Anthrop. Közl. *40;* 63–69. (1999)

PUBERTAL GROWTH AND MATURATION IN ATHLETIC BOYS

Júlia Pápai

Central School of Sports, Budapest, Hungary

Abstract: ***The author tested the effect of selection (and hard physical training) on the timing and magnitude of intense growth and the process of sexual maturation.*** *The aim of the present paper was (1) to estimate the timing and extent of peak growth velocity in three length measurements: body height, sitting height and iliospinale height; (2) to observe sexual maturation signs at the respective peak velocities of these dimensions; (3) to study the interrelations of somatic growth and its connections with maturation and (4) to study if events of sports differed in these. The subjects were 41 boys pursuing different sports events. They were followed up at least for five years from an initial age ranging between 10 and 13.*

Keywords: *Longitudinal study; Athletic boys; Body measurements; Peak growth velocity; Genital stages; Spermarche.*

Introduction

Besides the several cross-sectional growth studies, there are some longitudinal ones in Hungary that also include the adolescent period. Some of these only contain basic body measurements (Hegedüs and Székely 1968, Bakonyi et al. 1969, Rajkai 1970), while others may deal with body composition, somatotype, physiological parameters, physical performance and the process of maturation, etc. (Bodzsár 1980, 1986, 1988 Szöllősi 1982, Pápai and Szabó 1986, Bodzsár and Pápai 1989, Szöllősi and Jókay 1991, Eiben et al. 1992, Pápai et al. 1992, Szabó et al. 1992). Vargha and associates also determined percentiles for the growth velocity of height in the Budapest longitudinal study (1991). Sometimes they were planned to answer specific questions (eg. Buday and Kaposi 1994, Bodzsár 1996/97, Leffelholc et al. 1996/97).

In spite of its importance, very little attention has been devoted to the growth and biological development of athletic children (Pápai et al. 1991, 1994, Szabó et al. 1992). The potential effect of selection (and hard physical training) on the timing and magnitude of intense growth and the process of sexual maturation is one of the most interesting ones. This paper deals with some questions of pubertal growth and maturation in them.

The purposes were:

1. to estimate the timing and extent of peak growth velocity in three length measurements: body height, sitting height and iliospinale height;
2. to observe sexual maturation signs at the respective peak velocities of these dimensions;
3. to study the interrelations of somatic growth and its connections with maturation; and
4. to study if events of sports differed in these.

Material and methods

The subjects were 41 boys pursuing different sports events at Central School of Sports. They were followed up at least for five years from an initial age ranging between 10 and 13. The measurements were taken at half year intervals, in spring and autumn.

Special points of interest were the ages at maximum growth velocity, the amplitude of the peak and the size attained at the peak for the trunk and extremity components of height. Sexual maturation was described by Tanner's genital stages (1962) and the age of the first ejection, spermarche.

Maximum yearly increments, ages and lengths attained at these peaks were assessed graphically from the individual growth curves obtained by linear interpolation. Basic descriptive statistics and correlations only are presented.

Results and discussion

Table 1 shows the grand means for both somatic and maturation variables. We found the peak of the iliospinale height (ISH) to be the earliest one while peak velocity (PV) in sitting height (SH) was a later event, but of a similar amplitude. The age at peak height velocity (PHV) lay between those for limb and trunk lengths, but leg length (ISH) contributed more to peak height velocity.

For ISH we did not find direct reference, because the available studies referred to estimated leg length as the difference between height and sitting height. However, the PV timing of these three dimensions was the same and was comparable to other European reports (Tanner et al. 1976, Kemper et al. 1984, Beunen et al. 1988, Buckler 1990).

Table 1. Parameters of peak velocities of athletic boys (N=41).

	Height		Sitting height		Iliospinal height	
	Mean	SD	Mean	SD	Mean	SD
Age at Peak velocity (yr)	14.1	0.9	14.5	1.0	13.9	1.1
Peak velocity (cm/yr)	9.1	1.4	5.1	0.9	5.1	1.3
Size attained (cm)	162.9	5.8	85.6	3.4	92.1	5.1

Most boys were in genital stage 3 (G3) at the outset so only the ages when all the boys had entered stages 4 and 5 could be determined (Table 2). The first ejection indicates the functional maturation of the testicles and it occurs around entering G4. We did not find reports to compare our age data to in this respect. In this sample, spermarche occurred in the first third of G4, very close to PHV. The maximum increment in SH took place in the last third of G4.

Table 2. Parameters of maturity variables.

Critical ages	Mean	SD
Age at spermarche (yr)	14.2	0.8
Age at entering G4 (yr)	13.7	0.8
Age at entering G5 (yr)	14.9	0.9

G4–G5: genital stages of sexual development.

Tanner and associates (1976) also put maximum velocities of the lengths to the G4 stage. Recently Eiben and associates (1992) have reported longitudinal data on the Budapest boys. In their study the age at PHV was 13.5 yr and the median of maximum yearly increment was 7.5 cm. They found spermarche to occur at a median age of 13.3 when genital development was between stages 3 and 4. The succession of events in the Budapest study was therefore somewhat different from ours: our athletic boys developed these somatic and maturation signs later. At the same time, the data from a cross-sectional study of ours (Pápai et al. 1994) showed that the spermarche median of similarly athletic boys was quite close to the mean age observed in the present investigation and also coincided with that published on Hungarian average males (Eiben and Pantó 1984).

Table 3: Correlations between the parameters of peak velocity of the examined variables.

	Height	Sitting h.	Iliospinal h.
Height	———	0.81	0.85
Sitting height	0.60	———	0.77
Iliospinal height	0.56	0.43	———

Above the diagonal: The age at peak velocity (yr).
Below the diagonal: Peak velocity (cm/yr). $r_{39,\,5\%} = 0.30$

Table 3 contains the coefficients of the studied dimensions for the age and amplitude at PV. The ages at the respective velocity maxima showed close positive correlation. The three PV amplitudes were also interrelated although the coefficients were moderate (subdiagonal part of Table 3). In this way, this relationship was found to be a less strict rule.

Table 4. Correlations between the growth and maturity parameters.

Correlates	Height	Sitting h.	Iliospinal h.
Age at PV and PV	–0.46	–0.46	0.58
Age at PV and size at PV	–0.15	–0.02	0.18
Age at SP and age at PV	0.68	0.49	0.65
Age at G4 and age at PV	0.94	0.78	0.83

PV: Peak velocity (cm/yr) SP: Spermarche G: Genital stage $r_{39,\,5\%} = 0.30$

Table 4 demonstrates that age at peak velocity was negatively related to the extent of PV both for height and its components: the earlier the peak occurred, the higher its amplitude was. No relationship was found between the speed value attained at the peak and peak age. Tanner and co-workers (1976) also reported about a poor relationship in this respect.

The correlation between age at spermarche and that at PHV shows late maturers to experience PHV at a later age. The timing of spermarche and PHV is not so closely related as Tanner and associates (1976) found for the menarche and PHV of girls. The somatic correlates of the two maturation events might be different in the two genders in

the course of puberty. On the other hand, we found a quite close relationship between the timing of stage G4 and of the peaks. The morphogenetic and sexual effects of the sexual hormones, known to rise steeply after stage G3 (Winter 1978), appeared to dissociate less than the sexual ones proper, such as spermarche and G4.

Tables 5 through 7 present event-specific data for the groups with subject numbers above 5. Table 5 displays the ages at PHV. The timings were close to one another. The gymnasts were the only exception in that they had a late peak. The standard deviations were also comparable.

Table 5. Ages at PHV by sports events.

	Height		Sitting h.		Iliospinal h.	
	Mean	SD	Mean	SD	Mean	SD
Cycling (9)	13.9	1.2	14.8	1.2	13.7	1.2
Table-tennis (6)	14.0	0.9	14.4	0.9	13.9	0.9
M. pentathlon.(9)	14.1	0.9	14.2	0.9	14.1	0.9
Gymnastics (7)	14.9	0.8	15.5	0.7	14.7	1.0

As for leg length (ISH), the timings of the peaks for the events were similar to those of height. The cyclists only showed a rather early PV age for ISH and a relatively late one in SH. Gymnasts were the oldest in showing peak velocity in the height components. It is noted that spermarche occurred relatively the earliest in the cyclists and table-tennis players and the latest in the gymnasts.

Maximum yearly increments and SD's for height are shown in Table 6. The largest increment at the peak was found in the table-tennis players.

Values for the lower extremity (ISH) and SH displayed a similar sequence. Mean yearly gain at the peak of sitting height in the gymnasts was close to those of the other groups. Standard deviations showed that the cyclists were the most homogeneous group.

Table 6. Amplitudes of PV by sports events.

	Height		Sitting h.		Iliospinal h.	
	Mean	SD	Mean	SD	Mean	SD
Cycling (9)	9.2	1.2	4.5	0.6	5.2	0.7
Table-tennis (6)	10.7	1.8	5.8	0.6	5.6	2.2
M. pentathlon.(9)	8.5	1.4	5.1	1.1	5.2	1.4
Gymnastics (7)	8.2	1.1	4.9	0.9	4.3	0.8

Table 7 demonstrate the sizes (absolute length measurements) attained at the peak. There were remarkable differences between the groups. The pentathlonists were the tallest and the gymnasts the shortest at the age of PHV.

Cyclists with the earliest peak in leg length had the shortest lower extremity. While peaking relatively late in sitting height, their trunk was the longest. These data suggest that there were differences in both proportion and shape between the groups.

Two points are worth noting about this analysis. We observed that gymnasts experienced the latest peaks, the latest maturation and the smallest peak velocities. They have undergone selection not only concerning sport skills, but also for physique. Delayed growth both in the somatic characters and maturation is an advantage in this

sport. It was impossible to decide from these data whether this definitely late puberty was due to physical retardation, long-term physical work or both of them.

Table 7. Size attained at PHV by sports events.

	Height		Sitting h.		Iliospinal h.	
	Mean	SD	Mean	SD	Mean	SD
Cycling (9)	161.8	2.9	87.5	4.4	89.4	1.9
Table-tennis (6)	162.4	5.9	85.6	2.8	93.3	6.0
M. pentathlon.(9)	165.9	6.7	85.2	3.6	95.3	4.2
Gymnastics (7)	158.1	5.0	83.8	2.9	90.2	4.2

Our data also showed that for the other events the pressure for physical selection was less hard. However, it is noted again that the cyclists were the most homogenous group and experienced the earliest pubertal growth spurt in the lower extremity. One can but ask whether this early peak is related with the event, and if so, to what extent. Hard work restricted mainly to the lower limb may contribute to an earlier peak. Or else the fact that in this kind of work the legs do not bear the weight of the body may be of importance, too.

Conclusions

1. The timing of the peaks of adolescent growth spurt had a definite sequence in the three length measurements and they were positively interrelated.
2. The observed amplitude of the peaks was well comparable with the results of other studies, although we were aware of the fact that the methods used were different. This property of adolescent growth was the least influenced by the selection for a specific activity.
3. The signs of sexual maturation were also related. Spermarche occurred in the early phase of the G4 stage. All the peaks of the studied variables fell within this grade, too. The times of the peaks and maturation characteristics revealed that the stages of sexual development were in a closer connection with the longitudinal growth of the body than spermarche.
4. The question if sports have any specific effect on adolescent growth is hard to answer. There were certain differences between the groups of events in PV amplitude and timing as well as size at the peak. It is a problematic task to explain these minor differences, because individuals may vary markedly within the same group, further selection for event and physique could conceal the possible effects of long-term training.

*

A Magyar Biológiai Társaság Embertani Szakosztályának 324. szakülésén, 1999. december 13-án elhangzott előadás. *Közlésre beérkezett:* 1999. október 2-án.

References

Bakonyi F., Eiben O., Farkas Gy., Rajkai T. (1969): Tíz–tizenkilenc éves városi gyermekek növekedése az 1962–65. években végzett longitudinális vizsgálat alapján. – *Anthrop. Közl., 13;* 143–168.

Beunen, G.P., Malina, M.M., Van't Hof, M.A., Simons,.J., Ostyn, M., Renson, R., Van Gerven, D. (1988): *Adolescent Growth and Motor Performance – A Longitudinal Study of Belgian Boys.* – Human Kinetics: Champaign, Illinois. 102p.

Bodzsár, É.B. (1980): Physique and sexual maturation. – *Anthrop. Közl., 24;* 23–28.

Bodzsár, É.B. (1986): Age and sex variations of somatotype. – *Anthrop. Közl., 30;* 187–190.

Bodzsár, É.B. (1988): Changes in body composition in late childhood. – *Humanbiol. Budapest., 18;* 31–34.

Bodzsár, É.B. (1996/97): Sexual maturation, intelligence and self-assessment. – *Anthrop. Közl., 38;* 157–164.

Bodzsár, É.B., Pápai, J. (1989): Maturation and body composition. – *Humanbiol. Budapest., 19;* 215–218.

Buckler, J. (1990): *A Longitudinal Study of Adolescent Growth.* – Springer, London–Berlin–Heidelberg–New York–Paris–Tokyo–Hong Kong.

Buday, J., Kaposi, I. (1994): Body proportion and growth of mentally retarded boys – A longitudinal study. – *Humanbiol. Budapest., 25;* 435–440.

Eiben O.G., Farkas E., Körmendy I., Paksi A., Varga Teghze-Gerber Zs., Vargha, P. (1992): A budapesti longitudinális növekedésvizsgálat 1970–1988. (The Budapest Longitudinal Growth Study 1970–1988). – *Humanbiol. Budapest., 23.*

Hegedüs Gy., Székely A. (1968): A testi fejlődés dinamikus vizsgálatából leszűrt néhány törvényszerűség. – *Anthrop. Közl., 12;* 5–12.

Kemper, H.C.G., Storm–Van Essen, L., Van't Hof, M.A. (1984): Measurement of growth velocity and peak height velocity in teenagers. – in: Borms, J., Hauspie, R., Sand, A., Susanne, C., Hebbelinck, M. (Eds.): *Human Growth and Development.* – Plenum Publishing Corporation, New York–London. pp. 311–328.

Leffelholc, E., Bodzsár, É., Vedres, I. (1996/97): Some characters of somatopsychic status of children. – *Anthrop. Közl. 37;* 67–72.

Pápai, J., Bodzsár, É.B., Szabó, T. (1994): Mass fractions, somatotype and maturity status in athletic boys. – *Humanbiol. Budapest., 25;* 515–519.

Pápai, J., Szabó, T. (1986): The physique of urban girls. – *Anthrop. Közl., 30;* 221–225.

Pápai, J., Szabó, T., Szmodis, I. (1992): Age trends in the fractional body composition of athletic and non-athletic boys. – in: Szmodis, I., Szabó, T., Mészáros, J. (Eds.): *International Round-Table Conference on Sport Physiology.* MTE: Budapest. pp. 205–212.

Pápai, J., Szmodis, I., Bodzsár, É.B. (1992) Growth, maturation, and performance. – *Anthrop. Közl., 34;* 75–82.

Pápai, J., Szmodis, I., Szabó, T. (1991): The estimation of body composition by Drinkwater's method of fractionation in children – First observations. – in: Farkas, Gy. L. (Ed.): *Papers of the Scientific Session in Szeged (Hungary).* JATE–Univ. Ulm, Szeged–Ulm. pp. 215–224.

Rajkai T. (1970): Általános iskolás gyermekek növekedésének szakaszossága hosszmetszeti vizsgálat alapján. – *Anthrop. Közl.,* 26; 13–34.

Szabó, T., Pápai, J., Szmodis, I. (1991): The effect of intense physical training on some somatic indices and body composition. Two case histories. – in: Szmodis, I., Szabó, T., Mészáros, J. (Eds.): *International Round-Table Conference on Sport Physiology.* MTE: Budapest. pp. 213–226.

Szöllősi, E. (1982): Growth and development of pupils in Debrecen, based on a mixed-longitudinal study from their age of 13 to 18 years. – *Humanbiol. Budapest., 4;* 127–133.

Szöllősi, E., Jókay, M. (1991): Developmental rate in Debrecen girls from the age of 7 to 22 years. – *Anthrop. Közl.,* 33; 97–103.

Tanner, J.M. (1962): *Growth at Adolescence.* 2nd ed. – Blackwell, Oxford.

Tanner, J.M., Whitehouse, R.H., Marubini, E., Resele, L.F. (1976): The adolescent growth spurt of boys and girls of the Harpenden Growth Study. – *Ann. Hum. Biol.,* 3; 109–126.

Varga, P., Eiben, O.G., Farkas, M., Vargáné Teghze–Gerber, Zs.(1991): Percentiles of the human growth velocity, based on the "Budapest Longitudinal Growth Study". – *Anthrop. Közl., 33;* 81–86.

Winter, J.S.D. (1978): Prepubertal and pubertal endocrinology. – in: Falkner, F., Tanner, J.M. (Eds.): *Human Growth. Vol.2: Postnatal growth.* Plenum Press: New York–London. pp. 183–214.

Mailing address: Dr. Pápai Júlia
Central School of Sports
H–1146 Budapest, Istvánmezei u. 1–3.
Hungary