

A Study on Pattern of Growth in Height Among Children of Dhulikhel Municipality

Mansur DI¹, Shrestha A², Sharma K³, Mehta DK⁴, Shakya R⁵, Timalina B⁶

Abstract

Introduction: Growth reference charts are essential to assess appropriate growth of individual children. The height of an individual is the most widely accepted method for the evaluation of growth of the children. The child's height is primarily determined by the length of his/her bones, and thus the children become tall because their bones grow in length. The purpose of the present study was to develop the mean height reference charts for school going children residing in Dhulikhel and to evolve an easily applied formula to assess the height of the children at different age groups. **Material and Methods:** The present study consisted of 1726 healthy school going children (945 boys and 781 girls) aged 3-16 years, from different Schools of Dhulikhel Municipality during July – December 2014. Age was recorded in year and height of each child was measured cross-sectionally in centimeter and statistical analysis was done.

Results: It has been observed that there was a progressively increasing trend in the mean values of the height with advancement of age in both sexes. The study revealed that the adolescent growth spurt or highest peak velocity of girls (11-12 years) was attained earlier by one year than boys (12-13 years).

Conclusions: If a child's height is consistently or substantially different from the height of other children of the same age and gender, it indicates that the child may have a medical problem and requires monitoring or treatment. The trend of physical growth as observed in height may be expected to serve as the growth standards of Dhulikhel's children.

Key words: Age, Children, Growth pattern, Height, PHV

Introduction

Height of an individual grows throughout childhood and puberty. Growth in height ceases at 25 years of age, when epiphysis gets fused with diaphysis of growing long bones. After which no more bone growth can take place¹. At the same time, no two persons are alike, in their measurable characters especially height of an individual².

Few children will remain small throughout life, while others may reach normal size. Few children are taller than expected at a given age and sex, and few are shorter. Parents are more often concerned when their children are shorter than their age-mates. Children may

¹Dr. Dil Islam Mansur, MBBS, MS, Assistant Professor, ²Ms. Anupama Shrestha, MSc, Lecturer, ³Mrs. Kalpana Sharma, MSc, Lecturer, ⁴Mr. Dilip Kumar Mehta, MSc, Lecturer, ⁵Ms. Rojina Shakya, MSc, Lecturer, ⁶Mr. Binod Timalina, MSc, Resident. All from the Department of Anatomy, Kathmandu University School of Medical Sciences (KUSMS), Dhulikhel, Nepal

Address for correspondence:

Dr. Dil Islam Mansur
Assistant Professor
Department of Anatomy, Kathmandu University
School of Medical Sciences
Dhulikhel, Nepal
E-mail: dillislam@kusms.edu.np
Tel: 00977-9849678367

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ask parents why they are not as tall as their playmates, parents ask doctors, and doctors ask endocrinologists and geneticists when the growth of a child seems unusual³.

Growth velocity is independent of the height achieved by a child so it is a sensitive indicator of good or bad health regardless of previous growth delay⁴. The height is relatively a stable measurement of growth as opposed to body weight which reflects only the present health status of the child. On the other hand, the height indicates the events in the past also. The use of growth (height) chart is particularly valuable in studying the trend of height curve⁵.

Accurate serial height measurements documented over time on a growth chart are key in the evaluation of the children health and also serve as the foundation for the diagnosis of growth abnormalities such as stunting^{6,7}.

Rationale behind the present study was that very few parents in Dhulikhel were aware of the fact that their children's height depicts their health status. Thus, knowledge about the present average height for particular age group helps for regular monitoring of a child's growth and development. The perfect time for monitoring the proper growth and development is the growing period. So, this study was done in school going children of Dhulikhel in order to evaluate the pattern of growth in height among them.

Material and Methods

The material for the present study was based on a cross-sectional data collected on 1726 healthy children (945 Boys and 781 Girls) aged 3-16 years, from various school in Dhulikhel Municipality, Kavre, Nepal during the period from July to December 2014. Disabled children were excluded from the study. Age and height of each child was recorded in year and in centimeter respectively.

Age: The age of an individual was recorded from the data provided by the schools and simply by asking the children. Age was recorded in year. For example, if a child's age was 12 years and 6 months or above then his/her age was recorded as 13 years. But if he/she was 12 years and below 6 months then his/her age was recorded as 12 years.

Height: A vertical metal measuring tape was employed to measure the height. Children were asked to stand in upright posture on the flat surface with heels, buttocks, shoulders and back of the head touching the same coronal plane. Head was kept in such a way that lower margin of the orbital cavity and center of external acoustic meatus was in the same horizontal plane. Upper limbs were hanged by the side of the body with palm facing forward. Marking was done at the top of the head with right angled object like a clip board. The height of the child was measured from the floor to the mark with a non stretchable metal measuring tape in centimeter.

Statistical Analysis: The data were entered in Microsoft Office Excel and analyzed the data with SPSS (17.0). The data on height were analyzed for both sexes and considered each age group to assess annual growth in height. Growth pattern for height was graphically represented by distance curve however velocity curve

was also used to examine the height peaks of annual increments in both sexes⁸. The interval during which the maximum yearly height increment occurred was taken as age at peak height velocity (PHV)⁹.

Results

This study was carried out on the different age groups of school going children of Dhulikhel. Figure 1 and 2 showing distribution of numbers and mean height of boys and girls respectively. Age, gender, mean value and range of the body height; and standard deviation of studied subjects are presented in Table 1.

As shown in Table 1; the present study revealed that the mean height of 3 years girls and boys were 93.17 cm and 95.50 cm respectively which indicates the differences in height between boys and girls was 2.33 cm at the same age of both sexes. Similarly, 16 years boys had a mean height of 166.91 cm and 154.25 cm among girls at the same age group which indicates 12.66 cm difference in height between boys and girls. Thus, it has been concluded that boys were found to be taller than girls, except at 8, 10 and 12 years of age, when they appeared shorter than girls (Table 3).

The present study concluded that the mean height of boys varied from 95.50 cm to 166.91 cm aging from 3 years to 16 years respectively. The total gain in height from the age of 3 years to 16 years was 71.41 cm. The PHV was calculated as 12.83 cm during 12-13 years of age among boys. Hence, it was concluded that the mean height of boys increases with the advancement of age with the maximum increment occurring during 12 to 13 years. The velocity of growth of height is relatively high during 5 to 6 years and decreases until 12 years and then increases until an adolescent peak is reached at an average of 13 years as shown in Table 2. The rate of gain in height after the peak decreases and is <2.64 cm/year after 16 years. In the present sample, the distance curve also shows a gradual increase in height from 3 to 16 years as shown in Fig. 3, while the velocity curve indicates the highest rate of increment (12.83 cm/year) during the period of 12 to 13 years among the boys as shown in Fig. 4.

In the present study, it was found that the mean height of girls varied from 93.17 to 154.25 cm aging from 3 years to 16 years respectively. The total gain in height from the age of 3 years to 16 years of girls was 61.08 cm. The age at PHV was found during 11-12 years for girls, and the whole year velocity at PHV was observed as 9.57 cm/year for girls. Hence, it was concluded that the mean height of girls increases with the advancement of age with the maximum increment

(9.57 cm/year) occurring during 11 to 12 years. The velocity of growth of height is relatively high (8.16 cm/year) during 5 to 6 years and decreases until 11 years and then increases until an adolescent peak is reached at an average of 12 years as shown in Table 2. The rate of gain in height after the peak decreases and is <0.12 cm/year after 16 years. In the present study, the distance curve for height shows a gradual increase in height from 3 to 16 years as shown in Fig. 3, while the velocity curve indicates the highest rate of increment (9.57 cm/year) at the age of 12 years among the girls as shown in Fig. 4.

It has been also concluded that the mean values for height are observed to be progressively increasing till 13 years among boys and 12 years among girls; and showed a steady pattern of growth, and afterwards almost stationary pattern is noticed with decelerating

trend of growth progression in both sexes. This may indicate the period of growth spurts due to puberty which was found to be earlier among girls than boys by one year.

There is significant correlation coefficient between age and height ($r = 0.960, p < 0.01$) for boys, ($r = 0.959, p < 0.01$) for girls and ($r = 0.957, p < 0.01$) for both (boys and girls). It shows that there is strong positive correlation between age and height of children as shown in figures 5, 6 and 7.

The formula estimating average height of healthy children aged 3-16 years are:

$$\text{Height (cm)} = \text{Age (year)} \times 5.860 + 75.201 \text{ for boys}$$

$$\text{Height (cm)} = \text{Age (year)} \times 5.282 + 77.819 \text{ for girls}$$

$$\text{Height (cm)} = \text{Age (year)} \times 5.634 + 76.122 \text{ for both (boys and girls)}$$

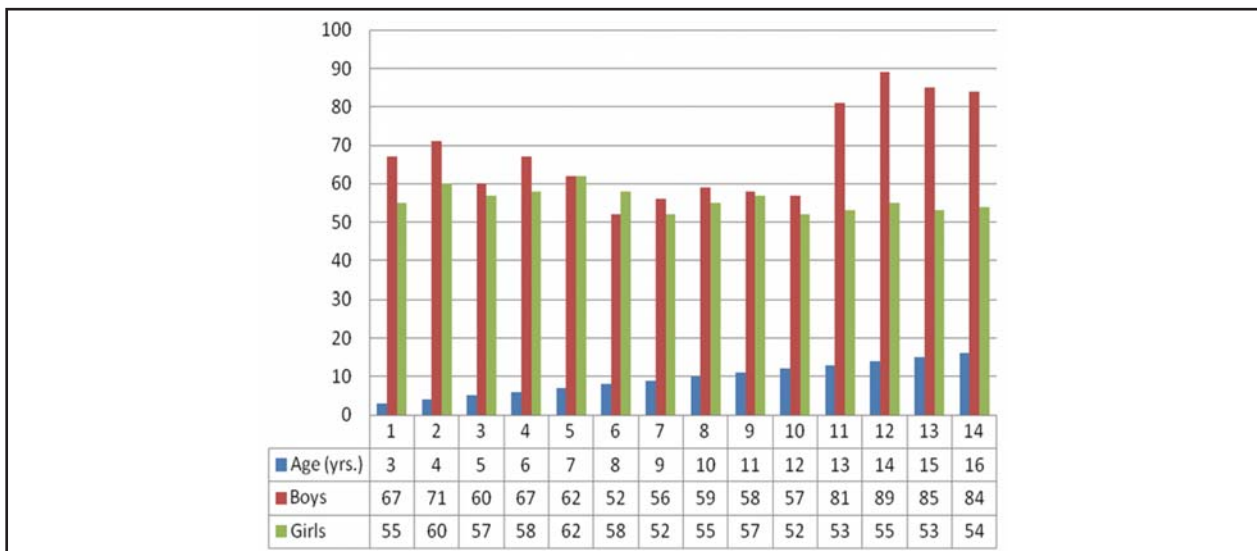


Fig. 1: Bar chart showing distribution of numbers of boys and girls according to their age

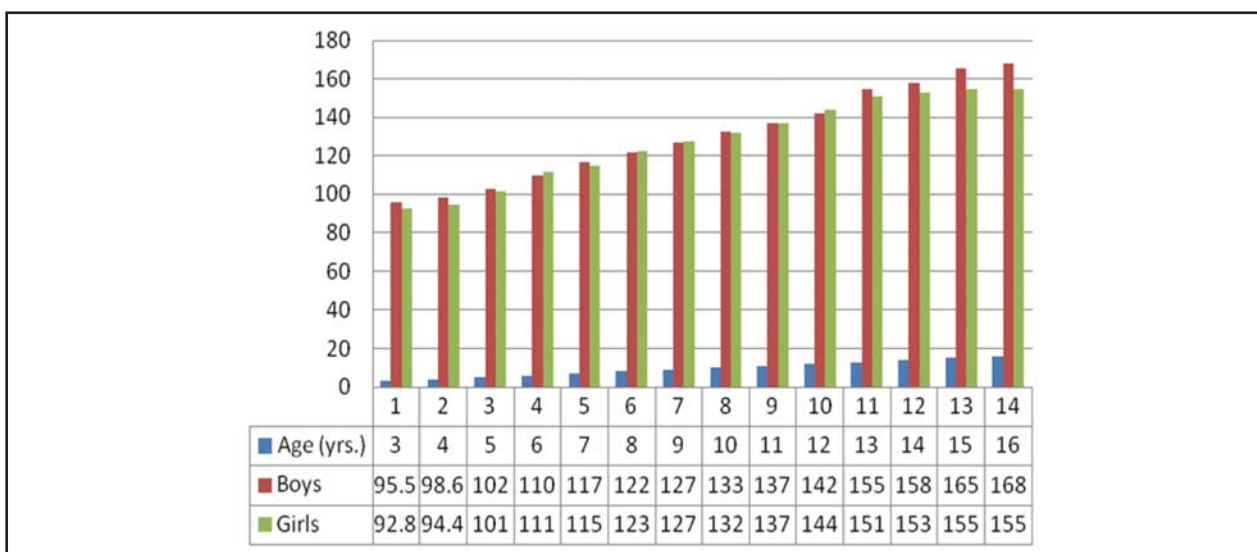


Fig. 2: Bar chart showing distribution of mean height (cm) of boys and girls according to their age

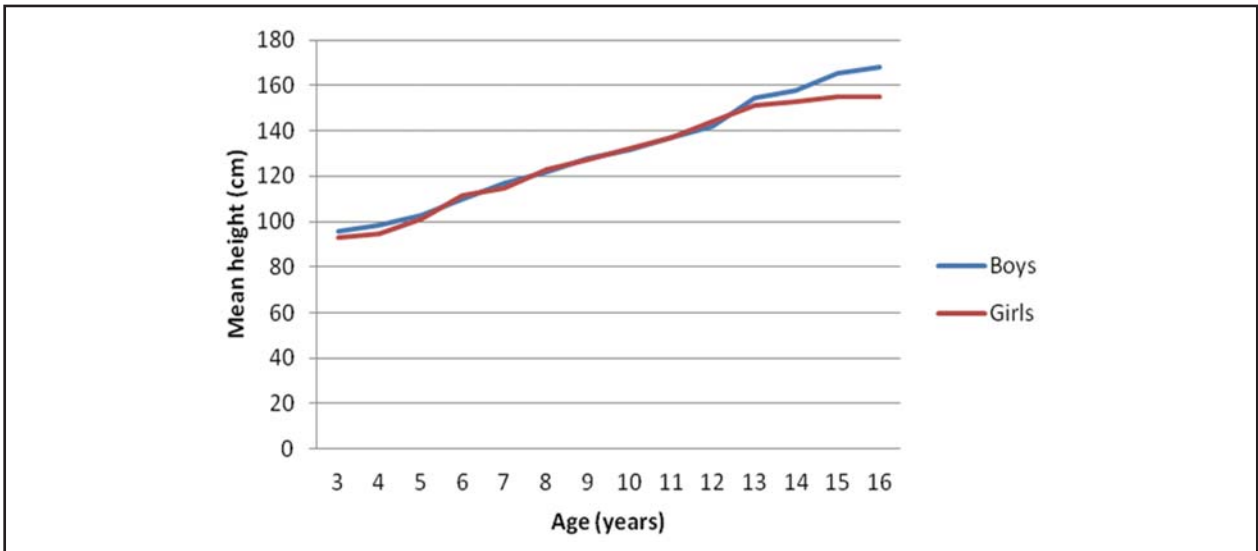


Fig. 3: The distance curve showing mean height of boys and girls according to age

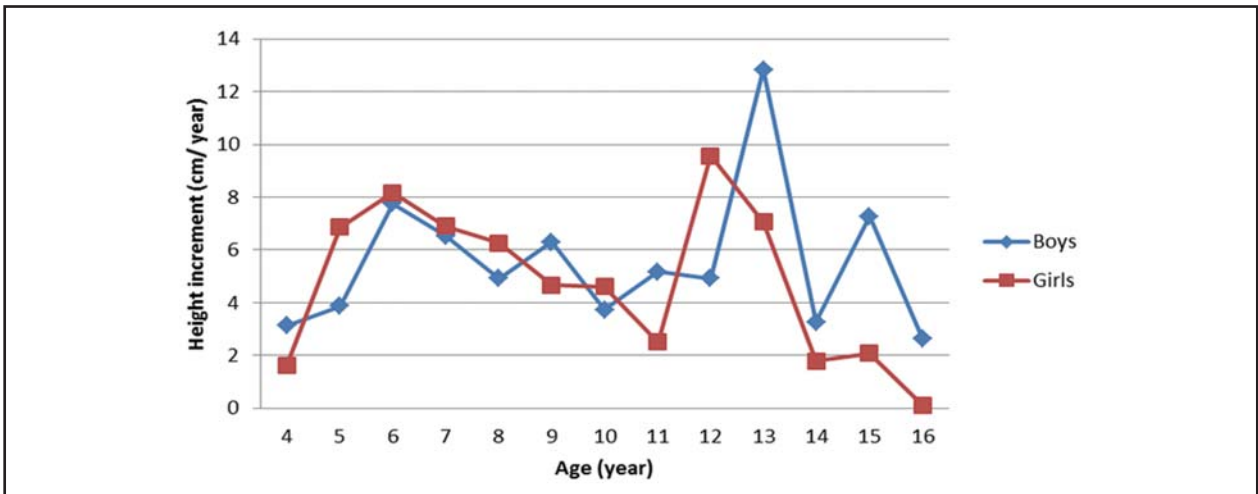


Fig. 4: The velocity curve showing peak height velocity (cm/year) among boys and girls

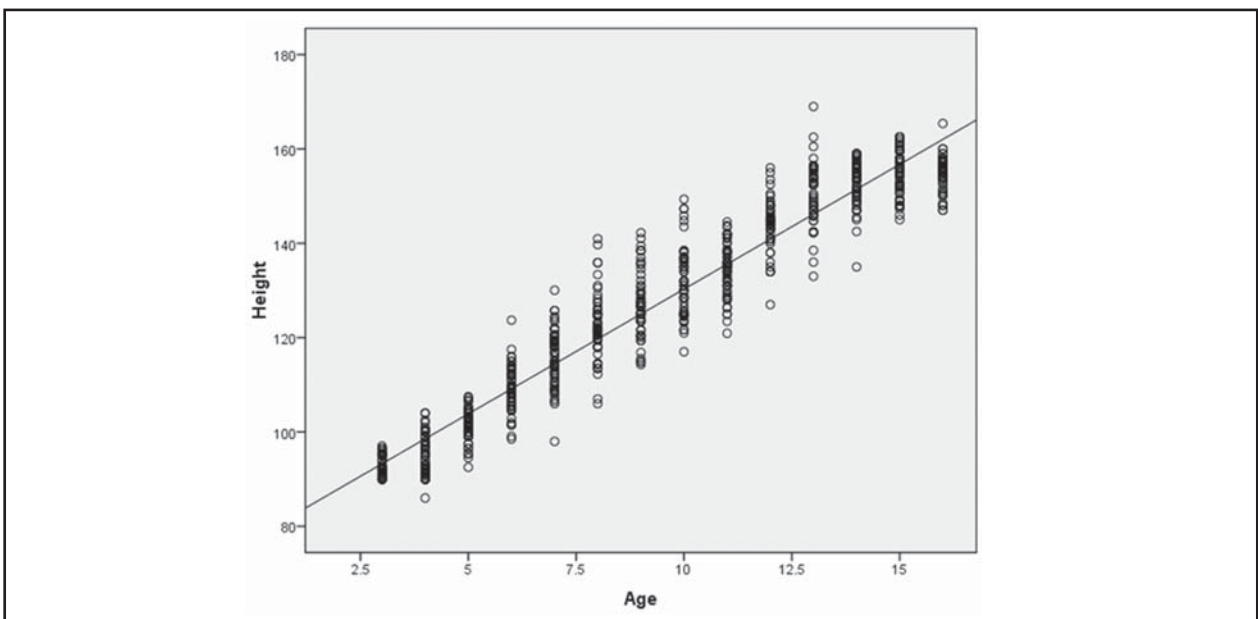


Fig. 5: Scatter diagram showing correlation between age and height of boys

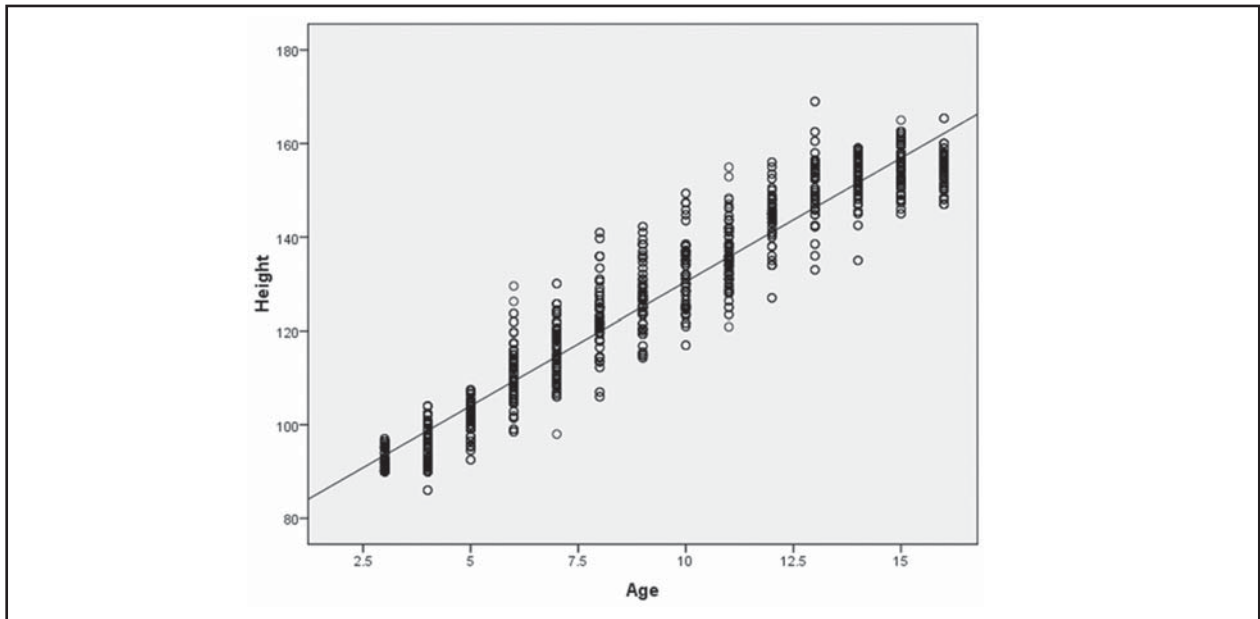


Fig. 6: Scatter diagram showing correlation between age and height of girls

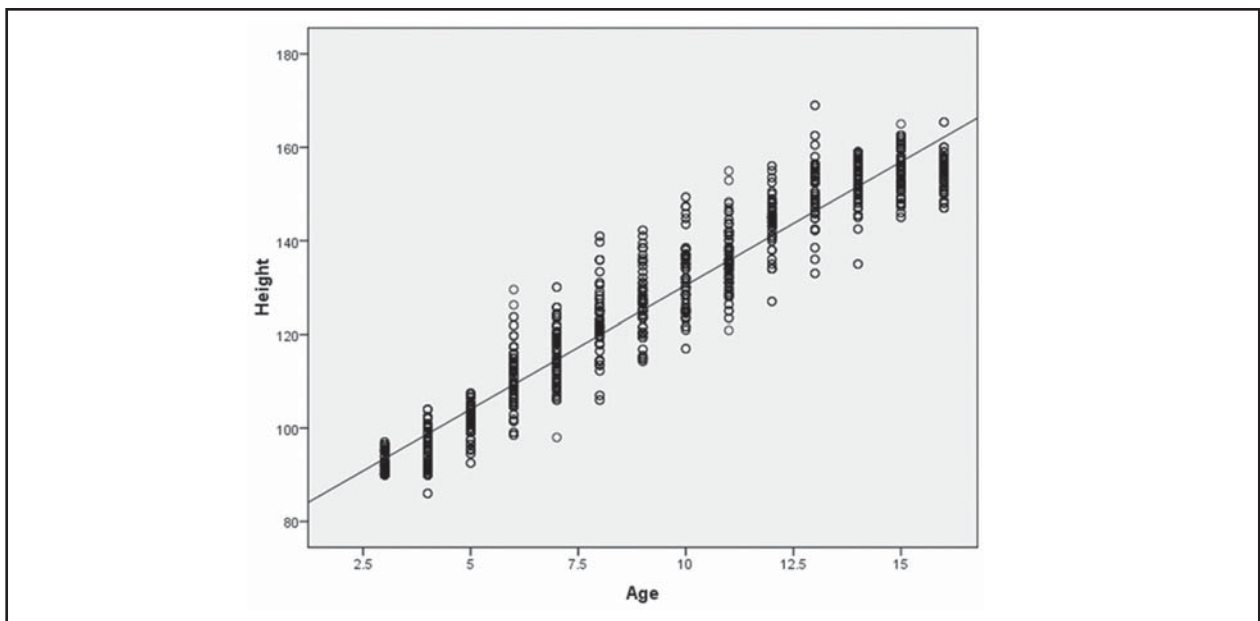


Fig. 7: Scatter diagram showing correlation between age and height of both sexes

Table 1: Descriptive statistical analysis of height at different ages of children

Age in Years	Boys (n = 945)			Girls (n = 781)		
	Sample size	Height in Range (cm)	Mean height (cm) \pm SD	Sample size	Height in Range (cm)	Mean height (cm) \pm SD
3	67	93–98	95.47 \pm 1.07	55	90 – 97	92.82 \pm 2.25
4	71	94–106	98.61 \pm 2.38	60	86 – 104	94.43 \pm 4.25
5	60	96.5–112	102.48 \pm 3.11	57	92.5 – 107.5	101.29 \pm 3.09
6	64	48.01–127	110.24 \pm 9.82	58	98.5 – 123.7	109.45 \pm 2.78
7	62	100.5–134.62	116.77 \pm 7.03	62	106 – 130	116.35 \pm 7.59
8	52	104–138.18	121.68 \pm 7.33	58	106 – 140.9	122.62 \pm 5.33
9	56	104–139.7	127.97 \pm 7.38	52	114.3 – 142.2	127.28 \pm 7.21
10	59	113–147.32	131.71 \pm 7.38	55	117 – 149.3	131.88 \pm 7.35
11	58	123.5–150.11	136.89 \pm 7.08	57	120.91 – 144.5	134.39 \pm 5.51
12	57	125.73–165.1	141.81 \pm 7.93	52	127 – 156	143.96 \pm 5.49
13	81	135.38–172.21	154.64 \pm 9.56	53	133 – 169	151.01 \pm 6.53
14	89	132.02–175.77	157.91 \pm 8.92	55	135 – 159	152.8 \pm 4.71
15	85	145–182.88	165.19 \pm 5.82	53	145 – 162.56	154.70 \pm 4.73
16	84	151–179	167.83 \pm 4.94	54	147 – 165.4	154.82 \pm 3.53

Table 2: Mean values of height at different ages of children with annual increment

Age in years	Height in cm					
	Boys (n = 945)			Girls (n = 781)		
	Mean height (cm)	Increment of height per year	% of increment of height per year	Mean height (cm)	Increment of height per year	% of increment of height per year
3	95.47			92.82		
4	98.61	3.14	4.33%	94.43	1.61	2.57%
5	102.48	3.87	5.34%	101.29	6.86	10.97%
6	110.24	7.76	10.70%	109.45	8.16	13.05%
7	116.77	6.53	9.01%	116.35	6.90	11.04%
8	121.68	4.91	6.77%	122.62	6.27	10.03%
9	127.97	6.29	8.68%	127.28	4.66	7.45%
10	131.71	3.74	5.16%	131.88	4.60	7.36%
11	136.89	5.18	7.14%	134.39	2.51	4.01%
12	141.81	4.92	6.78%	143.96	9.57	15.31%
13	154.64	12.83	17.70%	151.01	7.05	11.28%
14	157.91	3.27	4.51%	152.8	1.79	2.86%
15	165.19	7.28	10.04%	154.70	2.08	3.32%
16	167.83	2.64	3.64%	154.82	0.12	0.19%

Discussion

Growth reference charts are essential to assess an appropriate growth of individual children. Anthropometric measurement of height is the most widely accepted method for the evaluation of growth of children^{10,11}. Evaluation of chronic diseases and interpersonal relationships and stress screening in children is possible by following a child and his family over time through growth charts. A pediatrician can

detect relationships between physical, cognitive and motor growth¹².

The results of the present study showed significant differences in pattern of growth in height between boys and girls. The sexual dimorphism differences in mean values of height among the children were recorded, with the boys having higher values than the girls. Information emanating from this study confirms the result obtained by earlier researchers^{13,14}. A similar

trend also had been reported by the various authors in different population. The mean values were not different from other studies which reported higher values for boys among the children of Zaria, Nigeria¹⁵ and Canada¹⁶. This also agreed with the earlier works of Verma and Bayat et al. among the children from the Chhattisgarh, India and among the children from Arak, Iran respectively^{8,17}. Reports from other studies indicated the same trend of results for boys being higher in variables studied even before adult age^{18,19}.

The present study also concluded that the mean values of height were progressively accelerating with advancement of age in both boys and girls which was consistent with the result of a study conducted among the children (8-15 years) of interior part of Bijapur, Karnataka, India¹. A similar trend also noticed by Verma that the mean height gradually increases from 6 to 16 years among boys and girls with the advancement of age among children of Chhattisgarh, India⁸. A study also reported that the mean values for height were observed to be progressively increasing with advancement of age of the children of Visakhapatnam District, Andhra Pradesh, India²⁰.

Although growth velocity measurement (like most methods of growth monitoring) is of limited clinical value in primary care in developing countries, it has advantages as an epidemiological tool when compared with static anthropometric measurements. Velocity is more time specific than a distance measure like height for age: a normal velocity indicates current good health in children who are stunted from previous causes, and a reduced growth velocity suggests poor health even in children whose growth has not yet faltered appreciably on a distance chart⁵.

Data from cross sectional as well as longitudinal studies samples to estimate the age at peak height velocity had been used in previous studies on children and adolescents^{21,22}. Prediction of the pubertal growth spurt by measuring standing height was confirmed in the literature²³. The growth spurt is associated with the appearance of secondary sex characteristics in puberty. The pubertal growth characteristics including PHV and age at PHV contribute to final adult height²⁴.

In the present study, it was concluded that the age at PHV was 12-13 years in boys and 11-12 years in girls and whole year PHV was 12.83 cm/year in boys, and 9.57 cm/year in girls. It was also concluded that growth spurts was found to be earlier in girls than boys by one year. The results of present study were also supported by various studies. Such as a study was

done by Prabhjot et al. on 1082 children (500 girls and 582 boys) aged 6 to 15 years in India²⁵. They revealed that age at the PHV among girls between 11 to 12 years old age was attained earlier by one year than among boys (12-13 years). Another study also showed the age at PHV for American boys was 12-13 years (7.6 cm/year) and for American girls it was 11-12 years (6.8 cm/year)²⁶. Tanaka et al. calculated linear growth in 438 boys and 483 girls aged from 6 years to 17 years. They reported a mean age of PHV to be 11.2 years in girls and 13.0 years in boys. The mean PHV was 8.7 cm/year among girls and 10.3 cm/year among boys in Japan²⁷.

Age at the onset of growth acceleration is highly variable and sex-dependent. In contrast to the present study, the mean age at PHV was found to be slight variations in the different studies. In Taiwan, a study was done by Lee et al. and found that the mean age at PHV was 12.5 years for boys and 10.5 years for girls; the whole year PHV was 8.0 cm per year in boys and 7.0 cm per year in girls⁹. In Korea, Chae et al. conducted a study and revealed that mean age at PHV was 12 years in boys and 10 years in girls; PHV was 8.62 cm per year in boys and 7.07 cm per year in girls²⁸. In Saudi Arab, Al-Emran et al. reported that the age at PHV for Saudi boys was 13-14 years (8.2 cm/year) and for Saudi Girls it was at age 10-11 years (4.4 cm/year)²⁹.

In contrast to the present study, the mean age at PHV was found to be higher in different studies. Marshall et al. reported the mean of 14.0 years in boys³⁰ while Tanner et al. estimated it to be 13.9 years, with whole year PHV of 8.8 cm/year in boys²⁶. Billewicz et al. observed that PHV for boys and girls were 9.63 cm/year and 8.02 cm/year respectively³¹. Largo et al. reported an average of 12 years for PHV in girls and of 14 years in boys based on a Zurich longitudinal study, and the whole year PHV was 7 cm/year and 9 cm/year in girls and boys respectively³².

When the mean values for height of the present samples were compared with other studies, it was observed that Dhulikhel's Children were shorter than Iranian¹⁷, American²⁶, Korean²⁸ and British children³³. The differences in growth in height between Dhulikhel's children and those living in developed countries were ascribed till recently to possible environmental, genetic and socio-cultural factors. Conditions of these factors mainly, the nutritional statuses, socio-economic and environmental factors in developed countries are by no doubt better than those of Dhulikhel. Thus, the use of the CDC/NCHS standard for growth in height does not appear appropriate for the assessment of growth of Dhulikhel's Children.

Growth hormone, while being essentially unimportant for fetal development, is the most important hormone for postnatal growth. However, growth overall is a complex phenomenon that is affected not only by growth hormone and somatomedins, but also, thyroid hormones, androgens, estrogens, glucocorticoids and insulin. It is also affected of course by genetic factors and it depends on adequate nutrition. It is normally accompanied by an orderly sequence of maturational changes, and it involves secretion of protein and increase in length and size, not just an increase in weight³⁴.

Pubertal growth consists of a phase of accelerated growth, followed by a phase of growth deceleration, and eventual cessation of growth with closure of the epiphyses³⁵. All studies including the present study have shown almost similar growth patterns during childhood.

Conclusions

The data of the present study developed the mean height reference charts for children aged between 3-16 years old residing in Dhulikhel municipality. The trend of physical growth as observed in height may be expected to serve as the growth standards of Dhulikhel's children. The mean values of height of children indicate positive correlation with age among both the sexes. The age of peak height velocity (PHV) is an important indicator of tempo growth of a population and the girls in the present study attain PHV, somewhat one year earlier than of boys, although the magnitude of peak height velocity is greater in boys than the girls. This is one of the basic studies which provide the basic data on child growth which could be utilized by anatomists, forensic experts, anthropologists and nutritionists. It may also help pediatricians in their clinical practices.

The regression equations were also derived to assess the approximate height of a child of different age groups. If a child's height is consistently or substantially different from the height of other children of the same age and gender, it indicates that the child may have a medical problem and requires monitoring or treatment.

However, because of the possible ethnic differences between the Dhulikhel and other populations, the growth charts presented could serve as a better reference for future comparisons. It is recommended to have a large number of such studies involving large group of children, both boys and girls from various parts of the country to deduce a Nepalese standard.

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