CHANGES IN THE GROWTH AND DEVELOPMENT OF ADOLESCENTS IN A COUNTRY IN SOCIO-ECONOMIC TRANSITION 1993-2013

SPREMEMBE V RASTI IN RAZVOJU MLADOSTNIKOV V DRŽAVI S SOCIO-EKONOMSKIM PREHODOM V OBDOBJU 1993–2013

Tatjana ROBIČ PIKEL[1*], Tina MALUS[1], Gregor STARC[2], Petra GOLJA[1]

[1]University of Ljubljana, Biotechnical Faculty, Department of Biology, Večna pot 111, 1000 Ljubljana, Slovenia
[2]University of Ljubljana, Faculty of Sport, Gortanova ulica 22, 1000 Ljubljana, Slovenia

ABSTRACT

Keywords:
secular trends, growth spurt, body height, body proportions, leg length, leg-to-body height ratio, leg-to-trunk ratio

Introduction: Changes in human growth and development depend on genetic and environmental factors. In the case of Slovenia, the environmental factors changed as a result of the period of socio-economic transition that the country underwent between 1991 and 2013. The authors used anthropometric techniques to evaluate differences in body height, proportions and sexual maturity in 1,221 adolescents aged 14 in 1993, 2003 and 2013.

Methods: Data was collected as a part of the ACDSi study, which has monitored children's somatic growth and motor development every decade over the last 40 years.

Results: Between 1993 and 2013, a trend (p=0.08) towards increased body height was observed in males. The comparison of age at peak height velocity (PHV) between generations demonstrated a trend (p=0.07) of earlier entry into puberty in adolescents in 2013 compared to those in 1993. The leg-to-body height ratio increased (p<0.05) with every decade in males, while in females it decreased (p<0.05) in 2013. Similar trends were observed in the leg-to-trunk ratio. Contemporary generations experienced PHV at a younger age (p<0.05), which is true for both genders even in adolescents born no more than two decades (1993, 2013) apart. In both generations, females experienced PHV sooner than their male peers.

Conclusion: The authors assume that females of the 2013 generation reached puberty earlier than females of older generations. It is most likely that, unlike females from older generations and unlike males, they were already at the stage of trunk growth at the time of the measurements, which explains the observed changes in their trunk length, leg-to-body height and leg-to-trunk ratios in comparison to earlier generations.

IZVLEČEK

Ključne besede:
sekularni trendi, rastni sunek, telesna višina, telesna razmerja, dolžina nog, razmerje nog in telesne višine, razmerje nog in trupa

Uvod: Spremembe rasti in razvoja človeka so odvisne od genetskih in okolijskih dejavnikov. Slednji so se zaradi obsežnega socialno-ekonomskega prehodnega obdobja v Sloveniji med letoma 1991 in 2013 močno spremenili. Avtorji so z antropometrijo želeli oceniti možne razlike v telesni višini, telesnih razmerjih in spolnem dozorevanju pri 1.221 mladostnikih, ki so bili v letih 1993, 2003 ali 2013 stari 14 let.

Metode: Podatki so bili zbrani kot del študije ARTOS (Analiza razvojnih trendov otrok v Sloveniji), ki v zadnjih štirih desetletjih vsakih 10 let spremlja somatsko rast in motorični razvoj otrok.

Rezultati: Med leti 1993 in 2013 so pri moških mladostnikih opazili trend (p = 0,08) povečanja telesne višine. Primerjava starosti pri najvišji hitrosti višine (PHV) med generacijami je pokazala trend (p = 0,07) zgodnejšega vstopa v puberteto pri mladostnikih iz leta 2013 v primerjavi s tistimi iz leta 1993. Noge so bile pri moških v letu 2013 v povprečju daljše (p < 0,01) kot v letih 1993 in 2003, medtem ko se dolžina nog pri ženskah v dveh desetletjih ni spremenila. Po drugi strani pa je bil trup pri ženskah v letu 2013 daljši (p < 0,05) kot leta 1993, pri moških pa je bilo nasprotno (p < 0,05). Razmerje med dolžino nog in telesno višino se je pri moških z vsakim desetletjem povečalo (p < 0,05), medtem ko se je to razmerje pri ženskami v letu 2013 zmanjšalo (p < 0,05). Podobno so opazili pri razmerju med dolžino nog in dolžino trupa (p < 0,05). Mlajše generacije so PHV doživele pri nižji starosti (p < 0,05), kar velja za oba spola mladostnikov, rojenih ne več kot dve desetletji narazen (1993, 2013). V obeh generacijah so ženske PHV doživele prej (p < 0,05) kot moški vrstniki.

Zaključek: Na podlagi rezultatov domnevajo, da so ženske iz generacije 2013 puberteto dosegle prej kot ženske iz starejše generacije; najverjetneje so bile, v nasprotju z ženskami iz starejših generacij in moških v času meritev, že v fazi rasti trupa, kar pojasnjuje opažene spremembe v dolžini trupa, obeh razmerjih nog glede na telesno višino ali glede na dolžino trupa v primerjavi s prejšnjimi generacijami.

*Corresponding author: Tel. + 386 1 320 34 21; E-mail: tatjana.robic@bf.uni-lj.si

1 INTRODUCTION

The growth and development of the human body from birth and through childhood and adolescence are reflected in body size and the proportions of body parts in adulthood (1). Different secular trends in human growth and development, e.g. changes in childhood growth patterns and earlier sexual maturation, have been observed in many countries over the last century (2). Important factors underlying the secular growth changes are environmental factors such as industrialisation (2) and an increase in general economic status (3). By monitoring changes of growth in children and adolescents of the same age from different generations who had been affected by such factors, it should be possible to determine the impact of these changes on the pattern, velocity and duration of an individual's growth.

During childhood, different regions of the body experience different growth patterns (4). Distal parts of the limbs approach adult size sooner than their proximal parts (5): thus, in the lower extremities, the feet fully develop earlier than the tibia and the tibia grows faster (to an almost adult size) than the femur. The same pattern of growth is also observed in the upper extremities (6).

Childhood ends with puberty and adolescence. Puberty is the process of physical changes by which adolescents reach sexual maturity, i.e. become capable of reproduction, while adolescence can be described as a dynamic period characterised by rapid changes in body height, shape, and body structure, and by morphological gender differences (7). One of the characteristics of adolescence is the growth spurt, which is a period of accelerated leg growth that can be observed prior to accelerated trunk growth. In an interval during early adolescence, an individual will therefore have relatively long legs; this appearance will, however, disappear with the consequent increase in trunk length (8). Since females enter adolescence on average two years earlier than males, they have, on average, longer legs for a shorter period than males during early adolescence (9).

During their growth spurt, adolescents experience their peak height velocity (PHV), which is the fastest growth in body height (10). In females, PHV occurs between the ages of ten and 14 on average, which is approximately two years sooner than in males (11); this corresponds to the period of earlier entrance into adolescence in females compared to males (9). The age at PHV is the most commonly used indicator of biological maturity in longitudinal studies of puberty (1, 12), as data on age and corresponding body height is relatively easy and inexpensive to collect. By referring to PHV, we can accurately determine maximum growth during puberty and compare it between individuals (13). It has been reported that contemporary adolescents experience PHV (10) and final body height at

a lower chronological age (2) than their peers in previous generations.

The aim of the present study is to assess whether the change in environmental factors over a 20-year period (when Slovenia experienced significant socio-economic transition) was influential enough to be reflected in altered growth and the age at which adolescents achieved sexual maturity. The twin objectives of the study were therefore to determine whether the ratio between leg and trunk length changed among 14-year-old adolescents between 1993 and 2013, and whether adolescents experienced PHV earlier in 2013 than did adolescents of the same age two decades earlier. An earlier beginning of sexual maturity could be reflected in an earlier start to trunk growth (and consequently a smaller leg-to-body height ratio and leg-to-trunk ratio in adolescents of the same age from different generations). We hypothesised that this should be primarily evident in females, as they enter puberty earlier than males.

2 METHODS

2.1 Observed Population

To achieve the aims of this study, basic anthropometric data was obtained from three samples of 14-year-old subjects in Slovenia: from a sample measured in 1993, from a second sample measured in 2003 and from a third sample measured in 2013.

2.2 Sampling Procedure

The present study is a part of the longitudinal ACDSi project (Analysis of Children's Development in Slovenia), led by the Faculty of Sport of the University of Ljubljana, Slovenia and conducted in cooperation with other faculties. The project has been under way since 1970 (14). Measurements at primary schools take place every ten years in the same 11 locations all over Slovenia. The locations are selected to reflect four types of settlement (rural, rural-industrial, industrial-rural and industrial) and spread across the regions in order to be representative of the population as a whole (14). The project examines selected physical and developmental characteristics of children between the ages of 6 and 15. The measurements are pre-arranged with the administrators of the participating primary schools, with parental consent for participation being obtained in advance. In order to fulfil our research goals, we planned to include 200 children in each age- and sex-group, with an estimated drop-out rate of 15% (14).

2.3 Study Instruments and Measurements

Body height and leg length were measured. Body height was measured using a portable anthropometer (GPM, Switzerland). During this measurement, the subjects were

barefoot, their back was straight, their hands were relaxed alongside the body, their feet and knees were together, their heels touched the anthropometer, and their head was held in the Frankfurt horizontal (15).

Leg length was measured as the iliospinal height (i.e. the vertical distance between the iliac spine and the floor) (16). A shortened portable anthropometer (GPM, Switzerland) was used for this purpose. During the measurements, the subjects stood with their knees and feet together, and the examiner positioned the top of the anthropometer at the anterior superior iliac spine of the pelvis. Trunk length was calculated by subtracting leg length from body height. The leg-to-body height ratio (i.e. leg length as a proportion of the height of the whole body) was calculated by dividing leg length by body height. The leg-to-trunk ratio was calculated by dividing leg length by trunk length.

In addition, body height data for adolescents who were 14 years old in either 1993 or 2013 was obtained over four consecutive years from ages 10 to 14 from the national surveillance system of somatic and motor development (SLOfit). The SLOfit measurements take place every year in April and cover children and adolescents from all Slovenian primary and secondary schools from ages 6 to 18. Annual increments in body height (cm/year) were calculated for each individual as the differences in their body height between two consecutive years. The largest annual increment in body height was adopted as the PHV, while the lower margin of an annual interval in which the PHV was observed was adopted as the age at PHV.

2.4 Methods of Analysis

Descriptive statistics (means and standard deviation (SD)) were obtained for subjects' age, body height, leg and trunk length, as well as for both ratios. The values of the three generations were compared with a one-way analysis of variance (ANOVA) and Tukey's HSD post-hoc test. A student's t-test was used to compare PHV and age at PHV between the generations of 1993 and 2013. The level of statistical significance was set at $p < 0.05$.

3 RESULTS

3.1 Description of the Study Group

Anthropometric data was obtained from a total of 1,221 adolescents (674 males and 551 females) measured in 1993, 2003 and 2013. Response rate was approximately 82%, which represents around 2% of the entire population of children in primary schools in Slovenia (14). Their mean age, body height, leg and trunk length, leg-to-body height ratio, and leg-to-trunk ratio, as well as the corresponding p-values for the comparisons between the three generations are presented in Table 1.

Table 1. Typical values of body measurements (mean and standard deviation (SD)) in 14-year-old males and females in Slovenia in 1993, 2003 and 2013. ANOVA – one-way analysis of variance, HSD – honestly significant difference.

	Year of measurement				Tukey's HSD test (p)		
	1993	2003	2013	One-way ANOVA (p)	1993 vs. 2003	2003 vs. 2013	1993 vs. 2013
Males							
Subject number [N]	222	236	216				
Age [years]	14.1 (0.4)	14.0 (0.3)	14.2 (0.3)	<0.001	<0.001	<0.001	0.004
Body height [cm]	167.6 (8.7)	165.1 (8.3)	169.0 (7.7)	<0.001	0.001	<0.001	0.089
Leg length [cm]	96.4 (6.1)	95.7 (5.8)	98.9 (5.5)	<0.001	0.234	<0.001	<0.001
Trunk length [cm]	71.3 (4.5)	69.4 (4.5)	70.1 (5.2)	<0.001	<0.001	0.103	0.012
Leg-to-body height ratio [%]	57.5 (1.8)	58.0 (1.8)	58.5 (2.2)	0.017	0.003	0.004	<0.001
Leg-to-trunk ratio	1.36 (0.10)	1.38 (0.09)	1.42 (0.16)	<0.001	0.002	0.004	<0.001
Females							
Subject number [N]	179	209	163				
Age [years]	14.0 (0.5)	14.0 (0.3)	14.2 (0.3)	<0.001	0.788	<0.001	0.002
Body height [cm]	162.6 (6.8)	161.2 (5.9)	163.2 (5.9)	0.004	0.028	0.001	0.345
Leg length [cm]	92.8 (4.8)	92.1 (4.5)	92.5 (4.6)	0.314	0.129	0.457	0.473
Trunk length [cm]	69.8 (3.7)	69.1 (3.8)	70.8 (3.5)	<0.001	0.067	<0.001	0.009
Leg-to-body height ratio [%]	57.1 (1.6)	57.1 (1.9)	56.6 (1.7)	0.011	0.719	0.006	0.009
Leg-to-trunk ratio	1.33 (0.09)	1.34 (0.12)	1.31 (0.09)	0.016	0.616	0.010	0.011

3.2 Body Height

No significant differences in body height were detected in 14-year-old females between 1993 and 2013, although there was a trend (p=0.089) towards increasing body height in 14-year-old males. However, in comparison to the previous generation, males from the contemporary generation were taller at the age of 10 to 12 years. There was a noticeable difference in the body height of males and females between 1993 and 2003, and between the years 2003 and 2013. In both 1993 and 2013, males were on average 2.5 and 3.9 cm taller respectively, than their peers in 2003. Females in 2013 were on average 2 cm taller than their peers in 2003.

3.3 Leg and Trunk Length

In males, a significant difference in leg length and trunk length was observed between 1993 and 2013. Between 1993 and 2013, the leg length of males increased by an average of 2.5 cm, while their trunk length decreased by an average of 1.2 cm. In females, while leg length did not change significantly in the same 20-year period, trunk length did increase by an average of 1 cm between 1993 and 2013.

3.4 Leg-to-Body Height Ratio and Leg-to-Trunk Ratio

A comparison of leg-to-body height ratio and leg-to-trunk ratio between the generations of males from 1993, 2003 and 2013 demonstrates that relative leg length (i.e. in comparison with the rest of the body) increased significantly with each decade. The leg-to-body height ratio increased by 0.5 percentage points, i.e. from 57.5% to 58.5% in the period observed. In females, leg-to-body height ratio remained unchanged between 1993 and 2003 (57.1%), falling significantly to 56.6% in 2013. The leg-to-trunk ratio increased by approximately 0.03, i.e. from 1.36 to 1.42 in the period observed. In females, the leg-to-trunk ratio remained unchanged between 1993 and 2003 (at approx. 1.33) and fell significantly to 1.31 in 2013. This means that leg length accounted for a lower percentage of total body height and trunk with head for a larger percentage of total body height in females in 2013 in comparison to females from previous generations.

3.5 Peak Height Velocity (PHV)

For the calculation of PHV and age at PHV, data was successfully obtained from 236 14-year-old adolescents from 1993 and 311 14-year-old adolescents from 2013. The mean (SD) age at PHV determined for males of the 1993 and 2013 generations was 12.9 (1.0) and 12.7 (1.0) years respectively. The observed difference was close to the level of statistical significance (p=0.077). Females of the 1993 and 2013 generations were, on average, 11.4 (1.1) and 11.2 (1.0) years old at PHV, i.e. a trend similar to that in males was observed (p=0.071). Table 2 presents the number of adolescents of the 1993 and 2013 generations, who reached PHV at a particular age, values of their mean PHV for a particular age, as well as the corresponding p-values for the comparisons between the two generations.

Table 2. Mean (standard deviation (SD)) peak height velocity (PHV) of males and females in the 1993 and 2013 generations. Height increments for the calculation of PHV were obtained for each subject of the two generations from the annual anthropometric measurements performed nationally at schools. Any presented age is the lower margin of an annual interval in which the PHV was observed. The t-test relates to a difference in PHV between 1993 and 2013. NA – not applicable.

Year of measurement	No of subjects [N {%}]		PHV [cm/year (SD)]		T-test [p]
	1993	2013	1993	2013	1993 vs. 2013
Males					
Age at PHV [years]					
10	4 {3}	2 {1}	6.8 (2.3)	10.2 (5.4)	NA
11	5 {5}	33 {16}	11.0 (0.4)	8.6 (1.9)	0.003
12	34 {29}	33 {16}	10.1 (2.2)	9.2 (1.8)	0.037
13	40 {33}	97 {46}	9.4 (2.0)	9.9 (1.5)	0.048
14	36 {30}	44 {21}	9.5 (1.5)	9.2 (2.1)	0.237
Total	119 {100}	209 {100}	9.6 (2.0)	9.4 (1.9)	0.203
Females					
Age at PHV [years]					
10	30 {26}	32 {31}	8.4 (1.8)	8.0 (1.7)	0.220
11	32 {27}	34 {33}	8.5 (1.7)	7.8 (1.2)	0.042
12	44 {38}	25 {25}	8.4 (1.4)	8.1 (2.2)	0.282
13	6 {5}	10 {10}	8.1 (1.9)	8.2 (2.5)	0.413
14	5 {4}	1 {1}	7.2 (0.8)	7.0 (NA)	NA
Total	117 {100}	102 {100}	8.3 (1.6)	8.0 (1.7)	0.066

4 DISCUSSION

4.1 The Most Important Results of the Study

The results of the present study demonstrate that contemporary generations experience PHV at a younger age. This is true for both genders, even in adolescents born no more than two decades (1993, 2013) apart. As expected, females in both generations experienced PHV sooner than their male peers. The comparison between the 1993, 2003 and 2013 generations demonstrates that males have longer legs and females longer trunks in the latest generation compared to the two previous generations. At the same time, it appears that contemporary females and males experience somewhat different pubertal growth patterns in terms of intensity. While both experience earlier PHV, females experience a growth intensity that is similar to that of previous generations (of females), resulting in earlier conclusion of pubertal growth, while males experience earlier PHV than in previous generations, but also lower intensity. This results in their slower (although longer) pubertal growth. Related to the above, leg-to-body height ratio and leg-to-trunk ratio increased significantly in males and decreased significantly in females over the time period observed.

4.2 Comparison of the Results to the Results of Similar Studies

It has been reported that adolescence in females starts at least two years earlier than in males: females enter adolescence at the age of around 11 years on average and males at the age of 13 years on average (17, 18). Females also reach PHV earlier than males, as was confirmed in the study by Malina et al. (8) performed in North America and Europe between 1988 and 1998. In this study, females reached PHV between the ages of 11.3 (11 years and 4 months) and 12.2 years (12 years and 2 months), and males between the ages of 13.3 (13 years and 4 months) and 14.4 (14 years and 5 months). The study by Malina et al. (8) therefore observed a difference in age at PHV between the genders of approx. two years. This observation can be confirmed by the results of the present study, with females in the 1993 and 2013 generations reaching PHV approximately 1.5 years sooner than their male peers.

The comparison of PHV attainment between the 1993 and 2013 generations demonstrates that PHV was experienced earlier in the 2013 generation, suggesting an earlier onset of puberty in the most recent generation. In both genders, the age at PHV decreased for 3 months over a twenty-year period on average. This is consistent with findings from other studies from Denmark (18), Sweden (19), Japan (20), and Portugal (21), covering a longer period of 50 years or more, during which time these countries underwent an economic transition similar to Slovenia's, albeit at a slower pace. There is a lack of data on age at PHV across Eastern

and Southern Europe, as most of the studies have focused on age at menarche (e.g. Croatia (22), Poland (23)).

In terms of the growth of various parts of the body in human beings, legs are a part of the body, that grow faster than other segments from birth to puberty (5). The leg length of males and females from our study was quite similar to the situation reported for a wider region, e.g. in Croatia in 1997, where leg length at the age of 14 years was 99.0 cm in males (N=225) and 93.8 cm in females (N=209) (24). In most other studies of Eastern Europe (e.g. 25) leg length was obtained by subtracting sitting height from body height, which prevents a direct comparison of results. In our study, the leg-to-body height ratio and leg-to-trunk ratio – the proportion of leg length to trunk length – increased significantly in males over the three generations observed. By contrast, both ratios diminished in females over the course of the same 20- year period. According to the results of the present study, we can reasonably assume that females from the 2013 generation entered puberty sooner than females of previous generations. Moreover, it is most likely that girls from the 2013 generation had already been experiencing the trunk growth stage at the time the measurements were taken, in contrast to previous generations. This is supported by the leg-to-trunk ratio data, which indicates that in the most recent generation of females leg length accounted for a lower percentage of total body height then was the case with females from previous generations. In contrast, the leg length of males from the 2013 generation accounted for a larger percentage of total body height in comparison with males from previous generations. This indicates that, despite their earlier PHV timing, males from the 2013 generation were at an earlier phase of trunk growth than their peers from previous generations, which indicates that pubertal growth intensity was lower than in previous generations.

Our results regarding gender-specific changes in trunk and leg growth between adolescents of the same age between 1993 and 2013 (i.e. longer legs in males and longer trunks in females than in previous generations) are consistent with the study conducted by Bowles (26), where sitting height and leg length were compared at the same age between sons and fathers, as well as daughters and mothers, enrolled at Harvard University between 1840 and 1930 (all subjects had a high social status). In this study, sons were taller and heavier, and had a greater leg-to-body height ratio than their fathers, suggesting that, on a relative basis, the greatest change in the length of body segments between the generations appeared in the legs. Daughters were taller and heavier than their mothers, but had a greater trunk-to-body height ratio, suggesting that they had already entered the trunk growth stage. No data on PHV timing was reported for the participants (27).

Keyfitz (28) and Meredith and Meredith (29) reported that the mean height of ten-year-old children in 1892, 1923, 1930 and 1939 increased by 1.5 cm per decade. The observed secular trend in body height was caused by several factors. Although healthier diet was a strong factor, it could not be the sole responsible factor, as the same trend has been observed in various societies irrespective of the economic or social status of their individuals (30). In the present study, we did not detect significant differences in body height between the 14-year-old adolescents of the 1993 and 2013 generations. This was true for both genders. Interestingly, the body height of 14-year-old adolescents of the 2003 generation was less than that of the 1993 or 2013 generations. It is possible that the increase in body height in 1993 was superficial and influenced by the large number of child refugees from Bosnia and Herzegovina (31) who attended Slovenian schools in 1993, but who left Slovenia after 1995 (existing evidence shows that the population of Bosnia and Herzegovina is among the tallest in Europe (32)). The overall increase in mean body height between 2003 and 2013 may partly be explained by the process of economic transition, with Slovenia being one of a group of European countries in which significant social and economic changes have taken place in recent decades (33). The transition began in Slovenia in 1991 with the disintegration of the former Yugoslavia, the introduction of consumerism, increased nutritional intake from increased sale of highly processed food, and an increase in sedentary lifestyles resulting from increased use of screen technology. Entry into the European Union in 2004 and the subsequent closing of the gap with wealthier countries resulted in a significant change in GDP: from EUR 11 billion in 1993 to EUR 26 billion in 2003 to EUR 36 billion in 2013 (34). Significant (albeit less drastic) socio-economic changes were also observable in the decades prior to Slovenia gaining independence (34).

In many societies, improved environmental conditions have enabled children to reach their genetic maximum growth potential (7), which is the ability of an individual to reach their theoretical maximum height with proper development, training and nutrition. It has also been reported that puberty begins earlier in children who live in developed countries (35) and whose parents have a good social position (which is determined by good economic status, social power and reputation) (2). Despite the lack of evidence regarding the influence of socio-economic transition on pubertal growth in Eastern Europe, there is evidence that, with economic growth and consequently improved living conditions, the share of children from the region who are short for their age has decreased (36) and their BMI increased (37). Once the conditions for achieving maximum growth potential are established, full body height is probably attained first and earlier development established later. In our study on a sample from Slovenia,

a country that is still undergoing economic transition, no significant differences in body height were observed between 14-year-old adolescents born 20 years apart. However, we did observe a trend towards PHV timing in the most recent generation.

4.3 Limitations and Strengths of the Study

Limitations of our study were that we examined just as much particiapants to satisfy the criteria for the recommended sample size, furthermore, we did not ask the participants for ethnicity, also we did not determine the Tanner stages for pubertal development, as this is an invasive approach, which would risk higher refusal rates, and self-report approach by the children or their parents would result in 30-40% error. We did not use the same measuring device over 20 years, but we used device of identical standard, and body height was obtained only once a year and therefore also the observed difference in age at PHV. However, on the other hand our study has important strengths, as it is a longitudinal monitoring of children with a large number of different measurements and highly trained measuring team.

4.4 Importance of the Study for Public Health

According to the above, we can conclude that our study is important for public health, as it demonstrates that the socio-economic changes in Slovenia, that included a three-time increase in national GDP over the period of 20 years, were profound enough to result in earlier attainment of PHV in adolescents and, through earlier entrance into the period of the trunk growth, a change in body proportions over the observed two-decade period.

4.5 Possibilities for Future Research in the Field

In future research it can be reasonably assumed that the difference in age at PHV between generations would be even more pronounced, if the age at PHV could be determined more accurately for each individual, and measuring of sitting height would give us possibility to calculate leg length as substracting sitting height from body height, which would enable comparison of our results with similar studies in other countries.

5 CONCLUSION

In 14-year old males, leg-to-body height ratio increased with each decade from 1993 to 2013 due to the increased growth of legs in males and slower overall intensity of pubertal growth despite the earlier PHV timing in the most recent generation. In 14-year-old females, exactly the opposite phenomenon was observed (it was due to trunk growth). The differences in the results between the

genders can be explained by the fact that females enter puberty earlier. While they were at the same chronological age as the males, they were, according to the results of this study, already in the trunk growth stage. The present study demonstrates that even when environmental changes occur over a relatively short period of time (20 years in this case), they can affect growth/developmental patterns. The provision of a favourable environment that allows children to achieve their maximum growth potential is therefore of the utmost importance.

CONFLICTS OF INTEREST

The authors declare that no conflicts of interest exist.

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ETHICAL APPROVAL

The project was approved by the National Medical Ethics Committee of the Republic of Slovenia (No 52/03/14) and is in accordance with the Helsinki Declaration.

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