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Secular trend and social gradients in the menarcheal age of girls from eastern Poland between 1986 and 2016

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ABSTRACT: The age at menarche is changing together with the development of society. The intensities of secular trends vary in different countries, regions or even towns and villages. Therefore, the objective of the paper was to assess the changes of the menarcheal age of girls in groups defined by different levels of parental education and the number of children in a family as well as the general index of socioeconomic status.
The paper utilises the results of research conducted in the years 1985–1986, 2005–2006 and 2015–2016, covering 11 671 girls aged 10–16 from eastern provinces of Poland. Information about the date of birth, the date of the first period, place of residence, fathers' and mothers' education and the number of children in a family was collected. Research material was divided into groups stratified by mother's education, father's education, number of children in a family, size of place of residence and the general index of socioeconomic status (SES) was calculated. The results were processed statistically using one-way analysis of variance (ANOVA) and the Newman-Keuls method.
In all the assessed groups of girls the acceleration of maturation has been observed. Greater socio-economic differences of the menarcheal age of the respondents were observed in the years 1986–2006, whereas in the years 2006–2016 the differences were smaller. During the assessed period of 30 years, the most intensive acceleration in menarche was observed in the lowest social strata, i.e. in the daughters of parents with primary or vocational education, in those from the largest families and in those who were included in the group with the lowest SES point values. The lowest acceleration in the described indicator of development was found in girls from families with one or two children, whose parents had higher education degrees and the highest SES values.
The assessed schoolgirls still demonstrate the existence of social gradients in the menarcheal age but the gradients are smaller than 30 years ago.

KEY WORDS: age at menarche, secular trend, social groups

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Introduction

The World Health Organization in a broadly taken health definition, as its positive measures, indicates biological development and physical activity of individuals or groups at different stages of ontogenesis (Kemm and Close 1995). In biological development one of the most sensitive indicators of development is the age at menarche in girls. A lot of authors undertook to determine the impact of various factors on the age of occurrence of menarche. It was established, inter alia, that the determinants of the age at menarche are partly genetic factors (Morris et al. 2011; Dvornyk and Waqarul-Haq 2012), and only later non-genetic ones (Wang et al, 2012; Wagner et al. 2012; Ramnitz and Lodish 2013; Flom et al. 2017). The latter include factors related to the place of residence (Łaska-Mierzejewska et al. 2016; Saczuk et al. 2018), a socioeconomic situation (Amigo et al. 2012; Deardorff et al. 2014), family environment and its structure (Ellis et al. 2011; Milne and Judge 2011; Toromanović et al. 2015) and others.

Based on the studies of secular trends, as a result of the influence of environmental factors, it is known that the age at menarche may change together with the development of society (Flash-Luzzatti et al. 2014; Lee et al. 2016; Gomula and Koziel 2018). In world literature the occurrence of accelerated maturation was documented by scientists from both developed countries and the developing ones (Colle 2003; Mi Jung et al. 2006; Danubio and Sanna 2008; Łaska-Mierzejewska et al. 2016 and others). The phenomenon of faster maturation of young people was confirmed multiple times, indicating that the tempo of intergenerational changes depends on the socioeconomic level and the living conditions of a population. Lower intensity of secular trends was noticed in girls from countries with a lower standard of life. However, together with the improvement in the environmental conditions of individuals and their families, a faster rate of secular trends was observed. This is not a permanent phenomenon. In countries with a high level of industrialization, a significant inhibition of the trends of the menarcheal age is observed (Gohlke and Woelfle 2009). In addition, the changes differ, as far as their size is concerned, among individual countries, regions, and even places with a diversified level of urbanization or a different social milieu of families (Sławińska et. al. 2012; Kozlov and Vershubsky 2015; Xin-Nan et al. 2015; Łaska-Mierzejewska et al. 2016).

At the same time, the improvement in the conditions of daily life provided the impetus for emerging a lot of previously unknown health threats to a developing organism. The most dangerous one is the limitation of physical activity, especially of children and youth, which consequently leads to reducing the level of physical fitness (Huotari et al. 2010; Tomkinson et al. 2013; Venckunas et al. 2017) and increasing excessive body weight. It is reflected in a higher risk of developing a lot of metabolic syndromes (Feng 2008; Karapanou and Papadimitriou 2010; Bratke et al. 2017).

The last 30 years in Poland has been the time of sudden changes and socioeconomic as well as political transformations. This period saw the results of the deep crisis of the 1980s, socio-political transformation after 1989, and the accession to the European Union at the beginning of the 21st century. Therefore, it is interesting to find out what the direction of changes as well as the intensities of

secular trends and the size of social gradients of the age at menarche were in the years 1986–2016 in female inhabitants of eastern provinces of Poland from different social environments. Thus, the objective of the paper was to assess thirty years of changes of the menarcheal age of girls in groups with different levels of parental education and the number of children in a family, taking into consideration the general index of socioeconomic status of the families.

Material and methods

The paper utilises the results of the research on girls from eastern provinces of Poland collected during the realisation of three research projects. The first studies into the biological development of children and youth aged 7–18 were conducted in 1985 and 1986 as a part of the Priority Problem 10.7. The results of 2599 girls aged 10–16 were selected from this research. Only in these calendar age groups both menstruating and non-menstruating girls were found. Identical procedures were also applied in the research conducted in 2005 and 2006, as a part of the statutory research of the Academy of Physical Education in Warsaw (D.S. issue 45), from which the results of 5563 schoolgirls were selected for this paper, as well as in 2015 and 2016, as a part of the statutory research of the Academy of Physical Education in Warsaw (D.S. issue 203). This made it possible to collect the results of 3509 schoolgirls. The study was conducted with the help of research workers from the Faculty of Physical Education and Health in Biała Podlaska as well as students specially trained for this purpose. Detailed information on the number of researched girls in the respective years of the studies, taking into account the size of social groups, is compiled in Table 1.

Table 1. Number of girls participating in respective years of studies stratified by social groups

Fathers' education		primary	secondary	higher
	1986	1742	665	192
	2006	1883	2386	1294
	2016	875	1359	1275
Mothers' education		primary	secondary	higher
	1986	1692	695	212
	2006	1883	2386	1294
	2016	875	1359	1275
Number of children in a family		1 and 2 children	3 children	4 and more children
	1986	1047	791	761
	2006	3004	1522	1037
	2016	2003	904	602
Urbanisation level		village	small town	medium town
	1986	1292	779	528
	2006	1698	2091	1774
	2016	1820	951	738
Index of socioeconomic status		Low SES	Medium SES	High SES
	1986	1342	754	503
	2006	1644	2088	1831
	2016	1043	1143	1323

In all three years of the studies the same methods and techniques of research and statistical analysis were used. From the original questionnaire filled in by the parents of primary school pupils and postprimary school female students, the researchers utilised the data about the children's dates of birth, the occurrence of the first period in girls (yes – no), parents' education and the number of children in a family. The collected research material made it possible to stratify the girls into social groups according to the following criteria:

Taking into consideration the urbanisation level, the authors distinguished three groups: I – village residents, II – residents of small towns up to 25,000 population, and III – residents of medium towns of over 25,000 population. The last group also includes girls and boys from Białystok, the only city in this area. Due to a small number of respondents from this place, no separate group was distinguished.

Taking into consideration the education of fathers and mothers, the research material was divided into three levels of education. Group I (GR1) – primary education, including incomplete primary and vocational education, Group II (GR2) – secondary education, Group III (GR3) – higher education.

Similarly, three groups of families were distinguished in the family size variable: Group I – 4 or more children, Group II – 3 children, Group III – 1 or 2 children.

The general index of socioeconomic status (SES) was also calculated. Depending on the number of children in a family, fathers' and mothers' education as well as the size of the place of residence, the following number of points was assigned: in the groups based on the number of children in a family: one or two children – 3 points, three children – 2 points, four or more children – 1 point. Taking into account fathers' and mothers' education, the following number of points was assigned: higher education – 3 points, secondary education – 2 points, primary and vocational education – 1 point. The groups based on the size of the place of residence were assigned the following number of points: residents of villages – 1 point, residents of small towns – 2 points, residents of medium-sized towns – 3 points.

The sum of points (4 – 12) assigned to a respondent in the four above-mentioned variables made it possible to qualify each schoolgirl for one of the SES groups according to the following criteria: group I with low SES (SES I): 4–6 points, group II with medium SES (SES II): 7–9 points, group III with high SES (SES III): 10–12 points.

Having verified and coded the data, statistical analyses were performed. The calendar age was calculated on the basis of the difference between the date of the study and the date of birth with days and months being changed into the thousandth parts of a year. Subsequently, according to the formula proposed by Drozdowski (1962), the division into age groups was made. The group of 10-year-olds was composed of girls whose calendar age was between 9.500 and 10.499 years. It was analogical in the older age groups.

For the data collected with the „status quo" method, the mean age at menarche was calculated, using the probit method (according to Finney 1952), as well as measures of dispersion in groups, taking into consideration social variables.

Using one-way analysis of variance (ANOVA) and the Newman-Keuls meth-

od, the studies in different years assessed the significance of differences between the groups of different social status of the families (social gradients) as well as in the groups of the same social status of the families in different years of the studies (secular trends).

In order to determine the changes in the size of social groups, the percentage of the researched girls in 1986, 2006 and 2016 was calculated, taking into consideration parents' education and the number of children in a family as well as the SES index. Moreover, the values of the χ^2 test for differences between the number of girls in the social groups assessed in 1986, 2006 and 2016 was calculated. All statistically significant differences were verified at the $p<0.05$ level.

The research was conducted in accordance with the guidelines of the Declaration of Helsinki and was accepted by the Senate Ethics Committee of the Academy of Physical Education in Warsaw.

Results

Before commencing to achieve the main objective of the paper, it was essential to introduce the changes which had taken place in the social structure of families of the researched girls over the analysed period of 30 years. From 1986 to 2016, the level of parents' education as well as the percentage of respondents coming from families with 1 or 2 children increased, while the percentage of children and youth from large families decreased. The differences described above had an impact on the changes in the index of socioeconomic status of families (Figure 1, Table 2).

A statistically significant secular trend towards earlier maturation was found in all considered social groups. In groups defined by fathers' education, from 1986 to 2006 the largest decrease in the age at menarche was observed in the daughters of university graduates (0.33 year per decade), followed by the girls whose fathers had completed secondary schools (0.28 year per decade) and primary schools (0.23 year per decade). During the last decade a slower rate of secular trends was observed in eastern Poland, particularly in the group of girls whose fathers had completed higher or secondary education (Table 3).

Between 1986 and 2006 the most intensive acceleration of the age at menarche was observed in girls from maternal higher education group (0.35 year per

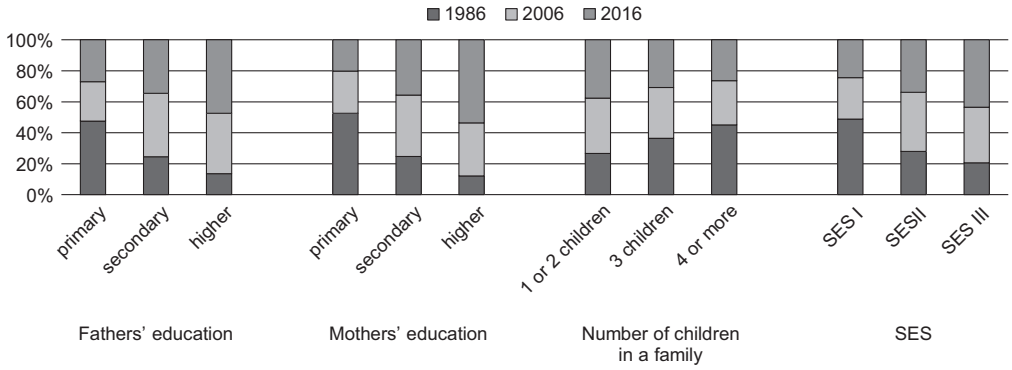

Fig. 1. Percentage of girls in social groups stratified by the years of studies

decade), followed by secondary education (0.34 year per decade), and primary and vocational education (0.28 year per decade). Between 2006 and 2016 the most intensive decrease in the age at menarche was found in group I girls, followed by group III, and group II (Table 4).

In terms of family size (Table 5), it was found that after the first two decades the greatest decrease in the age at menarche

Table 2. Differences in the percentage of the respondents in 1986, 2006, 2016 in social groups and statistical significance of differences (χ^2 test)

Year of study	Fathers' education			Mothers' education		
	GR I	GR II	GR III	GR I	GR II	GR III
1986–2016	−29.0*	10.4*	18.6*	−40.2*	12.0*	28.2*
2006–2016	2.2	−6.8*	4.6*	−8.9*	−4.2*	13.1*
1986–2006	−31.2*	17.2*	14.0*	−31.3*	16.1*	15.1*
Year of study	Number of children in a family			SES		
	GR I	GR II	GR III	SES I	SES II	SES III
1986–2016	−12.1*	−4.7*	16.8*	−26.9*	5.9*	21.0*
2006–2016	−1.5	−1.6	3.1	−2.7*	−4.2*	6.9*
1986–2006	−10.6*	−3.1*	13.7*	−24.2*	10.1*	14.1*

*statistically significant differences at $p<0.05$.

Table 3. Age at menarche in girls from eastern Poland in 1986, 2006, and 2016 stratified by fathers' education

	1986	2006	2016	Acceleration		
	$\bar{x}\pm$SD	$\bar{x}\pm$SD	$\bar{x}\pm$SD	1986–2016	2006–2016	1986–2016
GR I	13.51±1.22	13.09±1.28	12.85±1.39	0.46*	0.24*	0.70*
GR II	13.38±1.18	12.83±1.26	12.62±1.37	0.55*	0.21*	0.76*
GR III	13.31±1.23	12.65±1.32	12.51±1.42	0.66*	0.14*	0.80*
Differences	GR I–GR II	GR I–GR III	GR II–GR III			
1986	0.17	0.24*	0.07*			
2006	0.26*	0.44*	0.18*			
2016	0.23	0.34*	0.11*			

*statistically significant differences at $p<0.05$.

Table 4. Age at menarche in girls form eastern Poland in 1986, 2006, and 2016 stratified by mothers' education

	1986	2006	2016	Acceleration		
	$\bar{x}\pm$SD	$\bar{x}\pm$SD	$\bar{x}\pm$SD	1986–2016	2006–2016	1986–2016
GR I	13.48±1.37	12.93±1.51	12.75±1.56	0.55*	0.18*	0.73*
GR II	13.33±1.18	12.64±1.33	12.55±1.44	0.69*	0.09*	0.78*
GR III	13.29±1.22	12.59±1.16	12.49±1.27	0.70*	0.10*	0.80*
Differences	GR I–GR II	GR I–GR III	GR II–GR III			
1986	0.15	0.19	0.04			
2006	0.29	0.34*	0.05			
2016	0.20	0.26*	0.06			

**statistically significant differences at $p<0.05$

had appeared in the girls from families with 3 children (0.35 year per decade), followed by those from the largest families (0.28 year per decade), and the ones from families with 1 or 2 children (0.20 year per decade). Between 2006 and 2016 the highest rate of the secular trend in the age at menarche was observed in the girls from the largest families, followed by the ones from families with 3 children, and those from families with 1 or 2 children. All described differences were statistically significant.

Between 1986 and 2006 the highest acceleration in the age at menarche was observed in girls from villages (0.32 year per decade), followed by the ones from small towns (0.23 year per decade). A slower rate of secular trends was found in the female residents of medium-sized towns (0.26 year per decade). Between 2006 and 2016 the largest decrease in the age at menarche was observed in girls from group II, followed by the ones from group I, and those from group III (Table 6).

In terms of general SES, after the first two decades the greatest decrease in the age at menarche was found in the girls with the medium socioeconomic status (0.33 year per decade), followed by the lowest SES (0.29 year per decade), and the highest SES (0.28 year per decade). The following decade brought further decrease in the age at menarche. The highest intensity of secular trends was found in the lowest SES group, followed by the medium and high SES groups.

In all studies, the lowest age of the first period occurrence in the assessed

Table 5. Age at menarche in girls form eastern Poland in 1986, 2006, and 2016 stratified by family size

	1986	2006	2016	Acceleration		
	$\bar{x}$±SD	$\bar{x}$±SD	$\bar{x}$±SD	1986–2016	2006–2016	1986–2016
GR I	13.10±1.18	12.71±1.28	12.54±1.39	0.40*	0.17*	0.57*
GR II	13.45±1.21	12.84±1.33	12.64±1.44	0.61*	0.20*	0.81*
GR III	13.66±1.19	13.11±1.29	12.85±1.41	0.55*	0.26*	0.81*
Differences	GR I–GR II	GR I–GR III	GR II–GR III			
1986	0.34*	0.55*	0.21*			
2006	0.13*	0.40*	0.27*			
2016	0.10	0.31*	0.21*			

**statistically significant differences at $p<0.05$

Table 6. Age at menarche in girls from eastern Poland in 1986, 2006, and 2016 stratified by the size of place of residence

	1986	2006	2016	Acceleration		
	$\bar{x}$±SD	$\bar{x}$±SD	$\bar{x}$±SD	1986–2016	2006–2016	1986–2016
GR I	13.58±1.21	12.94±1.27	12.74±1.29	0.64*	0.20*	0.57*
GR II	13.33±1.20	12.88±1.23	12.61±1.34	0.45*	0.27*	0.81*
GR III	13.08±1.23	12.66±1.31	12.47±1.32	0.42*	0.19*	0.81*
Differences	GR I–GR II	GR I–GR III	GR II–GR III			
1986	0.25*	0.50*	0.25*			
2006	0.06	0.28*	0.22*			
2016	0.13*	0.27*	0.14*			

*statistically significant differences at $p<0.05$

Table 7. Age at menarche in girls from eastern Poland in 1986, 2006, and 2016 stratified by the index of socioeconomic status of families

	1986	2006	2016	Acceleration		
	$\bar{x}\pm$SD	$\bar{x}\pm$SD	$\bar{x}\pm$SD	1986–2016	2006–2016	1986–2016
GR I	13.57±1.25	13.02±1.34	12.80±1.39	0.55*	0.22*	0.77*
GR II	13.37±1.19	12.80±1.29	12.61±1.40	0.57*	0.19*	0.77*
GR III	13.20±1.22	12.65±1.27	12.50±1.35	0.55*	0.15*	0.70*
Differences	GR I–GR II	GR I–GR III	GR II–GR III			
1986	0.21*	0.38*	0.17*			
2006	0.53*	0.68*	0.15*			
2016	0.48*	0.58*	0.10*			

*statistically significant differences at $p<0.05$

girls was in the SES III group, whereas the highest one in the SES I group, and the differences between the discussed groups were at a similar level (Table 7).

During the analysed period of 30 years social gradients were noted in social groups where the difference in the age at menarche had changed. Across all years of studies, menarche occurred the earliest in the daughters of university graduates and the latest in the girls whose fathers and mothers had completed primary or basic vocational schools. The differences in the age at menarche between extreme groups increased between 1986 and 2006, whereas in the last decade, they decreased (Tables 3 and 4).

In terms of family size, across all years of studies, the smaller the family, the earlier menarche occurred. The differences in the age at menarche between respondents from extreme groups decreased across all years of studies (Table 5).

In all studies, menarche occurred the earliest in residents of medium-sized towns and the latest in girls from villages. The differences in the age at menarche between the extreme groups decreased across all years of studies (Table 6).

However, the higher the general SES, the earlier menarche occurred, with the greatest differences between the extreme SES categories found in 2006. The smallest differences were observed in 1986 (Table 7).

Discussion

One of the symptoms of sexual maturation is the occurrence of menarche in women. It demonstrates higher adaptability to the effects of environmental factors than somatic features (Łaska-Mierzejewska and Olszewska 2003). It has been documented in world literature that the better the environmental conditions, the earlier menarche occurs. This process started 150 years ago when it was described that in the middle of the 19th century girls began to menstruate at the age of 16–17 (Ong et al. 2006; Gohlke and Woelfle 2009). As compared to today's results, it indicates a downward trend of 3 to 4 months per decade (Ong et al. 2006). Despite the suggestions that the downward trend has slowed down or even completely stopped in some countries (Talma et al. 2013; Cabrera et al. 2014), there are regions where the trend of decreasing the age of menarche is still distinct (Cho et al. 2010; Prentice et al. 2010). The deterioration of living conditions caused by wars or long-term

economic crises slows down the developmental tempo or can even produce deceleration. When the effects of negative factors fade, the delays are quickly made up for. These observations were presented by Vecek et al (2012), Łaska-Mierzejewska et al. (2016), and Gomuła and Kozieł (2018).

The first results of the research presented in this paper date back to 1986, therefore they demonstrate the results of the aforementioned economic crisis. From the research by Saczuk et al (2018), it appears that at that time the female inhabitants of eastern provinces of Poland started to menstruate later than their peers from other regions of the country and from the Polish national sample. On the other hand, the differences observed in the girls assessed nowadays are smaller.

It can be assumed that the described rate of secular trends in the age at menarche was influenced to a large degree by the improvement in the standard of life, which reflects a technological advance of the population of eastern Poland. This advance is confirmed, inter alia, by the observed changes in the percentage of individual social groups over the last 30 years.

Between 1986 and 2016 a lower age at menarche was observed in all social groups of girls. The greatest differences in the age at menarche were noticed in girls from villages and the ones from large families, whose parents had higher education and belonged to the medium SES group. The smallest ones were found in girls from medium-sized towns, families with 1 or 2 children, who belonged to the highest and the lowest SES group, where parents had primary or vocational education. It needs to be emphasised that in all social groups the average age at menarche dropped below 13 years of age. Thus, according to the claim by Cole (2000), the minimum physiological limit of the average age at menarche, which should not exceed 13, was crossed. Therefore, the result of poor environmental conditions is the delay of menarche beyond this age. Thus, it can be assumed that significant improvement in the living conditions of the inhabitants of eastern Poland was one of the reasons for the drop in the age at menarche. It needs to be stressed that currently eating habits and the nutritional status of the respondents do not differ from the inhabitants of other environments and comply with the daily demand defined by the norms (Czeczelewski et al. 2001). This is important for the biological development of young people since the acceleration of menarche is also very closely related to the population's nutritional status, which is confirmed by a WHO report (2003) and Riley et al (1993). Moreover, it needs to be remembered that both late and early maturation may be regarded as a potential health risk factor. An early age at menarche is connected with an increase in the BMI (Feng 2008, Bratke et al. 2017), which may be the cause of the occurrence of metabolic syndromes, insulin resistance, and an increased risk of cardiovascular diseases (Feng 2008). This, in turn, is connected with a greater threat of cardiometabolic diseases in adulthood (Karapanou and Papadimitriou 2010). Furthermore, early menstruating girls tend to have elevated blood pressure and blood glucose levels irrespective of their body build (Remsberg et al. 2005). Late menarche, on the other hand, is connected with a lower bone mineral density, which consequently results in osteoporosis and increased fracture risk (Gerdhem and

Obrant 2004; Karapanou and Papadimitriou 2010). The presented research material does not contain data relating to the occurrence of menarche in female inhabitants of eastern Poland after the first studied decade. This would probably clarify the picture of the tempo of changes in children's and youth's maturation. However, based on the somatic features results presented by Saczuk (2018), it can be assumed that during the second decade of study, the trend in menarche was much more intensive compared to the first decade.

Based on the available research results, it was found that between 1986 and 2006 the intensities of trends increased together with a rise in the parental education level. However, during the next decade, opposite relationships were observed. Therefore, it can be assumed that during the period of political transformation parents with higher education adapted more easily to socioeconomic changes, providing their children with better developmental conditions. Thus, greater differences in the described secular trends were revealed and the distances in the menarcheal age between the discussed groups increased. After the accession to the European Union and the adaptation of lower social classes to a new economic situation, the „catch-up growth" phenomenon occurred, which, in turn, caused a drop in the values of gradients in parental education variables.

In the analyses of family size throughout the whole period of 30 years, a larger decrease in the age at menarche was found in the respondents from large families, whereas the smallest one in families with 1 or 2 children. This picture of long-term tendencies of changes caused a decrease in the described social gradients of the age at menarche. The researched schoolgirls experienced „catch-up maturation", modified by positive transformations of the environment they grew up in. Different types of EU subsidies directed at rural regions and small towns of eastern Poland, being one of the poorest regions of the European Union (Eurostat 2014), were not insignificant either. For it is a known fact that favourable environmental conditions cause genetic abilities of development to be utilised sooner, which is manifested in earlier growth and accelerated maturation of boys and girls (Kaczmarek 1995).

The described social gradients are in line with the results of research by other Polish authors (Wronka and Pawlińska-Chmara 2005; Łaska-Mierzejewska et al. 2016). Such clear relationships were not observed in other countries. Padez and Rocha (2003), while conducting research on girls in Portugal, found that the parental education level and family size did not have a significant impact on the mean age at menarche. On the other hand, while studying a group of women in the USA, Chavarro et al (2004) found that the age at menarche was positively correlated with family size. However, they did not observe such relationships when they analysed parental education. The intensity of secular trends in biological development shows the improvement of the living conditions of girls from eastern Poland. On the other hand, a decrease in social gradients, especially during the last decade, suggests that the biggest changes of this type were observed in the lower social classes. This fact is also confirmed by the described changes in girls from the groups where the general index of socioeconomic status was taken into consideration.

Conclusions

During the period of political transformation and after the accession of Poland to the European Union, the acceleration of maturation was observed in all social groups of girls from eastern Poland.

During the analysed period of 30 years, the obtained research results indicated a decrease in the size of social gradients of the age at menarche in girls from the groups defined by family size and the general SES. Such changes in the parental education groups were observed only in the last decade.

Secular trends in biological development reflect the improvement of the living conditions of girls from eastern Poland, whereas a decrease in social gradients suggests that the biggest changes were observed in lower social classes.

The biological effects of the „EU umbrella" over Polish agriculture and eastern provinces of the country contributed to catch-up growth in lower social classes.

Authors' contributions

JS and AW designed the study, oversaw the statistical analysis/interpretation and were the authors of the written content. PP was the author of the written content.

Conflict of interest

The authors declare that there is no conflict of interests regarding publication of this paper.

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