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:

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

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

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

**Anthropometric Assessments of Nutritional Status**

For assessing the nutritional status of children, 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 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 ± 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 67.1 cm 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).
**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 66.5 cm 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 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 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, 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 deviated 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.