THE KÖRMEND GROWTH STUDY: HISTORICAL BACKGROUND AND SECULAR TRENDS AMONG CHILDREN AGED 3-18 YEARS

Gábor A. Tóth[1], Csilla Suskovics[2], Péter Molnár[1], Henriette Dancs[2], Goran Sporis[3] and Zoran Milanovic[4]

[1] Institute of Biology, University of West Hungary, Szombathely, Hungary
[2] Faculty of Physical Education, University of West Hungary, Szombathely, Hungary
[3] Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia
[4] Faculty of Sport and Physical Education, University of Nis, Nis, Serbia

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Abstract

Körmend is a small town in West-Hungary, Europe. The Körmend Growth Study, launched in 1958 by Dr. Ottó Eiben and, from that time on, was repeated in every 10th year, was the first to demonstrate the existence of secular trends in growth and maturation of children. This repeated cross-sectional growth study proved to be a suitable tool to investigate several aspects of secular trends as well as differences between generations. The last survey, performed in the autumn of 2008, covered 27 body measures, monitored the maturation and the inheritance of body measures and, additionally, analyzed the link between growth and sleep disorders. In this paper the authors present an overview of the five decades of the Körmend Growth Study. Over this half-century, Körmend developed from an agricultural village into a moderately industrialized town. Its population increased, and its infrastructure improved remarkably. The growth characteristics of children also changed during this period. There were observable trends in the data, some of them evoked our concern. The physique of Körmend children became more linear but a bit fatter. Age at menarche also changed. These changes were mostly due to environmental factors covered by the concept of secular trend. Growth of Körmend children, characterized through body measurements, followed the changes of environmental factors in a fast and sensitive way.

Keywords: growth, maturation, secular trend, Körmend

Introduction

Growth and maturation of children is a dynamic and complex biological process, influenced by genetic and environmental factors. Children's growth pattern can change from time to time, therefore, it is necessary to investigate the somatic developmental status of the children repeatedly. The „Körmend Growth Study" (further on: KGS), a chain of repeated cross-sectional growth studies performed on children in the city of Körmend (Hungary) was one of the first realizations of this principle. Anthropological investigations have been performed in Körmend in every 10 years since 1958 in a systematic way. It is a widely accepted and scientifically proven theory that growth and maturation status of children is a fine indicator of the nutritional and health status of the population. In other words, information about growth and development of children and youth mirrors the biological status and/or welfare of a population (Taner, 1978; Taner, 1994; Eiben, 1998). Secular trend is one of the most attractive human biological discoveries of the 20-21 century. It is a world phenomenon: it is defined as long-term systematic changes in a wide variety of human biological traits, in successive generations, living in the same territory. Secular trend has already been investigated at different population levels such as in newborn babies, in growing children, in young adults or in the whole population (Eiben, 1988,1994). The KGS is a chain of repeated cross-sectional growth studies and so, it is a suitable tool to study several aspects of secular trend as well as differences between generations (Eiben, 2002).

The aim of the KGS (Eiben and Toth, 2000; Toth, 2005) was to perform systematic (using the same method) body measurements on children in Körmend and answer the following questions: 1. Have these body measurements changed over the last six decades? 2. If yes, how and in what direction? 3. What are the main factors explaining these changes? 4. Do these phenomena observed in Körmend correspond to the general trends, especially to the secular growth changes existing in Hungary? Growth and maturation of children is a dynamic process, influenced by genetic and environmental factors. It mirrors the biological status and/or welfare of a population. It should be mentioned that important changes happened in Hungary in the late 1980s: 1. The previous political structure collapsed. 2. Remarkable economic changes and general liberalization took place. 3. Cultural/mental changes commenced. (This last one was a long process.) All of these events had an influence on the growth and maturation process of the youth in Körmend a small city already in transition.

Material and methods

Place and subjects of the KGS. Körmend is a small West-Hungarian town. 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. In this aspect, his most significant contributions were the Hungarian National Growth Study (Eiben, Barabás, Pantó,1991), the Budapest Longitudinal Growth Study (Eiben, 1992) and the Körmend Growth Study (KGS) (Eiben, 2003). 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 organised by Tóth, Suskovics, Buda, (2009). The intention of the study 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) (see Table 1). Decimal age of the subjects was calculated.

Anthropometric measurements
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, Hiernaux, Jarman, 1969). The authors are experienced in these methods. Age at menarche was collected from girls, using the „status quo" method.

Statistical analysis
The statistical Package for Social Studies SPSS (v17.0., SPSS Inc., Chicago, IL) was used for statistical analysis. Statistical parameters such as means, standard deviations (SD), standard errors

(SE), and coefficients of variation (CV) were calculated. The ranges of variants (W) were also determined in each age-group giving the values of Vmin and Vmax. Age at menarche was collected from the 10-17 year-old girls, using the status quo method. Data to age at menarche were analyzed using probit analysis (Eiben and Toth, 2000; Suskovics, Tóth, 2009).

Results

Average height increased almost monotonously in all age-groups and in both sexes during the study period. A positive secular trend was observed, however, height differences between consecutive investigations were smaller in the last decades (Tables 2 and 3). It was encouraging to see the large mean height increase between K-58 and K-008 in several special age-groups. In the case of the 7 year-old boys (who just started the primary school) the mean height of 116.6 cm in K-58 increased to 128.9 cm in K-008. In girls, the same height measures were 117.5 and 124.3 cm, respectively. In the case of the 13 year-old pubertal boys, difference between K-58 and K-008 was almost 10 cm (149.6 and 159.3 cm, respectively). In the case of the same aged girls, the K-58 mean was 150.3 cm, whereas in K-008 it was 159.3 cm. The 18 year-old boys, the so-called "young adults" were 168.8 cm tall in K-58, and 175.9 cm in K-008.

Their female counterparts in K-58 had a mean stature of 161.5 cm, recently (K-008) 162.1 cm. By the way, the mentioned average height in the 18 year-old age group of K-008 were more or less equal with the estimated average stature of adult Hungarian men and women. In the case of body mass, our findings were similar to the observations concerning the height data, i.e. average weight increased monotonously in all age groups and in both sexes. These changes were parallel with the changes in stature (Tables 2 and 3). It is worth to highlight some important changes in weight in several special age groups. In 7 year-old boys, K-58 mean was 19.6 kg, in K-008 it was 23.1 kg. In girls, the correspondent means were 20.7 and 24.2 kg, respectively. The 13 year-old boys in K-58 weighted 38.0 kg, in K-008 this value was 49.5 kg. The girls' correspondent data were 39.1 and 47.4 kg, respectively. (Age at menarche in K-58 was m=13.53 year, in K-008 m=12.89 year [15].) In the 18 year-old groups, there were no large differences between the K-58 and K-008 weight data. Mean values in boys were 61.2 and 70.6 kg, in girls 52.4 and 59.2, respectively.

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

Table 2. Mean body height of boys and girls in the Körmend sample (Mean, *SD*, cm)

Age (years)	K-58 Mean	SD	K-68 Mean	SD	K-78 Mean	SD	K-88 Mean	SD	K-98 Mean	SD	K-008 Mean	SD
Boys												
3	94.0	4.0	99.0	3.3	97.0	3.0	99.6	3.9	98.0	3.4	98.4	4.0
4	100.4	5.0	100.8	6.6	102.3	4.0	104.2	6.0	104.9	3.4	104.8	5.4
5	107.1	6.4	109.6	5.1	109.0	4.4	110.7	6.8	111.0	5.0	112.5	4.7
6	112.4	5.2	116.5	9.2	115.5	5.0	118.0	5.4	118.0	5.0	119.4	5.7
7	116.6	4.9	120.6	4.7	121.0	5.4	123.8	6.3	123.3	6.4	128.9	14.0
8	122.7	5.2	125.9	5.0	126.3	5.8	128.8	5.9	129.6	6.0	132.6	11.1
9	129.0	6.7	131.1	6.1	133.3	6.4	134.5	5.8	135.4	6.9	136.4	6.3
10	134.3	7.4	136.7	6.3	138.3	6.5	139.0	6.4	139.2	6.9	142.5	7.9
11	135.6	6.7	141.5	7.7	142.7	5.9	144.1	6.6	145.5	8.0	146.4	5.8
12	143.5	7.5	146.5	6.7	148.3	7.0	149.8	7.9	151.9	7.6	154.1	7.5
13	149.6	6.8	152.0	7.3	155.6	8.4	158.0	8.6	159.3	8.8	159.3	8.8
14	152.9	8.9	156.7	8.2	162.2	8.2	165.2	8.6	168.3	8.3	167.1	9.1
15	161.3	8.3	164.3	8.9	166.9	8.1	170.2	8.9	173.4	7.8	170.3	11.6
16	165.1	6.4	167.8	7.1	170.7	6.6	173.0	7.2	175.5	7.6	176.3	9.0
17	166.5	7.1	171.3	6.6	172.3	5.8	176.0	6.8	176.0	6.9	180.0	9.5
18	168.8	9.8	171.8	7.1	172.7	6.3	176.5	9.2	176.3	8.5	175.9	9.7
Girls												
3	94.4	6.9	94.6	3.9	96.8	3.6	97.4	3.6	98.3	4.5	98.8	5.0
4	101.4	4.4	103.3	4.2	101.8	5.3	105.2	3.7	102.9	4.7	104.7	4.9
5	105.2	3.2	109.4	5.4	108.9	4.8	110.2	5.1	108.5	5.5	109.7	4.1
6	113.9	4.6	114.3	5.5	114.6	4.8	117.8	5.3	115.6	4.2	117.7	6.9
7	117.5	5.4	121.9	5.7	120.7	5.3	123.1	5.7	122.6	5.1	124.3	4.9
8	120.9	5.5	126.7	5.6	126.2	5.8	127.8	6.3	127.4	6.2	129.5	6.6
9	126.0	8.3	130.5	5.9	132.5	6.9	133.8	6.5	134.8	7.0	136.5	8.4
10	132.5	6.5	137.1	6.6	137.3	6.8	140.7	7.0	139.6	6.4	142.2	8.0
11	137.8	9.6	141.5	6.3	144.3	5.4	147.1	7.4	148.1	7.2	146.7	6.8
12	144.1	7.8	149.8	6.7	148.7	6.3	152.0	7.6	153.7	7.4	155.7	6.9
13	150.3	6.6	154.3	6.8	155.9	6.4	157.5	6.8	156.9	7.1	159.3	6.6
14	155.4	6.0	156.5	4.9	158.2	5.8	159.3	7.6	161.3	5.9	161.7	7.0
15	157.5	5.0	158.6	5.0	160.5	6.3	160.4	6.3	161.9	7.4	161.3	5.6
16	158.1	5.6	160.1	6.3	160.7	5.0	161.5	6.5	162.0	6.8	161.7	7.4
17	161.4	4.9	160.2	9.0	161.0	5.3	161.6	6.2	162.2	6.4	163.5	7.6
18	161.5	7.2	160.6	5.3	161.9	5.2	161.7	6.9	163.6	5.7	162.1	5.2

Table 3. Mean body weight of boys and girls in the Körmend sample (Mean, *SD*, kg)

Age (years)	K-58 Mean	SD	K-68 Mean	SD	K-78 Mean	SD	K-88 Mean	SD	K-98 Mean	SD	K-008 Mean	SD
Boys												
3	14.6	1.1	15.1	2.1	14.5	1.4	15.1	1.3	16.0	1.9	13.5	1.5
4	16.8	1.7	15.9	2.0	15.9	1.6	16.8	2.0	16.6	2.4	15.9	2.0
5	18.2	2.1	18.2	2.4	17.4	3.0	18.9	2.1	18.4	2.5	18.3	2.6
6	19.1	2.4	21.2	5.4	19.6	3.4	21.3	2.8	20.9	2.5	21.6	4.5
7	19.6	2.7	21.7	2.3	22.7	4.5	23.2	3.6	23.6	3.8	23.1	3.8
8	23.5	3.7	24.3	3.3	25.5	6.1	27.2	4.6	25.9	3.9	27.3	7.5
9	25.2	3.4	26.3	3.6	28.8	6.4	29.6	5.3	29.1	5.9	31.7	8.2
10	28.8	5.6	29.1	4.1	31.6	7.1	32.3	6.5	31.7	6.0	34.8	8.2
11	30.1	4.4	32.8	5.5	34.7	10.1	38.6	6.3	35.6	7.9	37.7	8.4
12	33.9	5.8	35.6	5.6	39.2	10.9.	41.3	9.0	39.8	8.7	44.3	11.9
13	38.0	5.5	39.5	6.4	43.3	10.2	46.6	10.4	45.4	9.5	49.5	14.0
14	41.1	8.8	44.8	7.7	50.5	7.4	57.4	10.3	52.2	9.6	56.2	15.4
15	50.2	8.9	50.9	7.9	54.1	12.9	60.7	8.8	57.1	11.1	60.0	14.8
16	54.4	7.6	56.4	9.4	59.3	10.3	60.6	8.8	62.1	10.6	71.3	17.9
17	56.5	7.9	60.2	7.5	59.6	12.5	65.9	7.7	65.5	9.4	74.7	19.7
18	61.2	9.8	60.6	4.6	63.6	10.2	66.2	8.1	65.6	11.2	70.6	16.4
Girls												
3	14.5	1.6	14.2	2.6	14.5	1.5	14.7	1.7	14.1	1.5	14.1	2.2
4	16.2	1.8	16.6	2.3	15.4	2.2	16.4	2.1	16.5	2.1	16.3	3.9
5	17.6	2.1	17.2	2.2	17.8	3.0	18.0	2.7	18.4	3.2	17.7	2.8
6	20.6	3.0	20.4	2.3	19.2	3.4	20.3	2.9	20.7	3.2	21.0	5.3
7	20.7	3.1	22.0	2.5	22.4	4.8	22.9	3.8	23.0	3.4	24.2	6.3
8	21.8	3.7	24.1	2.9	24.7	5.4	25.6	4.2	25.1	4.3	25.8	6.7
9	26.2	6.0	26.7	5.4	28.5	5.4	29.6	5.2	28.2	5.5	30.9	7.4
10	29.2	4.4	31.2	4.9	30.7	7.3	32.0	4.9	33.0	7.0	34.9	8.0
11	31.3	5.2	34.0	7.3	35.1	8.1	38.7	7.0	37.7	8.1	37.6	8.5
12	35.5	7.6	39.4	7.3	40.4	8.9	42.2	8.7	42.2	9.5	46.5	11.1
13	39.1	5.5	43.9	7.4	44.8	8.5	46.2	8.1	46.6	9.2	47.4	9.8
14	45.0	7.1	47.5	6.5	48.6	9.2	52.4	8.7	50.1	9.2	51.3	9.9
15	49.2	6.4	51.7	8.0	50.8	8.8	52.7	8.2	52.7	12.1	54.5	11.8
16	49.2	5.3	52.5	7.5	51.7	8.1	53.2	7.0	53.8	8.4	56.0	10.3
17	52.0	6.2	52.7	7.3	54.0	9.4	53.6	9.2	53.9	6.3	57.0	13.7
18	52.4	10.6	55.4	6.1	55.0	9.0	56.1	6.2	54.5	10.9	59.2	18.0

Discussion

Eiben has published several papers about the KGS. He has summarized the results of the first three-four investigations in a small monograph (Eiben, 1998), which contained a complete list of the earlier papers published about the KGS. Eiben has published a monograph about the KGS (Eiben, 2003). In this monograph he described all economic and social changes which influenced Körmend children's mode of life and somatic development. Health care system, nutritional conditions and communal supply have been improved remarkably. Schools and flats have been modernized, interpersonal relations have improved, too. Physical activity of boys and girls has changed as well. A slight shift in social stratification could also be observed. The population's relative genetic balance has somewhat altered, especially as an effect of migration in the last two decades. In this paper the authors present data related only to the height and weight distributions of youth in Körmend and highlight some important changes demonstrating the effect of environmental factors on the growth of Körmend youth. Both in height and weight, a positive secular trend was observed. The physique of Körmend boys and girls became more linear but a little bit fatter during the study period. Recording of the values of biceps, triceps, subscapular, suprailiac, abdominal and calf skinfolds and the bicondylus parameters became part of the anthropometric schedule from 1968 on. Distinctive skinfold values were observed at different phases of the children's growth. Differences in early childhood skinfold measures – especially in the truncal region – increased with age and developed as a highly characteristic indicator of gender dimorphism by the prepubertal-pubertal age. The observed increase in truncal skinfold values denoted an unfavorable tendency. Secular changes in skinfold measure were, in certain extent, due to the alterations of nutritional conditions and physical activity. Bone maturity values reflected the accelerative changes but not the secular trend. The lack of physical activity and the nutritional lapses were the major causes of this phenomenon (Suskovics, Tóth, 2011). During the five decades of the KGS data collection period remarkable changes took place in Körmend, this small West-Hungarian town. Urbanization was accomplished: an agricultural village developed to an industrialized town. Population genetic structure of the settlement changed through migration. The population increased and social regrouping took place. Medical care improved, it increased with 100-150 per cent. Degree of communal services improved. Household supply with electricity, water and gas became 100 per cent by today. Living conditions, flats and schools have been modernized. Interpersonal connections also changed in schools: instead of teachers with college qualifications, teachers with university degrees work in the schools. Physical activity and nutrition changed booth in quality and quantity. All of these changes were likely manifested in the (theoretical already given) growth pattern in Körmend youth.

Differences in early childhood skinfold measures – especially in the truncal region – increased with age and developed to be highly characteristic indicators of gender dimorphism by the prepubertal-pubertal age. Increased truncal skinfold values between study periods denoted an unfavorable tendency. Secular changes in skinfold measure were, in certain extent, due to the alterations of nutritional conditions and physical activity (Tóth, Suskovics, 2010). A positive/negative secular trend seemed to be manifested both in Körmend girls and boys. The anthropometric data of the KGS documented many human biological effects of irreproducible social events and/or changes exactly and in a very quick and sensitive way (Eiben, Tóth, 2005).

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KÖRMEND STUDIJA RASTA: POVIJESNA POZADINA I SEKULARNI TRENDOVI DJECE UZRASTA 3-18 GODINA

Sažetak

Körmend je gradić u Zapadnoj Mađarskoj – Europa. Körmend studija rasta, započeta 1958 od dr.Ottó Eibena, i od tog vremena ponavljana svaku 10-u godinu, zamišljena je da prikaže postojanje sekularnih trendova u rastu i sazrijevanju djece. Ova ponavljana međusekcijska strudija rasta pokazala se prikladan alat za istraživanje više aspekata sekularnih trendova kao i razlika između generacija. Zadnja anketa, provedena u jesen 2008 pokrila je 27 tjelesnih mjera, pratila sazrijevanje i nasljeđivanje tjelesnih mjera, i dodatno, analizirala poveznice između rasta i poremećaja sna. U ovom članku autori predstavljaju pregled 5 desetljeća Körmend studije rasta. Kroz ovih pola stoljeća, Körmend se razvio od agrikulturnog sela u umjereno industrijalizirani grad Populacija mu je narasla, a infrastruktura izvanredno napredovala. Karakteristike rasta djece također su se promijenile kroz ovo razdoblje. Primjetni su trendovi podataka, a neki upozoravaju na zabrinutost. Tjelesna građa djece Körmenda prati se sve više linearno ali su djeca deblja. Također se promijenila i pojava menarchae. Ove promjene uglavnom su uzrokovane okolišnim faktorima iskazane u sekularnim trendovima. Rast djece Körmenda opisane tjelesnim mjerama, prate promjene okolišnih faktora na ubrzani i osjetljiv način.
fast and sensitive way.

Ključne riječi*: rast, sazrijevanje, sekularni trend, Körmend*