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SECULAR CHANGES IN HEIGHT, BODY WEIGHT, BODY MASS INDEX AND PUBERTAL DEVELOPMENT IN MALE CHILDREN AND ADOLESCENTS IN KRAKOW, POLAND

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Summary. This study examined the secular changes in height, body weight, body mass index and pubertal development in male children and adolescents in Krakow (Poland) over the past 80 years, with an emphasis on the last decade (2000–2010). The survey of the population of Krakow is a continuation of observations conducted in that area for many years. The analysis aims to determine whether in the last decade Krakow still witnessed the secular trend, and what form the trend took. The body height and weight, and body mass index (BMI), of 1862 boys aged 3.5–18.5 years were analysed, against the background of a survey series from the years 1938 ($N = 1801$), 1971 ($N = 2045$), 1983 ($N = 3124$) and 2000 ($N = 2328$). The mean body height, in almost all age categories, was greater than in the past; however the final height over the last decade remained the same. The mean values of body weight and BMI increased, especially in the last decade. Also, an acceleration of puberty in boys was observed. The last 10 years saw an over 3-month decrease in the age of initial appearance of pubic hair in boys. In conclusion, the last decade saw cessation of the growing taller trend: maximum body height stabilized at approximately 179 cm, but weight and BMI increased. Also, a distinct acceleration of puberty was noticed. Lack of height increase, at the same time as weight gain and puberty acceleration, indicate a progressing developmental disharmony.

Introduction

The occurrence of secular trends is one of the best documented phenomena of human variation, although it is not fully explained from the point of view of its determinants. A tendency for inter-generational changes is especially noticeable in the processes of human growth and development, and morphological evolution. In consecutive decades people grew taller and taller, and entered puberty earlier. This positive trend was mainly associated with a broadly understood progress of civilisation, to which – among others – the following can be included: improvement in socioeconomic status, change in diet and

nutrition and considerable medical developments, which translate into better medical care and better hygienic and sanitary conditions. Observations of the way and pace of inter-generational transformations are, in this context, of special significance for the assessment of the effect of the socioeconomic factors described above. To put it simply, the acceleration of development and growth in children can be treated as an indicator of good general development of society. These issues are still relevant today and require further study, because in many populations such trends are still noticeable.

A further positive secular trend has been observed in many countries (Zellner *et al.*, 2007; Papadimitriou *et al.*, 2009; Cardoso & Caninas, 2010). The tendency for maximum growth spurt in body height has been, for some time now, slowed in the countries of northern Europe, in Italy (Danubio & Sanna, 2008), Japan (Kurokawa *et al.*, 2008) and also in some regions of Poland (Krawczyński *et al.*, 2003; Kaczanowski *et al.*, 2005; Sitek *et al.*, 2007). Apart from the trends in body dimensions, some trends in pubertal development have also been noticed, which – as in the case of body size – are not uniform; acceleration is seen in some population groups, while in others deceleration can be observed. Krakow in Poland can boast one of the best studies on the determination of secular trends. The latest survey of children and adolescents in the Krakow population is a continuation of observations that have been conducted in that area for almost a hundred years, and their analysis aims at determining whether in the last decade Krakow still witnessed that secular trend.

Methods

Data collected during a survey conducted by a team of academic researchers of the Department of Anthropology at the University School of Physical Education in Krakow, Poland, between 2007 and 2010, were used for the analysis. The above survey was part of a project financed by the Polish Council for Science and Technology, and was carried out with the permission of the Bioethics Council (26/KBL/OIL/2007) and with the consent of the children's parents or legal guardians.

The schools and kindergartens in the area of Krakow, where the measurements were taken, were selected at random. This paper presents the analysis of the body height and weight and BMI of 1862 boys aged between 3.5 and 18.5 years, against the background of a survey series from the years 1938 ($N = 1801$; Jasicki, 1938), 1971 ($N = 2045$; Gołąb, 1979), 1983 ($N = 3124$; Chrzanowska *et al.*, 1988) and 2000 ($N = 2328$; Chrzanowska *et al.* 2002). The age brackets were made taking into consideration the year of birth, e.g. the group of 3.5-year-olds included boys aged 3.00–3.99. The mean values of analysed characteristics are shown in Table 1. The mean age of Tanner Stage 2 for pubic hair was calculated by probit analysis, for all series of study (Tanner, 1963). Student's *t*-test was employed to assess the significance of differences in the selected traits in the last decade (2000–2010).

Results

According to the latest survey in the Krakow area, the mean body height in boys, in almost all age categories, was greater than in the case of their peers measured in 1938, 1971, 1983 and 2000 (Fig. 1). The mean body height of boys aged 3.5–18.5 was greater

Table 1. Means and standard deviation of body height, body weight and BMI in the last series of study (2010)

		Body height (cm)		Body weight (kg)		BMI (kg m^{-2})	
Age (years)	*N*	Mean	SD	Mean	SD	Mean	SD
3.5	61	101.9	3.9	17.0	2.6	16.4	1.9
4.5	127	108.1	5.0	18.5	2.5	15.8	1.4
5.5	128	113.7	4.6	20.4	3.0	15.7	1.6
6.5	134	120.7	5.2	24.0	4.3	16.4	2.1
7.5	137	127.7	6.2	27.0	5.6	16.4	2.4
8.5	126	133.8	6.5	31.5	7.3	17.5	2.8
9.5	113	138.6	6.2	35.3	8.5	18.3	3.5
10.5	91	142.9	6.9	37.3	12.2	18.0	4.2
11.5	81	148.9	6.1	40.9	8.1	18.3	2.9
12.5	64	157.0	8.6	44.8	10.4	18.0	3.0
13.5	183	164.7	8.6	56.3	12.3	20.6	3.5
14.5	198	170.1	8.2	61.4	14.9	21.1	4.3
15.5	153	174.2	6.8	64.5	11.4	21.2	3.3
16.5	106	175.9	6.9	68.7	13.6	22.0	4.9
17.5	77	177.8	5.8	69.5	11.8	22.0	3.5
18.5	83	178.7	6.6	71.2	11.3	22.5	3.3

by 0.79 cm, as compared with a group of boys in the same age bracket examined in 2000 (Tables 2 and 3). However, that difference did not maintain at an equal level in individual age categories. Nowadays, boys from the youngest groups are even slightly smaller than their peers from a previous decade. A clear difference can be seen in later years: the boys aged 8.5–9.5 years from the latest series of measurements were statistically significantly taller than their peers measured in 2000, and the boys aged 12.5–17.5 were also taller than their peers from a previous decade (at the age of 12.5–14.5 those differences were statistically significant). If it is assumed that body height at the age of 18.5 has reached its maximum value, then the boys measured in the last survey were almost identical in height as their peers from a previous decade. Secular changes in the body height of the subjects aged 7.5–18.5, counted per decade, presented themselves in the following way: between 1938 and 1971 body height increased on average by 1.94 cm/decade; from 1971 to 1983 it was smaller and equalled 0.70 cm/decade; whereas between 1983 and 2000 a sharp increase in the mean body height by 1.71 cm/decade was observed again, and it was still noticeable from 2000 to 2010, and equalled 1.05 cm/decade (Table 3). However, in the youngest age groups (3.5–6.5 years) the maximum growth in height was rather small in the last decade (Table 2).

On average, the body weight of boys aged 3.5–18.5 years, measured in 2010, was greater by 1.78 kg than that of their peers from a decade ago. Similarly, as in the case of body height in individual age categories, those differences looked different. Only the boys aged 4.5 and 5.5, examined during the latest survey (2010), were slightly heavier than those examined a decade ago. In all the remaining age categories that difference was always 'in favour' of the present day. The biggest differences were noticed in the subjects at the age of 8.5 (statistically significant difference) and 9.5. In the following

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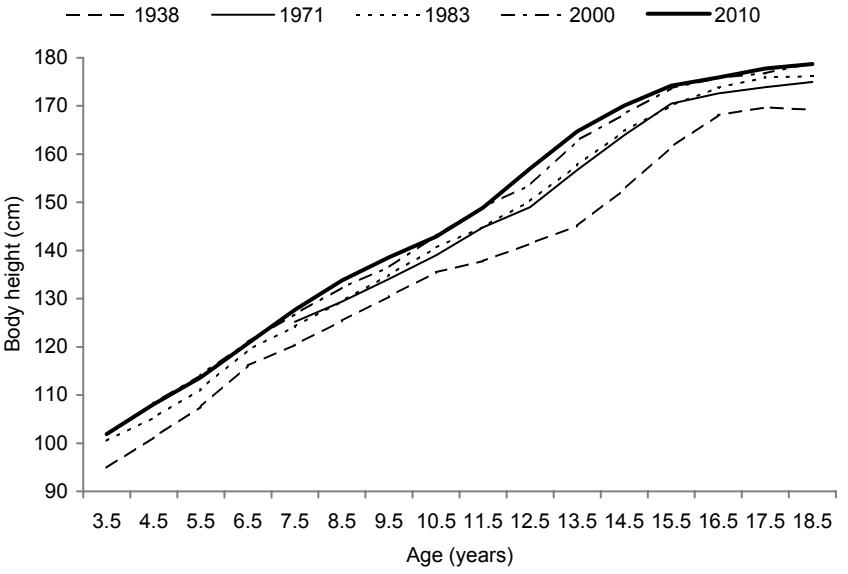

Fig. 1. Secular changes of body height in boys.

years that difference was slightly smaller, and from the age of 13.5 it rose abruptly. The subjects aged 13.5–16.5 examined in 2010 were statistically significantly heavier than their peers measured in 2000. The greatest body weight difference was at the age of 14.5 and it reached as much as 6.67 kg. At an early age (3.5–6.5 years) the body weights of the boys examined in 2010, 2000 and 1983 were almost identical (Fig. 2, Table 3). Only at the age of 7.5 was a gradual increase in differences noticed, and it reached its maximum value after the 12th year of life. The problem of weight gain counted per decade was puzzling; in the case of the subjects aged 7.5–18.5 it equalled 1.14 kg/decade between 1938 and 1971, then from 1971 to 1983 it grew slightly to 1.54 kg/decade, and between 1983 and 2000 it dropped slightly to 1.31 kg/decade, whereas the difference in body weight between the latest examinations in 2010 and the measurements from 2000 went up to 2.35 kg/decade, the greatest increase since anthropological measurements began in the Krakow area.

Table 2. Secular changes per decade between analysed series of study in boys aged 3.5–6.5

	Series of study			
	1938–1971	1971–1983	1983–2000	2000–2010
Body height (cm)	—	—	1.35	0.03
Body weight (kg)	—	—	0.01	0.08
BMI (kg m^{-2})	—	—	–0.44	0.14

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Table 3. Secular changes per decade between analysed series of study in boys aged 7.5–18.5

	Series of study			
	1938–1971	1971–1983	1983–2000	2000–2010
Body height (cm)	1.94	0.70	1.71	0.79
Body weight (kg)	1.14	1.54	1.31	1.78
BMI (kg m^{-2})	—	0.57	0.14	0.49

The mean BMI increased in boys (3.5–18.5 years) by 0.49 kg m^{-2} in the last decade. As in the case of body weight in the males aged 4.5–5.5 years examined in 2010, a smaller BMI was observed in comparison with that of their peers as measured in 2000. The boys measured in 2010 had a smaller BMI at the age of 7.5 and 12.5, but it resulted from a substantial body height increase in those years, and not from body weight loss. Statistically significant differences 'in favour' of the boys measured in 2010 were noticed at the age of 8.5 and then between 13.5 and 16.5, and at 18.5 years of age (in that case BMI was greater by 0.96 kg m^{-2}). From the age of 12.5, the boys from the last measurements were the heaviest as compared with all previous series of surveys in Krakow (Fig. 3). In the younger age categories (3.5–6.5 years) BMI was similar to that observed in the boys in 2000 and 1983 (Table 3). A distinct increase in BMI per decade was seen between 1971 and 1983; from 1983 to 2000 it was small and equalled 0.14 kg m^{-2}, whereas in the last decade its value went up sharply to 0.61 kg m^{-2}.

Puberty acceleration in boys was assessed on the basis of the second stage of pubic hair growth. From 1971 that stage of the development of pubic hair systematically

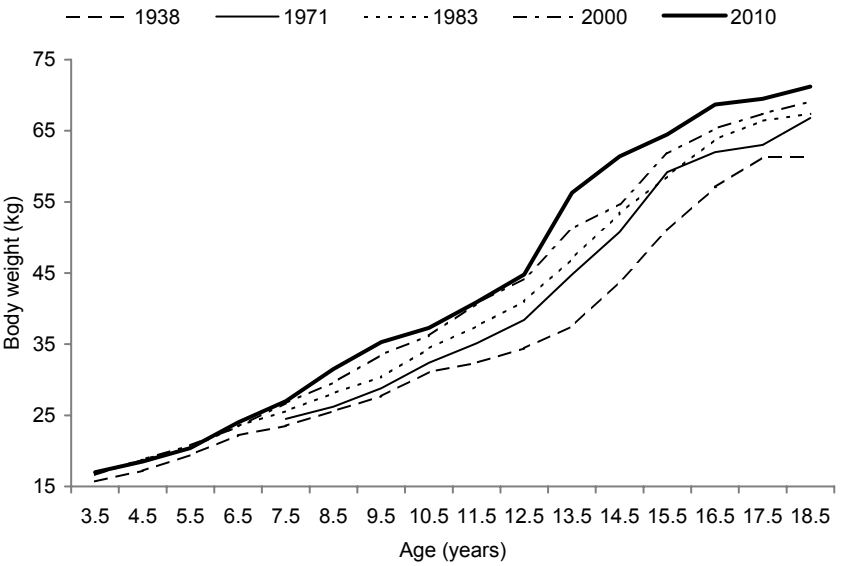

Fig. 2. Secular changes of body weight in boys.

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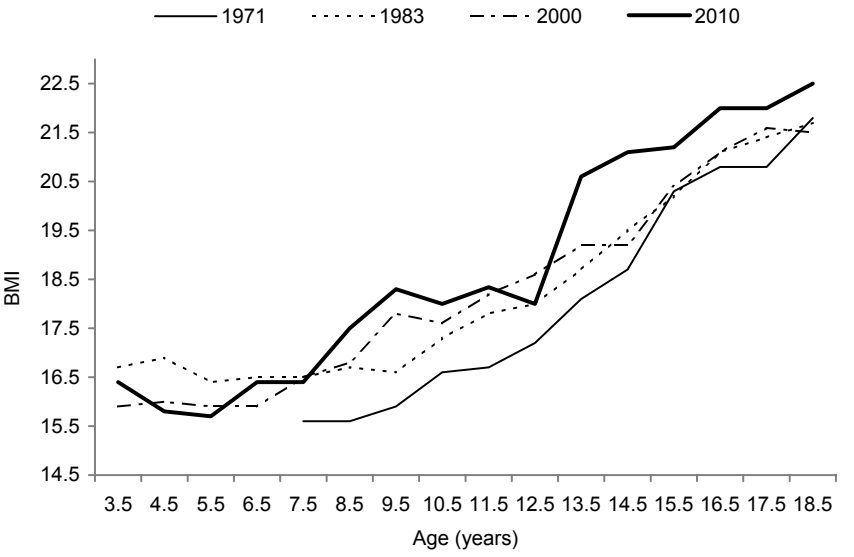

Fig. 3. Secular changes of body mass index (BMI) in boys.

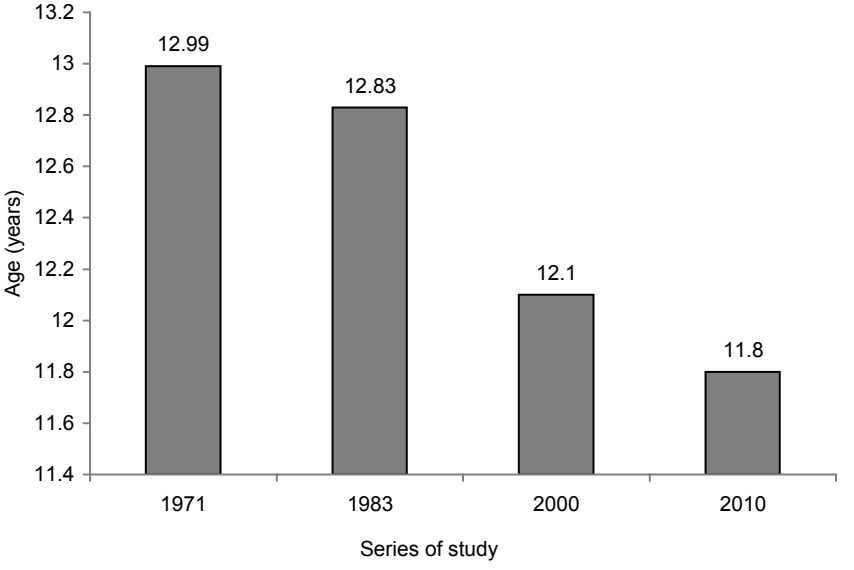

Fig. 4. The mean age of puberty onset (stage II of pubic hair) in boys.

appeared in younger and younger boys. In a survey series for a given year the mean age at which that stage appeared in boys equalled 12.99 years. Nowadays, after 40 years, that age had clearly shifted to 11.80 years, i.e. by almost 14 months (Fig. 4). The last decade (2000–2010) saw a decrease of over 3 months in the age of initial growth of pubic hair in boys.

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Discussion

The results of this somatic traits analysis, i.e. of body height and weight, BMI and rate of pubertal development, in a group of male subjects examined in Krakow in 2010 show that the tendency towards inter-generational changes is still present. The analysis of changes in body height in boys revealed that for the last several dozen years that trait systematically increased in value for the whole period under research, showing a greater or smaller intensity in different decades. A positive trend in body height, most often related to developmental acceleration, has been observed in the last decade in many countries worldwide. Body height in boys increased, among others, in the Czech Republic (Vignerová *et al.*, 2006), Portugal (Cardoso & Caninas, 2010), Belgium (Roelants *et al.*, 2009), Greece (Papadimitriou *et al.*, 2009), Brazil (Bianka Caliman *et al.*, 2006), Australia (Ranjitkar *et al.*, 2006), the Republic of South Africa (Hawley *et al.*, 2009), Mexico (Peña Reyes *et al.* 2009) and Hungary (Gyenis & Joubert, 2004). However, that trend was not constant everywhere and it did not always concern all age categories. For instance, in the case of the Chinese population the increase in body height was extremely big and no signs of its weakening have been observed up to now, which may suggest that it will be maintained in the future (Ji & Chen, 2008). In Mexico the inter-generational changes in body height were noticed only in boys, exclusively in the younger age groups (6–11), and at a later age that trend disappeared (Peña Reyes *et al.*, 2009). In Italy a positive trend was noticed already from the 1850s and lasted until the last decade of the 20th century (Arcaleni, 2006), but the results of the latest surveys show that it has already been hampered (Danubio & Sanna, 2008). Secular changes in body height in northern Europe and in many other highly developed countries have shown a similar course, but they have halted there now too (Malina, 2004). Surveys conducted in different regions of Poland have revealed a slightly different picture of inter-generational changes, but a positive trend was still observed in Warsaw (Palczewska *et al.*, 2000) and Rzeszow (Radochońska *et al.*, 2005).

In the last decades, considerably greater changes have been observed in body weight and BMI in the population of Krakow. In the younger age categories the inter-generational changes in these traits were not significant, but in the older age categories a sharp increase in both body weight and BMI was observed. A similar phenomenon has been noticed in most countries worldwide, e.g. in Germany (Zellner *et al.*, 2007; Meigen *et al.*, 2008), Italy (Danubio & Sanna, 2008), Portugal (Cardoso & Caninas, 2010), China (Zhang & Wang, 2010), Lithuania (Tutkuviene, 2005), Hungary (Mészáros *et al.*, 2008), Brazil (Costa *et al.*, 2011) and Cuba (Esquivel & González, 2010). The inter-generational changes in BMI are usually not observed in developing countries, but it is related to the fact that body height in those countries is still increasing (in proportion to body weight), which in effect does not cause changes in BMI (Hosseini *et al.*, 2010). Body mass index increase in the population of Lithuania presents a similar course as in Krakow: it is more often observed in teenage boys than in the younger ones (Tutkuviene, 2005).

The weight gain and BMI increase in the last decade are alarming phenomena and have become research projects for scientists from many research centres. An excessive increase in these traits could cause serious health problems in a substantial part of society in the future. As some authors suggest (Mucha & Kryst, 2010; Szczepanowska

et al., 2010), insufficient physical activity, the wrong diet and a passive way of spending spare time are, to a great extent, responsible for such a state. The level of physical activity fell drastically in the last 20–30 years in the countries of post-economic transformations (Maffeis, 2000; Roberts, 2000). Despite the fact that a majority of adolescents from Krakow declares active forms of spending their spare time, it seems that the energy expenditure during that time is too small to balance the energy supplied to the body by food intake (Libuda *et al.*, 2008). Also, children's and adolescent's diets are reported to be bad and inadequate for their physical activity. Surveys show that the consumption of carbohydrates and fats is far too high. In the last dozen or so years in the countries that recently went through significant economic transformations, access to sweet soft drinks, chocolate, chips and fast food has increased sharply (Kromeyer & Jaeger, 1995; Ulbricht, 1996). Surveys in many countries reveal that in recent years children and adolescents spend more and more of their leisure time in a passive way watching TV, playing computer games or surfing the Internet. Younger and younger children watch television regularly. In the USA, children become active television viewers already at about their 9th month of life, and at the age of 12 months they watch TV for 1 hour a day on average, and at the age of two they already spend 1.5 hours watching it (Zimmerman *et al.*, 2007). Surveys in Turkey also show that children spend more and more time watching television; on average the youngest ones spend 1.9 hours per day and that systematically increases in older children and adolescents (Kayiran *et al.*, 2010). In Poland, according to the latest questionnaires conducted by OBOP (Centre for Public Opinion Research in Poland; 30th April 2011), children older than 11 years spend 2.4 hours per day watching television and that quantity constantly increases up to 4 hours a day in the case of adults. For this reason children may not have enough physical exercise and their bodies may even lack of oxygen, which in turn may cause developmental disorders of their muscles, bones and respiratory and circulatory systems. A sedentary way of life, and the bad habits connected with it, also strongly contribute to a significant increase in children's BMI. It is well known that the time spent sitting and watching television or using the computer increases considerably the risk of being overweight and obese (Fulton *et al.*, 2009; De Gouw *et al.*, 2010). Spare time spent in a passive way clearly depends on the child's sex, age and parental socioeconomic status (Vicente-Rodríguez *et al.*, 2008). Bad nutritional habits and a sedentary way of life pose another problem. It has been proved that watching television for longer than 2 hours a day is connected with consuming energy-rich snacks and drinks (Manios *et al.*, 2009). It has also been shown that the amount of high-calorie snacks consumed is affected by mother's education: children of poorly educated mothers were found to eat three times more unhealthy products than those whose mothers had higher education (Rey-López *et al.*, 2011).

Children also spend a large amount of time using computers. Indeed, the energy expenditure while playing computer games is greater than while watching television or performing other activities in a sitting position, but it does not balance the amount of energy supplied with food (Rey-López *et al.*, 2008; White *et al.*, 2011). There is also evidence that even movement connected with getting to school may affect BMI. Children driven to school are in greater danger of becoming overweight or obese than their peers who walk to school (Wen *et al.*, 2010). It can be assumed that physical activity of children and adolescents is insufficient, despite their declarations. The more

time a child spends in a passive way, e.g. watching television or sitting in front of a computer, the heavier he or she is (Zellner *et al*., 2001), and the greater their risk of having abdominal obesity and cardiovascular diseases in the future (Martinez-Gomez *et al*., 2010). It is known that lack of exercise affects inter-generational changes in body weight and BMI in highly developed countries (Nagel *et al*., 2009). It seems that without firm action to increase physical activity and decrease the quantity, and increase the quality, of food consumed the growing trends in weight gain and BMI increase will continue.

The group of male subjects from Krakow also showed increasing acceleration of puberty. Some countries have witnessed similar trends (Ji *et al*., 2007), whereas in other places they have ceased (Bundak *et al*., 2007; Garcia Cuartero *et al*., 2010). The improvement in socioeconomic status clearly affected puberty acceleration in Poland in earlier decades. In the last decade the level of socioeconomic status did not change significantly and despite that the rate of pubertal development still accelerated. The results of the latest surveys suggest that it might not necessarily be a positive phenomenon. It has been proved that different types of psychological stress, e.g. growing in a one-parent family or frequent family conflicts, may accelerate the pace of pubertal development in girls (Wierson *et al*., 1993; Kim & Smith, 1998). In the last decade the number of divorces has increased considerably in Krakow (Cichocka & Żarów, 2002). Also, the content of some food products (e.g. phtalans or phytoestrogens), which belong to the so-called endocrine-disrupting chemicals (EDC), can modify child development (Walvoord, 2010). Yet, the influence of these substances on the human body has not been fully explained, because according to some studies they affect puberty acceleration (Wolff *et al*., 2008), and according to others they slow it down (Gladen *et al*., 2000). However, it has also been suggested that these substances may affect the quantity of fat tissue and disturb the energy balance of the body, which in turn may cause overweight and obesity (Bourguignon *et al*., 2010). A similar effect may also be caused by different types of environmental pollution which, depending on the type of substance, may modify the rate of pubertal development (Toppari & Juul, 2010).

In conclusion, the last decade saw the cessation of body height increase in Krakow, the maximum body height stabilizing at approximately 179 cm, but weight and BMI gains were still observed in boys; also distinct puberty acceleration, assessed on the basis of the age of pubic hair growth, was noticed. Cessation of height increase at the same time as weight gain, accompanied by puberty acceleration, show a progressing developmental disharmony.

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References

Arcaleni, E. (2006) Secular trend and regional differences in the stature of Italians, 1854–1980. *Economics and Human Biology* **4**, 24–38.

Bianka Caliman, S., Castro Franceschini Sdo, C. & Priore, S. E. (2006) Secular trends in growth in male adolescents: height and weight gains, nutritional state and relation with education. *Archivos Latinoamericanos de Nutrition* **56**(4), 321–328.

Bourguignon, J. P., Rasier, G., Lebrethon, M. C., Gérard, A., Naveau, E. & Parent, A. S. (2010) Neuroendocrine disruption of pubertal timing and interactions between homeostasis of reproduction and energy balance. *Molecular and Cellular Endocrinology* **324**(1–2), 110–120.

Bundak, R., Darendeliler, F., Gunoz, H., Bas, F., Saka, N. & Neyzi, O. (2007) Analysis of puberty and pubertal growth in healthy boys. *European Journal of Pediatrics* **166**(6), 595–600.

Cardoso, H. F. & Caninas, M. (2010) Secular trends in social class differences of height, weight and BMI of boys from two schools in Lisbon, Portugal (1910–2000). *Economics and Human Biology* **8**(1), 111–120.

Chrzanowska, M., Gołąb, S., Bocheńska, Z. & Panek, S. (1988) *Dziecko krakowskie.* Wydawnictwo Monograficzne AWF, Krakow.

Chrzanowska, M., Gołąb, S., Żarów, R., Sobiecki, J. & Brudecki, J. (2002) *Dziecko krakowskie 2000*. Wydawnictwo Monograficzne AWF, Krakow.

Cichocka, B. & Żarów, R. (2002) Zmiany sekularne wieku menarche u dziewcząt z Krakowa, Warszawy i Wrocławia w latach 1965–2000 a sytuacja psychosocjalna. *Pediatria Polska* **77**(4), 317–322.

Costa, F. S, Pino, D. L. & Friedman, R. (2011) Caregiver's attitudes and practices: influence on childhood body weight. *Journal of Biosocial Science* **43**(3), 369–378.

Danubio, M. E. & Sanna, E. (2008) Secular changes in human biological variables in Western countries: an updated review and synthesis. *Journal of Anthropological Science* **86**, 91–112.

de Gouw, L., Klepp, K. I., Vignerová, J., Lien, N., Steenhuis, I. H. & Wind, M. (2010) Associations between diet and (in)activity behaviours with overweight and obesity among 10–18-year-old Czech Republic adolescents. *Public Health Nutrition* **13**(10A), 1701–1707.

Esquivel, M. & González, C. (2010) Excess weight and adiposity in children and adolescents in Havana, Cuba: prevalence and trends, 1972 to 2005. *MEDICC Review* **12**(2), 13–18.

Fulton, J. E., Wang, X., Yore, M. M., Carlson, S. A., Galuska, D. A. & Caspersen, C. J. (2009) Television viewing, computer use, and BMI among U.S. children and adolescents. *Journal of Physical Activity and Health* **6** (Supplement 1), S28–35.

García Cuartero, B., Gónzalez Vergaz, A., Frías García, E., Arana Cañete, C., Díaz Martínez, E. & Tolmo, M. D. (2010) Assessment of the secular trend in puberty in boys and girls. *Anales de Pediatria (Barcelona)* **73**(6), 320–326.

Gladen, B. C., Ragan, N. B. & Rogan, W. J. (2000) Pubertal growth and development and prenatal and lactational exposure to polychlorinated biphenyls and dichlorodiphenyl dichloroethene. *Journal of Pediatrics* **136**(4), 490–496.

Gołąb, S. (1979) *Wpływ wybranych czynników rodzicielskich (wysokości ciała, wieku w chwili urodzenia dziecka, kolejności urodzenia dziecka oraz aktywności ruchowej) na poziom rozwoju morfologicznego i sprawności ruchowej dzieci i młodzieży w wieku od 7 do 19 lat*. Wydawnictwo Monograficzne AWF, Krakow.

Gyenis, G. & Joubert, K. (2004) Socioeconomic determinants of anthropometric trends among Hungarian youth. *Economics and Human Biology* **2**, 321–333.

Hawley, N. L., Rousham, E. K., Norris, S. A., Pettifor, J. M. & Cameron, N. (2009) Secular trends in skeletal maturity in South Africa: 1962–2001. *Annals of Human Biology* **36**(5), 584–594.

Hosseini, M., Taslimi, S., Dinarvand, P., Jones, M. E. & Mohammad, K. (2010) Trends in weights, heights, BMI and comparison of their differences in urban and rural areas for Iranian children and adolescents 2–18-year-old between 1990–1991 and 1999. *Child: Care Health and Development* **36**(6), 858–867.

Jasicki, B. (1938) Dynamika rozwojowa męskiej młodzieży szkolnej Krakowa, *Materiały i Prace Antropologiczne* **1**, PAU, Kraków.

Ji, C. Y. & Chen, T. J. (2008) Secular changes in stature and body mass index for Chinese youth in sixteen major cities, 1950s–2005. *American Journal of Human Biology* **20**(5), 530–537.

Ji, C. Y., Hu, P. J. & He, Z. H. (2007) Secular growth trends in the Chinese urban youth and its implications on public health. *Beijing Da Xue Xue Bao* [*Journal of Peking University. Health Sciences*] **39**(2), 126–131.

Kaczanowski, K., Głąb, H., Haduch, E., Mayer, B., Niedźwiecka, E., Schmager, J. *et al.* (2005) Wymiary i proporcje ciała dzieci i młodzieży Żywiecczyzny w latach 1962–2002. In Kaczanowski, K. (ed.) *Dziecko Żywieckie*. PiT, Kraków, pp. 19–91.

Kayiran, S. M., Soyak, G. & Gürakan, B. (2010) Electronic media use by children in families of high socioeconomic level and familial factors. *Turkish Journal of Pediatrics* **52**(5), 491–499.

Kim, K. & Smith, P. K. (1998) Childhood stress, behavioural symptoms and mother–daughter pubertal development. *Journal of Adolescence* **21**(3), 231–240.

Krawczyński, M., Walkowiak, J. & Krzyżaniak, A. (2003) Secular changes in body height and weight in children and adolescents in Poznan, Poland, between 1880 and 2000. *Acta Paediatrica* **92**(3), 277–282.

Kromeyer, K. & Jaeger, U. (1995) Effect of changed conditions on body height and body weight of preschool children in Jena. *Zeitschrift fur Morphologie und Anthropologie* **81**(1), 91–100.

Kurokawa, N., Nakai, K., Suzuki, K., Sakurai, K., Shimada, M., Kameo, S., Nakatsuka, H. & Satoh, H. (2008) Trends in growth status among schoolchildren in Sendai, Japan, 1994–2003: leveling-off of mean body height and weight. *Tohoku Journal of Experimental Medicine* **216**(4), 371–375.

Libuda, L., Alexy, U., Sichert-Hellert, W., Stehle, P., Karaolis-Danckert, N., Buyken, A. E. & Kersting, M. (2008) Pattern of beverage consumption and long-term association with body-weight status in German adolescents – results from the DONALD study. *British Journal of Nutrition* **99**(6), 1370–1379.

Maffeis, C. (2000) Aetiology of overweight and obesity in children and adolescents. *European Journal of Pediatrics* **159** (Supplement 1), S35–44.

Malina, R. M. (2004) Secular trends in growth, maturation and physical performance: a review. *Przegląd Antropologiczny* [*Anthropological Review*] **67**, 3–31.

Manios, Y., Kondaki, K., Kourlaba, G., Grammatikaki, E., Birbilis, M. & Ioannou, E. (2009) Television viewing and food habits in toddlers and preschoolers in Greece: the GENESIS study. *European Journal of Pediatrics* **168(7)**, 801–808.

Martinez-Gomez, D., Rey-López, J. P., Chillón, P., Gómez-Martínez, S., Vicente-Rodríguez, G., Martín-Matillas, M. *et al.* (2010) Excessive TV viewing and cardiovascular disease risk factors in adolescents. The AVENA cross-sectional study. *BMC Public Health* **10**, 274.

Meigen, C., Keller, A., Gausche, R., Kromeyer-Hauschild, K., Blüher, S., Kiess, W. & Keller, E. (2008) Secular trends in body mass index in German children and adolescents: a cross-sectional data analysis via CrescNet between 1999 and 2006. *Metabolism* **57**(7), 934–939.

Mészáros, Z., Mészáros, J., Völgyi, E., Sziva, A., Pampakas, P., Prókai, A. & Szmodis, M. (2008) Body mass and body fat in Hungarian schoolboys: differences between 1980–2005. *Journal of Physiological Anthropology* **27**(5), 241–245.

Mucha, A. & Kryst, Ł. (2010) Nadwaga a aktywność fizyczna młodzieży bielskiej. In Łuczak, J. & Bronowicki, S. (eds) *Zdrowotne aspekty aktywności fizycznej.* Monografie WWSTiZ, No. 4, pp. 71–78.

Nagel, G., Wabitsch, M., Galm, C., Berg, S., Brandstetter, S., Fritz, M. *et al.* (2009) Determinants of obesity in the Ulm Research on Metabolism, Exercise and Lifestyle in Children (URMEL-ICE). *European Journal of Pediatrics* **168**(10), 1259–1267.

Palczewska, I., Niedźwiecka, Z., Szilagyi-Pągowska, I. & Pawlik, K. (2000) Trend sekularny wzrastania dzieci i młodzieży warszawskiej w ciągu ostatnich dwudziestu lat. *Medycyna Wieku Rozwojowego* **4**(2), 161–176.

Papadimitriou, A., Konstantinidou, M., Christopanou, H., Xepapadaki, P., Giannouli, O. & Nicolaidou, P. (2009) Secular trend in body height of schoolchildren in Northeast Attica, Greece. *Journal of Pediatric Endocrinology and Metabolism* **22**(1), 13–17.

Peña Reyes, M. E., Cárdenas Barahona, E. E., Lamadrid, P. S., Del Olmo Calzada, M. & Malina, R. M. (2009) Growth status of indigenous school children 6–14 years in the Tarahumara Sierra, Northern Mexico, in 1990 and 2007. *Annals of Human Biology* **36**(6), 756–769.

Radochońska, A., Dudzik, S. & Perenc, L. (2005) Trend sekularny w rozwoju fizycznym dzieci z Rzeszowa w wieku od 7 do 14 lat. *Przegląd Medyczny Uniwersytetu Rzeszowskiego* **3**(2), 113–120.

Ranjitkar, S., Lin, N. H., Macdonald, R., Taylor, J. A. & Townsend, G. C. (2006) Stature and skeletal maturation of two cohorts of Australian children and young adults over the past two decades. *Australian Orthodontic Journal* **22**(1), 47–58.

Rey-López, J. P., Vicente-Rodríguez, G., Biosca, M. & Moreno, L. A. (2008) Sedentary behaviour and obesity development in children and adolescents. *Nutrition, Metabolism and Cardiovascular Diseases* **18**(3), 242–251.

Rey-López, J. P., Vicente-Rodríguez, G., Répásy, J., Mesana, M. I., Ruiz, J. R. *et al.* (2011) Food and drink intake during television viewing in adolescents: the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study. *Public Health and Nutrition* **22**, 1–7.

Roberts, S. O. (2000) The role of physical activity in the prevention and treatment of childhood obesity. *Pediatric Nursing* **26(1)**, 33–36.

Roelants, M., Hauspie, R. & Hoppenbrouwers, K. (2009) References for growth and pubertal development from birth to 21 years in Flanders, Belgium. *Annals of Human Biology* **36**(6), 680–694.

Sitek, A., Szkudlarek, A. & Antoszewski, B. (2007) Secular changes in the physical development of students of the Medical University of Łódź. *Folia Morphologica (Warsaw)* **66**(1), 62–68.

Szczepanowska, E., Merski, J., Górnik, K., Pławińska, L. & Drozdowski, L. (2010) *Otyłość i nadwaga a turystyczna i rekreacyjna aktywność fizyczna człowieka – wybrane problemy*. In Łuczak, J. & Bronowicki, S. (eds) *Zdrowotne aspekty aktywności fizycznej*. Monografie WWSTiZ, No. 4, pp. 87–106.

Tanner, J. M. (1963) *Rozwój w okresie pokwitania*. PZWL, Warsaw.

Toppari, J. & Juul, A. (2010) Trends in puberty timing in humans and environmental modifiers. *Molecular and Cellular Endocrinology* **324**(1–2), 39–44.

Tutkuviene, J. (2005) Sex and gender differences in secular trend of body size and frame indices of Lithuanians. *Anthropologische Anzeiger* **63**(1), 29–44.

Ulbricht, G. (1996) Nutritional changes in Eastern Germany since 1990. In Edwards, J. S. A. (ed.) *Culinary Arts and Sciences. Global and Nutritional Perspectives*. Southampton, Boston, pp. 297–305.

Vicente-Rodríguez, G., Rey-López, J.P., Martín-Matillas, M., Moreno, L.A., Wärnberg, J., Redondo, C. *et al.* (2008) Television watching, videogames, and excess of body fat in Spanish adolescents: the AVENA study. *Nutrition* **24**(7–8), 654–662.

Vignerová, J., Brabec, M. & Blahá, P. (2006) Two centuries of growth among Czech children and youth. *Economics and Human Biology* **4**(2), 237–252.

Walvoord, E. C. (2010) The timing of puberty: is it changing? Does it matter? *Journal of Adolescence Health* **47**, 433–439.

Wen, L. M., Merom, D., Rissel, C. & Simpson, J. M. (2010) Weight status, modes of travel to school and screen time: a cross-sectional survey of children aged 10–13 years in Sydney. *Health Promotion Journal of Australia* **21**(1), 57–63.

White, K., Schofield, G. & Kilding, A. E. (2011) Energy expended by boys playing active video games. *Journal of Science and Medicine in Sport* **14**(2), 130–134.

Wierson, M., Long, P. J. & Forehand, R. L. (1993) Toward a new understanding of early menarche: the role of environmental stress in pubertal timing. *Adolescence* **28**(112), 913–924.

Wolff, M. S., Britton, J. A., Boguski, L., Hochman, S., Maloney, N., Serra, N. *et al.* (2008) Environmental exposures and puberty in inner-city girls. *Environmental Research* **107**(3), 393–400.

Zellner, K., Ulbricht, G. & Kromeyer-Hauschild, K. (2007) Long-term trends in body mass index of children in Jena, Eastern Germany. *Economics and Human Biology* **5**(3), 426–434.

Zhang, Y. & Wang, S. (2010) Prevalent change in overweight and obesity in children and adolescents from 1995 to 2005 in Shandong, China. *Asia-Pacific Journal of Public Health*. DOI: 10.1177/1010539509360571

Zimmerman, F. J., Christakis, D. A. & Meltzoff, A. N. (2007) Television and DVD/video viewing in children younger than 2 years. *Archives of Pediatric and Adolescence Medicine* **161**(5), 473–479.