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SYMPOSIUM

Studies on sexual maturation of Hungarian children

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ABSTRACT The purpose of this paper is to give a summary review of the Hungarian reports on the sequence and timing of the respective stages of the secondary sex characteristics and on the age at menarche and oigarche. Also such studies are to be reviewed here that had dealt with the effect of environmental factors modifying sexual maturation or with the secular changes in the rate of maturation in the past one hundred years.
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KEY WORDS

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A quite considerable part of auxological research in Hungary has been devoted to the subject of physiological maturation. However, most of these studies are concerned basically with sexual maturation, its timing and the factors influencing its rate.

As the system consisting of the hypothalamus, the pituitary gland and the gonads matures and becomes more active during puberty, secondary sex characteristics develop gradually. In this phase the momentary grade of sexual maturity can be judged by the respective developmental stages of axillary and pubic hair, of the breast in girls and of the genitalia and facial hair in boys. The beginning of pubertal development is signalled by an enlargement of the areolae mammae, respectively of the testes, and/or by the appearance of pubic hair. However, when menarche or oigarche occurs, they indicate the beginning of the functional maturation of the gonads, which is a more advanced state of sexual development.

The purpose of this paper is to give a summary review of the Hungarian reports on the sequence and timing of the respective stages of the secondary sex characteristics and on the age at menarche and oigarche. Also such studies are to be reviewed here that had dealt with the effect of environmental factors modifying sexual maturation or with the secular changes in the rate of maturation in the past one hundred years.

The sequence and timing of the development of secondary sex characteristics

One of the most conspicuous morphological change in puberty is the development of the secondary sex characteristics. Yet relatively few studies have been carried out to clarify the sequence and timing of the respective stages. The locations where these events have been studied systematically include Debrecen (Jonás et al. 1968), the Bakony region (girls; Bodzsár 1978-1979), Székesfehérvár (Bodzsár 1982, 1992), Szeged (girls; Farkas 1969), Csongrád county and different parts of country (Farkas et al. 1981-1984), the Jászság region (Pápai 1982), Jászberény (longitudinal study; Pápai 1979-84) and Pécs (Dóber 1983-1984). Eiben and his associates carried out a longitudinal study in Budapest in 1970-1988. The Debrecen team of child gynaecology organized a longitudinal study of adolescent girls; this keeps going ever since (Borsos et al. 1977; Csoknyai and Borsos 1986, 1989; Beller et al. 1991; Borsos 1993, 1998). Örley (Örley 1973, 1975; Örley et al. 1980) has repeatedly reported on the development of sex characteristics in selected groups attending the outpatient department of child gynaecology. Pápai has studied athletic children (Pápai et al. 1994, 1996/97; Pápai 1996a, 1997) and Buday studied the intellectually and visually impaired (Buday 1979, 1981, 1998; Buday and Kaposi 1995, 1996).

The developmental stages of the secondary characteristics were estimated by using Tanner's scales in the majority of the studies, but the methods of data analysis did vary. Farkas (1986a) reported on telarche (12.44 yrs), pubarche (12.60 yrs) and the median of axillarche (12.60 yrs); but it is rather difficult to compare his values with median ages estimated by logit or probit analysis (Dóber 1992; Pápai 1992; Bodzsár 1999). In the Budapest longitudinal study (Eiben et al. 1992) another approach was taken, namely weighted averages were used to estimate the developmental grades associated with the respective chronological ages. It is a pity that although also Bodzsár (1983, 1991) reported similarly analyzed data for the Bakony girls, the two series of values cannot be compared because age groups were defined differently.

Despite such problems the general tendencies in the manifestation of the secondary sex characteristics can be summarized for Hungary as follows.

Pubertal development of the breast and pubic hair is not synchronous in the Hungarian girls: it is the breast that

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usually starts first. Nevertheless, as maturation proceeds, development catches up in these characteristics so that after stage 3 they develop in parallel (Bodzsár 1982, 1991; Beller et al. 1991; Pápai 1992; Dóber 1992). This initial discord between breast and pubic hair development was corroborated also by Farkas (1986a) and Eiben and associates (1992). Data conflicting with the mentioned ones have also been reported (Farkas 1969); individual variability is very broad (Bodzsár 1982, 1999; Pápai and Bodzsár 1986). The second stage of axillary hair coincides usually with stage 3 or 4 of the breast (Bodzsár 1982, 1984; Beller et al. 1991).

Age at menarche correlates best with the development of the breasts with r = 0.91 (Bodzsár 1984); menarche occurs after the age of peak height velocity when the breasts usually are in stage B3. Menarche is likely to occur when the breasts and pubic hair had already passed stages B3 and P3, respectively (Bodzsár 1983; Bodzsár and Pápai 1989; Pápai 1992). In the boys growth spurt is relatively delayed in comparison with genital development since almost the whole period of faster growth takes place after stage G2 (Bodzsár and Pápai 1989; Pápai 1992). Oigarche occurs about genital stage G3. Male pubic hair development is also somewhat delayed when it is compared to the pubertal development of the genitalia. However, stage P4 is usually attained at a younger age than G4. Table 1 demonstrates the common trends in the sequence and timing of pubertal stages by combining the estimates of the samples studied at Jászberény, Pécs and Székesfehérvár.

As well known, pubertal growth spurt in the female occurs about two years earlier than in the male; accordingly, a 12-year-old girl of average growth rate is already very near to her peak velocity of growth whereas a peer-age boy still maintains his prepubertal growth rate. In spite of the marked difference in the timing of the growth spurt there is little discordance between males and females in the starting age of sexual maturation: the lagging behind of male genitalia is not more than a few months. It is rather the change in the look of males that is belated, because growth spurt, facial hair development and breaking of the voice take place only when the genitalia had nearly completed their development.

Table 1. Median age (yrs) of breast (B2–B5), pubic hair (PH2–PH5) and genital (G2–G5) stages in Jászberény (Jbr), Pécs and Székesfehérvár (Szfv) children.

	Girls				Boys		
Stages	Szfv	Pécs	Jbr		Szfv	Pécs	Jbr
B2	10.09	9.96	10.4	G2	11.58	11.97	11.7
B3	11.24	11.32	11.4	G3	13.04	13.12	12.7
B4	12.59	12.90	12.6	G4	14.29	13.57	13.3
B5	13.98	16.41	—	G5	15.61	14.47	—
PH2	10.29	10.14	10.7	PH2	11.68	11.81	12.0
PH3	11.56	11.56	11.5	PH3	13.23	13.31	12.8
PH4	12.45	12.70	12.6	PH4	14.08	13.71	13.7
PH5	13.42	15.52	—	PH5	15.10	14.63	—

The analysis of the median ages for the respective pubertal stages of the secondary sex characteristics in the early and late maturing girls has shown that they differ not only in the onset of their pubertal processes, but also in the duration of the stages: transition from one stage into another takes usually longer in late maturers (Bodzsár and Pápai 1989).

Age at menarche – an indicator of a population's rate of sexual maturation

Variability between and within populations in sexual maturation and the secular change of maturation rate have generally been approached by estimating the age at menarche. This finds its reason in the fact that the event of the first menstruation is not only an easily observable indicator of a new developmental stage of the reproductive system, but it also signals the end of intense skeleto-muscular growth. It has been known since long (Pagliani 1877) that menarche occurs after the peak of pubertal height velocity, at a time when already 95% of final stature had been reached.

The occurrence of menarche *per se* does not imply full reproductive capacity. Girls reporting menarche, for example, at an age of 12 will become fertile only at an age of 14 or older. The correlation coefficient between the age at menarche and bone age has been found to be 0.5-0.6 (Tanner 1962). Menarche usually occurs at a bone age of 12 to 14 while the range of calendar age for the same varies between 10 and 16 years. This indicates that sexual maturation proceeds in a more intimate relationship with bone age than with chronological age.

Menarche as a term denoting the occurrence of the first menstruation was introduced by Stratz in 1908. The very first study on menarche was conducted by Haller (1778), but it was in Manchester, the home of the industrial revolution, where acceptable sample sizes were first investigated. In the years between 1827 and 1838 Roberton and associates (1830, 1832, 1851) collected their data from the women delivering their child in the Manchester hospital, and estimated the mean age at menarche to be 15.2 years. Roberton was also the first to analyze the differences between menarcheal age means for women living under diverse climatic conditions.

There are at least two reasons why studies on the age at menarche became so widespread in Europe already in the 19th century. The first and primary motivation was to gather exact data relying on which the fight for social reforms could get a sound basis of factual evidence. In this sense the relationship between age at menarche and socio-economic status, living conditions was of considerable importance.

The second motive was a purely clinical consideration: in order to arrive at a gynaecological diagnosis of sterility or amenorrhea (an absence of menstrual cycles) one had to know the age interval during which menarche may occur in the women living under poor, mediocre, or good social conditions.

Data on the mean age at menarche in Hungary are available since the 1860s when the first data of orientation were collected by Semmelweis (Table 2). The first systematic data collection was that of Doktor's (1891), and it was Véli (1947-1948) who first reported on the age at menarche in a statistically flawless manner.

The early data on menarche were based on the recall method that relies on memory. Recording the actually existing status in sexual maturation (the status-quo method) has become the method of choice only since the 1960s. Since then median age at menarche has been estimated by probit analysis. It should be noted that Wilson and Sutherland (1950) were the first to employ probit analysis for estimating median age at menarche from data collected by the status-quo method.

Probit analysis may use various techniques (graphical approach on probability paper, regression analysis, maximum-likelihood approximations) the estimated medians of which often differ slightly. As these age medians do depend on the technique of estimation, the latter should be specified in every report. Maximum-likelihood probit regression is now generally recommended, because it is free from the subjective effects of graphical fitting, maintains "its robustness against effects of rare events" and helps "to get an idea about the fit of the empirical data to the model assumptions" (Danker-Hopfe and Wosniok 1991).

Age at oigarche

The first sign of the onset of puberty in boys is an enlargement of the testes. This organ grows very little during the whole period preceding puberty: the average prepubertal volume of a testis is about 3 ml. Larger volumes are always indicative of the fact that puberty has already begun (in an adult male testicular volume averages 12-25 ml). Pubertal increase in testicular size is closely associated with the maturation of hormonal and reproductive functions. During childhood the number of spermatogoniums increases, but Sertoli cells are yet undifferentiated. While the interstitial tissue of the testis is poorly structured and does not contain Leydig cells before puberty, the earliest signs of the functional maturation of the germinal epithelium is when Sertoli cells begin their differentiation and spermatogoniums start dividing. The onset of spermatogenesis eventually results in the occurrence of oigarche or spermarche, *i.e.* the first ejaculation of sperm.

Although this event indicates that the phase of fertility has begun, the exact properties of the sperm of this time are still unknown. In contrast with menarche that occurs after the peak of height velocity, oigarche precedes this phase of growth, thus not only psycho-social maturity is child-like at this period of life, but also the boys' look and physique.

Concerning age at oigarche as a sign of male maturation there are very few studies available (Table 3). With one exception these studies estimated the median age at oigarche by using probit analysis. The results show that urban or rural habitat has had a demonstrable effect on maturation and that the shift of the median towards a younger age could be evidenced in the boys as well.

Environmental factors influencing age at menarche

There are a number of factors that act on the rate of growth and maturation and in this way also on the time when menarche occurs (Thoma 1960). The fact that menarcheal age is under genetic control was evidenced by studies carried out in twins and relatives (Grimm 1952; Damon et al. 1969; Huber 1973; Tanner 1962). Concordance between the timing of growth processes and maturation, e.g. PHV, PWV and menarcheal age, was found to be closer in monozygotic than in dizygotic twins (Fischbein 1977); difference in the timing of menarche was 2-3 months in MZ twins, but 8-9 months in DZ ones. Family studies also confirmed the genetic control of menarcheal age since children of late maturing parents were late maturers themselves (Tanner 1962). Correlation between the ages at menarche of female relatives was 0.9 in MZ twins, 0.6 in DZ twins, and 0.3 between mothers and daughters. In respect of this last coefficient one has to take account also of a possible effect of the secular trend, because environmental conditions may markedly affect the manifestation of internal (genetic and endocrine) controlling factors in the process of growth and maturation.

Adequacy of nutrition is the most important external condition. In turn, nutrition depends on the combined effect of a number of other external agents. Naturally, there are external factors that do not influence merely the conditions governing nutrition but have also a direct effect on Man as a living biological entity, namely, factors such as climatic conditions, altitude of the habitat or seasonal changes proper. As Man is not only a biological, but a social being, social agents may also modify the growth and maturation of children.

Geographical characteristics of the habitat, such as regional mean temperature, dampness, barometric pressure, meteorological fronts, dominant winds, insolation, etc., as well as altitude have an impact on the rate of metabolic processes, thus also on the rate of growth and maturation. There is little doubt about this fact although it is very difficult to distinguish their specific action from other environmental agents. The geographical conditions of Hungary display no sharp differences between the respective regions so the number of relevant studies is very small. Farkas (1979a, 1982) has demonstrated negative correlations of menarcheal age with the hours of insolation per year, respectively with mean annual temperature, and a positive coefficient with the altitude of the habitat above sea level.

An impressive number of studies have been published

Table 2. Hungarian data on the age at menarche.

Site of sampling	Author of report	Year of sampling	Menarcheal age (yrs)
Hungary	Semmelweis	1860s	15-19+
Budapest	Doktor	1891	15.33+
Budapest	Jankovich	1880-1893	15.5+
Budapest	Jankovich	1936	14+
Hungary	Frigyesi	1948	15.5+
Kaposvár	Véli and Thoma	1948-1949	13.9+
Hungary	Fekete	1955	13-14+
Körmend	Eiben and Thoma	1957	13.2
Körmend	Eiben	1958	13.6
Szeged	Farkas	1958-1959	13.20
Budapest*	Thoma	1959	12.75
Budapest*	Dezső	1960	12.97
Salgótarján*	Dezső	1960	12.94
Nógrád county* (villages)	Dezső	1960	12.73
Mezőtúr*	Timár	1960	13.27
Kaposvár*	Véli	1960-1961	12.98
Szombathely*	Eiben	1961	13.48
Körmend*	Eiben	1961	13.53
Kőszeg*	Eiben	1961	13.49
Vas county* (villages)	Eiben	1961	13.37
Ajka*	Eiben	1961	13.22
Szeged*	Farkas	1961	13.07
Csongrád county* (rural areas and towns)	Farkas	1961	13.40
Debrecen*	Rajkai	1961-1962	12.96
Hungary ** (merged data)	Bottyán	1959-1961	13.23
West Hungary (villages)	Eiben	1960-1961	13.27
Szeged agglomeration	Farkas	1961	13.30
Szeged and neighbouring region	Farkas	1961	13.22
Kaposvár	Véli	1962	12.98
Orosháza	Farkas	1963	13.00
Pécs	Farkas	1963	12.80
West and Central Hungary (villages)	Eiben	1965	13.13
Ócsa and Dabas	Vágó	1967-1968	13.10
Körmend	Eiben	1968	12.75
Kecskemét	Farkas	1969	13.04
Ócsa and Dabas	Vágó	1971	13.10
Székesfehérvár	Bodzsár	1972	12.61
Fejér county (villages)	Bodzsár	1972	12.80
Gyoma	Farkas	1974	12.79
Demecser	Nyilas	1971	13.01
Kaposvár	Bodzsár	1985	12.72
Eger	Pantó	1976	12.84
Rétköz	Nyilas and Tóth	1976-1979	13.03
Körmend	Eiben	1978	12.80
Bakony region villages	Bodzsár	1977-1978	12.68
Veszprém	Bodzsár	1978	12.61
Érd	Gyenis and Szerényiné	1979	12.85
Csepel	Csóla and Jung	1979-1980	12.58
Kaposvár	Környei et al.	1981	12.69
Ócsa-Dabas	Vágó	1981	12.92
Somogy county	Eiben et al.	1982	12.55
Székesfehérvár	Bodzsár	1982	12.65
Nagyatád	Várhegyi	1982	12.63
Békéscsaba	Farkas et al.	1983	12.72
Szabolcs-Szatmár-Bereg county (merged data)	Nyilas	1987-1989	12.71
Rétköz	Nyilas	1987-1989	12.46
Nyírség	Nyilas	1987-1989	12.96
Bereg	Nyilas	1987-1989	12.91
Jászság (villages)	Pápai	1983	12.75
Jászberény	Pápai	1981-1984	12.40
Debrecen	Borsos and Csoknyai	1979-1984	12.65
Hungary	Eiben and Pantó	1981-1984	12.79
Hungary	Farkas	1981-1984	12.79
Budapest	Eiben et al.	1970-1988	12.40
Körmend	Eiben	1988	12.93
Pécs	Dóber and Királyfalvi	1983-1984	12.90
Székesfehérvár	Bodzsár	1992	12.58
Fejér county	Bodzsár	1992	12.71
Somogy county (villages)	Suskovics	1996	12.63

Symbols: + = recall method; ** = material produced by merging data marked by an asterisk

Table 3. Estimates on age at oigarche in Hungary.

Site	Author	Year of sampling	Sample size	Oigarcheal age (yr.)
Budapest	Dezső (1965)	1965	662	13.10
Székesfehérvár	Bodzsár, Pápai (1994)	1981	2106	13.52±0.12
Jászság region	Bodzsár, Pápai (1989)	1983	712	13.77±0.05
	Pápai (1992)	Urban boys	302	14.05±0.12
		Rural boys	410	13.62±0.06
Hungary	Eiben, Pantó (1984)	1981-1984	2641	14.11±0.09
		Urban boys		13.86±0.10
		Rural boys		14.37±0.11
Budapest	Eiben et al. (1992)	1970-1988[a]	972	13.10[b]
Székesfehérvár	Bodzsár and Pápai (1994)	1991	2076	13.55±0.13

Symbols: [a] = longitudinal study, [b] = median obtained by graphical curve fitting.

that demonstrate and analyze the relationship between socio-economic environment and child development. All of them support the observation that remarkable differences in body dimensions and maturity status do exist between children when their social background is dissimilar. When material resources available to the family are ample, the children are usually taller and heavier and reach their respective stages of maturity at a younger age than their less privileged peers.

In studying these aspects research mostly concentrates on factors that have been evidenced to reflect the socio-economic status of the parents reliably. Accordingly, the most commonly employed indicators are parental level of education, parental profession, family size, per-capita income, the grade of provision with modern conveniences of the habitat, the settlement's level of urbanization, the number of inhabitants living in the community, the level of health care and access to medical services. Naturally, these items have a different weight in contributing to the socio-economic status of the family, and it is quite obvious that they exert their influence in combination and in a complex and closely interrelated way despite that most studies deal with each of them separately.

Reports on the complex analysis of menarcheal age and social environment were published by Eiben (1967, 1968a, 1972) concerning a large sample of girls living in West Hungary, by Bodzsár (1975a, b, 1976, 1991) for Central Hungary, and by Farkas (1962, 1978, 1982, 1986b, 1990; Farkas and Szekeres 1982; Farkas et al. 1985) for various regions of the country with a South Hungarian focus of interest. These studies were carried out in dissimilar samples and at different times, nevertheless they unanimously evidenced that age at menarche depended on the environment and that unfavourable social conditions could delay the time when menarche occurred.

There was full accord between the studies that analyzed parental education and profession (Bodzsár 1975, 1976, 1977a, 1991, 1998, 1999; Eiben 1968a, 1972, 1989; Pantó 1980a, b; Farkas 1980, 1982, 1986a, 1990; Farkas et al. 1985). The relationship of menarcheal age with paternal or maternal level of education was found to be monotonously negative while the rate of maturation was consistently slower in the families where the parents were manual workers. This means that the lower parental education is, the older will the daughter be when her menarche occurs. The same applies to growing family size or sibling numbers and order of birth.

There was full agreement between the inferences arrived at by Eiben (1972) and Bodzsár (1975a, 1984) concerning menarcheal age and the floor area of the home where the child lived. The per-capita surface area is a relatively accurate indicator of the family's economic status and with its reduction the median age at menarche tends to grow.

Menarcheal age has shown positive correlation with the age of the parents at the time of the daughter's menarche, but paternal age delays menarche less than maternal age (Bodzsár 1975a; Farkas 1986a). When Farkas (1979b, 1986a) analyzed menarcheal age medians for girls living in diversely sized settlements, he reported lower medians for the more urbanized regions and for the larger communities.

Miscellaneous factors influencing age at menarche

It is a rather old observation that the distribution of menarche over the calendar year is not uniform, but shows seasonal oscillation (Engle and Shelesnyak 1934; Valsik 1934). The relevant Hungarian studies have demonstrated a higher peak in winter and a smaller one in summer (Eiben and Bodzsár 1970; Bodzsár 1975a; Farkas 1986a, 1990; Csoknyai and Borsos 1985). The reports on the joint distribution of menarcheal and birth months have shown a high grade of coincidence (Eiben and Bodzsár 1970; Bodzsár 1975a, b; Pantó 1980a; Farkas 1986a).

Findings concerning the relationship between menarcheal age and complexion (colour of the eye and hair) are in part conflicting. Bottyán and associates (1963) and Eiben (1968a) reported that girls with a darker complexion matured at a younger age. Bodzsár (1974) used rank correlation and partial coefficients in analyzing the same and could not

demonstrate any correlation between eye and hair colour and menarcheal age. Farkas (1986a) compared the median ages at menarche of girls grouped by eye colour and hair colour and found that menarcheal age correlated only with hair pigmentation but not with eye colour. He was of the opinion that girls with darker hair matured at a younger age.

Studies comparing the dimensions of children of the same age but of different stages of maturation have shown a connection between the patterns of maturation and growth (Bodzsár 1975a, 1984, 1996; Pantó 1980b; Farkas 1986a, 1990; Farkas and Takács 1986; Pápai 1985, 1996b; Pápai and Bodzsár 1986; Bodzsár and Pápai 1989/90; Pápai et al. 1991). The differences in body dimensions are quite marked when children divided into pre- and post-menarcheal/oigarcheal groups are compared. The relatively more mature girls and boys are consistently taller and larger. Early maturing girls differ also in their body proportions: the trunk is longer and more robust in post-menarcheal girls. The studies on body composition showed full agreement in the observation that menarche occurred only after relative body fat had attained certain level, despite that fat accumulation proceeded faster after menarche (Bodzsár and Pápai 1989; Bodzsár 1991; Csoknyai 1998). Girls with a dominantly endomorph physique are more likely to be early maturers than dominantly ectomorphs (Bodzsár 1980, 1982, 1984; Pápai 1985, 1992).

Secular change in sexual maturation

Sexual maturation occurring at an increasingly younger age is closely related with the secular change in growth. Most of the observations speaking for an earlier occurrence of sexual maturity refer to the age at menarche.

Relying on writings that survived from the age of the Greek polis states and the Roman Empire, Backman (1948) was of the opinion that in the civilized societies of ancient Europe – and possibly also during the Middle Ages – menarche occurred at about 14 years of age, and it was only in the beginning of the 18th century that it became as delayed as the age of 17 or 18. He related the delay in maturation as well as every aspect of delayed growth to a deterioration of living conditions for broad layers of society in connection with the beginnings of industrialization.

In the course of the last one hundred years age at menarche has been found to occur at a gradually younger age in several European and North American countries. In these countries menarche now occurs in girls 2 to 4 years earlier than a century before. The rate of this shift in Europe has been 3 to 4 months per decade, and only wars or economic crises could temporarily break this trend (Bodzsár and Susanne 1998).

However, in some of the developed countries, for instance, in Belgium, Norway and Sweden, this tendency has changed during the last two decades: median age at menarche is no longer moving towards a younger age in there countries whereas the former trend still continues in North America, Greece, Germany and the Netherlands. In some regions of Poland, Croatia and Russia (Bielicki and Hulanicka 1998; Godina 1998; Prebeg 1998; Bodzsár and Susanne 1998b; Susanne et al. 1998b) even a reversal of the former secular change has been observed, *i.e.* age at menarche became comparatively older.

For Hungary, the inferences on the secular change in maturation rely on the following studies (see Table 2).

- The national surveys of 1860, 1948 and 1955 (recall method), and those of 1959-1961, 1983 and 1984 (status-quo method);
- the Budapest surveys of 1891, 1880-1893, 1836 (recall method), and those of 1959, 1960 and 1981 (status-quo method);
- data grouped by community size in studies referring to settlements of various sizes for the period of 1953-1992 (status-quo method);
- two consecutive surveys made by the present author in Fejér county (Middle Hungary) in 1972 and 1992. The 1972 sample contained 8,133 girls, the 1992 one consisted of 7,122 young subjects. In addition to the status-quo query, all post-menarcheal girls were asked to report on the recalled date of their first menstruation. In these surveys also the mothers were asked about their age at menarche (recall method). After having grouped the replies of both the mothers and the daughters by the year of their birth. Not only the change in the median age at menarche could be demonstrated, but also the time course of the 10th and 90th centiles.

In the interpretation of all these data two conflicting but related aspects had to be considered:

- secular changes in maturation were usually scaled in the same units (age in years) despite the dissimilar age group intervals used in the respective studies;
- depending on the period of data collection menarcheal age was estimated by two basically different methods.

To resolve the conflict concerning the first point all available data were treated as expressions of a global trend in the country and in Budapest the capital. In order to express the change in the method of data collection a separate treatment of the respective data was also necessary: 1959 was chosen as the switch-over point between the retrospective and the status-quo methods. Since fluctuations in the secular trend were relatively small, the secular shift in menarcheal age was estimated by fitting a linear trend line. Regression coefficients in the figures that follow refer to slopes in year per year units.

There were altogether six national studies between 1850 and 1985 (Fig. 1). The overall rate of decrease of 4.2 months/decade agrees well with those found for the West European countries. However, there was an impressive difference in the

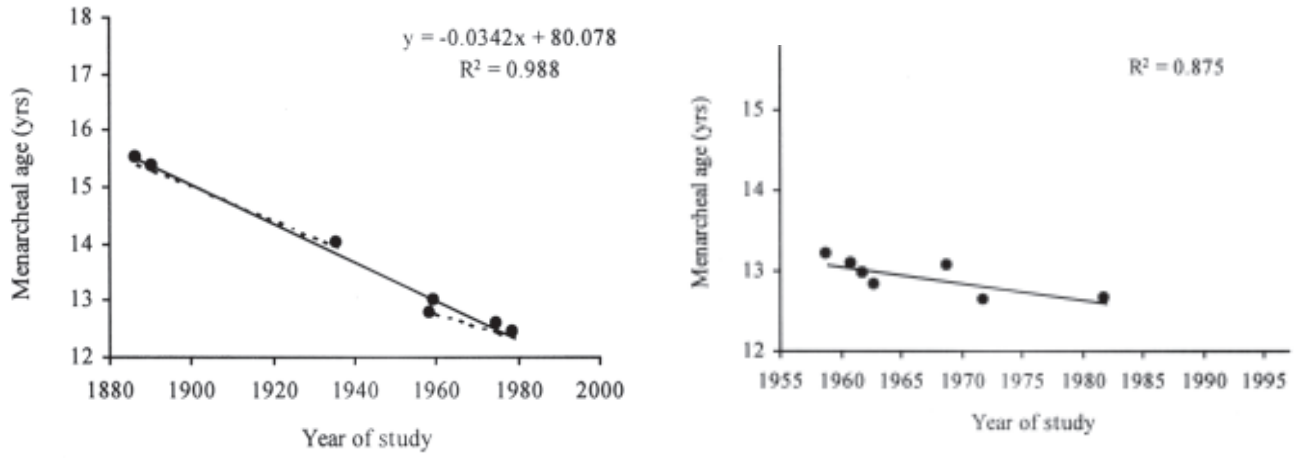

Figure 1. Secular trend in menarche based on national surveys.

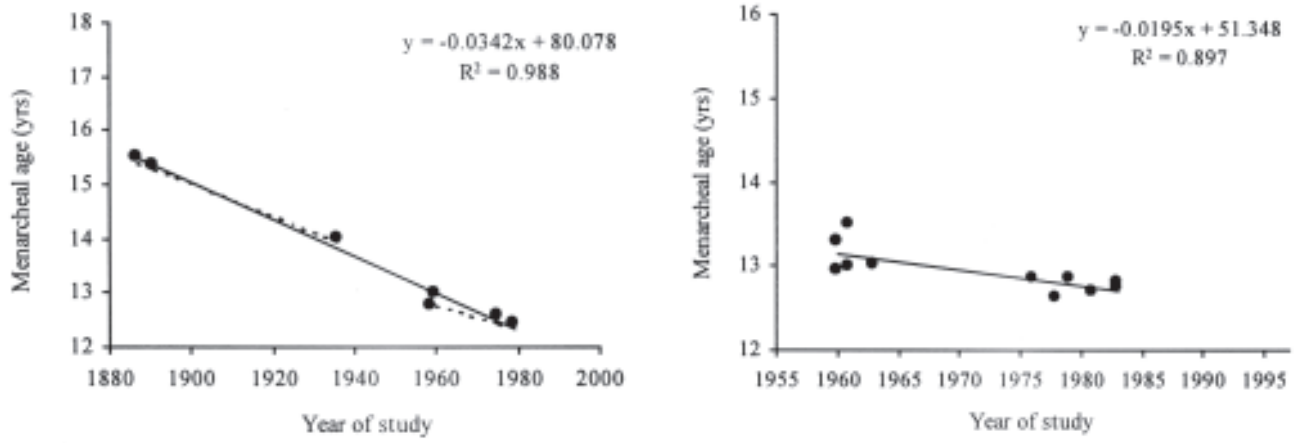

Figure 2. Secular trend in menarche based on Budapest surveys.

rates found before and after 1959. The rate of decreasing age at menarche was 3.6 months per decade between 1860 and 1955; whereas it was a mere 1.4 months per decade since 1959.

The overall trend for the capital (Fig. 2) agreed largely with that of the nation-wide studies, with a rate of 4.1 months/decade. In the capital too, there were slope differences between the periods, but smaller ones than for the country: before the 1940s the rate was 3.6 months/decade and it was 2.5 months/decade later.

When the rate of accelerated maturation was studied by linear regression in the variously sized settlements (Fig. 3), the fastest rate of decreasing age at menarche was found in the smallest communities (3.1 months/decade). The girls living in towns with 100, 300 thousand inhabitants displayed a secular rate of 2.5 months/decade which was almost the

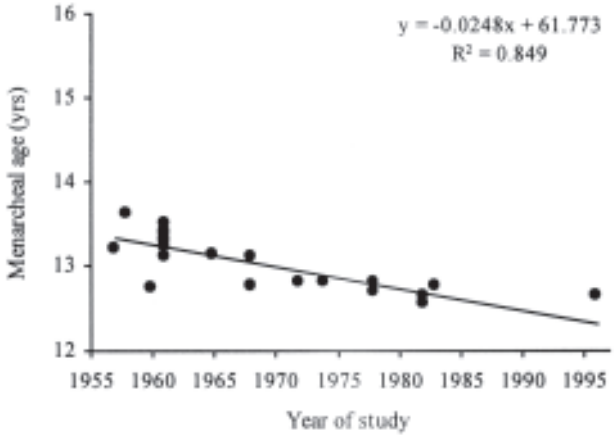

Figure 3. Secular trend in menarche by settlement size.

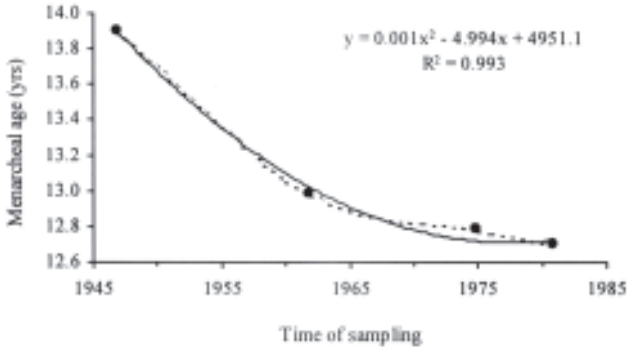

Figure 4. Secular trend in menarche at Kaposvár.

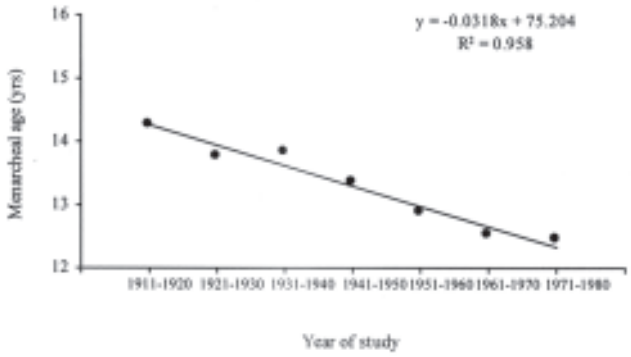

Figure 5. Secular trend in menarche at Fejér county.

same as that found for the capital. The same rate was 2.3 for the girls of the settlements having a size of between 20 and 80 thousand inhabitants.

Naturally, one can find several instances that differ from these general tendencies. Re-investigations reporting a stagnation for the same settlement or a right shift of the age at menarche are not uncommon. A part of such instances of divergence may be related to differences in socio-economic development and need not arise directly from settlement size proper.

Unfortunately, the number of studies repeated at the same community over a longer time span is very small. The studies carried out at Kaposvár, Körmend, Szeged and Székesfehérvár are therefore especially important.

The observations of the Körmend Growth Study embracing 40 years with surveys repeated every tenth year are well documented and known worldwide (Eiben 1975, 1977, 1978, 1982, 1985, 1988, 1994). In this West Hungarian town the rate of maturation was considerably accelerated between 1958 (13.53±0.09 years of age at menarche) and 1968 (12.75±0.04) to level off later (1978: 12.80±0.04) and to increase again in 1988 (12.93±0.20). In his 1994 report Eiben emphasized that the Körmend population had undergone a definite change in the relative balance of the gene pool owing to the effects of migration taking place in the seventies and eighties.

Median age at menarche in the Szeged girls decreased from the 13.2 years in 1958-59 to 12.73 years in 1966-67. The median age obtained for the 1981-82 survey was 12.68, an observation indicating a levelling off in the time course of maturation rate (Farkas 1962, 1969; Farkas and Szekeres 1982; Farkas et al. 1985).

The first survey of Véli at Kaposvár dates back to 1947. Employing probit analysis he re-evaluated his data in 1968 so also these data could be compared to later observations. As visible in Fig. 4, maturation rate did definitely change also in Kaposvár, *i.e.* it has become substantially slower after the sixties.

Fejér county is one of the industrially most developed regions of the country. The studies on the menarcheal age of daughters and mothers were carried out in 1972 and 1992 (Bodzsár 1975a, 1976, 1982; Pápai and Bodzsár 1986; Bodzsár and Pápai 1989). The analysis of the centile distributions of the maternal cohorts arranged by the birth dates showed that

- the rate of the decrease in the mean age at menarche in the retrospective study (Fig. 5) was close to that of the nationwide studies;
- variability around the median age at menarche gradually decreased;
- menarche occurred later in the mothers born during the economic crisis of the thirties; the reversal of the trend was more marked in the early maturers (Fig. 6);
- as demonstrated by the curves for the cumulative percentages over the 70 years (Fig. 7), early maturers were more affected by the secular change in the age at menarche: the shift observable for the 90th percentage was approximately 3 years while the same for the 10th percentage was

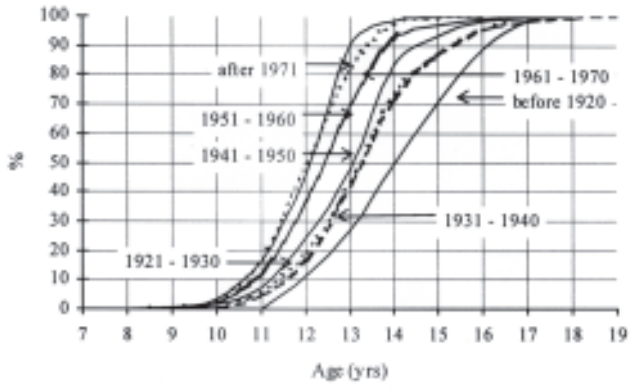

Figure 6. Change in the cumulative frequency of menarche in Fejér county.

Figure 7. Changes in the centile curves of menarche in Fejér county.

merely one and half years.

When the same samples were grouped by parental level of education and by sibling numbers, secular decrease in menarcheal age turned out to consist of two tendencies of opposing direction: maturation rate was becoming slightly faster in the children living under more favourable social conditions, but became slower in those living under less favourable conditions (Table 4).

Discussion

There are three main problems one has to face in studying secular changes in menarcheal age: 1) the representativeness of the various samples, 2) the change that took place in the method of data collection and 3) the problem of comparability between the dissimilar ways of estimation (Bodzsár and Susanne 1998b).

These problems are present in almost every retrospective study of human growth because of the changes occurring across a longer period of history, and had to be faced also in reviewing the Hungarian reports on the topic.

The analysis of the global change in Hungary had to be broken into two periods the reason for which was the change of the methods used in both data collection and estimation of menarcheal age. The apparently arbitrarily chosen cut-point of 1960 (actually 1957) is due solely to these methodological considerations. Before this time all the studies had been performed by using the recall method, after this date every study employed probit analysis of data collected by the status-quo method. This basic difference in sampling justifies a separate presentation of the two periods. Thus, further consideration is necessary only for the fitting of a common regression line to all the available data points irrespective of the employed method. As in all relevant studies of secular change, the only excuse can be that a strict observance of comparable methodology would bereave us from any demonstration of the trend despite the availability of old records. Accordingly, no tests of significance of the difference between the central values is warranted, in particular since few of the older reports associated means with variability, and most of them failed to report on the actual age of the respondents. Status-quo results consistently refer to medians. A common treatment of all the available data is therefore a compromise one cannot help.

Table 4. Menarcheal age (yrs) medians as a function of social factors in Fejér county.

Time of sampling	1972	1982
The father's level of education		
low	12.84±0.03	12.87±0.04
high	12.58±0.09	12.51±0.02
The mother's level of education		
low	12.87 ± 0.06	12.91 ± 0.03
high	12.75 ± 0.09	12.76 ± 0.07
Number of siblings		
two or less	12.76±0.02	12.63±0.03
three or more	12.92±0.08	12.96±0.06

A fact one can be certain of is that some shift in menarcheal age was present in both periods. The problem of significant differences (if any) in the slope of the secular trend of menarcheal age in Hungary cannot be settled with precision, so the figures obtained should be regarded as the best possible approximations. Although the caution to be exerted in the interpretation of menarcheal age data may vary depending on the authors, just the same or very similar considerations apply to all the European samples reported for the period before the 1950s. A statistically correct treatment of data collected by different methods and reported by the authors either as means or medians would not substantially improve the reliability of actually incomparable values. This study being a review of reports, the present author refrained from statistical hypothesis testing in presenting the results. As mentioned, the latter are and should be regarded as workable approximations with an unknown error of precision.

While the trend in menarcheal age appears to continue, the comparison of samples A and B of the Fejér county study speaks for a deceleration of the same. In addition, a rather consistent reduction in the range of variability could be observed in our own data (Figs. 6 and 7).

This reduction, being due mainly to a decrease in the number and percentage of late maturers, points to the biological limits concerning the effect of more favourable environmental conditions. This statement is further supported by the slightly faster trend in the small settlements (Fig. 3). The influence attributable to socio-economic layers in maturation has persisted in the last twenty years (Table 4). There was a small but significant difference between the social subgroups (parental educational level, the, number of siblings) in sample A. This difference was greater in sample B. It was found that menarche occurred later than before in

the less privileged groups and earlier in the more privileged ones. This may suggest a reversal of the secular trend in the lower social classes.

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