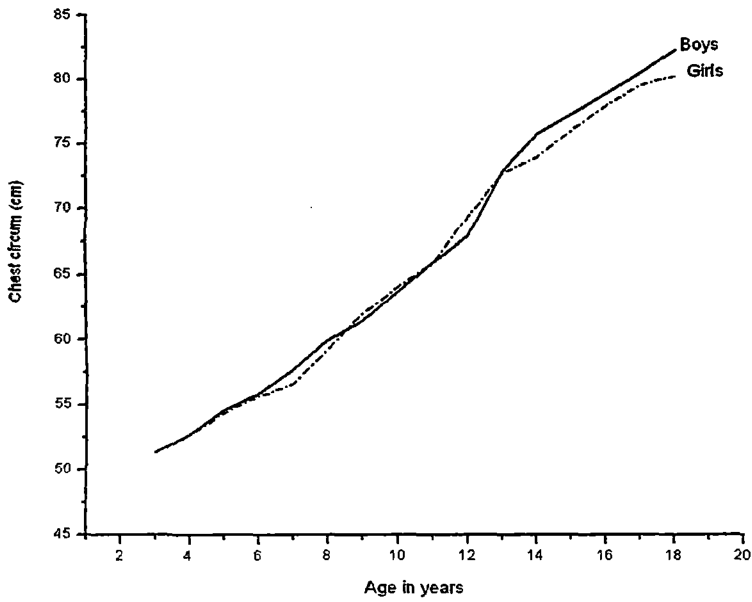

Figure 3.12 Distance curves for chest circumference of boys and girls

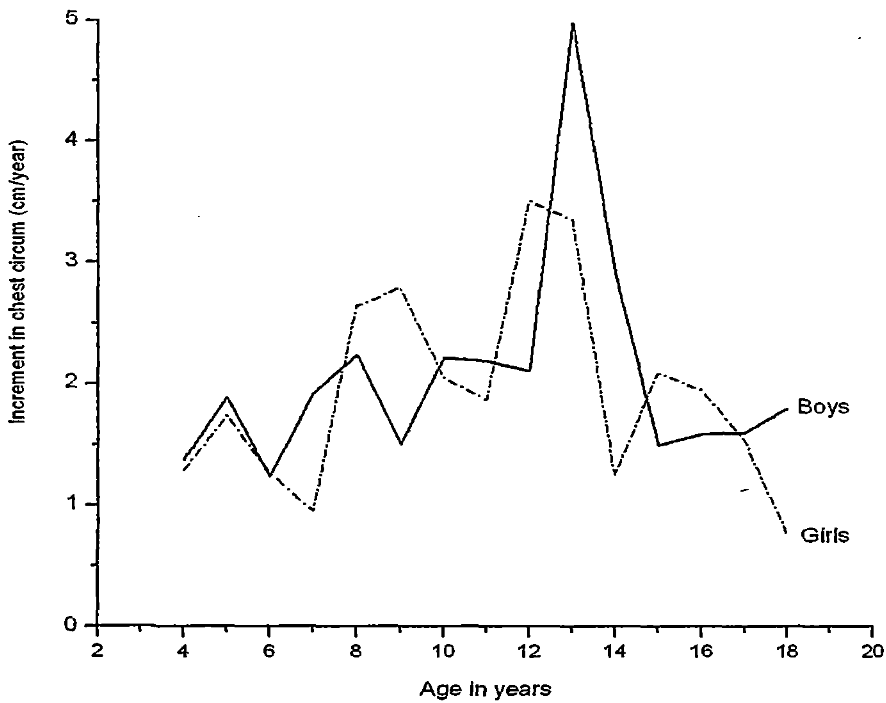

Figure 3.13 Velocity curves for chest circumference of boys and girls

As for the annual growth rate, Figure 3.13 shows that the velocity rate is by and large higher in boys from the age group 3 to 7, 10-11, 13-14 and 17 years onwards. The growth rate is higher in girls only at age groups 6 to 9, 11 to 12 and 15-16 years. The total gain in chest circumference from 3 to 18 years of age is more in boys (31.07 cm) than in girls (29.03cm). In boys, the maximum gain of 4.98 cm occurs at 13 years, while in girls it takes place at the age of 12 years (3.51 cm), accounting to about 16.03% and 12.09% of the total gain from 3 to 18 years for boys and girls, respectively. Like in the case of upper arm circumference, it may be suggested that the adolescent spurt with respect to chest circumference occurs at 12 and 13 years in girls and boys, respectively.

CHAPTER IV.

NUTRITIONAL STATUS

In this chapter, we shall describe the nutritional status in relation to certain socioeconomic factors. Anthropometric indices like weight-for-age, height-for-age and BMI-for-age are used for the assessment of the nutritional status. The nutritional status is then correlated with certain socioeconomic factors.

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 weight-for-height for assessing the nutritional status of the children. We have also made an attempt to correlate these indices with certain socioeconomic variables

such as household income, maternal education and family size. The findings of the study may be presented briefly as follows:

Weight-for-age

Weight-for-age, expressed as a Z-score of the individual weight relative to CDC growth references, is considered as one of the indicators of underweight. The means and standard deviations of the z-score for weight-for-age are given in **Table 4.1.** It is seen that the overall mean Z-score of weight-for-age is significantly higher in girls than in boys ($t = 2.27$, $p < 0.05$). As for the sex differences at different age groups, it is found that boys had a greater Z-score than girls only at 6 and 13 years of age. The girls are significantly greater in Z-score at 3, 9 and 16 years onwards.

Table 4.1. Mean z-scores for weight-for-age of both boys and girls

Age	Boys			Girls			
(yrs)	Number	Mean	SD	Number	Mean	SD	t-value
3	30	-1.95	1.89	30	-0.71	1.26	2.99*
4	31	-1.18	1.13	33	-0.75	0.83	1.72
5	30	-0.95	0.83	26	-1.39	1.12	1.68
6	28	-0.83	0.97	31	-1.32	0.44	2.52*
7	28	-1.34	1.00	30	-1.10	1.19	0.84
8	30	-1.12	0.95	33	-1.28	0.65	0.79
9	31	-2.19	1.50	34	-1.53	0.85	2.19*
10	30	-1.64	0.98	49	-1.45	0.63	1.06
11	33	-1.78	0.99	42	-1.70	0.56	0.43
12	28	-1.70	0.50	42	-1.45	0.71	1.65
13	31	-0.94	0.87	38	-1.44	0.84	2.43*
14	40	-0.70	0.54	42	-0.93	0.58	1.83
15	34	-1.14	0.49	36	-1.17	1.05	0.13
16	31	-1.42	0.52	31	-1.09	0.52	2.51*
17	30	-1.64	0.67	30	-1.08	0.66	3.30*
18	30	-1.79	0.53	30	-1.38	0.71	2.56*
Total	495	-1.38	1.04	557	-1.25	0.84	2.27*

*$p < 0.05$

Table 4.2. Nutritional status according to weight-for-age (based on CDC references)

Nutritional status	Boys (N =495)		Girls (N = 557)	
	Number	Percent	Number	Per cent
3-9 years				
Above normal (> + 2 score)	0	0.00	0	0.00
Normal (≥ -2 to +2 Z-score)	123	59.13	133	61.29
Moderate (-2 to -3 Z-score)	56	26.92	78	35.94
Severe (< -3 Z-score)	29	13.94	6	2.76
Total	208	100.00	217	100.00
$\chi^2 = 0.21$, D.F. = 1, $p > 0.05$				
10 to 18 years				
Above normal (> + 2 score)	0	0.00	0	0.00
Normal (≥ -2 to +2 Z-score)	168	58.54	206	60.59
Moderate (-2 to -3 Z-score)	108	37.63	128	37.65
Severe (< -3 Z-score)	11	3.83	6	1.76
Total	287	100.00	340	100.00
$\chi^2 = 0.27$, D.F. = 1, $p > 0.05$				
3 to 18 years				
Above normal (> + 2 score)	0	0.00	0	0.00
Normal (≥ -2 to +2 Z-score)	291	58.79	339	60.86
Moderate (-2 to -3 Z-score)	164	33.13	206	36.98
Severe (< -3 Z-score)	40	8.08	12	2.15
Total	495	100.00	557	100.00
$\chi^2 = 0.47$, D.F. = 1, $p > 0.05$				

χ^2 test for sex differences in the prevalence of underweight

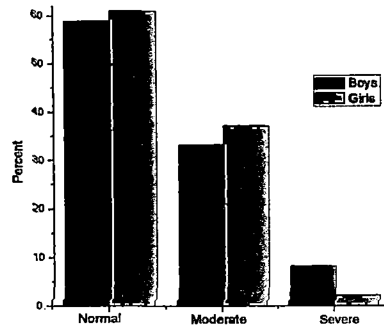

Figure 4.1. Nutritional status of children of all age groups according to weight-for-age

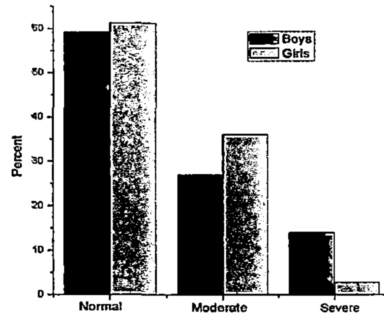

Figure 4.2. Nutritional status of children aged 3-9 years according to weight-for-age

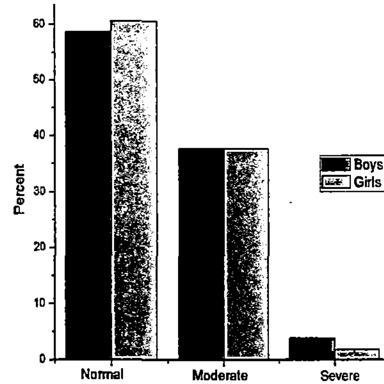

Figure 4.3. Nutritional status of children aged 10-18 years according to weight-for-age

The nutritional status of children according to weight-for-age is given in **Table 4.2**. It is found that about 58.79% of boys and 60.86% of girls for all age groups are in the normal category (-2 to + 2 of Z-scores) of nutritional status. The prevalence of moderate (-2 to –3 of Z-scores) and severe (below –3 of Z-scores) forms of underweight among boys is 33.13% and 8.08%, respectively. Among girls, these frequencies are found to be 36.98% and 2.15%, respectively. Thus, the prevalence of severe form of underweight is lower in girls, whereas the prevalence of moderate underweight is higher in girls than in boys (**Figure 4.1**). Nevertheless, the overall prevalence of underweight (below - 2 Z-score) was higher in boys (41.21%) than girls (39.14%). The sex differences in the prevalence of underweight are, however, not statistically significant ($\chi^2 = 0.47$, D.F. = 1, $p > 0.05$).

Table 4.2 also shows the percentage distribution of underweight children according to two arbitrary age groups. In the age group 3-9 years, about 26.92% and 13.94% of boys, and 35.94% and 2.76% of girls are in the categories of moderate and severe forms of underweight, respectively. **Figure 4.2** shows that the sex differences in the prevalence of underweight in this age group are similar to those observed for all age groups as mentioned above. It is observed that girls had a lower prevalence of severe underweight, but were higher in the prevalence of moderate underweight. On the other hand, the overall prevalence of underweight is higher in boys (40.87%) than in girls (38.71%) in this age group, despite the absence of statistical significance ($\chi^2 = 0.21$, D.F. = 1, $p > 0.05$).

In the older age group 10-18 years, the prevalence of moderate and severe forms of underweight among boys was found to be 37.63% and 3.83%, respectively. These frequencies were respectively 37.65% and 1.76% among girls. **Figure 4.3** shows that the sex differences are not clearly perceptible, although the prevalence of severe underweight was slightly lower in girls. Like in the age group 3-9 years, the overall prevalence of underweight (i.e., moderate plus severe forms) in this age group was also higher in boys (41.46%) than in girls (39.41%), although the difference is not statistically significant ($\chi^2 = 0.27$, D.F. = 1, $p > 0.05$).

Overall, the prevalence of underweight for all sexes and ages was found to be 40.11%. The present findings indicate that there are no differences between the sexes with respect to the prevalence of underweight, although it was slightly higher in boys than in girls. Also, the differences between the two major age groups are not statistically significant, although it was slightly higher in the older age group. We shall discuss this issue in the next chapter.

Table 4.3. Mean z-scores for height-for-age of both boys and girls

Age (yrs)	Boys			Girls			t-value
	Number	Mean	SD	Number	Mean	SD	
3	30	-1.16	1.00	30	-1.15	1.16	0.05
4	31	-1.36	1.17	33	-1.01	1.19	1.20
5	30	-1.12	0.94	26	-1.22	1.54	0.30
6	28	-1.30	1.03	31	-1.39	1.32	0.31
7	28	-1.41	1.21	30	-1.59	0.92	0.66
8	30	-1.50	0.88	33	-1.81	0.85	1.44
9	31	-1.66	1.14	34	-1.68	0.93	0.09
10	30	-1.72	0.67	49	-1.73	0.76	0.09
11	33	-1.78	0.96	42	-1.60	0.76	0.92
12	28	-1.56	0.66	42	-1.41	0.54	0.01
13	31	-1.25	0.88	38	-1.82	0.78	2.84*
14	40	-1.43	0.65	42	-2.18	0.60	5.45*
15	34	-1.76	0.52	36	-2.13	0.50	3.00*
16	31	-2.14	0.50	31	-2.07	0.63	0.49
17	30	-2.45	0.63	30	-1.98	0.65	2.85*
18	30	-2.49	0.55	30	-1.91	0.66	3.66*
Total	495	-1.63	0.94	557	-1.68	0.93	0.90

*$p < 0.05$

Height-for-age

Height-for-age, expressed as a Z-score of the individual relative to CDC growth references, is considered in the present study as an indicator of short stature or stunting due to inadequate nutrition. The mean z-scores of height-for-age are presented in **Table 4.3** for both boys and girls. It is observed that that the sex differences are significant only during the adolescent period. The height-for-age Z-scores were significantly higher in boys than in girls from 13 to 15 years of age. On the other hand, girls had greater Z-scores from 17 to 18 years of age. These differences may be related to the differences in rates of growth concerning adolescent growth spurts.

Table 4.4. Nutritional status according to height-for-age (based on CDC references)

Nutritional status	Boys (N =495)		Girls (N = 557)	
	Number	Percent	Number	Per cent
3-9 years				
Above normal (> + 2 score)	0	0.00	0	0.00
Normal (≥ -2 to +2 Z-score)	127	61.06	136	62.67
Moderate (-2 to -3 Z-score)	66	31.73	65	29.95
Severe (< -3 Z-score)	15	7.21	16	7.37
Total	208	100.00	217	100.00
$\chi^2 = 0.12$, D.F. = 1, $p > 0.05$				
10 to 18 years				
Above normal (> + 2 score)	0	0.00	0	0.00
Normal (≥ -2 to +2 Z-score)	117	40.77	122	35.88
Moderate (-2 to -3 Z-score)	148	51.57	200	58.82
Severe (< -3 Z-score)	22	7.66	18	5.29
Total	287	100.00	340	100.00
$\chi^2 = 1.57$, D.F. = 1, $p > 0.05$				
3 to 18 years				
Above normal (> + 2 score)	0	0.00	0	0.00
Normal (≥ -2 to +2 Z-score)	244	49.29	258	46.32
Moderate (-2 to -3 Z-score)	214	43.23	265	47.58
Severe (< -3 Z-score)	37	7.47	34	6.10
Total	495	100.00	557	100.00
$\chi^2 = 0.93$, D.F. = 1, $p > 0.05$				

χ^2 test for sex differences in the prevalence of stunting

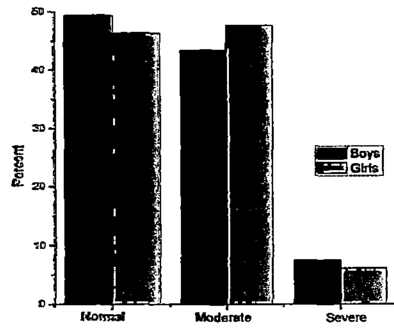

Figure 4.4. Nutritional status of children of all age groups according to height-for-age

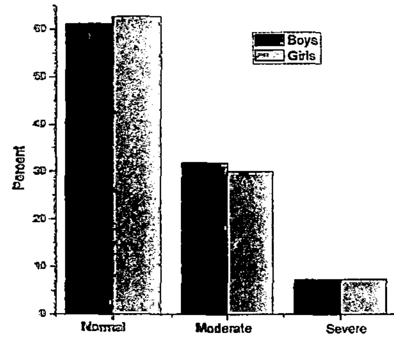

Figure 4.5. Nutritional status of children aged 3-9 years according to height-for-age

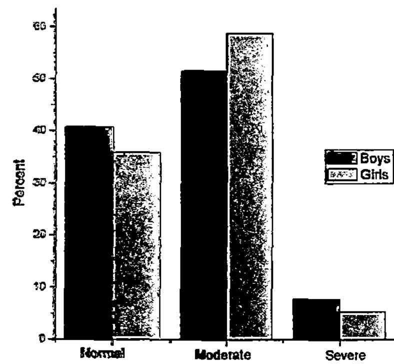

Figure 4.6. Nutritional status of children aged 10-18 years according to height-for-age

In order to have a better understanding whether the nutritional status is better in boys or girls, an attempt has been made to show in **Table 4.4** the percentage distribution of children according to age groups and grades of nutritional status based on height-for-age. Overall, **Table 4.4** indicates that about 49.29%, 43.23% and 7.47% of boys were in the categories of normal, moderate and severe forms of short stature or stunting as indicated by height-for-age. Among girls, these frequencies are 46.32%, 47.58% and 6.10%, respectively. **Figure 4.4** shows a similar pattern of distribution to that obtained according to weight-for-age. The prevalence of moderate form of stunting was higher in girls, but they had a lower prevalence of the severe form of stunting as compared with boys. Pooling the data on moderate and severe forms of stunting, it is however found that the overall prevalence of stunting (below – 2 Z-scores) was lower in boys (50.71%) than in girls (53.68%), despite the absence of statistical significant ($\chi^2 = 0.93$, D.F. = 1, $p > 0.05$).

Table 4.4 also shows the percentage distribution of underweight children according to two arbitrary age groups. In the age group 3-9 years, about 31.73% and 7.21% of boys, and 29.95% and 7.37% of girls are in the categories of moderate and severe forms of stunting, respectively. **Figure 4.5** shows that the prevalence of the two forms of stunting in age group 3-9 years are by and large similar in both boys and girls, although the former were slightly higher in the prevalence of moderate stunting than the latter. The overall prevalence of stunting (i.e. moderate plus severe forms) was also slightly higher in boys (38.94%) than in girls (37.33%) in this age group ($\chi^2 = 0.12$, D.F. = 1, $p > 0.05$).

In the age group 10-18 years, the prevalence of moderate and severe forms of stunting among boys was found to be 51.57% and 7.66%, respectively. These frequencies were respectively 58.82% and 5.29% among girls. **Figure 4.3** shows that the sex differences in the prevalence of the two forms of stunting are clearly perceptible. The prevalence of moderate stunting was higher in boys, whereas the prevalence of severe stunting was slightly lower in girls than boys. Nevertheless, the present analysis indicates that the overall prevalence of stunting (i.e., moderate plus severe forms) in the age group 10-18 years was higher in girls (64.11%) than in boys (59.23%). However, this sex difference was not statistically significant ($\chi^2 = 1.57$, D.F. = 1, $p > 0.05$).

Overall, the present findings indicate that about 52.28% of children were stunted. There are no statistical differences between the sexes with respect to the prevalence of stunting,

although it was higher in girls than in boys. However, the prevalence of stunting in the higher age group was much higher than that in the lower age group for both boys and girls, and the differences between the two major age groups are highly statistically significant in both boys ($\chi^2 = 19.86$, D.F. = 1, $p < 0.0001$) and girls ($\chi^2 = 32.24$, D.F. = 1, $p < 0.0001$). This difference between age groups may be associated with both biological and nutritional factors. We shall discuss this issue in the next chapter (we may discuss the applicability of international growth references).

Table 4.5. Mean z-scores for BMI-for-age of both boys and girls

Age	Boys			Girls			
(yrs)	Number	Mean	SD	Number	Mean	SD	t-value
3	30	-1.03	2.70	30	0.89	1.05	0.27
4	31	0.33	1.07	33	0.59	1.09	0.93
5	30	0.32	1.46	26	-0.12	1.31	0.54
6	28	0.57	1.50	31	0.08	0.64	1.65
7	28	0.09	0.72	30	0.18	1.82	0.23
8	30	0.16	1.10	33	0.08	0.73	0.37
9	31	-1.11	1.44	34	-0.44	1.11	2.11*
10	30	-0.40	0.90	49	-0.17	0.78	1.23
11	33	-0.49	0.87	42	-0.48	0.65	0.09
12	28	-0.59	0.69	42	-0.39	0.72	1.14
13	31	0.14	0.83	38	-0.31	0.85	0.84
14	40	0.48	0.39	42	0.29	0.70	1.51
15	34	0.10	0.38	36	0.07	0.83	0.20
16	31	0.03	0.43	31	0.14	0.50	0.90
17	30	0.01	0.36	30	0.13	0.40	1.22
18	30	-0.19	0.39	30	-0.16	0.41	0.30
Total	495	-0.09	1.19	557	-0.01	0.95	1.34

*$p < 0.05$

BMI-for-age

The means and standard deviations of BMI-for-age Z scores are given in **Table 4.5**. It is seen that that the overall mean Z-score is slightly higher in girls than in boys. The sex differences with respect to different age groups are found to be significant only in the age group 9 years ($t = 2.11$, $p < 0.05$). In this age group, the girls are significantly greater in BMI-Z-score-for-age as compared with boys. Overall, the sex differences in BMI Z-scores are not clearly perceptible.

Table 4.6. Nutritional status according to BMI-for-age (based on CDC references)

Nutritional status	Boys (N =495)		Girls (N = 557)	
	Number	Percent	Number	Per cent
3-9 years				
Above normal (> + 2 score)	12	5.77	11	5.07
Normal (≥ -2 to +2 Z-score)	163	78.37	180	82.95
Moderate (-2 to -3 Z-score)	18	8.65	24	11.06
Severe (< -3 Z-score)	15	7.21	2	0.92
Total	208	100.00	217	100.00
$\chi^2 = 1.34$, D.F. = 1, $p > 0.05$				
10 to 18 years				
Above normal (> + 2 score)	0	0.00	0	0.00
Normal (≥ -2 to +2 Z-score)	269	93.73	307	90.29
Moderate (-2 to -3 Z-score)	17	5.92	33	9.71
Severe (< -3 Z-score)	1	0.35	0	0.00
Total	287	100.00	340	100.00
$\chi^2 = 2.45$, D.F. = 1, $p > 0.05$				
3 to 18 years				
Above normal (> + 2 score)	12	2.42	11	1.97
Normal (≥ -2 to +2 Z-score)	432	87.27	487	87.43
Moderate (-2 to -3 Z-score)	35	7.07	57	10.23
Severe (< -3 Z-score)	16	3.23	2	0.36
Total	495	100.00	557	100.00
$\chi^2 = 2.85$, D.F. = 1, $p > 0.05$				

χ^2 test for sex differences in the prevalence of underweight

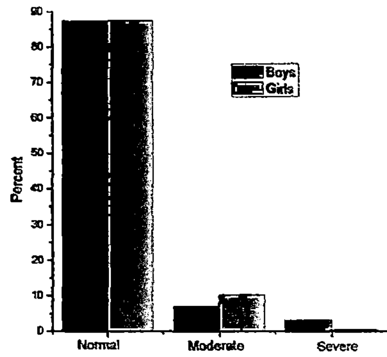

Figure 4.7 Nutritional status of children of all age groups according to BMI-for-age

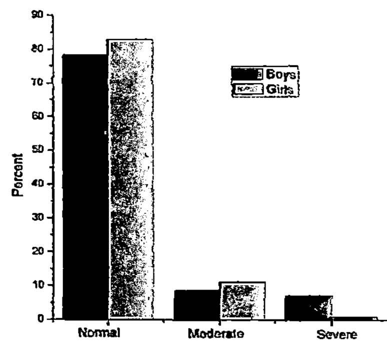

Figure 4.8. Nutritional status of children aged 3-9 years groups according to BMI-for-age

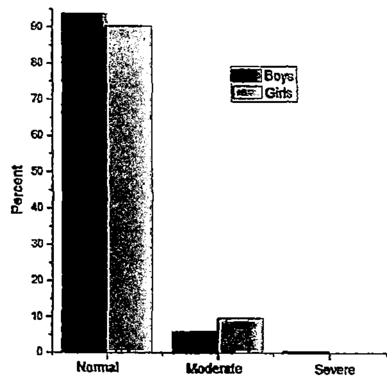

Figure 4.9. Nutritional status of children aged 10-18 years groups according to BMI-for-age

Table 4.6 shows the percentage distribution of children according to age groups and levels of nutritional status based on BMI-for-age. BMI-for-age is considered as an indicator of wasting or underweight relative to height. It is found that about 87.27%, 7.07% and 3.23% of boys were in the categories of normal, moderate and severe forms of wasting. Among girls, these frequencies are 87.43%, 10.23% and 0.36%, respectively. Thus, it indicates that the prevalence of moderate form of wasting was slightly higher in girls, whereas the prevalence of severe wasting was higher in boys **(Figure 4.7).** Nevertheless, the present study clearly indicates that the nutritional status as indicated by BMI-for-age is much better than that indicated by weight-for-age and height-for-age. This holds true for both boys and girls. The overall prevalence of wasting (below – 2 Z-scores) was by and large similar in both boys (10.30%) and girls (10.59%), giving a total incidence of about 10.46%. **Table 4.6** further indicates that overweight is also emerging, which was about 2.42% in boys and 1.97% in girls.

Table 4.6 shows the percentage distribution of undernourished children according to two arbitrary age groups. In the age group 3-9 years, about 8.65% and 7.21% of boys, and 11.06% and 0.92% of girls are in the categories of moderate and severe forms of wasting, respectively. Although the prevalence of moderate wasting is higher in girls (**Figure 4.8**), the overall prevalence of wasting (below – 2 Z-scores) is higher in boys (15.87%) than in girls (11.98%) in this age group, despite the absence of statistical significance ($\chi^2 = 1.34$, D.F. = 1, $p > 0.05$). **Table 4.6** further shows that the prevalence of overweight was also fairly marked in this age group for both boys (5.77%) and girls (5.07%). As a matter of fact, the prevalence of overweight was absent in the older age group of 10-18 years. Thus, it these rates of overweight may be indicative of emerging childhood obesity, which is likely to form a double burden of undernutrition and overnutrition in the next decade or so as observed in other developing countries.

In the age group 10-18 years, **Table 4.6** and **Figure 4.9** show that the prevalence of moderate wasting was higher in girls (9.71%) than in boys (6.27%), although it was not statistically significant ($\chi^2 = 2.45$, D.F. = 1, $p > 0.05$). Nevertheless, the present findings indicate the absence of significant difference between the sexes by age groups, although the prevalence of overweight is likely to exist in the lower age group 3-9 years. We shall further analyze our data in the following section. But it is clearly evident that the nutritional status as

indicated by BMI-for-age is much better than that indicated by weight-for-age and height-for-age.

Summary on nutritional status

It is evident from the present study that the major nutritional problem in the present population is that of stunting, followed by underweight. The prevalence of stunting was lower in boys (50.71%) than in girls (53.68%), although it was not statistically significant. It is also observed that the prevalence of stunting was significantly higher in the older age group as compared with the younger age groups. It holds true for both boys and girls. On the other hand, the prevalence of underweight was higher in boys (41.21%) than in girls (39.14%), and there were no significant differences between age groups, although it was slightly higher in the older age group. With respect to BMI-for-age, the prevalence of wasting was by and large similar in both boys (10.30%) and girls (10.59%), and there were no significant differences between age groups. However, the prevalence of overweight seemed to be higher in the lower age group, which is likely to be an emerging problem in the next decade or so. It is also clearly evident that the nutritional status as indicated by BMI-for-age is much better than that indicated by weight-for-age and height-for-age.

Overall, it is found that about 40.11%, 52.28% and 10.46% of the children in the present study were underweight, stunted and wasted, respectively. Following the classificatory criteria proposed by Gorstein *et al.*, (1994), which are given in Table 4.14, we may conclude that the present population is likely to be characterized by a very high prevalence of underweight and stunting with a high prevalence of wasting. We shall discuss this issue in Chapter VI.

Table 4.7. Criteria for assessing severity of under-nutrition in a population*

	Prevalence (%)			
Indicator	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)

UNDERNUTRITION AND SOCIOECONOMIC CORRELATES

In this section, we shall make an attempt to understand how the undernutrition of children is associated with age, sex and certain socioeconomic factors. These factors will be considered as risk factors of undernutrition as indicated by odds ratios derived from logistic regression analysis. Two models were considered in carrying out the logistic regression analysis. In model 1, the unadjusted OR with 95% confidence interval (CI) was computed as an exponential of the coefficient of logistic regression for all the covariates under consideration. In model 2, the OR was adjusted for those variables that are significantly associated with undernutrition.

Risk Factors of Underweight

Table 4.8 shows the prevalence of underweight according to age, sex and socioeconomic conditions. The ORs showing the risk of underweight to these factors were derived from logistic regression models. It is found that underweight is significantly associated with household income and parental education, but it is not significantly associated with age, sex and family size, although the prevalence of underweight is greater in boys as well as in the older age group.

As for household income, **Table 4.8** shows that children from low income group had about 2 times greater in risk of being underweight as compared to children belonging to the high income group (OR = 2.05, 95% CI: 1.01-2.30, $p < 0.0001$). Also, middle income group children had about 1.68 (95% CI: 1.14-2.47, $p< 0.009$) times greater in risk of being underweight as compared to those in the high income group. Adjusting for maternal and paternal education in model 2, the effect of household income is still significant ($p < 0.02$). It is found that the children belonging to the low and middle income groups had respectively about 1.9 and 1.6 times greater in risk of being underweight as compared with those belonging to the high income group. This indicates that household income is the very important factor in regulating the weight status of children in the present population.

With respect to maternal and paternal education, **Table 4.8** shows that children of illiterate mothers had about 1.6 (95% CI: 1.13-2.33, $p < 0.009$) times greater in risk of being

underweight than those children whose mothers were educated up to secondary and above. What interesting is that even children of mothers with primary education (lower and upper primary) had a greater risk of underweight when compared with those children whose mothers were educated up to secondary, or above secondary. The same is true with paternal education. Children of illiterate fathers had about 1.5 (95% CI: 1.02-2.18, $p < 0.04$) times greater in risk of being underweight than those children whose fathers were educated up to secondary and above. However, when household income is included in the model (Model 2), the effect of maternal and paternal education disappeared. This reveals that household income is more important than parental education in patterning the weight status in the present population. Thus, we may conclude that although parental education does exerts its influence on the prevalence of undernutrition among children, household income seems to be more important. This clearly reveals, as normally expected, that economic condition is very important in regulating the nutritional status of children in the present study.

Table 4.8. Results of logistic regression analysis on risk factors of underweight

Parameters	N	Prevalence %)	Model 1*		Model 2**	
			OR (95% CI)	P-level	OR (95% CI)	P-level
Age groups (years)						
3-9	429	169 (39.39)	-	-	-	-
10-18	627	253 (40.35)	1.03 (0.80-1.32)	0.849	-	-
Sex						
Girls	557	218 (39.14)	-	-	-	-
Boys	495	204 (41.21)	1.09 (0.85-1.40)	0.493	-	-
Income group						
High	202	57 (28.22)	-	-	-	-
Middle	292	116 (39.73)	1.68 (1.14-2.47)	0.009	1.59 (1.08-2.35)	0.02
Low	558	249 (44.62)	2.05 (1.45-2.91)	0.000	1.92 (1.34-2.74)	0.001
Maternal education						
Secondary	288	96 (33.33)	-	-	-	-
Primary	543	227 (41.80)	1.44 (1.07-1.94)	0.017	1.28 (0.94-1.74)	0.118
No education	221	99 (44.80)	1.62 (1.13-2.33)	0.009	1.37 (0.94-1.99)	0.097
Paternal education	254	85(33.46)	-	-	-	-
Secondary	588	247 (42.01)	1.44 (1.06-1.96)	0.020	1.26 (0.92-1.73)	0.147
Primary	210	90 (42.86)	1.49 (1.02-2.18)	0.038	1.42 (0.97-2.09)	0.074
No education						
Family size	259	100 (38.61)	-	-	-	-
Small	659	268 (40.67)	1.09 (0.81-1.46)	0.567	-	-
Medium	134	54 (40.30)	1.07 (0.70-1.64)	0.745	-	-
Large						

*Unadjusted odds ratio, **Adjusted odds ratio

Risk Factors of Stunting

Table 4.9 shows the risk factors of stunting as indicated by odds ratios like in the case of underweight shown above. It is found that the unadjusted odds ratios are significant with respect to age and household. Other covariates like sex, parental education and family size are not significantly associated with the prevalence of stunting. With respect to age, it is found that risk of stunting was 2.64 (95% CI: 2.05-3.40, $p < 0.0001$) times greater among children in the older age group 10-18 years when compared with those in the younger age group 3-9 years. The OR was significant even after adjusting for household income and parental education (CI = 2.60, 95% CI: 2.01-3.25, $p < 0.0001$). Therefore, it is likely that age of children plays a very important role in regulating the height-for-age in the present population.

As for household income, Table 4.9 shows that children in the low income group had about 2.58 (95% CI: 1.32-5.05, $p < 0.006$) times greater in risk of being stunted when compared with those in the high income group. Similarly, the risk of stunting was about 2.41 (95% CI: 1.11-5.24, $p < 0.027$) times greater among children in the middle income group when compared with the children in the high income group. Adjusting for age, the effect of income is still significant even after removing the effect of age. It is found that children in the low income group had about 1.71 (95% CI: 1.22-2.41, $p < 0.002$) times greater in risk of being stunted when compared with those in the high income group. However, the OR for the children in the low income group was not significant as compared with the children in the high income group (OR: 1.30, 95% CI: 0.89-1.89, $p > 0.05$). Nevertheless, it is evident that household income is an important factor in influencing the prevalence of stunting in the present population.

Table 4.9. Results of logistic regression analysis on risk factors of stunting

Parameters	N	Prevalence %)	Model 1*		Model 2**	
			OR (95% CI)	P-level	OR (95% CI)	P-level
Age groups (years)						
3-9	429	162 (38.12)	-	-	-	-
10-18	627	388 (61.88)	2.64 (2.05-3.40)	0.000	2.60 (2.01-3.25)	0.000
Sex						
Girls	557	251 (53.68)	-	-	-	-
Boys	495	251 (50.71)	0.89 (0.70-1.13)	0.335	-	-
Income group						
High	202	85 (42.08)	-	-	-	-
Middle	292	147 (50.34)	2.41 (1.11-5.24)	0.027	1.30 (0.89-1.89)	0.175
Low	558	318 (42.08)	2.58 (1.32-5.05)	0.006	1.71 (1.22-2.41)	0.002
Maternal education						
Secondary	288	144 (50.00)	-	-	-	-
Primary	543	277 (51.02)	1.04 (0.78-1.39)	0.781	-	-
No education	221	33 (58.37)	1.40 (0.99-2.00)	0.061	-	-
Paternal education						
Secondary	254	127 (50.00)	-	-	-	-
Primary	588	308 (52.38)	1.10 (0.82-1.48)	0.526	-	-
No education	210	115 (54.76)	1.21 (0.84-1.75)	0.307	-	-
Family size						
Small	259	135 (52.12)	-	-	-	-
Medium	659	356 (54.02)	1.08 (0.81-1.14)	0.659	-	-
Large	134	59 (44.03)	0.72 (0.48-1.10)	0.098	-	-

***Unadjusted odds ratio, **Adjusted odds ratio**

Table 4.10. Results of logistic regression analysis on risk factors of wasting

Parameters	N	Prevalence %)	Model 1*		Model 2**	
			OR (95% CI)	P-level	OR (95% CI)	P-level
Age groups (years)						
10-18	627	51 (8.13)	-		-	-
3-9	429	59 (13.75)	1.82 (1.22-2.71)	0.003	1.83 (1.23-1.73)	0.003
Sex						
Girls	557	59 (10.59)	-	-	-	-
Boys	495	51 (10.30)	0.97 (0.65-1.44)	0.878	-	-
Income group						
High	202	19 (9.41)	-	-	-	-
Middle	292	31 (10.62)	1.14 (0.63-2.09)	0.661	-	-
Low	558	60 (10.75)	1.16 (0.67-1.99)	0.591	-	-
Maternal education						
Secondary	288	29 (10.07)	-	-	-	-
Primary	543	57 (10.50)	1.05 (0.65-1.68)	0.847	-	-
No education	221	24 (10.86)	1.09 (0.61-1.93)	0.772	-	-
Paternal education						
Secondary	254	28 (11.02)		-	-	-
Primary	588	57 (9.69)	0.87 (0.54-1.40)	0.557	-	-
No education	210	25 (11.90)	1.09 (0.62-1.94	0.767	-	-
Family size						
Small	259	29 (11.20)	-	-	-	-
Medium	659	73 (11.08)	0.99 (0.63-1.56)	0.659	-	-
Large	134	8 (5.97)	0.51 (0.22-1.14)	0.098	-	-

***Unadjusted odds ratio, **Adjusted odds ratio**

Risk Factors of Wasting

The risk factors of wasting in terms of odds derived from logistic regression models are presented in **Table 4.10**. Unlike in the case of underweight and stunting, the effects of socioeconomic factors on wasting are not statistically significant in the present population. However, the prevalence of wasting was significantly greater among children in the lower age group (14%) than that in the higher age group (8%). In other words, it is found that children in the age group 3-9 years had about 1.82 (95% CI: 1.22-2.71, p< 0.003) times greater in risk of wasting as compared with those in the age group 10-18 years. Adjusting for household income, the OR was still significant (OR: 1.30, 95% CI: 0.89-1.89, p > 0.05). The household income was adjusted because it is likely that children in the low and middle income groups had greater risk of wasting when compared to those in the high income group, although the OR was not statistically significant. Thus, it cannot be totally ruled out the role of household income in regulating the prevalence of wasting in the present population.

CHAPTER V

DISCUSSION AND CONCLUSIONS

In this chapter, we shall discuss the findings of the present study by taking into consideration the other findings in other populations especially in Northeast India. We shall also make a comparison with the CDC growth references in order to derive our discussion and conclusions.

GROWTH PATTERN

The pattern of human growth serves as a type of mirror that reflects the biocultural evolution of human population. 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, for many of these also arises through differential rates of growth of particular parts of the body relative to others." Therefore, growth is a variable indicator, which can be used to identify either one or both genetic and environmental conditions in a population.

In the present study, the findings on the growth pattern of children are presented in Chapter III. The main purpose of the Chapter is to understand the sex differences in growth of Khasi children from 3 to 18 years. In doing so, comparative tables and figures of data on both boys and girls are presented throughout the Chapter. In discussing the growth pattern, or growth characteristics of children relative to age and sex, 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).

Weight and height

The sex differences in weight are significant only in the younger and older age group, i.e., aged < 7 years and 12 years and above. Girls are significantly heavier than boys at 3 and 4 years of age, and boys are heavier than girls from 5 to 6 years of age. On the other hand, boys

are significantly heavier than girls after 12 years of age. Using the fourth degree polynomial model, the smooth curve confirms that both boys and girls are by and large similar in weight from 7 to 12 years of age. Thereafter, boys are taller than girls at all ages. The estimated age at peak velocity is 12.8 years for girls and 13.7 years for boys.

With respect to height, we have followed the Preece-Baines model 1 (PB1) of curve smoothing. The results indicated that the curve is by and large similar in both boys and girls up to about 12 years of age, and thereafter it is greater in boys. The estimated values for adult height are 157.5 cm for males and 152.0 cm for females. This indicates that both boys and girls have reached their adult height by the age of 18, although the girls may continue to grow. The present observation seems to confirm the earlier observation among the urban Khasis (Khongsdier and Mukherjee, 2003) and that observed among the girls of Assamese Muslims in Assam (Begum and Choudhury, 1999). The differences between the sexes in respect of the biological parameters are statistically significant as expected. The estimated age at maximum increment, presumably considered as age at peak height velocity, was 11.1 years for girls and 12.2 years for boys with the approximate height of 131.7 cm and 137.4 cm, respectively. Thus, it indicates that the adolescent growth spurt in height occurs about 1 year earlier in girls as compared to boys. Therefore, these findings on weight and height are by and large in confirmation with the general observation that much of the sex differences are a consequence of the variation in growth rates during the adolescent period (Tanner, 1978; Bogin, 1999). In other words, the sex differences in growth pattern are significant only during and after adolescent period.

Sitting height

Like in the case of height, the fitted curves, according to PB1 model, indicated that both boys and girls were similar in sitting height from 3 to about 12 years of age. Both boys and girls have reached their adult sitting height by the age of 18, and the adult sitting height in boys (81.78cm) are significantly higher than in girls (78.56 cm). It is found that boys have reached their adult sitting height at about 18 years of age. Like in the case of height, the estimated age at peak velocity is higher in boys (12.5 years) than in girls (11.2 years). Thus, the present analysis indicates that the adolescent growth spurt occurs earlier in girls than in boys, and the higher sitting height in boys at 18 years of age is largely due to their higher growth rate from 13 to 16 years of age. It is reported that among the Assamese Muslim 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 study is comparable to that reported for the Assamese Muslim boys and girls.

Subischial height

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 except during the adolescent period. The higher subischial length in girls from 10 to 12 years of age may be attributed to adolescent growth spurt as in the case of sitting height. According to PBI model, both boys and girls have by and large reached their adult subischial length by the age of 18, although girls may still continue to grow. Thus, we are not in position to conclude 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). However, our findings suggest that adolescent growth spurt in subischial length occurs earlier than that of sitting height. It is found that the estimated age at peak velocity in subischial length was 11.5 years for girls and 12.0 years for boys with the approximate height of 66.5cm and 65.8 cm, respectively.

GROWTH STATUS

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).

In order to have a better understanding of the growth status of children in the present study, an attempt has been made to compare our findings with the CDC and ICMR growth references. We shall restrict only to weight and height as data on other anthropometric measurements are not available in the CDC growth references (NCHS, 2000).

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 Khasi children, 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 CDC 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 boys in comparison with the CDC and ICMR growth references. It can be observed from the Figure that the mean weight of the Khasi boys is above the 50th percentile of ICMR growth references across ages. It is also well above the 5th percentile but below the 50th percentile of CDC growth references from 3 to 8 years of age. The curve for Khasi boys is more or less according to the 5th percentile of the CDC growth references from 8 to 12 years of age, and it is again above the 5th percentile up to about 16 years of age.

Like in the case of boys, the mean weight of girls is above the 50th percentile of ICMR growth references across ages (**Figure 5.2**). Similarly, the curve for girls lies above the 5th percentile but below the 50th percentile of CDC growth references from 3 to 8 years of age. From 8 to 12 years, the growth curve is more or less between to the 5th percentile of the CDC references, and thereafter it lies between the 5th and 50th percentiles.

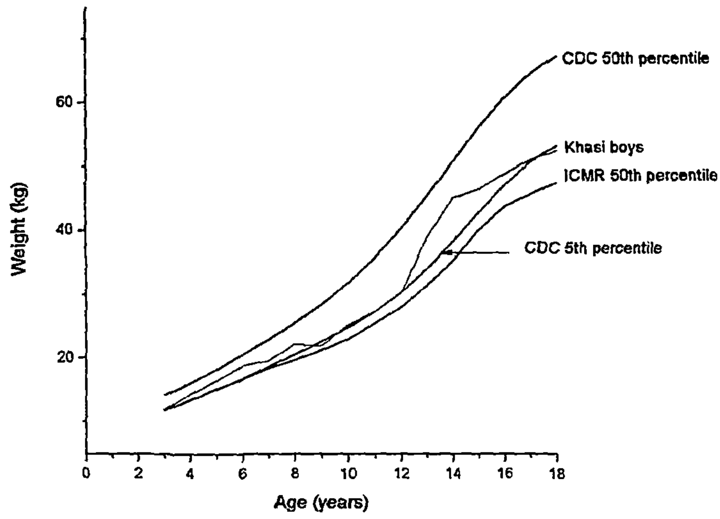

Figure 5.1. Weight of boys in comparison with CDC and ICMR growth references

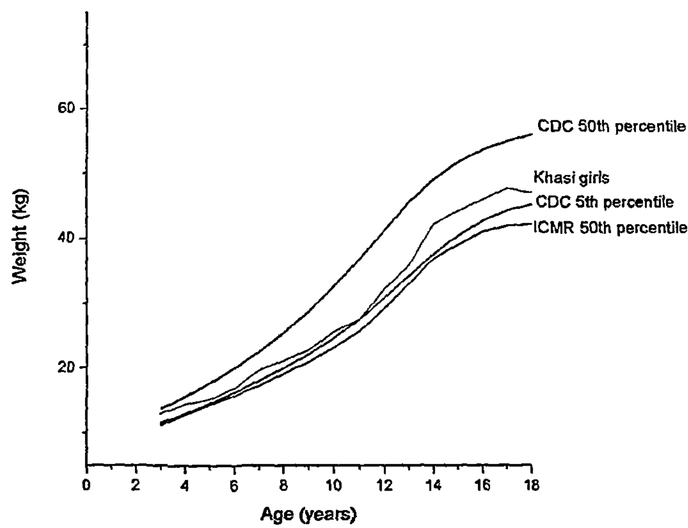

Figure 5.2. Weight of Khasi girls in comparison with growth references

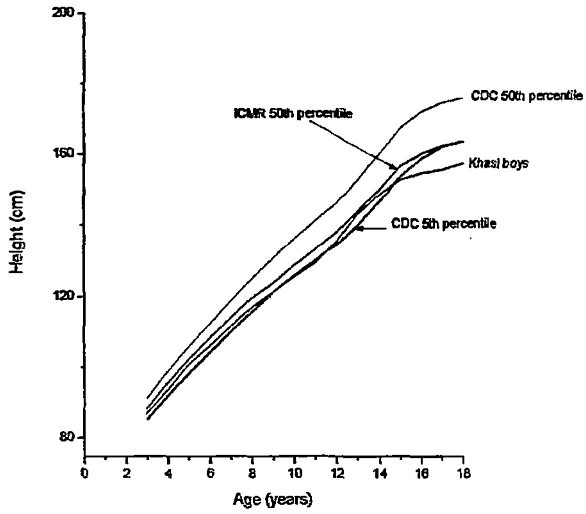

Figure 5.3. Height of Khasi boys in comparison with growth references

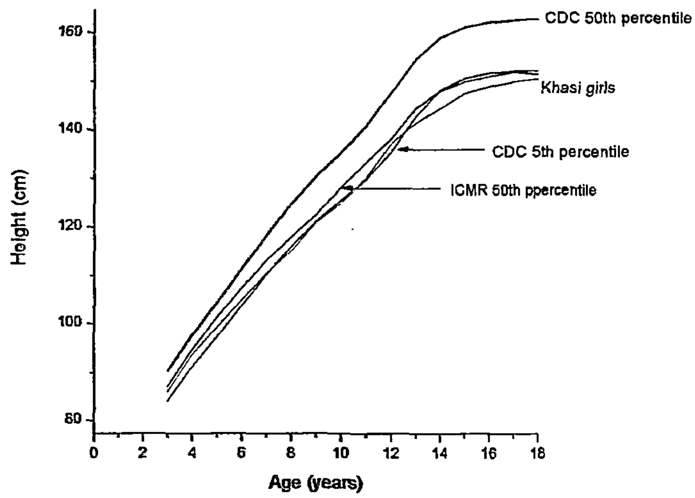

Figure 5.4. Height of Khasi girls in comparison with growth references

Height

With respect to height, **Figure 5.3** shows the mean height of Khasi boys plotted against CDC and ICM growth references. It can be observed that the Khasi boys are above the 5th percentile of the CDC growth references but below the 50th percentile of the ICMR growth references from 3 to about 8 years of age. Thereafter, the curve is more or less in the 5th percentile of the CDC growth references up to about 12 years of age. The curve moves towards the 50th percentile of the ICMR growth reference during the adolescent period, i.e., between 12 and 14 years of age. However, it moves markedly below the 5th percentile of the CDC growth references after 14 years of age.

As for girls, **Figure 5.4** shows that the curve is well above the 5th percentile of the CDC growth references from 3 to 7 years of age, and it is more or less according to the 50th percentile of the ICMR growth references from 3 to 4 years of age. However, like in the case of boys, the curve is more or less in the 5th percentile of the CDC growth references up to about 11 years of age. Except during the adolescent spurt, the curve is much below the 5th percentile of the CDC growth references especially after 12 years of age.

Overall, it indicates that both boys and girls are above the 5th percentile of the CDC growth references from 3 to about 7 or 8 years of age. Thereafter, the curves for both boys and girls followed the 5th percentile growth trajectory of CDC growth references up to adolescent period, and thereafter the curves were below the 5th percentile of the CDC growth references.

These present findings may have certain implications for the role of biological and environmental factors including socioeconomic factors. Several authors have argued that the growth pattern of children in developing countries deviate significantly from the international growth references 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). The present findings, especially on boys, also confirm that the growth curve is well above the 5th percentile but below the 50th percentile of CDC growth references from 3 to 8 years of age, and thereafter it is similar to the 5th percentile.

Comparison with Neighbouring Populations

As already mentioned in Chapter II, very few growth studies have been carried out in Northeast India, especially from 3 to 18 years of age. Recently, two growth studies were carried out: one among the urban Khasi of Meghalaya (Mukherjee, 2002) and the other among the Assamese Muslims of Assam (Begum and Choudhury, 1999). Thus, we shall restrict our comparison with only the urban Khasi and Assamese Muslims children.

Weight

It can be observed from **Figure 5.5** that the Khasi boys of the present study are more or less similar to the Assamese Muslim and urban Khasi boys from 3 to 11 years, and thereafter they are heavier than the Assamese Muslim and urban Khasi boys. Like in the case of boys, **Figure 5.6** shows that the Khasi girls of the present study are more or less similar to the Assamese Muslim and urban Khasi girls from 3 to 12 years, and thereafter the Assamese Muslim girls surpassed them up to about 14 years of age. After 14 years of age, the Assamese Muslim and urban Khasi girls are heavier than the Khasi girls of the present study.

Thus, it is evident from **Figures 5.5** and **5.6** that both boys and girls of the present study are by and large similar to their Assamese Muslim and urban Khasi counterparts up to about 12 years of age. Thereafter, the boys are heavier than the Assamese Muslim and urban Khasi boys, whereas girls are lighter than the Assamese Muslim and urban Khasi girls after 14 years of age.

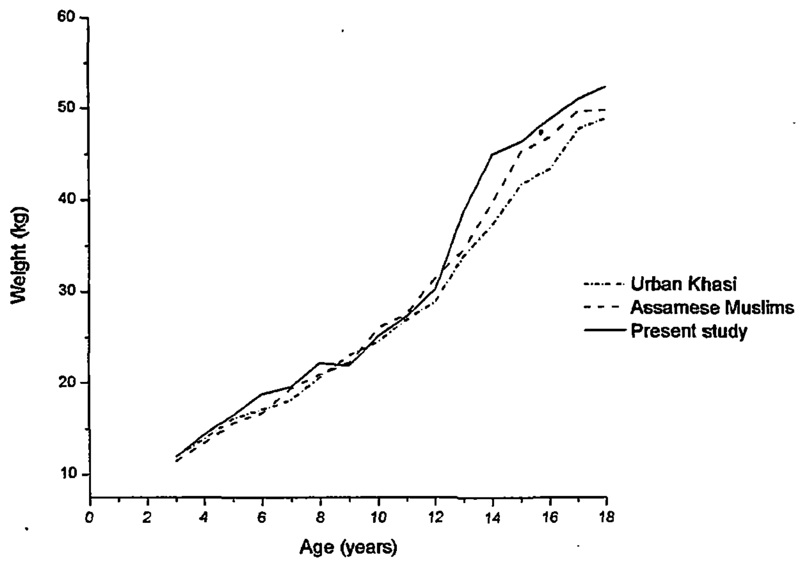

Figure 5.5. Weight of boys in comparison with other populations

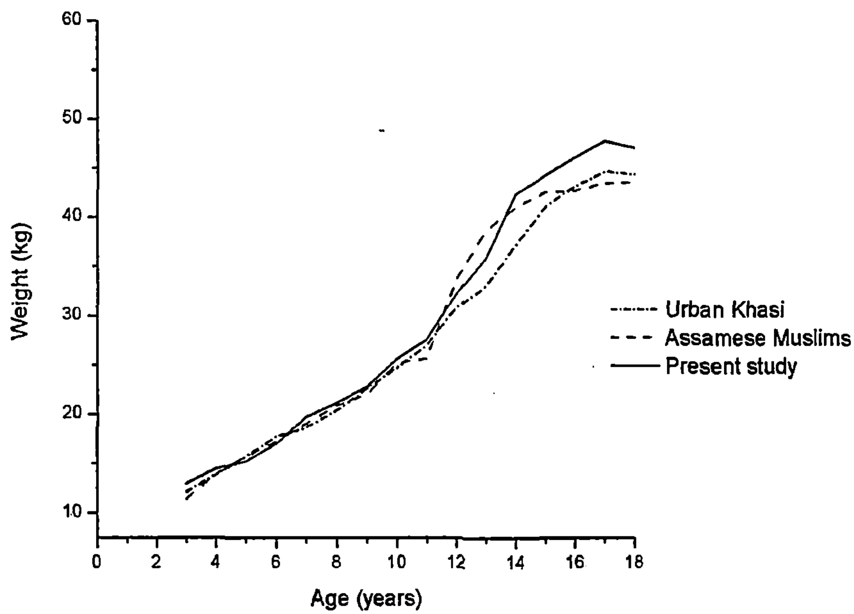

Figure 5.6. Weight of girls in comparison with other populations

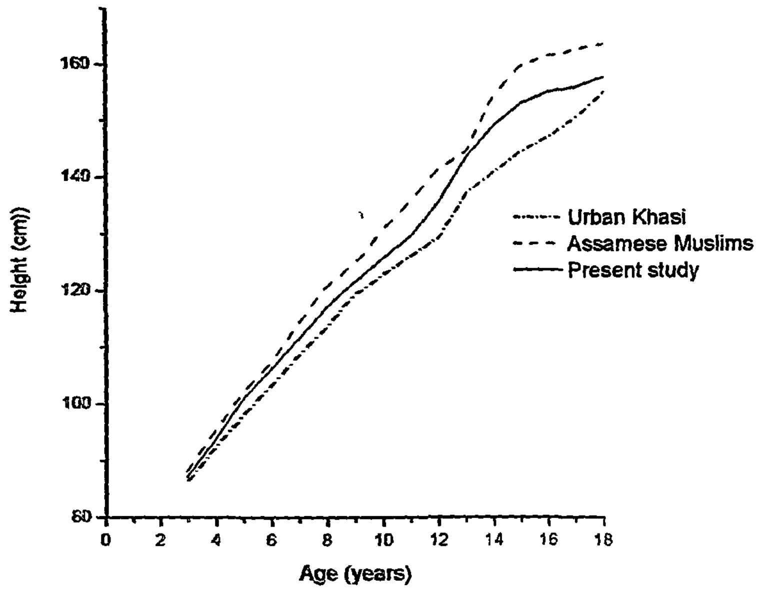

Figure 5.7. Height of boys in comparison with other populations

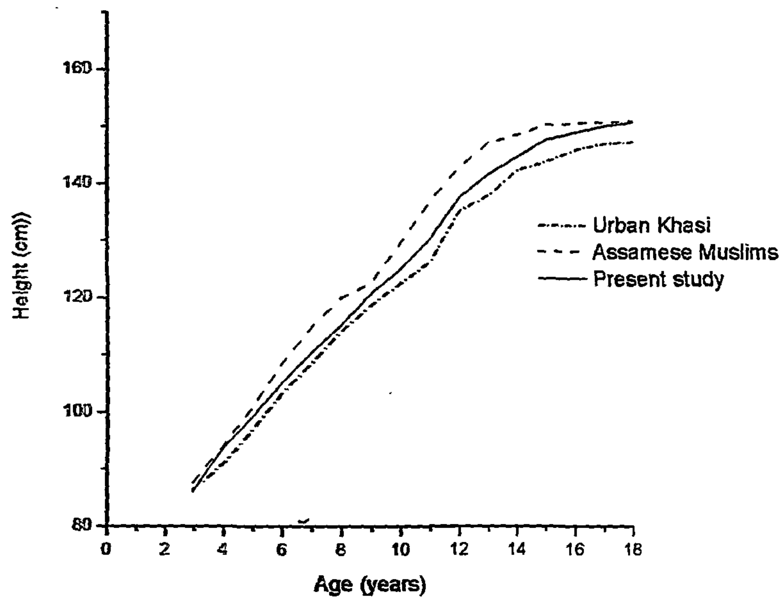

Figure 5.8. Height of girls in comparison with other populations

Height

Figure 5.7 shows that the Khasi boys of the present study are taller than the urban Khasi but shorter than the Assamese Muslim boys across age groups. Thus, it is contrary to expectation that the urban Khasi boys are taller than their counterparts in the rural area. Instead, it is also seen that the Khasi boys of the present study are by and large similar to the Assamese Muslim boys from 3 to 6 years of age, and thereafter the latter surpassed the former across ages. Like in the case of boys, the Khasi girls of the present study are similar to the Assamese Muslim girls from 3 to 5 years, and thereafter they are surpassed by the Assamese Muslim girls across ages, although they are taller than the urban Khasi girls (**Figure 5.8**).

Sitting height

As for sitting height, the Khasi boys of the present study are slightly greater than their urban counterparts from 3 to about 9 years of age (**Figure 5.9**). However, they are above the urban Khasi boys but much below the Assamese Muslim boys after 9 years of age. The situation is somewhat different in the case of girls. **Figure 5.10** shows that the Khasi girls of the present study are by and large similar to their Urban Khasi counterparts across ages, but they are shorter in sitting height than the Assamese Muslim girls.

Chest circumference

Figure 5.11 shows the mean chest circumference of boys in comparison with the Assamese Muslim and urban Khasi boys. It is seen that the Khasi boys of the present study are similar to the Assamese Muslim boys, but they are lower than the urban Khasi boys up to about 12 years of age. During the adolescent period, they are similar to their urban counterparts. However, they are lower than the Assamese Muslim and urban Khasi boys after 16 years of age. As for girls, **Figure 5.12** shows that they are in between the Assamese Muslim and urban Khasi girls from 3 to 6 years of age, and thereafter they are similar to the urban Khasi girls across ages.

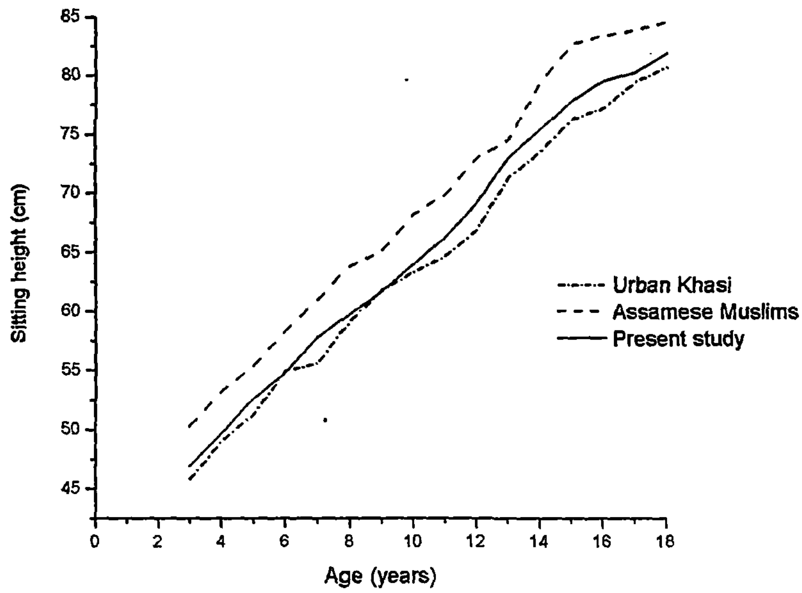

Figure 5.9. Sitting height of boys in comparison with other populations

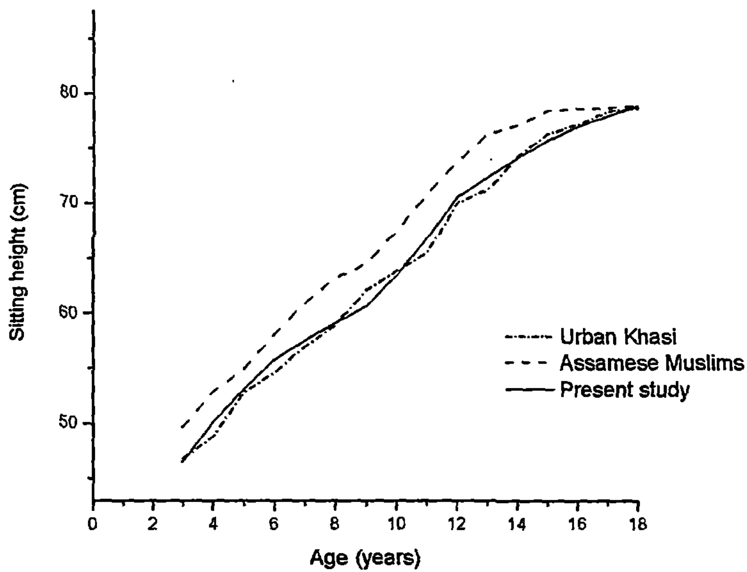

Figure 5.10. Sitting height of girls in comparison with other populations

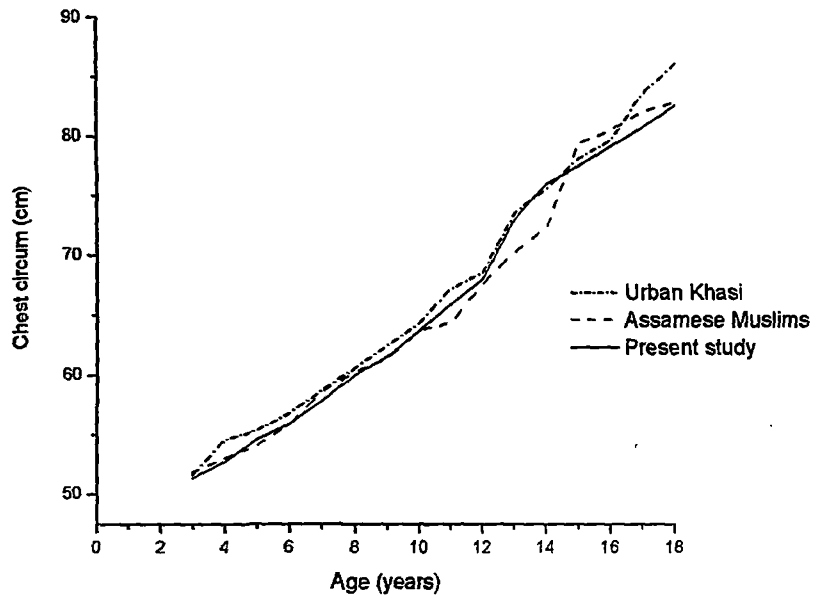

Figure 5.11. Chest circumference of boys in comparison with other populations

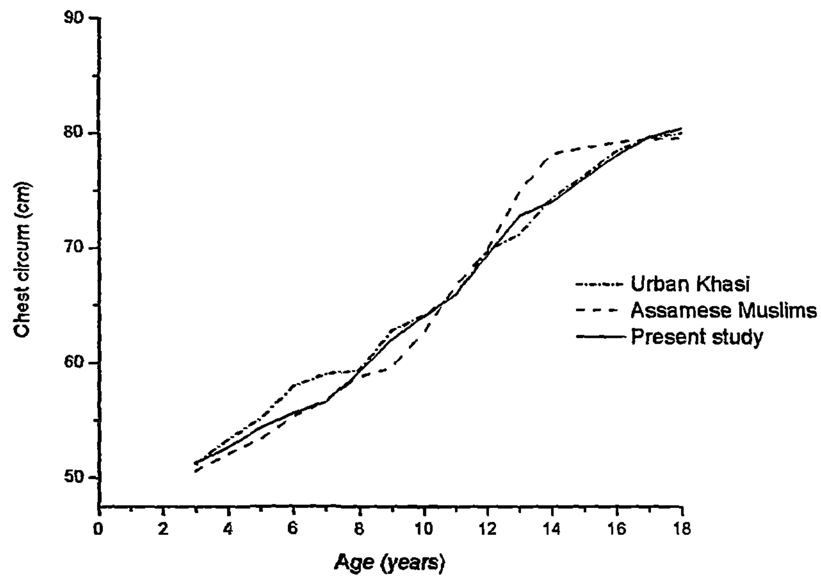

Figure 5.12. Chest circumference of girls in comparison with other populations

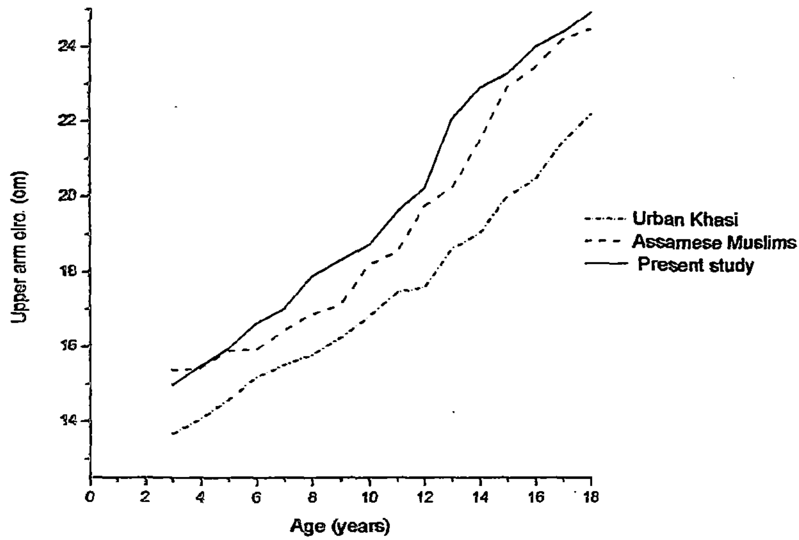

Figure 5.13. Mid upper arm circumference of boys in comparison with other populations

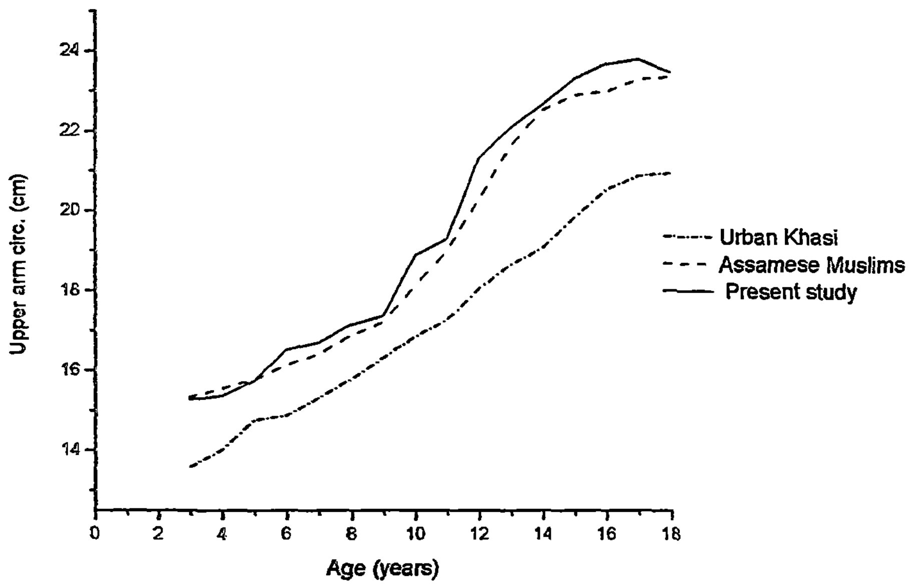

Figure 5.14. Mid upper arm circumference of girls in comparison with other populations

Upper arm circumference

Figure 5.13 shows the mid upper arm circumference of boys in comparison with the Assamese Muslim and urban Khasi boys. The figure shows that the boys of the present study have a broader mid upper arm circumference than both the Assamese Muslim and urban Khasi boys across ages. They are however similar to the Assamese Muslim boys from 3 to 5 years of age. Like in the case of boys, **Figure 5.14** shows that the mid upper arm circumference for the girls of the present study is greater than that for the Assamese Muslim and urban Khasi boys across ages.

On the basis of the above comparison, we may conclude that the Khasi children of the present study are by and large similar in body weight to their Assamese Muslim and urban Khasi counterparts up to about 12 years of age. Thereafter, the boys are heavier than the Assamese Muslim and urban Khasi boys, whereas girls are lighter than the Assamese Muslim and urban Khasi girls after 14 years of age. As for stature, they are taller than their urban counterparts across ages. They are similar to the Assamese Muslim children from 3 to about 6 years of age, and thereafter they are surpassed by the Assamese Muslim children. On average, they are however similar to their urban counterparts in respect of sitting height and chest circumference, irrespective of certain exceptions. It is also observed that the Khasi children of the present study have a have a broader mid upper arm circumference than both the Assamese Muslim and urban Khasi boys across ages.

NUTRITIONAL STATUS

In the previous Chapter, we have presented our findings on the nutritional status of the 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 CDC growth references. 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). We have presented our findings on the nutritional status in Chapter IV. It may be briefly summarized as follows:

(i) The overall prevalence of underweight for all sexes and ages was found to be 40.11%. It was slightly higher in boys (41.21%) than in girls (39.14%) despite the absence of statistical difference between the sexes. In addition, the differences between the younger age group (3-9 years) and older age group (10-18 years) are not statistically significant, although it was slightly higher in the older age group (**Table 4.2**).

(ii) The overall prevalence of stunting for all sexes and ages was 52.28%. It was higher in girls (53.68%) than in boys (50.71%), although it was not statistically significant (Table. The prevalence of stunting in the higher age group was significantly higher than that in the lower age group. It holds true for both boys and girls. However, the prevalence of stunting in the younger age group 3-9 years was also slightly higher in boys (38.94%) than in girls (37.33%). The situation is reverse in the older age group 10-18 years, which indicated the higher prevalence of stunting in girls.

(iii) The overall prevalence of wasting for all sexes and ages was 10.46%. The prevalence of wasting was by and large similar in both boys (10.30%) and girls (10.59%), and there were no significant differences between age groups. However, the prevalence of overweight seemed to be higher in the lower age group, which is likely to be an emerging problem in the next decade or so. It is also clearly evident that the nutritional status as indicated by BMI-for-age is much better than that indicated by weight-for-age and height-for-age.

Overall, it is found that about 40.11%, 52.28% and 10.46% of the children in the present study were underweight, stunted and wasted, respectively. Following the classificatory criteria proposed by Gorstein *et al.*, (1994), we may conclude that the present population is characterized by a very high prevalence of underweight and stunting with a high prevalence of wasting. It is higher than that reported for the Hmar children of Manipur (Khongsdier and Varte, 2005) and Lotha children of Nagaland (Tsopoe, 2003). However, it is lower than that reported for the urban Khasi children, but by and large similar to those reported by the NFHS-3 (IIPS and Macro International, 2009). The difference between the rural and urban Khasi data may be because of two main reasons: It has been observed that the children of the present study are taller than the urban Khasi. Secondly, it may also because of the differences in the use of growth references.

In general, the present study has revealed the absence of statistical differences between the sexes in all the three forms of undernutrition. This observation is consistent with the earlier

studies that gender differences in nutritional status are not the main problem among populations in Northeast India, especially among the tribal populations (Khongsdier *et al.*, 2005). In Southeast Asia, many scholars have often reported that child mortality is higher in females than in males due to anti-female discriminations in access to nutrition, education and health care (Das Gupta, 1987; Muhuri and Preston, 1991; Arnold *et al.*, 1998). In this part of the globe, sons are preferred over daughters due to different economic, social and cultural factors (Mayer, 1999; Arnold *et al.*, 2002; Mishra *et al.*, 2004), which are operating differently in different population groups or culture areas. For example, it was suggested that excess female child mortality was lower in South than in North India due to variation in kinship systems and female autonomy, i.e., the "capacity to manipulate one's personal environment" (Dyson and Moore, 1983). Females in South India enjoy more autonomy relative to males than do females in the North, and the magnitude of anti-female discrimination among children in access to food distribution and medical care is less in the South. On the basis of the first and second Indian National Family Health Surveys data, Mishra *et al.* (2004) also found that boys were more likely than girls to be fully immunized in North than in South India. On the contrary, girls aged below 3 years were more likely than boys to be underweight and stunted in the South than in the North. In addition, it has been suggested that economic and political factors, including political will, are more important than kinship structures in patterning gender differences between North and South India (Rahman and Rao, 2004).

Considering the findings of the present study, one may argue that the absence of sex differences in nutritional status among the Khasi children of the present study may be related to the practice of matrilineal system of society. It may, however, be noted that little is known about anti-male bias in the Khasi society (Gurdon, 1981; Pakyntein, 1999), which can be considered as comparable to anti-female bias as in other parts of South Asia including India (Jejeebhoy and Sathar, 2001; Fikree and Pasha, 2004). Further, recent studies have revealed the absence of gender differences even among patrilineal societies in Northeast India. Instead, there is an evidence of the higher prevalence of undernutrition in boys than in girls (Khongsdier *et al.*, 2005). This may have certain implications if we take into consideration the higher prevalence of underweight in boys than in girls of the present study, despite the absence of statistical differences. It is generally believed that underweight is more related to environmental condition like inadequate nutrition and infection. Therefore, the higher prevalence of underweight in boys

may be related to the sex differences in responses to environmental factors. It has been suggested that girls are better "buffered" than boys against environmental factors like inadequate dietary intakes (Stinson, 1985; Bogin, 1999). This phenomenon has also been observed among the Lotha children of Nagaland (Tsopoe, 2003) and the Hmar children of Manipur (Khongsdier *et al.,* 2005). Little is known about this problem in other Indian populations, thereby warranting more studies. Nevertheless, it is obvious that anti-female bias in India varies from one population to another or from one culture area to another, which might not be detected statistically at the national level (Marcoux, 2002). It is, therefore, crucial to understand the role of cultural diversity in patterning health and nutritional disparity in India. It is obvious, in this context, that there is a need for a holistic, community-based approach to understanding the health and nutritional inequalities in India.

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, in addition to genetic factors. It may be mentioned that the higher prevalence of stunting in girls was also observed among the Lotha children of Nagaland (Tsopoe, 2003). As hinted above, it is unlikely that the phenomenon is due to patrilineal or matrilineal system of the society. Instead, it may be related to the relevance of international growth references to populations in Northeast India. It is evident that the prevalence of stunting in the higher age group was much higher than that in the lower age group for both boys and girls, and the differences between the two major age groups are highly statistically significant in both boys. We shall discuss briefly the relevance of the international growth references in the following section.

Relevance of International growth references

In Chapter I, we have mentioned that there are considerable differences between and within populations in the rate of physical growth and attainment of body size at any given age (Eveleth and Tanner, 1990). Such differences are often attributed to both genetic and environmental factors. However, growth retardation especially in developing countries is mainly due to environmental factors, including inadequate nutrition, infections and poor socio-economic conditions. Empirical evidence shows that under-five children belonging to the higher socio-

economic strata in developing countries have shown similar growth patterns to their coevals in developed or high-income countries (Habitch *et al.*, 1974). Accordingly, growth retardation is generally considered an indicator of poor nutritional status, or failure in the expression of the "genetic potential" for growth (Gopalan, 1992). Accordingly, the growth curves of well-nourished children in high-income countries are widely used to assess or monitor the growth and nutritional status of children all over the world. It is argued that since children in high-income countries are unhindered by nutritional deprivation, thereby enjoying the maximal growth permitted by their genetic potential, they constitute a reference group against which to assess the nutritional status of all other groups of children. For this purpose, international standards, or growth references, such as the CDC growth references are widely used for assessing the nutritional status of children all over the world. The children who are below – 2 SD or – 2 Z score of these standards/references are classified as undernourished relative to their sex and age groups.

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 (1995) has pointed out 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, there is considerable evidence of the population differences in growth and development.

On the basis of his observation on the populations of India and Nepal, Seckler (1982) suggested that the children treated as mild and moderate undernourished, according to height for age with reference to international standards, should be regarded as "small but healthy." According to Seckler (1982), "about 90% of all the malnutrition found in these countries are those 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 to height ratio will also be light people, their consumption requirements will also be less than conventionally estimated" (Author's italics). This may have certain implication if we also take into consideration our present findings. It is found that the

overall prevalence of wasting for both boys and girls was only 10.46% as compared to the prevalent rates of underweight and stunting, which are 40.11%% and 52.28%% as measured by weight-for-age and height-for-age, respectively. These results in the Khasi children of the present study clearly indicate that the prevalence of under-nutrition according to weight-for-height is not as high as that indicated by weight-for-age and height-for-age.

Seckler was of the opinion that there were no functional impairments in the range of mild to moderate malnutrition as defined by growth standards, "because this range represents an adaptive response of body size to adverse conditions *in order to avoid these impairments*"(Author's italics). Accordingly, he suggested that appropriate reference standard for the assessment of undernutrition should be lower than the recommended reference value predicted under the concept of genetic potential for growth. Payne (1992), though in a different way, also supported that the scientific concept of nutrition should be concerned not with the failure of meeting some normative targets, but with the failure of maintaining the functional capabilities relative to nutritional intake. On the contrary, most of the individuals below the standards as proposed under the concept of genetic potential for growth do not show such functional impairment. Payne (1992) criticized the genetic potential theory for supporting the armpit of obesity and associated risks of NCDs.

The "small but health" hypothesis has been severely criticized by many scholars (Gopalan, 1992; Bogin, 1999), but its significance lies with the concept of small body size. It may be noted that Tanner (1978) warned against assuming that being small is necessarily bad. "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 of small body size is that it enables a person to survive and sustain his level of activity in a given habitat of nutritional constraint, because a smaller body requires less energy. However, if the level of productivity in such small people is low, it proves to be disadvantageous (Ulijaszek, 1995, Strickland and Tuffrey, 1997).

In the present study, we are not dealing with the physical activity of the children, and thereby we are not in a position to either refute or support the above contention. However, it is clear that the applicability of the international growth references tends to be more irrelevant during and after adolescent period. It has been observed that both boys and girls are above the

5th percentile of the CDC growth references from 3 to about 7 or 8 years of age. Thereafter, the curves for both boys and girls followed the 5th percentile growth trajectory of CDC growth references up to adolescent period, and thereafter the curves were below the 5th percentile of the CDC growth references. This can also be observed with respect to the prevalence of stunting which is significantly related to age. We hope that future studies will shed much more light on this problem.

Socio-economic Condition and Under-nutrition

Under-nutrition affects all sexes and ages. What makes the situation more serious is that children under 5 years of age are the most vulnerable victims. Under-nutrition predisposes an individual to infection and *vice versa*. It is one of the major risk factors for infections and diseases (WHO, 2000a). About 50% of the total annual deaths in children under 5 years of age are associated with under-nutrition in developing countries (Rice *et al.*, 2000; WHO, 2000b). Under-nutrition is attributable not only to poor access to food but also to other poor environmental conditions, such as poor housing and hygienic conditions, unsafe drinking water, heavy workloads, lack of preventive and control measures of locally endemic diseases and infections (Khongsdier, 2002). These poor environmental conditions are the common characteristics of population groups belonging to the lower socio-economic strata of the society, especially in developing countries (de Onis *et al.*, 2000). In other words, the major cause of under-nutrition is poverty compounded by other poor environmental conditions that predispose an individual to morbidity and mortality. There is considerable evidence that children in the lower socio-economic groups especially in developing countries are often the victims of malnutrition and its associated morbidity and mortality (WHO, 2000a). In the present study, we have also observed that the prevalence of underweight and stunting is significantly higher in children with low economic condition. The important implication of the present study is that nutritional status is an indicator of not only the health inequality but also the social inequality in the Khasi society and perhaps in many populations in developing countries.

CONCLUDING REMARKS

As normally expected, the present study has revealed that there are significant differences between boys and girls in respect of growth patterns, especially during the adolescent period because of the inter- and intra-individual variation in timing of growth spurt. According to PB1 model, both boys and girls are similar in height up to about 12 years of age, and thereafter it is

greater in boys. The estimated values for adult height are 157.5 cm for males and 152.0 cm for females. This indicates that both boys and girls have reached their adult height by the age of 18, although the girls may continue to grow. The present observation seems to confirm the earlier observation among the urban Khasis (Khongsdier and Mukherjee, 2003) and that observed among the Assamese Muslims girls (Begum and Choudhury, 1999). However, it is likely that the girls of the present study may still continue to grow more in terms of lower extremity or leg length. Thus, we are not in position to conclude 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). However, our findings suggest that adolescent growth spurt in subischial length occurs earlier than that of sitting height.

The present study has also indicated that both boys and girls are above the 5th percentile of the CDC growth references from 3 to about 7 or 8 years of age. Thereafter, the curves for both boys and girls followed the 5th percentile growth trajectory of CDC growth references up to adolescent period, and thereafter the curves were below the 5th percentile of the CDC growth references. These present findings may have certain implications for the role of biological and environmental factors including socioeconomic factors. Several authors have argued that the growth pattern of children in developing countries deviate significantly from the international growth references 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). The present findings, especially on boys, also confirm that the growth curve is well above the 5th percentile but below the 50th percentile of CDC growth references from 3 to 8 years of age, and thereafter it is similar to the 5th percentile.

As for nutritional status, the present study has revealed the absence of statistical differences between the sexes in all the three forms of undernutrition. This observation is consistent with the earlier studies that gender differences in nutritional status are the main problem in population in Northeast India, especially among the tribal populations (Khongsdier and Varte, 2005). However, despite the absence of statistical differences, the prevalence of underweight was higher in boys than in girls, whereas the prevalence of stunting was higher in

girls than in boys. It is generally believed that underweight is more related to environmental condition like inadequate nutrition and infection. Therefore, the higher prevalence of underweight in boys may have certain implications for the sex differences in responses to environmental factors. It has been suggested that girls are better "buffered" than boys against environmental factors like inadequate dietary intakes (Stinson, 1985; Bogin, 1999). This phenomenon has also been observed among the Lotha children of Nagaland (Tsopoe, 2003) and the Hmar children of Manipur (Khongsdier and Varte, 2005). Little is known about this problem in other 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, in addition to genetic factors. It may be mentioned that the higher prevalence of stunting in girls was also observed among the Lotha children of Nagaland (Tsopoe, 2003). Thus, it is unlikely that the phenomenon is due to patrilineal or matrilineal system of the society. Instead, it may be related to the relevance of international growth references to populations in Northeast India. It is evident that the prevalence of stunting in the higher age group was much higher than that in the lower age group for both boys and girls, and the differences between the two major age groups are highly statistically significant in both boys. Therefore, it is likely that the applicability of the international growth references tends to be more irrelevant during and after adolescent period. This can also be observed with respect to the prevalence of stunting which is significantly related to age. We hope that future studies will shed much more light on this problem.

The present study has revealed that the prevalence of undernutrition, especially underweight, is significantly associated with household income and parental education. Therefore, the present study confirms the earlier observation that socioeconomic factors like income and parental education play a very important role in regulating the nutritional status of children (Eveleth and Tanner, 1990; Bogin, 1999).

Last but not least, the present study has also certain policy implications. Overall, it is evident that there is a high prevalence of undernutrition among the Khasi children, which is also consistent with the recent report by the NFHS-3 (IIPs and Macro International, 2009). Therefore, nutrition policies like the nutrition supplementary programme should be intensified in the state. 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 Khasi population over time.

CHAPTER VI

SUMMARY

This thesis is concerned with the growth and nutritional status of Khasi children in the West Khasi Hills District of Meghalaya. By the term "growth" we mean a regular process of quantitative increase in size or mass of different tissues and organs of the body especially from conception to adulthood. On the other hand, nutritional status refers to 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 nutritional status 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 (BMI)-for-age for assessing the nutritional status of the children.

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."

In addition, 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).

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). The same is true in Northeast India. (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). Recently, a growth study was carried out among the Khasi of Shillong (Mukherjee, 2002). The study dealt with both growth and nutritional status of urban Khasi children. However, it was not clear about the growth and nutritional status of rural Khasi children in Meghalaya, especially in the West Khasi Hills district. According to the National Family Health Survey-3 (IIPS and Macro International, 2009), the prevalence of undernutrition among under-five children in Northeast India is highest in Meghalaya. But it is not clear whether the situation is same for children aged 5 years and above. Therefore, the present study was carried out among the Khasi children of rural areas in the West Khasi Hills district of Meghalaya.

CHAPTERIZATION

The thesis has been divided into six chapters. The first chapter gives a general introduction relating to the scope and importance of the study. It also gives a brief review of related literature. The objectives and statement of problem are also given in this chapter along with a brief description of the study population and study area. The 2nd Chapter describes the nature and methods of data collection. The findings on growth and nutritional status are presented in Chapters III and IV, respectively. Chapter V discusses the findings of the study in the light of other studies. It also discusses the social and biological implications of the findings. Chapter VI gives the summary and conclusions.

OBJECTIVES OF STUDY

1. To describe the growth pattern of Khasi children aged 3 to 18 years.
2. To assess the nutritional status of these children, using certain anthropometric indices relative to the recommended growth references.

3. To analyze the effects of demographic and socio-economic factors such as age, sex, family size, household income and educational level of parents on the nutritional status of children.

MATERIALS AND METHODS

Study Area and Population

The present study was conducted on West Khasi Hills District of the State of Meghalaya, which is predominantly inhabited by the Khyriam Khasis (i.e. about 473 villages). In the present study the term 'Khasis' will be used to refer to the Khynriam Khasis inhabited in the West Khasi hills district of Meghalaya.

Data on Growth of Children: The present study of physical group was based on a cross sectional sample of Khasi boys and girls aged between 3-18 years. Following are the anthropometric measurements taken on 255 boys and 252 girls:

1. Weight (Kg)
2. Height vertex (cm)
3. Sitting height vertex (cm)
4. Bi acromial Diameter (cm)
5. Bi iliac Diameter (cm)
6. Mid upper arm circumference (Left arm) (cm)

An attempt was made to follow as far as possible the standard techniques of taking the measurements as described in Weiner and Lourie (1981).

Preece-Baines Model 1 (PB1)

In the present study, I 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, θ = 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, I have taken three anthropometric indices – weight-for- age, height-for-age and weight-for-height - which are considered as the indicators of nutritional status. For classifying the children into different grades of nutritional status, we have calculated the Z-score of individuals in relation to the CDC 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 the following levels of nutritional status:

Above normal = above + 2 Z-score

Normal = -2 to + 2 Z-score

Moderate = -2 to – 3 Z-score

Severe = Below –3 Z-score

SOCIO-ECONOMIC CATEGORIES

In the present study, certain socio-economic variables were classified arbitrarily into different groups and/or categories with a view to understanding their influence on demographic variables. Our classification may be briefly described as follows:

Income groups: Data on household income were collected directly from the heads of the households and they were cross-checked taking into consideration some aspects of socio-economic conditions like housing condition, types of occupation, land holding, and monthly expenditure. The per capita monthly income of the households was classified as follows:

Above 75th percentile (Rs.500) = High income group (HIG)

50th to 75th percentile (Rs.333-500) = Middle income group (MIG)

Below 50th percentile (Rs. 333) = Low income group (LIG)

Educational Level: Data on educational attainment of individuals in the present study were arbitrarily classified as follows: The category **illiterate** includes those individuals who were unable to read and write and those who had no education but could read or write their names. The individuals who attended school up to standard VII were grouped into **Primary** level of education. The individuals with educational level from VIII and above were grouped into **Secondary level** of education.

Family Size: The family size was classified into three categories. The individuals who lived in a household with less than 5 family members were considered as having a **Small Family Size.** The **Average/Medium Family Size** includes those individuals who lived in a household with 5-6 family members. The individuals who lived in a household with more than 6 family members were grouped in the category of **Large Family Size.**

Statistical Analyses

The data collected for the present study were quantified and analysed statistically, using SPSS Window software. The data were presented in terms of means, standard deviation, standard error and proportions or percentages. The differences between two means were tested by using t-student test, and the differences between proportions were tested by using the chi-square test. Logistic regression analysis was used for analyzing the effects of socioeconomic factors on the nutritional status of children in which the odd ratios (OR) with 95% confidence were derived from the regression coefficients.

FINDINGS OF THE PRESENT STUDY

As already mentioned, the findings of the present study are presented in chapters III and IV. I shall briefly present them as follows:

Growth Pattern: The growth pattern of the Khasi children in the present study are described in terms of 7 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 girls are heavier than boys at 3 and 4 years of age and it is significant at 3 years of age ($t = 2.01$, $p < 0.05$). On the other hand, boys are significantly heavier than girls from 5 to 6 years of age, and there are no significant differences between the sexes at 7 and 8 years of age. However, girls are heavier than boys from 9 to 12 years, and the differences are significant at 12 years of age. This may be associated with the adolescent growth spurt in girls at 12 years of age. It is further observed that boys are significantly heavier than girls after 12 years of age, and the differences are statistically significant, except at 15 years of age.

Using the fourth degree polynomial model, the mean values were smoothed in order to estimate the maximum age at peak velocity. It is found that both boys and girls are more or less similar in weight from 7 to 12 years of age, and thereafter the boys surpassed the girls. Using the first derivative of the fitted polynomial model, it is found that the velocity is higher in boys than in girls from 3 to about 5 years of age, and thereafter it is higher in girls up to about 11 years of age. The estimated age at peak velocity is 12.8 years for girls and 13.7 years for boys with the peak weight velocity of 3.9 kg and 4.7 kg, respectively.

Height

It is found that boys are in general taller than girls across ages, except during the adolescence from 11 to 12 years when girls are taller than boys. The differences between the sexes are statistically significant after 14 years of age. Following the Preece-Baines model I (PBI), the means are smoothed in order to estimate the adult body mass and maximum age at peak velocity. Unlike the raw data, girls are slightly taller than boys up to about 9 years of age. The growth curve is by and large similar in both boys and girls up to about 12 years of age, and thereafter it is greater in boys.

The estimated values for adult height are 157.5 cm for males and 152.0 cm for females. This indicates that both boys and girls have reached their adult height by the age of 18, although the girls may continue to grow. The present observation seems to confirm the earlier observation among the urban Khasis (Khongsdier and Mukherjee, 2003) and that observed

among the girls of Assamese Muslims in Assam (Begum and Choudhury, 1999). The differences between the sexes in respect of the biological parameters are statistically significant as expected.

The estimated age at age at peak height velocity was 11.1 years for girls and 12.2 years for boys with the approximate height of 131.7 cm and 137.4 cm, respectively. Thus, it indicates that the adolescent growth spurt in height occurs about 1 year earlier in girls as compared to boys, although the peak height velocity is by and large similar in both boys (5.6 cm/year) and girls (5.4 cm/year). It is observed that the velocity is higher in boys from 3 to about 7 years of age, and thereafter it is higher in girls till about the age of 11 years. These differences may be attributed to the adolescent growth spurt which occurs in girls from 11 to 12 years of age. Overall, the boys are higher in growth rates across ages, especially after 11 years of age.

Sitting Height

On average, the raw data show that boys are slightly greater in sitting as compared to girls. However, girls have greater sitting height than boys at 5 and 12 years of age, and the difference is statistically significant at 12 years of age ($t = 2.01$, $p < 0.05$). The higher mean values of sitting height in boys are statistically significant from 15 to 18 years of age. This can also be observed from the distance curve fitted according to PB1 model to the mean values for both boys and girls. It indicates that both boys and girls are similar in sitting height from 3 to about 12 years of age. It is also found that both boys and girls have reached their adult sitting height by the age of 18, and the adult sitting height in boys are significantly higher than in girls (difference $\pm$ SE = 3.22 ± 0.85, $p < 0.001$).

The velocity curve, derived from the fitted PBI function, shows that both the sexes gained their sitting height continuously from 3 to 18 years of age. It is observed that the velocity is higher in boys from 3 to about 7 years of age, and thereafter it is higher in girls till about the age of 11 years. These differences may be attributed to the adolescent growth spurt which occurs in girls from 11 to 12 years of age. The estimated age at peak height velocity was 11.2 years for girls and 12.5 years for boys with the approximate height of 67.1cm and 70.9 cm, respectively. Like in the case of height, the adolescent growth spurt in sitting height occurs about 1 year earlier in girls as compared to boys, although the peak height velocity is by and large similar in both boys (2.8 cm/year) and girls (2.6 cm/year).

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Subischial Length

It is found that boys are significantly greater in subischial length at 5, 6, and across ages from 14 years onwards. The distance curve fitted according to PBI model indicates that boys have a greater subischial length than girls from about 3 to 9 years, and thereafter the latter surpassed the former up to about 12 years of age. However, boys are greater in subischial length from the age of 13 onwards. The higher subischial length in girls from 10 to 12 years of age may be attributed to adolescent growth spurt as in the case of sitting height. According to PBI model, both boys and girls have by and large reached their adult subischial length by the age of 18. It can be observed that the difference between the observed and the estimated adult subischial length for boys and girls are 0.13 and 0.79 cm, respectively. Thus, it indicates that both boys and girls have reached their adult size by the age of 18, although girls may still continue to grow. The sex difference in adult size is statistically significant (difference ± SE = 2.89±0.64, $p < 0.01$).

The velocity curve shows that both the sexes gained their sitting height continuously from 3 to 18 years of age. It is observed that the velocity is slightly higher in boys from 3 to 5 and 11 to 14 years of age. On the other hand, girls have a higher velocity from about 7 to 10 and 15 years onwards. These differences may be attributed to the adolescent growth spurt which occurs in girls from 11 to 12 years of age. The estimated age at peak velocity in subischial length was 11.5 years for girls and 12.0 years for boys with the approximate height of 66.5cm and 65.8 cm, respectively. Unlike the case of sitting height, the adolescent growth spurt in subischial length occurs about 0.5 year earlier in girls as compared to boys, although the peak velocity is by and large similar in both boys (2.8 cm/year) and girls (2.6 cm/year).

COMPARISON WITH OTHER POPULATIONS

Weight

It is observed that the mean weight of the Khasi boys is above the 50th percentile of ICMR growth references across ages. It is also well above the 5th percentile but below the 50th percentile of CDC growth references from 3 to 8 years of age. The curve for Khasi boys is more or less according to the 5th percentile of the CDC growth references from 8 to 12 years of age, and it is again above the 5th percentile up to about 16 years of age. Like in the case of

boys, the mean weight of girls is above the 50th percentile of ICMR growth references across ages. Similarly, the curve for girls lies above the 5th percentile but below the 50th percentile of CDC growth references from 3 to 8 years of age. From 8 to 12 years, the growth curve is more or less between to the 5th percentile of the CDC references, and thereafter it lies between the 5th and 50th percentiles.

As already mentioned, very few growth studies have been carried out in Northeast India, especially from 3 to 18 years of age. Thus, we shall restrict our comparison with only two growth studies that were carried out during the last decade: one among the urban Khasi of Meghalaya (Mukherjee, 2002) and the other among the Assamese Muslims of Assam (Begum and Choudhury, 1999).

It is observed that the Khasi boys of the present study are more or less similar to the Assamese Muslim and urban Khasi boys from 3 to 11 years, and thereafter they are heavier than the Assamese Muslim and urban Khasi boys. Like in the case of boys, the Khasi girls of the present study are more or less similar to the Assamese Muslim and urban Khasi girls from 3 to 12 years, and thereafter the Assamese Muslim girls surpassed them up to about 14 years of age **(Figure 5.6)**. After 14 years of age, the Assamese Muslim and urban Khasi girls are lighter than the Khasi girls of the present study. Thus, it is evident that both boys and girls of the present study are by and large similar to their Assamese Muslim and urban Khasi counterparts up to about 12 years of age. Thereafter, the boys are heavier than the Assamese Muslim and urban Khasi boys, whereas girls are heavier than the Assamese Muslim and urban Khasi girls after 14 years of age.

Height

It is observed that the Khasi boys are above the 5th percentile of the CDC growth references but below the 50th percentile of the ICMR growth references from 3 to about 8 years of age. Thereafter, the curve is more or less in the 5th percentile of the CDC growth references up to about 12 years of age. The curve moves towards the 50th percentile of the ICMR growth reference during the adolescent period, i.e., between 12 and 14 years of age. However, it moves markedly below the 5th percentile of the CDC growth references after 14 years of age. As for girls, it is found that the curve is well above the 5th percentile of the CDC growth references from 3 to 7 years of age, and it is more or less according to the 50th percentile of the ICMR

growth references from 3 to 4 years of age. However, like in the case of boys, the curve is more or less in the 5th percentile of the CDC growth references up to about 11 years of age. Except during the adolescent spurt, the curve is much below the 5th percentile of the CDC growth references especially after 12 years of age.

Overall, it indicates that both boys and girls are above the 5th percentile of the CDC growth references from 3 to about 7 or 8 years of age. Thereafter, the curves for both boys and girls followed the 5th percentile growth trajectory of CDC growth references up to adolescent period, and thereafter the curves were below the 5th percentile of the CDC growth references.

In comparison with the Assamese Muslim and urban Khasi children, it is found that that the Khasi boys of the present study are taller than the urban Khasi but shorter than the Assamese Muslim boys across age groups. Thus, it is contrary to expectation that the urban Khasi boys are taller than their counterparts in the rural area. Instead, it is also observed that the Khasi boys of the present study are by and large similar to the Assamese Muslim boys from 3 to 6 years of age, and thereafter the latter surpassed the former across ages. Like in the case of boys, the Khasi girls of the present study are similar to the Assamese Muslim girls from 3 to 5 years, and thereafter they are surpassed by the Assamese Muslim girls across ages, although they are taller than the urban Khasi girls.

Sitting height

As for sitting height, the Khasi boys of the present study are slightly greater than their urban counterparts from 3 to about 9 years of age. However, they are above the urban Khasi boys but much below the Assamese Muslim boys after 9 years of age. The situation is somewhat different in the case of girls. It is that the Khasi girls of the present study are by and large similar to their Urban Khasi counterparts across ages, but they are shorter in sitting height than the Assamese Muslim girls.

Chest circumference

As for chest circumference, it is found that the Khasi boys of the present study are similar to the Assamese Muslim boys, but they are lower than the urban Khasi boys up to about 12 years of age. During the adolescent period, they are similar to their urban counterparts. However, they are lower than the Assamese Muslim and urban Khasi boys after 16 years of age. On the other

hand, the curve for girls lies between the Assamese Muslim and urban Khasi girls from 3 to 6 years of age, and thereafter it is similar to the urban Khasi girls across ages.

NUTRITIONAL STATUS

For assessing the nutritional status of the 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 CDC growth references. 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).

The major findings of the present study on nutritional status may be briefly summarized under the following points:

Weight-for-age

Weight-for-age, expressed as a Z-score of the individual weight relative to CDC growth references, is considered as one of the indicators of underweight. It is found that the overall mean Z-score of weight-for-age is significantly higher in girls than in boys ($t = 2.27$, $p < 0.05$). As for the sex differences at different age groups, it is found that boys had a greater Z-score than girls only at 6 and 13 years of age. The girls are significantly greater in Z-score at 3, 9 and 16 years onwards.

It is found that about 58.79% of boys and 60.86% of girls for all age groups are in the normal category (-2 to + 2 of Z-scores) of nutritional status. The prevalence of moderate (-2 to – 3 of Z-scores) and severe (below –3 of Z-scores) forms of underweight among boys is 33.13% and 8.08%, respectively. Among girls, these frequencies are found to be 36.98% and 2.15%, respectively. Thus, the prevalence of severe form of underweight is lower in girls, whereas the prevalence of moderate underweight is higher in girls than in boys. Nevertheless, the overall prevalence of underweight (below - 2 Z-score) was higher in boys (41.21%) than girls (39.14%). The sex differences in the prevalence of underweight are, however, not statistically significant ($\chi^2 = 0.47$, D.F. = 1, $p > 0.05$).

As for age groups, it is found that in the age group 3-9 years, about 26.92% and 13.94% of boys, and 35.94% and 2.76% of girls are in the categories of moderate and severe forms of

underweight, respectively. It is observed that girls had a lower prevalence of severe underweight, but were higher in the prevalence of moderate underweight. On the other hand, the overall prevalence of underweight is higher in boys (40.87%) than in girls (38.71%) in this age group, despite the absence of statistical significance ($\chi^2 = 0.21$, D.F. = 1, $p > 0.05$).

In the older age group 10-18 years, the prevalence of moderate and severe forms of underweight among boys was found to be 37.63% and 3.83%, respectively. These frequencies were respectively 37.65% and 1.76% among girls. It indicates that the sex differences are not clearly perceptible, although the prevalence of severe underweight was slightly lower in girls. Like in the age group 3-9 years, the overall prevalence of underweight (i.e., moderate plus severe forms) in this age group was also higher in boys (41.46%) than in girls (39.41%), although the difference is not statistically significant ($\chi^2 = 0.27$, D.F. = 1, $p > 0.05$).

Overall, the prevalence of underweight for all sexes and ages was found to be 40.11%. The present findings indicate that there are no differences between the sexes with respect to the prevalence of underweight, although it was slightly higher in boys than in girls. Also, the differences between the two major age groups are not statistically significant, although it was slightly higher in the older age group.

Height-for-age

Height-for-age, expressed as a Z-score of the individual relative to CDC growth references, is considered in the present study as an indicator of short stature or stunting due to inadequate nutrition. It is observed that that the sex differences in mean z-scores of height-for-age are significant only during the adolescent period. The height-for-age Z-scores were significantly higher in boys than in girls from 13 to 15 years of age. On the other hand, girls had greater Z-scores from 17 to 18 years of age. These differences may be related to the differences in rates of growth concerning adolescent growth spurts.

It is found that about 49.29%, 43.23% and 7.47% of boys were in the categories of normal, moderate and severe forms of short stature or stunting as indicated by height-for-age. Among girls, these frequencies are 46.32%, 47.58% and 6.10%, respectively. It is observed that the prevalence of moderate form of stunting was higher in girls, but they had a lower prevalence of the severe form of stunting as compared with boys. Overall, the prevalence of stunting

(below – 2 Z-scores) was lower in boys (50.71%) than in girls (53.68%), despite the absence of statistical significant ($\chi^2 = 0.93$, D.F. = 1, $p > 0.05$).

In the age group 3-9 years, about 31.73% and 7.21% of boys, and 29.95% and 7.37% of girls are in the categories of moderate and severe forms of stunting, respectively. The prevalence of the two forms of stunting in age group 3-9 years are by and large similar in both boys and girls, although the former were slightly higher in the prevalence of moderate stunting than the latter. The overall prevalence of stunting (i.e. moderate plus severe forms) was also slightly higher in boys (38.94%) than in girls (37.33%) in this age group ($\chi^2 = 0.12$, D.F. = 1, $p > 0.05$).

In the age group 10-18 years, the prevalence of moderate and severe forms of stunting among boys was found to be 51.57% and 7.66%, respectively. These frequencies were respectively 58.82% and 5.29% among girls. The sex differences in the prevalence of the two forms of stunting are clearly perceptible. The prevalence of moderate stunting was higher in boys, whereas the prevalence of severe stunting was slightly lower in girls than boys. Nevertheless, the present analysis indicates that the overall prevalence of stunting (i.e., moderate plus severe forms) in the age group 10-18 years was higher in girls (64.11%) than in boys (59.23%). However, this sex difference was not statistically significant ($\chi^2 = 1.57$, D.F. = 1, $p > 0.05$).

Overall, the present findings indicate that about 52.28% of children were stunted. There are no statistical differences between the sexes with respect to the prevalence of stunting, although it was higher in girls than in boys. However, the prevalence of stunting in the higher age group was much higher than that in the lower age group for both boys and girls, and the differences between the two major age groups are highly statistically significant in both boys ($\chi^2 = 19.86$, D.F. = 1, $p < 0.0001$) and girls ($\chi^2 = 32.24$, D.F. = 1, $p < 0.0001$). This difference between age groups may be associated with both biological and nutritional factors.

BMI-for-age

It is found that that the overall mean Z-score is slightly higher in girls than in boys. The sex differences with respect to different age groups are found to be significant only in the age group 9 years ($t = 2.11$, $p < 0.05$). In age group 9 years, the girls are significantly greater in BMI-Z-

score-for-age as compared with boys. Nevertheless, the overall sex differences in BMI Z-scores are not clearly perceptible.

As for the prevalence of wasting, it is found that about 87.27%, 7.07% and 3.23% of boys were in the categories of normal, moderate and severe forms of wasting. Among girls, these frequencies are 87.43%, 10.23% and 0.36%, respectively. It indicates that the prevalence of moderate form of wasting was slightly higher in girls, whereas the prevalence of severe wasting was higher in boys. Nevertheless, the present study clearly indicates that the nutritional status as indicated by BMI-for-age is much better than that indicated by weight-for-age and height-for-age. This holds true for both boys and girls. The overall prevalence of wasting (below – 2 Z-scores) was by and large similar in both boys (10.30%) and girls (10.59%), giving a total incidence of about 10.46%. It is also observed that overweight is also emerging, which was about 2.42% in boys and 1.97% in girls.

In the age group 3-9 years, about 8.65% and 7.21% of boys, and 11.06% and 0.92% of girls are in the categories of moderate and severe forms of wasting, respectively. Although the prevalence of moderate wasting is higher in girls, the overall prevalence of wasting (below – 2 Z-scores) is higher in boys (15.87%) than in girls (11.98%) in this age group, despite the absence of statistical significance ($\chi^2 = 1.34$, D.F. = 1, $p > 0.05$). The prevalence of overweight was also fairly marked in this age group for both boys (5.77%) and girls (5.07%). However, the prevalence of overweight was absent in the older age group of 10-18 years. Thus, it these rates of overweight may be indicative of emerging childhood obesity, which is likely to form a double burden of undernutrition and overnutrition in the next decade or so as observed in other developing countries.

In the age group 10-18 years, it is found that the prevalence of moderate wasting was higher in girls (9.71%) than in boys (6.27%), although it was not statistically significant ($\chi^2 = 2.45$, D.F. = 1, $p > 0.05$). Nevertheless, the present findings indicate the absence of significant difference between the sexes by age groups, although the prevalence of overweight is likely to exist in the lower age group 3-9 years.

Overall, it is found that about 40.11%, 52.28% and 10.46% of the children in the present study were underweight, stunted and wasted, respectively. Following the classificatory criteria

proposed by Gorstein *et al.*, (1994), we may conclude that the present population is likely to be characterized by a very high prevalence of underweight and stunting with a high prevalence of wasting.

UNDERNUTRITION AND SOCIOECONOMIC CORRELATES

Logistic regression analysis was carried out in order to understand how the undernutrition of children is associated with age, sex and certain socioeconomic factors. Two models were considered in carrying out the logistic regression analysis. In model 1, the unadjusted odds ratio (OR) with 95% confidence interval (CI) was computed as an exponential of the coefficient of logistic regression for all the covariates under consideration. In model 2, the OR was adjusted for those variables that are significantly associated with undernutrition.

Risk Factors of Underweight

It is found that underweight is significantly associated with household income and parental education, but it is not significantly associated with age, sex and family size, although the prevalence of underweight is greater in boys as well as in the older age group.

As for household income, it is found that children from low income group had about 2 times greater in risk of being underweight as compared to children belonging to the high income group (OR = 2.05, 95% CI: 1.01-2.30, $p < 0.0001$). Also, middle income group children had about 1.68 (95% CI: 1.14-2.47, $p < 0.009$) times greater in risk of being underweight as compared to those in the high income group. Adjusting for maternal and paternal education in model 2, the effect of household income is still significant ($p < 0.02$). It is found that the children belonging to the low and middle income groups had respectively about 1.9 and 1.6 times greater in risk of being underweight as compared with those belonging to the high income group. This indicates that household income is the very important factor in regulating the weight status of children in the present population.

With respect to maternal and paternal education, it is found that children of illiterate mothers had about 1.6 (95% CI: 1.13-2.33, $p < 0.009$) times greater in risk of being underweight than those children whose mothers were educated up to secondary and above. What interesting is that even children of mothers with primary education (lower and upper primary) had a greater risk of underweight when compared with those children whose mothers were educated up to secondary, or above secondary. The same is true with paternal education. Children of illiterate

fathers had about 1.5 (95% CI: 1.02-2.18, $p < 0.04$) times greater in risk of being underweight than those children whose fathers were educated up to secondary and above. However, when household income is included in the model (Model 2), the effect of maternal and paternal education disappeared. This reveals that household income is more important than parental education in patterning the weight status in the present population. Thus, we may conclude that although parental education does exert its influence on the prevalence of undernutrition among children, household income seems to be more important.

Risk Factors of Stunting

It is found that the unadjusted odds ratios are significant with respect to age and household. Other covariates like sex, parental education and family size are not significantly associated with the prevalence of stunting. With respect to age, it is found that risk of stunting was 2.64 (95% CI: 2.05-3.40, $p < 0.0001$) times greater among children in the older age group 10-18 years when compared with those in the younger age group 3-9 years. The OR was significant even after adjusting for household income and parental education (CI = 2.60, 95% CI: 2.01-3.25, $p < 0.0001$). Therefore, it is likely that age of children plays a very important role in regulating the height-for-age in the present population.

As for household income, shows that children in the low income group had about 2.58 (95% CI: 1.32-5.05, $p < 0.006$) times greater in risk of being stunted when compared with those in the high income group. Similarly, the risk of stunting was about 2.41 (95% CI: 1.11-5.24, $p < 0.027$) times greater among children in the middle income group when compared with the children in the high income group. The effect of income is still significant even after removing the effect of age. It is found that children in the low income group had about 1.71 (95% CI: 1.22-2.41, $p < 0.002$) times greater in risk of being stunted when compared with those in the high income group. However, the OR for the children in the low income group was not significant as compared with the children in the high income group (OR: 1.30, 95% CI: 0.89-1.89, $p > 0.05$). Nevertheless, it is evident that household income is an important factor in influencing the prevalence of stunting in the present population.

Risk Factors of Wasting

Unlike in the case of underweight and stunting, the effects of socioeconomic factors on wasting are not statistically significant in the present population. However, the prevalence of wasting

was significantly greater among children in the lower age group (14%) than that in the higher age group (8%). In other words, it is found that children in the age group 3-9 years were about 1.82 (95% CI: 1.22-2.71, $p < 0.003$) times greater in risk of wasting as compared with those in the age group 10-18 years. Adjusting for household income, the OR was still significant (OR: 1.30, 95% CI: 0.89-1.89, $p > 0.05$). The household income was adjusted because it is likely that children in the low and middle income groups had greater risk of wasting when compared to those in the high income group, although the OR was not statistically significant. Thus, it cannot be totally ruled out the role of household income in regulating the prevalence of wasting in the present population.

CONCLUDING REMARKS

As normally expected, the present study has revealed that there are significant differences between boys and girls in respect of growth patterns, especially during the adolescent period because of the inter- and intra-individual variation in timing of growth spurt. According to PB1 model, both boys and girls are by similar in height up to about 12 years of age, and thereafter it is greater in boys. The estimated values for adult height are 157.5 cm for males and 152.0 cm for females. This indicates that both boys and girls have reached their adult height by the age of 18, although the girls may continue to grow. The present observation seems to confirm the earlier observation among the urban Khasis (Khongsdier and Mukherjee, 2003) and that observed among the Assamese Muslims girls (Begum and Choudhury, 1999). However, it is likely that the girls of the present study may still continue to grow more in terms of lower extremity or leg length. Thus, we are not in position to conclude 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). However, our findings suggest that adolescent growth spurt in subischial length occurs earlier than that of sitting height.

The present study has also indicated that both boys and girls are above the 5th percentile of the CDC growth references from 3 to about 7 or 8 years of age. Thereafter, the curves for both boys and girls followed the 5th percentile growth trajectory of CDC growth references up to adolescent period, and thereafter the curves were below the 5th percentile of the CDC growth references. These present findings may have certain implications for the role of biological and

environmental factors including socioeconomic factors. Several authors have argued that the growth pattern of children in developing countries deviad significantly from the international growth references 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). The present findings, especially on boys, also confirm that the growth curve is well above the 5th percentile but below the 50th percentile of CDC growth references from 3 to 8 years of age, and thereafter it is similar to the 5th percentile.

As for nutritional status, the present study has revealed the absence of statistical differences between the sexes in all the three forms of undernutrition. This observation is consistent with the earlier studies that gender differences in nutritional status are not the main problem among populations in Northeast India, especially among the tribal populations (Khongsdier *et al.*, 2005). However, despite the absence of statistical differences, the prevalence of underweight was higher in boys than in girls, whereas the prevalence of stunting was higher in girls than in boys. It is generally believed that underweight is more related to environmental condition like inadequate nutrition and infection. Therefore, the higher prevalence of underweight in boys may have certain implications for the sex differences in responses to environmental factors. It has been suggested that girls are better "buffered" than boys against environmental factors like inadequate dietary intakes (Stinson, 1985; Bogin, 1999). This phenomenon has also been observed among the Lotha children of Nagaland (Tsopoe, 2003) and the Hmar children of Manipur (Khongsdier *et al.*, 2005). Little is known about this problem in other 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, in addition to genetic factors. It may be mentioned that the higher prevalence of stunting in girls was also observed among the Lotha children of Nagaland (Tsopoe, 2003). Thus, it is unlikely that the phenomenon is due to patrilineal or matrilineal system of the society. Instead, it may be related to the relevance of international growth references to populations in Northeast India. It is evident that

the prevalence of stunting in the higher age group was much higher than that in the lower age group for both boys and girls, and the differences between the two major age groups are highly statistically significant in both boys. Therefore, it is likely that the applicability of the international growth references tends to be more irrelevant during and after adolescent period. This can also be observed with respect to the prevalence of stunting which is significantly related to age. We hope that future studies will shed much more light on this problem.

The present study has revealed that the prevalence of undernutrition, especially underweight, is significantly associated with household income and parental education. Therefore, the present study confirms the earlier observation that socioeconomic factors like income and parental education play a very important role in regulating the nutritional status of children (Eveleth and Tanner, 1990; Bogin, 1999).

Last but not least, the present study has also certain policy implications. Overall, it is evident that there is a high prevalence of undernutrition among the Khasi children, which is also consistent with the recent report by the NFHS-3 (IIPs and Macro International, 2009). Therefore, nutrition policies like the nutrition supplementary programme should be intensified in the state. 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 Khasi population over time.

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