GENDER DIFFERENCES AND SECULAR TRENDS IN HEIGHT, PATTERN OF GROWTH AND MATURATION DURING PUBERTY

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Abstract: *The 'Körmend Growth Study' (KGS) was a series of cross-sectional anthropological surveys repeated in every 10 years in a small Hungarian town for more than 50 years. In this paper the authors are reporting data concerning a special period of children`s development, the puberty and pre-puberty period. Growth patterns of children (aged 3–18 years) were examined in 1958, 1968, 1978, 1988, 1998 and 2008 and were compared. Significant gender differences and secular trends were observed in the growth pattern of 9-15 year old children. Pubertal girls were temporarily taller than their male counterparts. Physical maturation appeared in an earlier age, and lasted for a shorter duration. This paper also focuses on changes in ages at menarche. In the frame of the KGS, data of age at menarche were collected with the "status quo" method, and was analyzed using probit analysis. In the first period of the study positive secular trends were observed in Körmend but by the end of the 20th century secular changes slowed down and reached stagnation.*

Key words*: Secular trend; Körmend Growth Study, Puberty, Growth patterns, Age at menarche.*

Introduction

Growth and maturation of children is a dynamic and complex biological process, influenced by genetic and environmental factors. Secular changes in growth of children, as well as in newborn babies, in young adults and also at the whole population level has already been described and analyzed. Secular trend is defined as long-term systematic changes in a wide variety of human biological traits, in successive generations, living in the same territory (Eiben 1988). It is considered as one of the most attractive human biological discoveries of the 20-21st century.

Several environmental factors influence the growth process of children. It has already been shown that if these factors are favourable (a) growth rate (height, weight and other body measurements) tends to be greater (b) age at puberty, menarche and oigarche is lower, (c)

puberty of girls, when they are temporarily higher than their male counterparts, appears earlier, and (d) the length of this period is shorter (Eiben 1988).

In this paper, the authors highlight and discuss these phenomena (differences in height, changes of the growth patterns, age at menarche) in the puberty and pre-puberty period of children development based on the Körmend Growth Study (KGS).

Materials and methods

Körmend is a small West-Hungarian town (in Central Europe). The KGS was started in the middle of the 1950s by professor Eiben. Dr. Ottó Eiben (1931-2004) was professor and chair at the Department of Anthropology at Eötvös Loránd University, and, after his retirement, a fellow at the Churchill College in Cambridge. He was considered as the most dominant figure in Hungarian human biology. The principal field of his scientific research activity was the growth and maturation of children and the secular trend. His favorite work was undoubtedly the KGS. The KGS was started in 1958 by Ottó Eiben, and thereafter he repeated his investigations in every ten years – K-58, K-68, K-78, K-88. In 1998 the study was carried out by Eiben and Tóth– K-98, and after Eiben's death KGS (K-008) was organized by Tóth (Eiben 2003, Eiben and Tóth 2000, 2005, Tóth et al. 2009).

The intention of KGS was to involve all healthy, 3-18 year-old boys and girls living in the town, i.e. all pre-schoolers and school children. The representation was usually well over 95%, except in the case of K-98 (76%), and in the case of K-008 (72%). Exercising their personality rights, several parents refused assisting the investigation in 1998 and in 2008. The last cross-sectional study (2008) has been carried out on 1563 children (757 girls and 806 boys) (Table 1). Decimal age of the subjects was calculated.

Table 1: Samples of the Körmend Growth Study (KGS)

Year of investigation	Study	Number of inhabitants in Körmend	Number of children investigated
1958	K-58	7500	1656
1968	K-68	10000	1736
1978	K-78	12000	2420
1988	K-88	12400	2867
1998	K-98	12200	2029
2008	K-008	12100	1563

The anthropometric program of the KGS was very extensive. Fifteen body measurements and 10 head and face measurements were taken in 1958 (K-58). In K-68 21 body measurements were taken, and during K-78, K-88, K-98 and K-008, on the basis of the same principle, 23 body measurements formed the anthropometric program.

The instruments used for these investigations were internationally standardized tools: GPM and Harpenden anthropometer, Holtain bicondylar vernier caliper, Lange skinfold caliper, steel tape measure and portable weighing machine.

Methods and techniques of the investigations were in accordance with internationally accepted standards described by Martin and Saller (1957). The recommendations of the

International Biological Programme, Human Adaptability section were also taken into consideration (Tanner et al. 1969). Age at menarche was collected from girls, using the „status quo" method and analyzed with probit analysis. A linear regression curve and a trend line were fitted onto the data to indicate tendency. With this method not only the direction, but also the speed of the change was illustrated.

Results and Discussion

The length of the transition period between pre-puberty and puberty, when girls were temporarily taller then their male counterparts, changed noticeably. In all investigation period the „quasi peak of growth spurt" appeared earlier in girls than in boys. This period, however, appeared earlier and became shorter over the decades of the KGS (Eiben 1988, 1994).

Table 2. shows the average height of 9-15 year-old Körmend boys and girls during the six investigation periods of the KGS. Changes in means during the study period show a positive secular trend. Values at the lower part of the table are framed where the girls are higher than the same-age boys. The length of this period is four years in K-58 (between 11 and 14 years of age), however, in K-98 it is only three years, and it appears between 10 and 12 years of age. Today (in K-008), it makes only two years, and it appears between 11 and 12 years of age. Based on the comparison of the results of „The Hungarian National Growth Study" (1983-1986) (Bodzsár and Zsákai 2008) and the (second) „National Representative Growth Studies" (Bodzsár and Zsákai 2007) it was concluded that during the last 20 years growth pattern of children has been changed (Eiben et al. 1991). KGS gave an opportunity for the verification and further refinement of this statement and enabled the investigation of this phemenon with higher temporal resolution than the earlier reported 20 years. For the statistical evaluation and comparison of body measurement data the Penrose distance definition was used. We have shown that the above mentioned changes in the growth pattern of children occurred at different time periods for girls and for boys; for girls it took place in the 1990s (K-98) (Fig.1.), whereas for boys it happened ten years later (K-008) (Fig. 2). These new findings are in good agreement with the results of earlier investigations, while they represent a significant step towards the understanding of gender differences in children development.

Age at menarche is presented in Figure 3. It has also changed over the previous decades. The age at menarche at the first study (K-58) was M=13.53 years. This represented the highest value among all of the other investigations which was carried out at that time and therefore it was higher than the result of the national-wide sample in 1959-61 (Bottyán et al. 1963). The age at menarche in Körmend had been decreasing during the first period of the study and by 1998 it became the lowest age at menarche that time in Hungary (M=12.75 years) (Eiben 2001). This was followed by stagnation, then by a reversal of the trend. These changes in children's growth pattern might reflect important temporal alterations of living conditions in the town. Körmend has formerly been a rural-like settlement featuring agriculture as a primary sector. Despite that fact, the purveyance was markedly poor in the decades of the socialistic regime. After the regime change the average income and the living standard started to increase notably, while the food market reached a never seen glut. Additionally, since the 1990's, people became more and more conscious concerning nutritional health and lifestyle. The changes involve a significant shift towards industrialization, too. Moreover, the population of Körmend had undergone certain changes affecting its relative genetic balance not only because of the inland migration of labour force observed between 1970–1980 (Eiben 2001), but, from the early 1990's on, by an *en masse*

Table 2: Height of the 9-15 year old Körmend boys and girls

| Age (year)	K-58	K-68	K-78	K-88	K-98	K-008
Boys						
9	128.62	131.18	132.87	134.50	135.4	136.4
10	134.20	137.29	139.10	138.76	139.2	142.5
11	135.60	141.20	142.46	143.98	145.5	146.4
12	143.76	145.26	148.26	149.92	151.9	154.1
13	148.81	152.07	155.21	157.95	159.3	159.3
14	153.00	156.85	162.91	165.07	168.3	167.1
15	161.62	164.04	166.76	170.23	173.4	170.3
Girls						
9	125.45	130.09	132.60	134.03	134.8	136.5
10	132.39	137.06	137.97	140.70	139.8	142.2
11	137.72	141.44	144.07	146.59	148.1	146.7
12	144.35	149.35	148.09	151.92	153.7	155.7
13	149.81	154.75	155.80	157.56	158.9	159.3
14	155.31	156.33	158.26	159.62	162.3	161.7
15	157.76	158.62	160.54	160.40	161.9	161.3
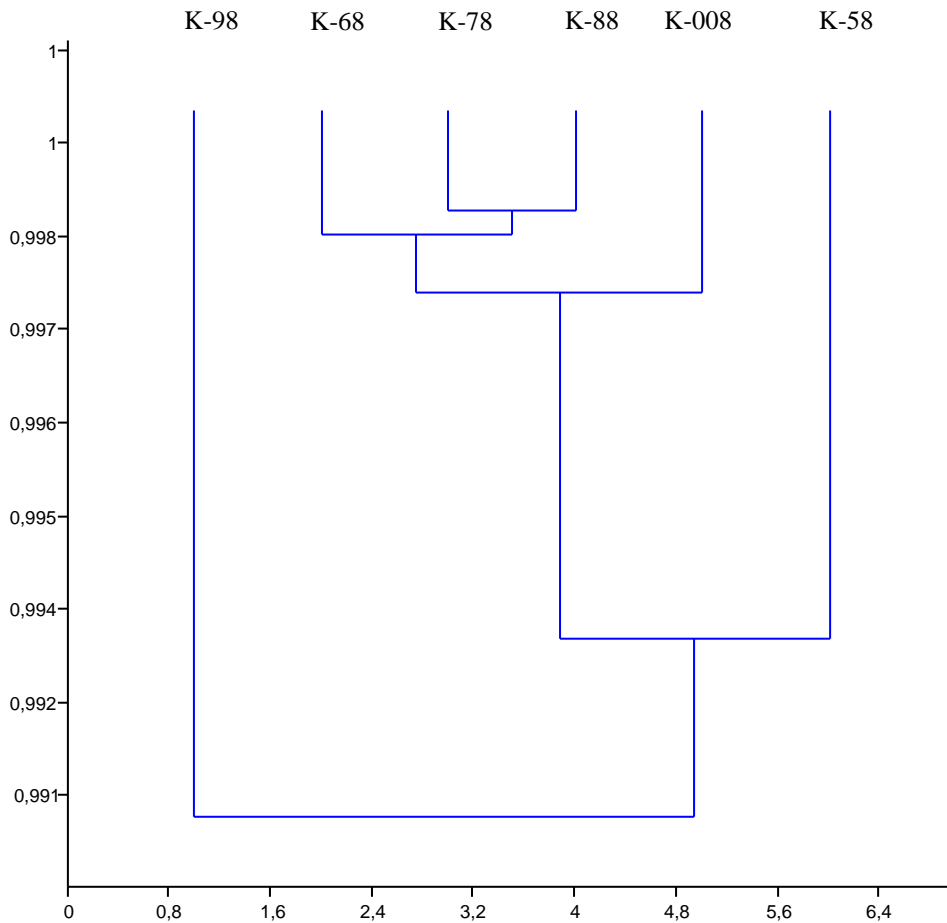
Fig. 1: The change of the growth patterns of the girls

transborder immigration of Hungarian speaking inhabitants mainly of Szekler origin. These socio-economic changes revealed both in a rapid quantitative and qualitative improvement in nutrition and a distinct shift in ethnogenetic constitution as well.
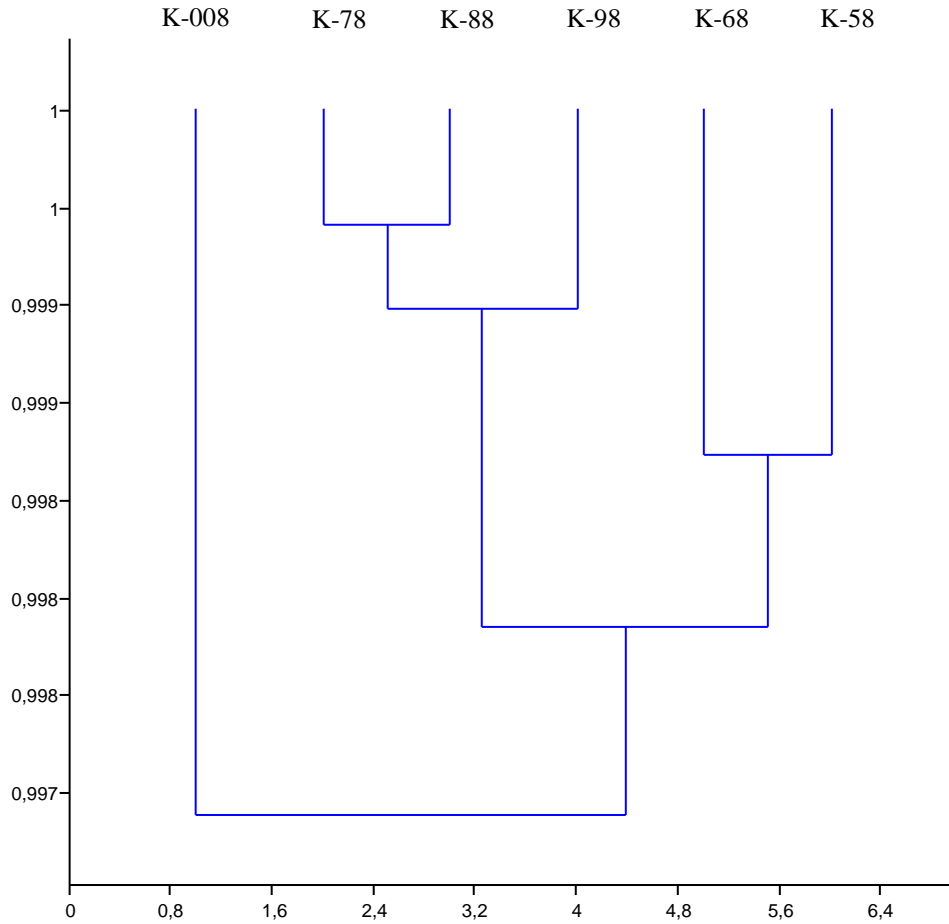

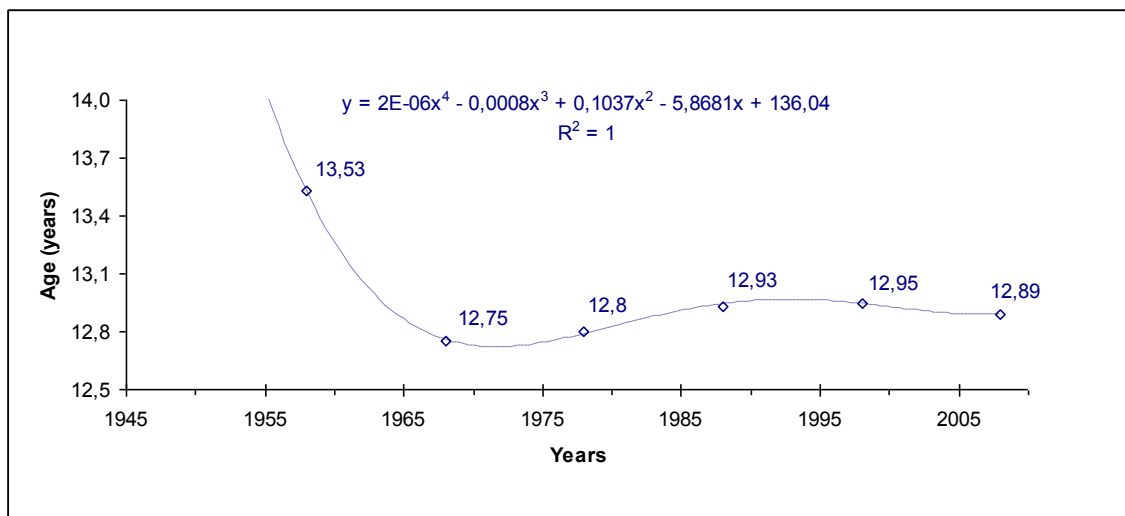Fig. 2: The change of the growth patterns of the boys

Fig. 3: Regression equations and trend lines for age at menarche in Körmend

It seems that in the time-frame of the KGS Körmend boys and girls gained access to their genetical growth and developmental potential. This is in accordance with general human biological trends observed in Hungary. A positive secular trend was observed in the growth pattern of Körmend children. The anthropometric data in the KGS documented the human biological effects of unreproducible, favourable social changes closely and with a very short delay.

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