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Research Article

Assessment on growth pattern of Khasi children in the state of Meghalaya, India

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ABSTRACT

Background: This paper makes an attempt to describe the growth pattern and their sexual differences among the Khasi tribe in the state of Meghalaya in India. In the study we include 495 girls and 557 boys aged 3 to 18 years.
Methods: In this Study the weight and height of these children were taken. Preece-Baines model 1 (PB1) has been used. This model was adopted for fitting the means of weight and some important linear measurements (Preece and Baines 1978), 1 using Levenberg-Marquardt method through SPSS (version 17.0) and origin software (version 8.0) for windows. 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, etc. according to sex and age groups.
Results: The growth pattern of the Khasi children in the present study are described in terms of anthropometric measurement is observed that girls are heavier than boys at 3 and 4 years of age and boys are significantly heavier than girls from 5 to 6 years old. However girls are heavier than boys at the age of 12 years of age. It is further observed that boys are significantly heavier than girls and are statistically significant, except at the age of 15. It is found that both boys and girls are more or less similar in weight from 7 to 12 years of age.
Conclusions: In terms of height boys are generally taller than girls across ages except at adolescence from 11 to 12 years where girls are taller than boys. The differences between the sexes are statistically significant after 14 years of age; the estimate values for adult height are 157.5 in males and 152 in females.

Keywords: Growth, Weight, Height, Sitting, Growth pattern, Sex differences

INTRODUCTION

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 behavioral scientists with different interests and objectives of study. To pediatricians 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 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.[1]

According to Tanner, "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.[2] 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."

Further, Eveleth and Tanner 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.[3] 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: Eveleth and Tanner).[2,3]

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 the 19th century.[4] 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."[5] 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.[6,7] Tanner has also suggested that the differences between the sexes in height during adulthood are mainly due to the longer period of male growth.[5]

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, one of the basic reasons is perhaps related to differential number of X-chromosomes, which are two in females and one on males.[8] 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.[7]

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, the adolescent growth spurt must have its own intrinsic evolution values, and is not just a by-product of slow pubertal development.[7] 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.[9] Attainment of adolescent growth spurt during pubertal stage is generally followed by the slow growth rate, and finally by growth cessation.

In light of the above review this study is conducted with an objective; (1) To describe the growth pattern of Khasi children aged 3 to 18 years in terms of anthropometric variables; (2) To understand the differences between the sexes in growth pattern among these children.

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 235 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 growth was based on a cross sectional sample of Khasi boys and girls aged between 3-18 years. Following are the anthropometric measurements taken 557 boys and 495 girls.

1. Weight (Kg)
2. Height vertex (cm)

Statistical analyses

Preece-Baines model 1 (PB1)

In the present study, we have used the mathematical model proposed by Preece and Baines, which is referred here as PB1 model. This model was adopted for fitting the means of weight and some important linear measurements, using Levenberg-Marquardt method through SPSS (version 17.0) and origin software (version 8.0) for windows. The model is expressed as follows: [1]

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

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.[10-14]

All data were managed and analysed 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, etc. according to sex and age groups.

RESULTS

Growth pattern

The growth pattern of the Khasi children in the present study is described in terms of 2 anthropometric measurements. In this study, we shall restrict to weight and height which are generally used as important anthropometric variables for assessing the growth patterns of children.

Table 1: Statistical constants of weight (kg) for boys and girls.

Age (years)	Boys			Girls			t-value
	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

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.

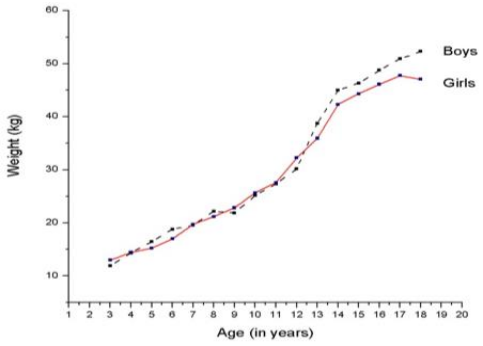

Figure 1: Distance curve for weight of boys and girls

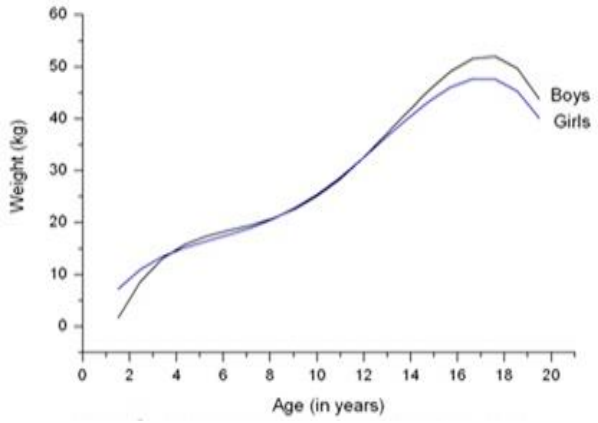

Figure 2: Smooth distance curves for weight according to the 4th degree polynomial model.

Table 2: Statistical constants of height (cm) for boys and girls.

Age (yrs)	Boys			Girls			t-value
	Mean	SD	Increment	Mean	SD	Increment	
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*

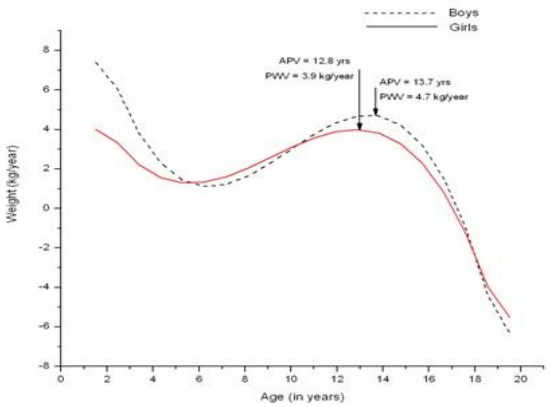

Figure 3: Velocity curves (first derivatives of the fitted function) indicating age at peak velocity (APV) and peak weight velocity (PWV).

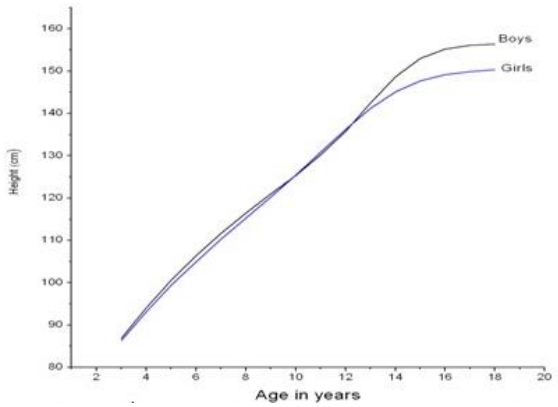

Figure 4: Smooth distance curves according PBI model.

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.

Table 3: Parameter estimates according to PB1 model.

Sex	h1±SE	h0±SE	s1±SE	s0±SE	0±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

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.

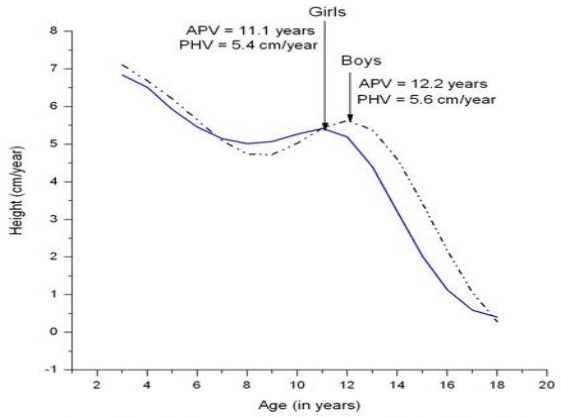

Figure 5: Velocity curves (first derivatives of the fitted function) indicating age at peak velocity (APV) and peak height velocity (PHV).

DISCUSSION

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 according to Khongsdier and Mukherjee, and that observed among the Assamese Muslims girls.[15,16]

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 has shown that the rural South 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. 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.

CONCLUSION

In terms of height, boys are generally taller than girls across ages except at adolescence from 11 to 12 years where girls are taller than boys. The differences between the sexes are statistically significant after 14 years of age; the estimate values for adult height are 157.5 in males and 152 in females.

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