Physical Growth of the Children in Phitsanulok: A Comparison Between Those with Normal and Undernutrition

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Abstract

Child growth reflects hereditary patterns and environmental constituents. To reveal the ages at onset of growth spurt (OGS) and at peak height velocity (PHV), the present study investigated the height of 255 Phitsanulok children in relation to their age, gender and nutritional condition. In the normal nutritional (NN) group, the obtained results on ages (years + standard deviation) at OGS were 10.68 + 0.34 for girls and 11.44 + 0.30 for boys, and ages at PHV were 12.50 + 0.31 for girls and 14.49 + 0.30 for boys. In the undernutritioned (UN) group, the OGS and PHV for UN girls, as well as the OGS for UN boys, were more retarded than those in the NN condition. However, UN boys possessed an earlier age at PHV, when compared with NN boys. The data obtained in this study may be valuable for children's health-related professionals to determine and provide an appropriate prevention and/or treatment.

Keywords: age, gender, nutrition, height

Introduction

Growth of children is depended on hereditary patterns, hormones, and nutritional behaviors (Satoh *et al*., 1997; Ali *et al*., 2001; Mauras, 2001). Body size changes from birth to adulthood, and a combination of morphological and physiological changes in the whole body leads to puberty (Cederquist, 1990).

Body changes do not commence at the same age, nor is their duration the same in all children, and adolescent growth spurt is a main somatic indicator of puberty (Marshall and Tanner, 1986). Cederquist (1990) illustrates that growth velocity curve in a child during puberty rises to a maximum, then quickly begins to fall again, and the maximum speed of growth called peak height velocity (PHV) is at the height of the curve. The standard graph of height in relation to age helps describe whether a child gains an appropriate height for his respective age.

Prior to puberty, nutrition plays an important role in children and directly affects their physical qualities (Wang, 2002b). According to Thailand's Ministry of Public Health (2000), an undernutritioned (UN) child weighs less than 90% of the standard value in relation to his age, and an involvement of long-term undernutrition causes a child to be shorter when compared to those in the same age.

Data on physical growth are useful for health-related work and nutritional promotion. To the best of our knowledge, there has been no available evidence of physical growth data in normal nutritioned (NN) and UN children of Phitsanulok (PHS). It was then the prime objective of this investigation to disclose such data to the society.

Subjects and methods

To reduce the bias, a stratified random sampling method was conducted during selection of the subjects. Briefly, 165 names of schools in 9 districts of PHS were obtained from Office of Primary Education at PHS and then alphabetically arranged. After different numbers had been provided to each school, one out of three from the assigned numbers was chosen and, subsequently, 55 names of schools were obtained.

From 255 students who had no involvement of systemic diseases, the data were collected with special references to sex, height, as well as their birthdate, month and year. During the collection periods, their age ranged between 14 to 15 years old, and the data on their height were collected while they were studying from grade 4 to 9.

According to the criteria on the child height (Ministry of Public Health, 2000), the subjects were divided into children with normal- and under - nutritional status. Height velocity (HV) of each child was computed and its equation was as follows:

HV at age_n = height at age_n – height at age_{n-1} (n = years of age).

A calculation of mean values, as well as their standard deviations, of HV at each age was performed. In each group, onset of growth spurt (OGS) and PHV were also determined, as previously described by Cederquist (1990).

Using the SPSS Release 10.0.1 (SPSS Inc.), the data were examined by a Chi-square test (Table 1), a Student’s t-test (Table 2) and an analysis of variance (Table 3). Significance of the differences was selected at $P < 0.05$.

Results

Table 1 shows that 106 (41.57%) subjects in this investigation were girls and 149 (58.43%) were boys. According to their nutritional conditions, 234 children (91.77%) were categorized into the NN group, while the rest (8.23%) were the UN group. Within the NN group, 101 (39.61%) were girls and 133 (52.16%) were boys and the difference in their numbers was significant (P = 0.036). Within 21 UN children, 5 (1.96%) and 16 (6.27%) of them were girls and boys, respectively. A significant difference in their numbers was also observed (P = 0.016).

Table 1. Number (and percentage) of children in relation to their gender and nutritional conditions

Gender	Total	Normal nutrition	Undernutrition
Female	106 (41.57)	101 (39.61)	5 (1.96)
Male	149 (58.43)	133 (52.16)	16 (6.27)
		P = 0.036*	P = 0.016*

* Chi-square test, significant difference at $P < 0.05$

An increase in the mean body height was recognized each year in the children of both nutritional groups (Table 2). Compared with boys, girls with an age between 10.0 and 12.9 years old seemed taller, but with nonsignificant differences ($P > 0.05$). However, during 13.0-15.9 years of age, mean body height observed in boys was significantly more than that of girls ($P < 0.05$). Figures 1 and 2 reveal that NN children possessed an OGS (mean + S.D. years of age) at 10.68 + 0.34 (girls) and 11.44 + 0.30 (boys). In comparison with that in boys, HV in girls was slightly higher (about 0.1 cm/year) until approximately 11.50 years of age. In addition, HV in boys was clearly higher (about 1-5 cm/ year) than that in girls after the age of 13 years (Figure 2). It was found that PHV (mean + S.D. years of age) were at 12.50 + 0.31 in girls and at 14.49 + 0.30 in boys, as indicated by arrows in Figure 2.

Among UN groups as shown in Table 2, girls when compared with boys were non-significantly taller and shorter than boys during 10.0-12.9 and 13.0-14.9 years of age, respectively. Afterwards, during 15.0-15.9 years of age, mean height values of boys were significantly more than those of girls (P = 0.022). Figures 3 and 4 show that UN children possessed an OGS (mean + S.D. years of age) at 13.52 + 0.22 (girls) and 12.28 + 0.26 (boys). In comparison with that in boys, HV in girls was clearly lower (about 1-4 cm/year) from the beginning of OGS (Figure 4). However, PHV (mean + S.D. years of age) were at 14.52 + 0.22 in girls and at 13.38 + 0.24 in boys, as shown by arrows in Figure 4.

ANOVA in Table 3 reveals that children's gender affected their body height during 14.0-15.9 years of age ($P < 0.01$), whereas nutritional condition affected the body height in all age periods ($P < 0.01$), except during 10.0-10.9 years of age (P = 0.099). However, the interaction of these two factors did not affect child height in any age period ($P > 0.05$).

Discussion

This study revealed the ages at which changes of body height in PHS girls and boys were observed. Despite our careful exploration, we failed to find any past reports on such data in relation to nutritional conditions among PHS children.

In the present study, children's gender was found to affect body height. Among NN children, girls' and boys' ages (mean + S.D. years old) at which their OGS had been detectable were 10.68 + 0.34 and 11.44 + 0.30, respectively. Our data corresponded with the previous results obtained from American (Abbassi, 1998), Swedish (Taranger and Hägg, 1980), and Japanese (Ali *et al*., 2001) in that girls presented OGS at an earlier age than boys did. Our data and other investigations have suggested OGS to be a gender-related phenomenon. Girls with Turner syndrome (45, X) have been reported on a failure in their physical growth (Davenport *et al*., 2002). Nevertheless, their final height can be improved by growth hormone (GH) administration (Batch, 2002). Hence, an association of human growth and GH is certain. Estrogen has been disclosed to be responsible for controlling the feedback amplification of GH production during puberty even in the male (Keenan *et al*., 1993). Moreover, androgen is reported to exert a tonic inhibition of GH secretion, due to the fact that such inhibition could be abolished by an androgen receptor blockade (Metzger and Kerrigan, 1993). In a review done by Mauras *et al*. (1996), it has been concluded that the differential timing of the onset of puberty in girls and boys was regulated by the dichotomy of estrogen and androgen effects. Taken together, girls' earlier age at OGS supports sex factor as one of the influences.

Ages (years) at PHV for children residing in different regions of the world has been reported to be 11.2-12.2 in girls and 13.0-13.9 in boys (Largo *et al*., 1978; Tanaka *et al*., 1988; Abbassi, 1998; Liu *et al*., 2000). In the present study, it was 12.50 + 0.31 for girls and 14.49 + 0.30 for boys. The discrepancy between their findings and ours remains to be clarified, yet attributable to the differences in genetic as well as environmental constituents. Some variations of human growth have been reported among different ethnic groups (Goldenberg *et al*., 1991; Johnson *et al*., 1993; Nies *et al*., 1999), and outbreeding seems to be the most commonly mentioned genetic factor possibly associated with the change in human growth (Tanner, 1968; Malina, 1979). Tanner (1989) stated that, in the last century, there has been a dramatic increase in the mobility of people within and between populations, causing a gradual relative decline in the reproduction rate within breeding isolates and a simultaneous increase in the frequency of outbreeding. Consequently, this demographic alteration has been proposed to affect human stature by the genetic phenomenon, which was supported by a report of Hulse (1964). Environmental factors provide for better socioeconomic conditions and improved health status. Rural children have been reported to grow less than those in the urban areas (Wang, 2002a). Tanner (1968) has suggested a reduction of the family size as a significant environmental factor. Moreover, a small family size is likely to result in the improved living conditions, the increased food intake, and the decrease in the frequency of disease. All of these effects lead to a positive influence on general health, which can explain a more retarded PHV in the developing PHS children than those in other developed regions.

Table 2. Children's body height (cm) categorized by their nutrition conditions, gender, and age (years)

Normal nutrition										
Age	Girls			Boys			Mean difference	Standard error difference	t	*P* - value
	Mean ± SD	Min	Max	Mean ± SD	Min	Max				
10.0 – 10.9	139.29 ± 8.38	124.5	152.0	137.12 ± 9.25	120.0	160.0	2.170	1.848	1.175	0.243
11.0 – 11.9	142.30 ± 7.76	124.5	157.0	140.56 ± 8.74	127.0	163.0	1.742	1.380	1.262	0.209
12.0 – 12.9	147.17 ± 8.18	127.5	161.0	145.59 ± 7.36	132.0	166.5	1.589	1.087	1.462	0.145
13.0 – 13.9	151.10 ± 5.80	140.5	163.0	153.34 ± 8.72	133.0	175.0	-2.147	1.006	-2.135	0.034*
14.0 – 14.9	154.02 ± 4.91	143.0	165.0	160.29 ± 7.46	139.0	176.0	-6.274	0.890	-7.048	0.000*
15.0 – 15.9	155.43 ± 4.41	146.0	166.0	163.41 ± 5.79	151.0	177.0	-7.974	0.946	-8.426	0.000*

Undernutrition										
Age	Girls			Boys			Mean difference	Standard error difference	t	*P* - value
	Mean ± SD	Min	Max	Mean ± SD	Min	Max				
10.0 - 10.9	132.25 ± 6.01	128.0	136.5	131.50 ± 8.00	120.0	136.5	0.750	6.395	0.117	0.911
11.0 - 11.9	133.88 ± 3.71	130.0	138.5	133.31 ± 7.79	122.0	145.5	0.563	4.181	0.135	0.896
12.0 - 12.9	137.63 ± 3.15	134.0	140.5	134.38 ± 6.34	125.0	147.0	3.240	3.341	0.970	0.348
13.0 - 13.9	139.00 ± 4.06	136.0	143.0	142.14 ± 5.16	132.5	152.0	-3.143	2.564	-1.226	0.237
14.0 - 14.9	143.50 ± 2.65	140.0	147.0	146.58 ± 4.09	138.0	153.0	-3.077	1.991	-1.546	0.142
15.0 - 15.9	146.13 ± 1.44	144.5	148.0	152.17 ± 4.34	145.0	160.0	-6.042	2.272	-2.660	0.022*

* Difference between girls and boys for the respective age and nutritional condition significant at $P < 0.05$

Table 3. Factors influencing body height of the children in each age period

Age (years)	Source of variation	F-value	*P*-value
10.0 - 10.9	Gender Nutritional condition Interaction of gender and nutritonal condition	0.147 2.772 0.035	0.702 0.099 0.852
11.0 - 11.9	Gender Nutritional condition Interaction of gender and nutritonal condition	0.195 9.025 0.051	0.659 0.003* 0.821
12.0 - 12.9	Gender Nutritional condition Interaction of gender and nutritonal condition	1.138 21.573 0.145	0.287 0.000* 0.704
13.0 - 13.9	Gender Nutritional condition Interaction of gender and nutritonal condition	1.562 32.904 0.095	0.212 0.000* 0.758
14.0 - 14.9	Gender Nutritional condition Interaction of gender and nutritonal condition	7.357 49.394 0.860	0.007* 0.000* 0.355
15.0 - 15.9	Gender Nutritional condition Interaction of gender and nutritonal condition	19.907 42.772 0.378	0.000* 0.000* 0.540

* Significant difference at $P < 0.05$.

Table 4. Comparison of ages (years) of the children's onset of growth spurt and peak height velocity as reported in the previous (Jaruratanasirikul *et al.*, 1996) and in the present studies

Girls	Previous study	Present study	
		Normal nutritioned	Undernutritioned
Onset of growth spurt	10	10.68 + 0.34	13.52 + 0.22
Peak height velocity	10	12.50 + 0.31	14.52 + 0.22

Boys	Previous study	Present study	
		Normal nutritioned	Undernutritioned
Onset of growth spurt	11	11.44 + 0.30	12.28 + 0.26
Peak height velocity	13	14.49 + 0.30	13.38 + 0.24

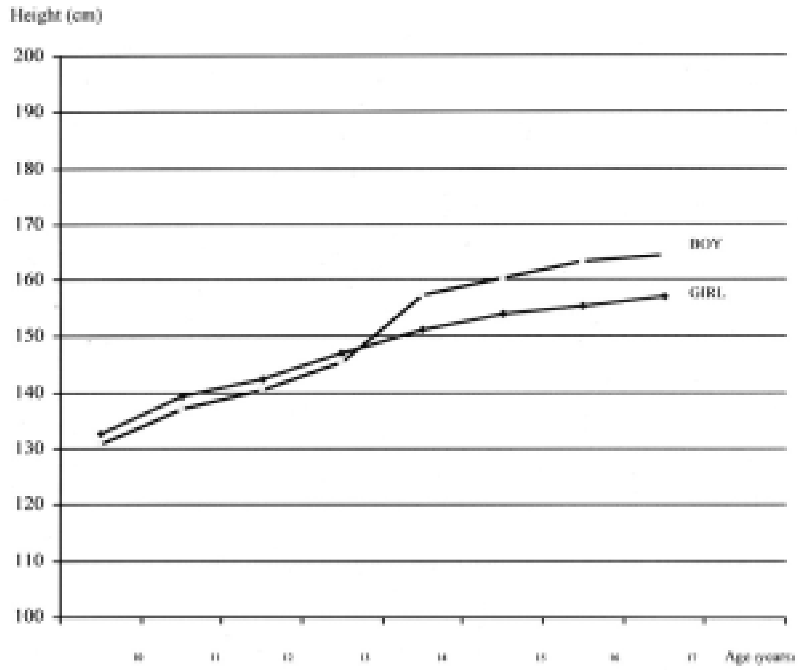

Figure 1. Height (cm) of normal nutritioned children in relation to their age (years)

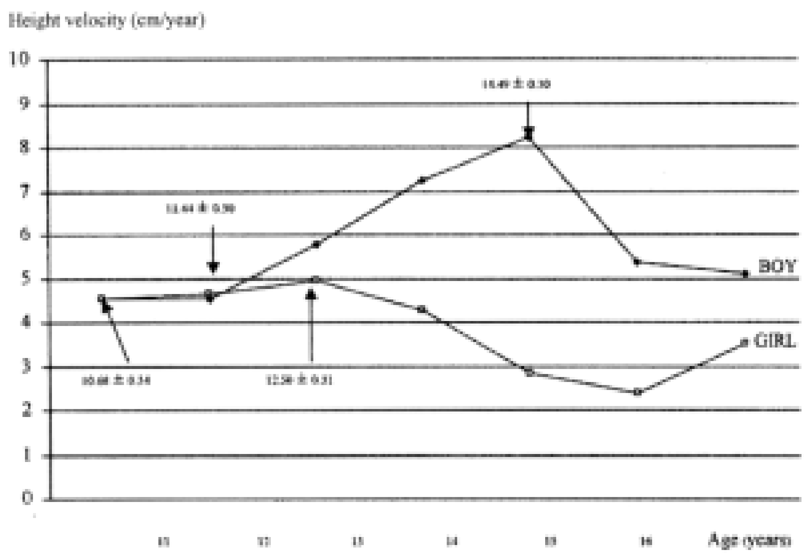

Figure 2. Height velocity (cm/year) of normal nutritioned children in relation to their age (year). Left and right arrows pointing upwards indicate girl's onset of growth spurt and peak height velocity, respectively. Left and right arrows pointing downwards represent boy's onset of growth spurt and peak height velocity, respectively.

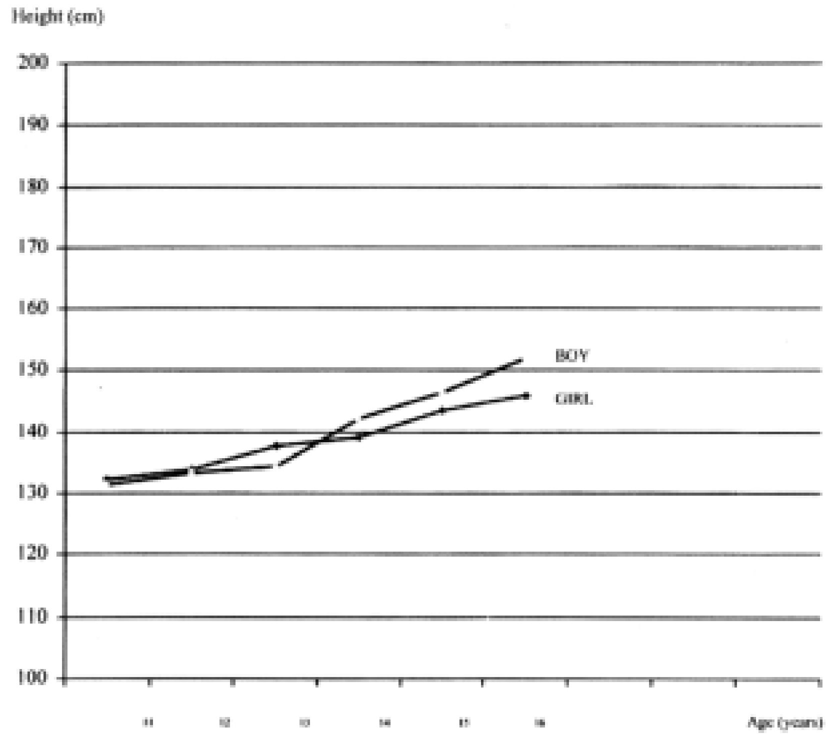

Figure 3. Height (cm) of undernutritioned children in relation to their age (year)

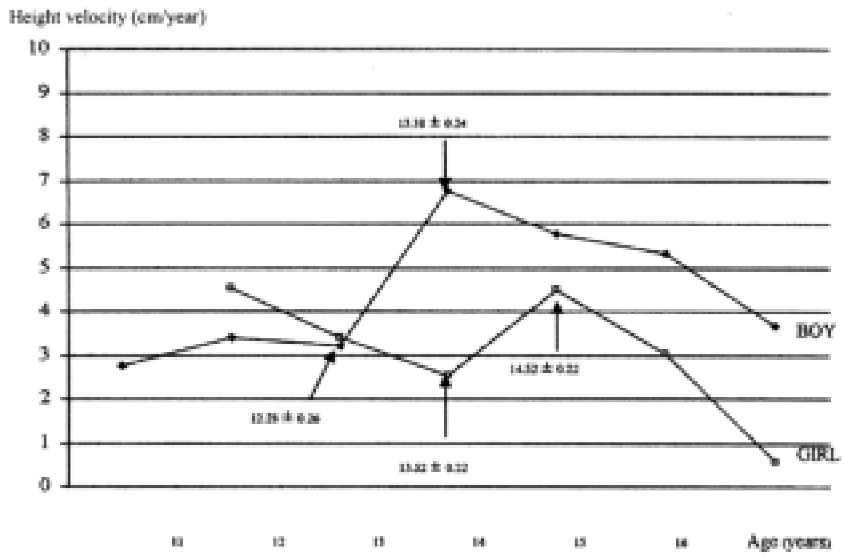

Figure 4. Height velocity (cm/year) of undernutritioned children in relation to their age (year). The two arrows pointing upwards on the left side indicate onset of growth spurt. The arrow pointing upwards on the right side indicates girl's peak height velocity, whereas that pointing downwards indicates boy's peak height velocity.

When compared with Hat-Yai children (Jaruratanasirikul *et al.*, 1996) as shown in Table 4, NN children in PHS possessed the same age of OGS, but older ages of PHV. However, UN children showed later periods of both OGS and PHV, in spite of a slight difference in PHV between Hat-Yai boys and those with an UN condition in PHS. Since OGS in children is partially resulted from socioeconomic and standard living situations (Takaishi, 1994), the similarities between those in the previous report and NN children in ours implied a comparably developed level of such situations between PHS and Hat-Yai people. However, the rest of our results have been differed from Hat-Yai children. The differences are likely explained by our increased measurement errors. The height measurements in ours were made by multiple teachers in a clinical setting, whose methods had not been calibrated. On the contrary, the height measurements of Hat-Yai children were performed by well-trained personnel in a research setting. Additionally, the nutritional conditions of the children residing in PHS province, particular the UN group, and in the city of Hat-Yai might play a considerable role that caused such differences. These explanations are supported by a review recently done by Karlberg (2002) in that the age of OGS is not related to PHV's age and that the nutrition in childhood stands out as the most significant factor for the timing of puberty, apart from the genetic factor.

Among several environmental factors, nutrition is the most frequently mentioned one and dietary intake interacts with other environmental factors. In addition, nutrition is part of a complex of factors and all of which are responsible for improved environmental circumstances in general (Malina, 1979; van Wieringen, 1986). However, undernutrition could be easily recognized among children in developing countries. Some researchers have reported that UN condition could be more commonly observed among boys than girls (Jacks *et al.*, 2002; Venkaiah *et al*., 2002), and our exploration correlated well with theirs, despite a fewer number of our investigated subjects. In the present study, UN girls possessed more retarded ages of both OGS and PHV than NN girls did. Nonetheless, this trend was not observed in boys. In comparison with those of NN boys, the age at OGS of UN boys was more retarded, but PHV was earlier. In other words, UN boys possessed a shorter period of growth before they reached their maximum growth. Although such trend in the UN boys was inexplicable, we surmised that an earlier age at PHV of UN boys might be related to their age and gender-related activity patterns.

Due to the fact that the data presented here are collected from a small number of girls and boys residing in PHS, the obtained results might not be able to reflect the real physical growth of all PHS children. Moreover, it is rather speculative to suggest that the growth characterization of Thai children with NN or UN condition might correspond with that shown in this study. However, the results pointed out an importance of the nutritional conditions in body height.

Conclusion

In the present study, the obtained results on ages at OGS and PHV for girls and boys in PHS followed the same trend as previously reported elsewhere, although the respective ages were more retarded. Among the NN children, girls presented OGS and PHV earlier than boys. Our study revealed that the OGS and PHV for UN girls, as well as the OGS for UN boys, were observable in later ages than those in the NN condition. However, the opposite results on the age at PHV were disclosed in boys. The data in this study may be valuable for children's health-related professionals to determine and provide an appropriate prevention and/or treatment.

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