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SYMPOSIUM

A rewiev of Hungarian studies on growth and physique of children

Éva B. Bodzsár*

Department of Biological Anthropology, Eötvös Loránd University, Buapest, Hungary

ABSTRACT The purpose of this paper is to give a summary overview of the contributions that have dealt with the secular change in the growth pattern of Hungarian children and youth as observed during the past hundred years. We will note how some absolute body dimensions have changed, what modifications are discernible in the rate of growth, and comment on the effects these had on body shape. We also touch upon the inferences that have been arrived at in the study of body composition and somatotyping. Under the assumption that growth patterns depend on the environment an analysis follows that compares the growth data of the subpopulations living under diverse socio-economic conditions and it also attempts to outline the divergent trends in their physical development. The concluding section emphasizes the ways in which research results can be applied for practical purposes.
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body measurements
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In Hungary, a significant part of anthropological research has been devoted to the varieties of physique in the recent populations, to the patterns of human growth and development, and to the ways in which the manifestation of these patterns depends on the environment and creates differences between the studied groups. The fact that research in this field has already begun relatively early in the history of this discipline, namely at the end of the last century, shows how timely our anthropologist fathers recognized the importance of understanding physical constitution and the process of human growth.

We owe the first professional studies of growth in Hungary to Tivadar Kézmárszky and Sámuel Scheiber. Kézmárszky (1873) recorded body mass and length in neonates; Scheiber (1881) reported on the stature of recruits. These pioneering studies, which deserve mention even in the early European history of anthropology, were followed until World War I by only a few non-systematic examinations that failed to employ even a consistent methodology. These examinations were carried out mostly by physicians whose undoubted merit was that they contributed valuable reference data to the later research of long-term changes in the growth pattern.

World War I shook the social, economic and political life of our country severely. The monarchy broke up, state boundaries were redrawn, nation-states replaced the former multi-ethnic empire. It took some years until a new phase could begin in the research of growth under the changed conditions. Starting with the early twenties (and closing with the outbreak of World War II) a long series of growth studies has begun. One cannot fail to perceive how sampling, collecting information as well as data processing have grown increasingly elaborate.

The first – and very outstanding – study introducing the period after World War I came from Lajos Bartucz the famous scholar and teacher of generations of anthropologists (1923). Another great personality to whom many of us feel indebted is the paediatrician György Véli whose pre- and post-war activity (from 1935 to 1972) contributed a considerable amount of reference data to the growth studies of our times.

The twenties and thirties were also the period in which the studies of body constitution started. In those times it was the medical aspect (Gorka 1920; Csörsz 1927; Korányi 1930; Buday 1934-35, 1943; Szabó 1938) rather than the morphological aspect of physique that stood in the focus of interest. Yet, these studies served as a good basis for the research of morphological constitution that developed in the sixties and has kept producing important observations ever since.

The political and social changes that followed World War II were again quite radical and profound. Thus it is fully justified to speak of another, third period of growth studies which has lasted till our days. Moving the boundaries of, and expulsion of minorities from, our country as well as the neighbouring ones modified the ethnic composition of the populations to some extent. However, the "revolutionary" change in the political establishment reshaped every layer of our society. It also affected several of the environmental factors that could influence human growth.

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*Phone/Fax: 36(1)266-7857, E-mail: bodzsar@ludens.elte.hu

The first study of this period was Véli's work (1948) reporting on how the war affected child growth and development. He stated that the deterioration of socio-economic conditions – caused by the war and involving a wide layer of society – brought about developmental retardation, *i.e.* the generation that grew up during the war years was lagging behind its peers of the pre-war times both in its dimensions and in its grade of development. Another great personality of the early post-war years was Mihály Malán (1934, 1936, 1947, 1956) chair of the department of anthropology at University of Debrecen, who had a real impact on the directions taken by subsequent Hungarian anthropological research through his students.

The studies launched in the early fifties already complied in their methodology of data collection and analysis with the modern requirements (Eiben 1951; Rajkai 1951; Farkas 1960; Arday 1971). In 1951 Rajkai started the longitudinal study of growth in the Hajdusámson children. This was the first opportunity to find an exact answer to the problem of age-dependent change in Hungarian growth rate. In a paper published in 1956 he laid down also the framework of principles to be followed by sports anthropology in our country.

In the sixties and seventies the medical aspect of studying physique became gradually replaced by an interest in the body build of athletes; in this field the main motive was that of discovering the specific traits of elite athletes engaged in the various events (Rajkai 1963a; Szabó-Bende 1966; Szabó and Szabó 1969; Eiben 1972a,b, 1975a; Farmosi 1972, 1986; Eiben et al. 1986; Szmodis 1987). Interest in the exercising child was the primary motivation that has led to an extension of Heath and Carter's anthropometric somatotype (Carter and Heath 1990) and Conrad's anthropometric growth type (1963) for the smaller than adult dimensions and to the formulas by which these properties of the body could be easily computed (Hebbelinck et al. 1972; Szmodis et al. 1976; Szmodis 1977). This new methodology was widely adopted so the analysis of age-linked changes and sex-dependent differences in the morphological physique of the child has soon become an integral and routine part of studies in growth and development (Eiben 1972b, 1975a, 1982a, 1985, 1988a; Frenkl and Mészáros 1979; Bodzsár 1980, 1982a, 1984a, 1986; Pápai 1992; Mohácsi et al. 1994).

In the sixties, Hungary joined the Human Adaptability Project of the International Biological Program. This implies that since then the methods of data collection, processing, analysis and evaluation employed by the Hungarian research workers have almost always conformed to the international recommendations. In this way the observations made in the Hungarian growth studies have become fully comparable with the respective data of all the other countries participating in the project.

Since that time the number of cross-sectional and longitudinal studies has kept growing; a part of them was regional, another part was national in its scope. The selection of the regions and their representative sampling has followed a carefully programmed design; the respective studies were coordinated by the anthropological departments of the universities. The best evidence for the development of this discipline in Hungary is that there are now several centres (Budapest, Szeged, Debrecen-Nyíregyháza, Pécs) around which experts in one or other branch of human biology (anthropologists, paediatricians, school physicians and hygienists, specialists in the treatment of handicapped children, psychologists and sports scientists) can gather.

The past more than a hundred years have witnessed the birth of such a long series of variously oriented studies that it would be a vain attempt to review them all in the allotted brief space. Fortunately, the history of most of these disciplines has already been followed up by separate studies. Utilizing Malán's work ("Az élő magyarság embertani kutatása"; published as a chapter of the "Magyar Népkutatás Kézikönyve" in 1947) and the bibliography of Allodiatoris (1958) on the anthropology of the Carpathian Basin, Eiben (1962) gave a thematic review about the papers on child growth up to 1961. The studies that had dealt with the growth and physique of children and young adults between 1961 and 1975 were reviewed by Bodzsár (1975). Eiben's "The History of Human Biology" in Hungary appeared in 1988 while Farkas and Dezső's monograph on "A magyar antropológia története a kezdettől napjainkig" was published in 1994; both of these works treat the history of the respective directions of research, the stages of their development as well as the resulting papers and reports with a particular care and detail, and they also describe the institutions and people that have been involved in that work. Thus the present author can satisfy herself by pointing out merely the main directions of orientation and the pathways followed by the Hungarian studies of growth and development.

In what follows I wish to give a summary overview of the contributions that have dealt with the secular change in the growth pattern of Hungarian children and youth as observed during the past hundred years. We will note how some absolute body dimensions have changed, what modifications are discernible in the rate of growth, and comment on the effects these had on body shape. I also touch upon the inferences that have been arrived at in the study of body composition and somatotyping. Under the assumption that growth patterns depend on the environment an analysis follows that compares the growth data of the subpopulations living under diverse socio-economic conditions and it also attempts to outline the divergent trends in their physical development. The concluding section emphasizes the ways in which research results can be applied for practical purposes.

The change of body dimensions in this century

National growth studies

Growth studies have a relatively long history in Hungary. The first data date back to the 1870s (Kézmárszky 1873). While the number of regional growth studies increased impressively since the 1920s, only three national surveys were carried out since then, and two of them refer to the same period. The first national data collection was performed by Bartucz (1923) between 1910 and 1920; he was interested in the stature of schoolchildren and reported on 36,646 subjects. Two surveys were made between 1981 and 1984. The first was Eiben and associates' 1.5% representative sample (N= 41,000) that contained tests of physical condition in addition to a detailed record of anthropological dimensions for the age range between 3 and 18 years. The second survey embraced three dimensions measured in 55,665 subjects aged between 3 and 20 years, and referred to various regions of the country with a diversity of territorial representativeness and age distribution (Farkas 1986). The comparison of the national studies revealed that – in spite of a dissimilar age grouping – there were essential differences at every age, that male stature had grown more than female height while relative growth did not differ between the genders (Figs. 1 and 2).

By using only the national surveys it was impossible to find out how the rate of height growth changed during the 60 years that elapsed between the two occasions. To compensate for the missing data Eiben and Pantó (1981) re-evaluated every study that concerned schoolchildren between 1910 and the end of the 1970s, and estimated the secular change in the growth rate by using the weighted averages for stature and weight at all ages merged for each decade.

Means for height and body mass in peer-age children grew after the 1950s, but the rate of this increase slowed down in both sexes after the 1970s (Fig. 3 and 4). Drops observable in the post-war years of both world wars might be due to the adverse effects of these crises. In interpreting data referring the years before World War II, however, one has take account of the fact that after 10 years of age only the children of the more privileged families attended schools. Therefore it is likely that the depression or retardation of growth caused by the war was greater than the extent inferred simply from these data.

The largest difference in the stature of male peer-age children was at the age of 15 when observations for the fifties and sixties were compared. The same was found at 13 years of age for the sixties and seventies, and at 12 years for the seventies and eighties. This may be interpreted as a sign of a left shift in the pubertal growth spurt.

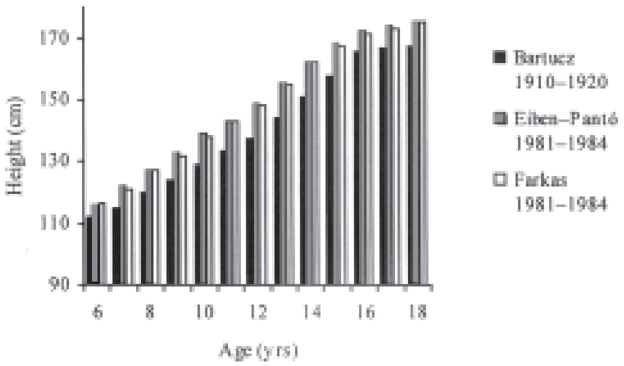

Figure 1. Height (cm) of the boys of 6–18 years of age in the tens and the eighties.

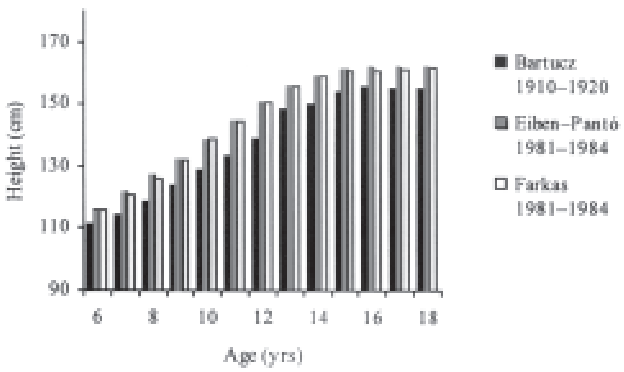

Figure 2. Height (cm) of the girls of 6–18 years of age in the tens and the eighties.

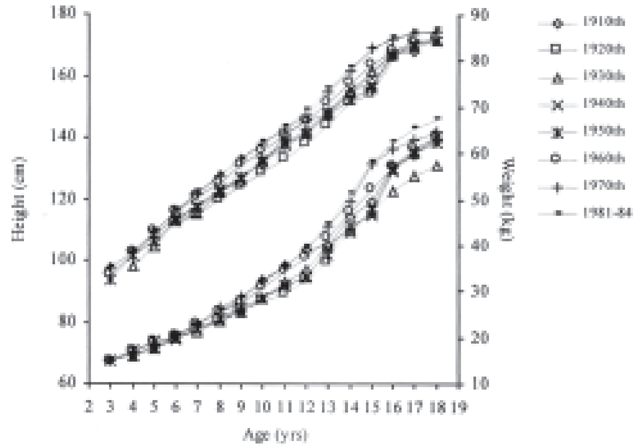

Figure 3. Body height (cm) and weight (kg) of the boys of the 3–18 years of age in XX. century.

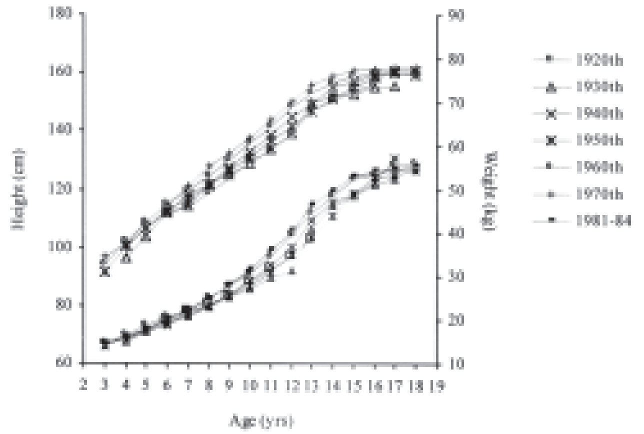

Figure 4. Body height (cm) and weight (kg) of the girls of the 3-18 years of age in XX. century.

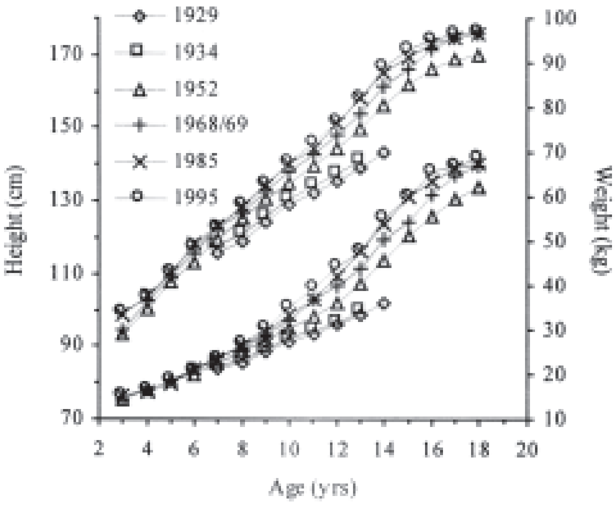

Figure 5. Secular change in height (cm) and weight (kg) of Budapest boys aged 3 to 18.

Budapest growth studies

The study of child growth in the capital began in the early 1910s (Tuszkai 1911; Nagy 1914), but the reports dated from the late twenties (Szondi 1929, Braunhoffner 1930) and early thirties (Braunhoffner 1934) have been more often referenced. Szondi reported normal zones for schoolchildren aged between 6 and 13 while Braunhoffner analyzed weight and height data for nearly 100,000 school-age youngsters. Many similar studies followed. One of these is M. Viola's representative investigation (1952) that deserves special mention, because this was the basis of the first Hungarian table of standards for physical development at 3 through 18 years of age for the children living in the capital. Published by "Budapest Város Iskola-egészségügyi Szolgálata", this volume contained – in addition to ones of height and weight – tables for the means and sd's of chest girth during inspiration and expiration and the difference of the latter as well as norms of these for every age group. Eiben and associates (1971) made a representative survey of the kindergartens and schools of the capital in 1968 and 1969. The most recent data of the Budapest agglomeration refer to 1995 and were reported by Németh (1996/97), Németh and Eiben (1997) and Eiben et al. (1991, 1998) as follow-up studies to the national growth study carried out by Eiben and associates.

The series of height and weight data of the Budapest children from 1930 till 1990 displays a definitely increasing trend with a different increment depending on the period studied, and on the age and sex of the subjects (Fig. 5 and 6). Similarly to those observed in the national data, the increments of height and weight in the males were greater than in the females. The secular increment of male height ranged between 0.6 and 2.4 cm per decade in the 43 years between 1952 and 1995, the one for female stature was 0.6-1.7 cm for the ages of 3 through 18. The secular increment per decade

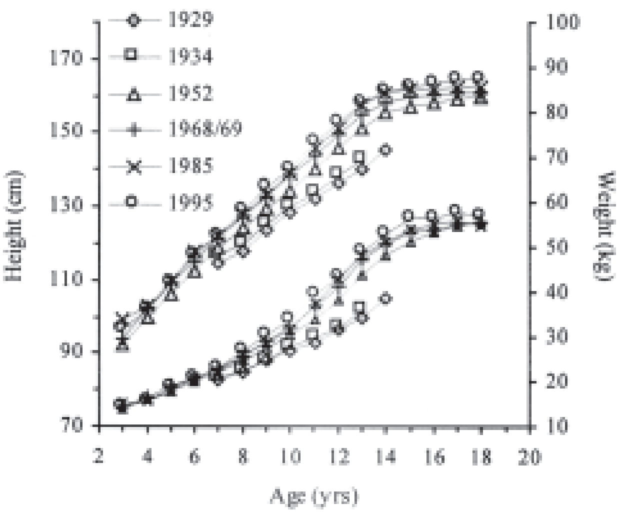

Figure 6. Secular change in height (cm) and weight (kg) of Budapest girls aged 3 to 18.

for male weight varied from 0.2 to 2.3 kg for the ages of 6 through 18, that for female weight from 0.2 to 1.3 kg. The largest differences were observed during puberty: 1.8-2.4 cm, and 1.8-2.3 kg for the males aged between 11 and 15 years, and 1.5-1.7 cm, and 1.1-1.3 kg for the females aged between 11 and 14 years respectively. This means that also growth rate has become faster.

The total secular increase in height and weight during the 43 years was 6.17 cm and 8.87 kg in the males of 18 years, respectively 4.72 cm and 3.78 kg in the females. The very small differences between the data referring to 1985 and

1995 may point to a radical reduction or perhaps complete cessation of secular growth.

Between 1959 and 1985 the age-group means of sitting height showed significant differences only during puberty in the males while at every age from puberty to age 18 in the girls. These findings suggest that there was no secular increase in sitting height, but growth rate became accelerated in the boys while female absolute sitting height grew larger. In the last decade there was no change in mean sitting height in either sex.

Shoulder width was found to have grown in both genders, but the rate of increase has slowed down in the females since 1985. The secular increment between 1985 and 1995 was nearly the same at every age. This led to the inference that differences were due to an absolute growth rather than to an acceleration of growth rate. On the other hand, the secular change in bicristal width could be attributed only to a change in growth rate since this dimension had not changed during the past 40 years (Eiben et al. 1998; Bodzsár 1998).

Regional growth studies

The trends observable in the growth patterns of children living in the several regions of Hungary were similar to those found in the Budapest children until the 1980s, only the extent and rate of their change was different. Such differences are a reflection of the inequalities existing in the economic development of the settlements. A generally applicable inference is that since the seventies and eighties the rate and extent of secular change levelled off in the larger, more urbanized and/or faster developing communities (Véli 1948, 1953, 1957, 1967, 1972; Rajkai 1951, 1963b, 1967a, 1970; Eiben 1977, 1982b; Bodzsár 1977, 1982b, 1984a, 1991a; Eiben et al. 1978; Szöllősi and Jókay 1978, 1988, 1991; Bodzsár and Véli 1980; Pantó 1980; Mészáros et al. 1981; Nyilas 1982a; Szöllősi 1982, 1998; Gyenis and Szerényiné Pásztor 1984; Bodzsár and Pápai 1992; Pápai 1992, 1996; Gyenis et al. 1993; Pap et al. 1997, 1998a, b, c). In contrast, the inhabitants of the settlements in which the improvement of socio-economic conditions and urbanization had started only during the last three decades display considerable secular increment and growth rate keeps accelerating in them even in the late eighties and early nineties (Nyilas 1982b; Gelencsér et al. 1986; Gyenis et al. 1993; G. Szabó et al. 1993, 1997).

Some regional studies have drawn attention to the problem that secular change can fluctuate both in extent and direction, depending on the period studied and on the respective age-group intervals (Eiben 1977, 1988a; Farkas and Szekeres 1982b; Farkas 1983a, 1986, 1990; Bodzsár and Pápai 1994; Szabó and Nyilas 1997; Bodzsár 1998). Studies to come only can clear whether these fluctuations have occurred in a random fashion or signalled a lasting absence of any trend or perhaps the fact that the trend became reversed.

Changes in adult height

Peer-age children of the various generations have been found to differ in their dimensions. The problem of whether these dimensional differences are attributable to differences in growth rate or to additional genuine growth or both cannot be settled by any further analysis or comparison of these children's data. In order to give a correct answer one has to know the comparable dimensions of the adults in the studied generations.

When changes in the height of the Hungarian adult population need be estimated, one has recourse to the data that were collected by the ethnic studies of physical anthropology, to recruit records and/or to the anthropometric data of a special subgroup of young adults, namely university or college students.

It was Bartucz (1912, 1913) who began the analysis and systematic interpretation of height data in respect of the ethnicities living in our country. He used his own ethnic studies as well as the available recruit records. He estimated the mean height of the Hungarian males to be 167.02 cm and the mean height of the Hungarian females to be 156.1 cm. He also noticed that remarkable regional differences existed (Bartucz 1938):

The available ethnic studies refer to various years and regions and were not systematic. Despite that they were not representative of the whole population of the country, they allow two statements of inference. The first is that stature varied markedly by region such that mean stature was found to decrease from northwest to southeast. The second is that mean adult height displayed a positive secular trend over time (Nemeskéri 1938, 1953; Thoma 1957; Kelemen 1968; Farkas and Lipták 1973a, b; Bodzsár and Eiben, 1973; Farkas et al. 1977; Henkey 1975; Henkey and Kalmár 1982).

In his ethnic studies carried out between 1957 and 1971 in the population living between the rivers Danube and Tisza, Henkey (1975) stated that people born after 1937 were markedly taller than the older generations though some slighter increase in stature could already be discovered in the people who were born after 1924. Farkas and associates (1977) performed their ethnic studies in Gyoma in 1974 and reported considerable differences between the mean height of people aged between 24 and 40 years and that of people aged between 41 and 60. This difference was +2.1 cm in favour of the younger males and +3.55 cm in favour of the younger females. Also the difference between the sexes has changed: it was 11.56 cm for the younger age interval while 13.01 cm for the older one. In the ethnic study of Farkas and Lipták (1973b) at Vésztő no change was found in the sexual difference between the subgroups of the same age intervals as mentioned above (the respective differences being 12.32 and 12.37 cm).

While Henkey's 1975 report only emphasized that the mean height of the 18-23-year-old males had increased more than that of the peer-age females, a secondary analysis of his data disclosed that sexual dimorphism in stature was more marked in the younger groups than in the older ones. To draw an inference about the trend in the sexual dimorphism of stature would be, however, unwarranted by these data only.

The earliest studies concerning mean recruit height date back to the seventies of the past century Scheiber: 164.6 cm (1881), Körösy: 163.1 cm (1878). Goehlert (1881) and Le Monnier (1882-1883) even undertook the task of mapping regional mean recruit stature over the entire Austro-Hungarian Monarchy for the first half of the 1870s. Basing on recruiting protocols Véli (1957) and Kádár and Véli (1971, 1977) conducted a rather systematic study of mean adult heights corresponding to the geographic regions beginning with the 1930s. In 1973 Nemeskéri and colleagues (1977, 1983) collected a 10% sample of the recruits born in 1955 and performed a complex analysis of demographic, anthropological and medical data to estimate body development.

By fitting a fourth-power regression polynomial to the Hungarian data available on the mean height of recruits and soldiers (Nemeskéri et al. 1983; Eiben 1988a), three growth phases of dissimilar rate could be discerned: the average rate of growth in stature was 0.6 mm per yr. in those born between 1840, and 1910, it was 0.75 mm per yr. in the ones born between 1910 and 1940 while it was 1.35 in those born between 1940 and 1957 (Bodzsár 1998).

Nemeskéri and associates (1983) compared the mean height of the 1870-1873 recruits reported by Goehlert (1881) to that of the conscripts studied in 1973. The difference was 7.9 cm. Eiben (1988) arrived at an estimate of 6 cm in 75 years, respectively one of 8.5 cm in 105 years by reanalyzing the military annals for those born in 1848-1849 (= 162.8 cm) and 1852 (= 162.1) as well as for those born in 1927 (= 168.1 cm) and 1957 (= 171.3 cm). His basis was the data series reported by Véli (1953), and by Nemeskéri et al. (1983).

Naturally, these data are biased by several errors. One of them is that none of the data were representative of the country, but were collected at diverse sites. Another important source of error may be that in the studied period very important changes occurred in the area of the country (it became reduced to about one-third of its previous area), in the number of its inhabitants and also in its ethnic composition.

The fact that regional variation in mean adult height has been remarkable is evidenced by the studies of Goehlert (cit. Bartucz 1938), the ethnic studies of Bartucz (1938), the data of Kádár and Véli (1971) for the recruits of 1957-1967, and of Nemeskéri and associates (1977, 1983) for the 1973 recruits as well as by the regional reports of Henkey and Kalmár (1982). Figure 7 shows the distribution of mean stature by counties and also the extent of the change in 100 years.

An analysis of the reports by Kádár and Véli (1971) as well as by Nemeskéri and associates (1983) allows not only to demonstrate the change in mean adult height and the regional differences, but also the manifestation of socio-economic agents. Urban populations have been consistently taller than rural ones and stature has been always the tallest in the largest city, namely Budapest the capital (Fig. 8).

A relatively large amount of data is available for the special subpopulation of young adults, namely college and university students, since the 1930s (Table 1). Figure 9 shows the development of mean height in the university youth of Budapest and Debrecen.

Inferences drawn by basing on these data may be biased by the facts that these students were not of an identical age range and that the social background of the students was not

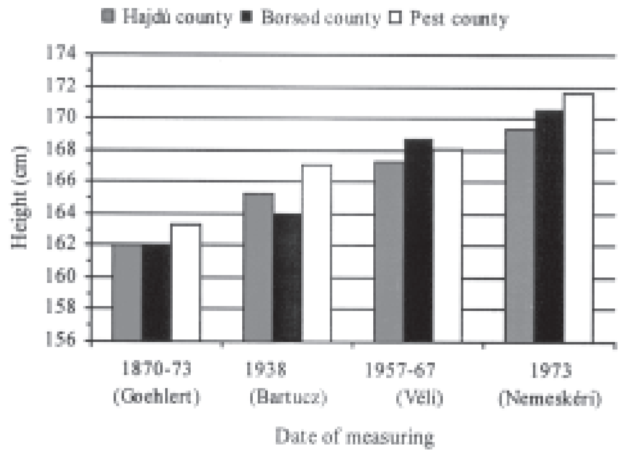

Figure 7. Secular change and regional differences in mean stature of recruits.

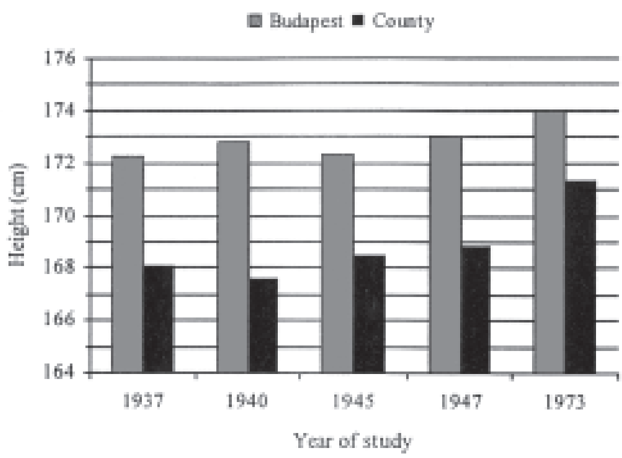

Figure 8. Secular change and urban-rural differences in mean stature of recruits.

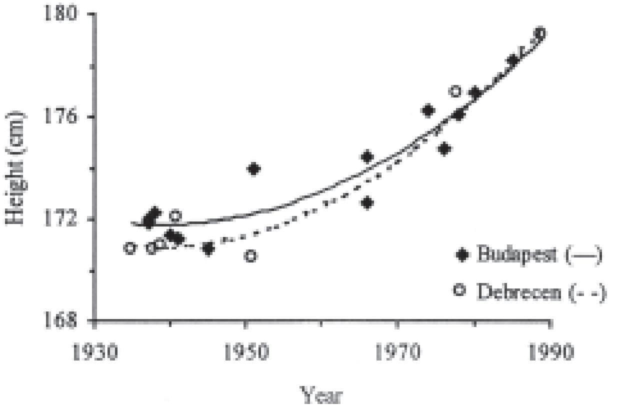

Figure 9. Curves of mean height in Budapest and Debrecen students.

the same before and after World War II. Anyway, it can be stated that adult mean stature has become markedly taller in Hungary since the end of the fifties, and that the increment in stature was nearly the same in the students of the Debrecen and Budapest universities. However, when students at the Budapest University of Technology were grouped by their place of birth, the change in stature turned out to be greater in those born in the country and not in Budapest. Further significant differences were found between the subgroups of paternal education and profession (Gyenis and Till 1981, 1986; Gyenis 1997).

Mészáros and associates (1982) analyzed the body dimensions of young adults (mostly aged 18-19) reporting for the entrance examinations of the Hungarian University of Physical Education by orthogonal polinomials year by year between 1972 and 1981. The continuation of this work was reported by Farkas and associates for the complete period between 1972 and 1991. The linear component was significant and positive. Height varied more in the females (more than 3 cm between the tallest and shortest groups) than in the males (less than 1.5 cm).

By summarizing the findings about the mean height of adults, recruits and university students, it can be stated that not only the rate of growth has become faster, but also mean Hungarian adult height has increased in both genders since the 1950s. These data are, however, not suitable to arrive at an unbiased estimate, because they represent very different strata of society and also the sampling frame has changed.

Change of body shape in the XX. century

The observations have thus shown that the extent and direction of the secular change may be different for the respective body dimensions inclusive of the possibility of no change at all. When such events are integrated by taking account of changes in different directions, the issues may affect body proportions, body composition and body shape as well.

Weight for height in the Budapest girls did not change practically for statures between 120 and 150 cm while it grew in the males (Fig. 10 and 11). Below 120 cm and above 150 cm weight for height decreased in both sexes (Bodzsár 1998). This measure displayed no remarkable change in the Körmend children between 1958 and 1988 either (Eiben 1977, 1994).

The secular increment in stature was due to a proportional growth of the trunk (sitting height) and the lower limb (Eiben 1985; Bodzsár and Pápai 1994). This statement is corroborated by the Budapest data too (Németh 1996/97). The direction of the change in the transversal to longitudinal proportion of the trunk was dissimilar in the respective

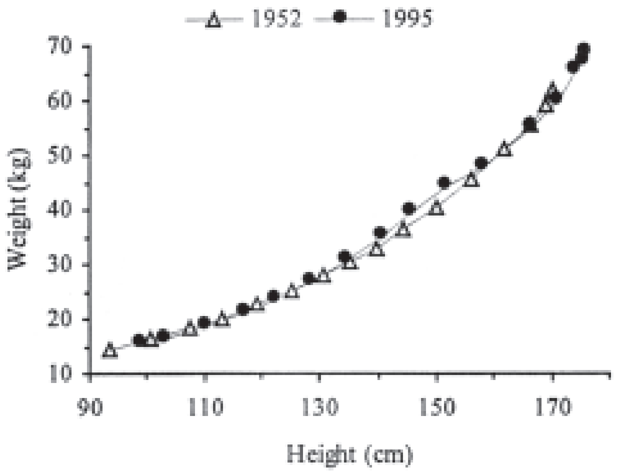

Figure 10. Weight-for-height data in 1952 and 1995 for Budapest boys aged 3 to 18.

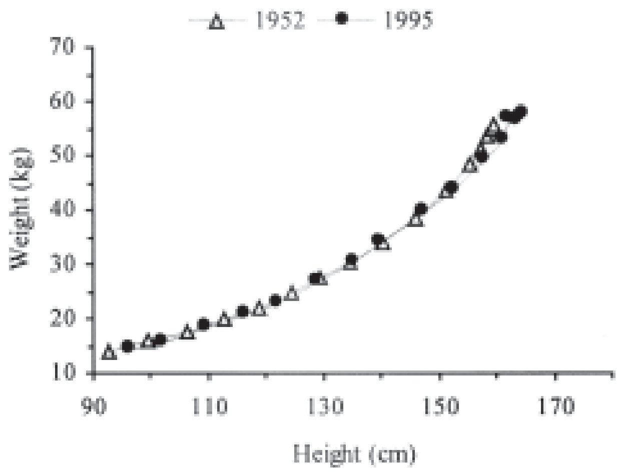

Figure 11. Weight-for-height data in 1952 and 1995 for Budapest girls aged 3 to 18.

Table 1. Reports on the mean height (cm) of college and university students.

Author and date	Locality	Year of study	Male sample	Male mean	Female sample	Female mean
Neuber (1936)	Debrecen	1935–36	237	170.77	–	–
Apor (1941)	Budapest	1937–38	1,554	171.87	–	–
Apor (1941)	Budapest	1938–39	1,427	172.23	–	–
Jeney (1940)	Debrecen	1938–39	742	170.77	–	–
Mezey (1940)	Budapest	1935–39	3,000	172.00	–	–
Jeney (1942)	Debrecen	1939–40	739	170.90	256	159.17
Allodiatoris (1952)	Budapest	1940–41	–	–	868	160.82
Allodiatoris, Nemeskéri (1970)	Budapest	1940–41	1,289	171.37	347	160.78
Allodiatoris, Nemeskéri (1970)	Budapest	1941–42	605	171.24	446	160.46
Balogh (1942)	Debrecen	1941–42	748	172.00	126	159.10
Nemeskéri (1970)	Budapest	1945–46	1,356	170.86	523	160.17
Rajkai (1952)	Debrecen	1951	1,000	170.42	–	–
Rajkai, Jancsó (1955)	Debrecen	1952–53	–	–	133	158.40
Rajkai (1957)	Debrecen	1953–54	–	–	262	159.14
Molnár (1968)	Budapest	1951/52, 1956	3,541	174.00	2,679	162.20
Molnár (1968)	Budapest, Debrecen, Miskolc	1956	4,490	172.61	1,517	160.68
Eiben (1965)	Szombathely	1964	–	–	179	159.80
Rajkai (1965)	Nyíregyháza	1965	–	–	99	160.53
Eiben, Gyenis (1972)	Budapest	1966	191	172.60	139	162.14
Nemeskéri (1970)	Budapest	1966	813	174.45	794	161.31
Mészáros et al. (1982)	Budapest	1972–1981	1,199	174.77	1,122	162.27
Till, Gyenis (1977)	Budapest	1974–75	726	176.26	196	164.66
Gyenis, Till (1986)	Budapest	1976–85	6,951	176.9.6	1,381	164.60
Mészáros et al. (1982)	Budapest	1978	130	176.04	102	164.54
Pápai (1984)	Jászberény	1974	–	–	267	161.04
Szöllősi, Jókay (1994)	Debrecen	1978–79	115	176.86	–	–
Szöllősi, Jókay (1994)	Debrecen	1979–80	–	–	188	163.29
Pápai (1984)	Jászberény	1980	–	–	188	162.65
Bodzsár et al. (1987)	Budapest	1985–86	847	178.16	831	164.58
Szöllősi (1998)	Debrecen	1986–92	650	179.14	414	165.84

regional studies. The Körmend observations show the pelvic region to have become proportionally narrower in both sexes between 1958 and 1968, with no change ever since (Eiben 1988a). The ratios of longitudinal to transversal dimensions did not change in the Székesfehérvár boys between 1981 and 1992, but the pelvic region of the females became larger proportionally (Bodzsár and Pápai 1994). The proportions of the transversal dimensions of the trunk did change in the Székesfehérvár boys and the Budapest children: their shoulder width decreased in proportion to bicristal width.

Naturally, there is no way to make any generalizable statement about the changes that might have occurred in the body shape of Hungarian children by basing on the relatively few regional studies that were sufficiently detailed to make an analysis of proportions feasible. One may infer from the data on weight for height to an increasingly more linear body build, but the increase in absolute stature was not associated with a change in the ratio of trunk length to lower limb length, which latter would speak for an increase in the linearity of body conformation.

By approaching body build as a whole, *i.e.*, in the way the "Gestalt" principle requires, the two studies that centred around physique revealed the existence of two slightly conflicting tendencies: Eiben's (1985) analysis of the changes occurring in the physique of the Körmend children between 1968 and 1978 was that both sexes had developed a more endomorphic mean somatotype. The change in the morphological constitution of the Budapest children – as estimated from data gathered in 1975, 1981 and 1991 by Mohácsi and associates (1994) – was found to be directed towards a slightly more leptomorphic and less hyperplastic growth type of Conrad, that is, towards a flatter trunk and less robust body build for the ages of 14 through 18 years.

Age and sex dependent variations of body build

When we review the reports of puberty (Eiben 1967, 1977, 1982b, 1994; Bodzsár 1975, 1982b, 1991, 1997; Farkas 1982b,1983a, b; Farkas és Szekeres 1982a; Dóber 1991, 1992; Pápai 1992, 1996; Pápai et al. 1991, 1992a, 1994; Pap et al. 1997, 1998b, c) that deal with the age and sex linked changes and differences observed in the relative measures and indices of physique, we find that the ratio between transverse and sagittal chest diameters, that of the transverse chest diameter to shoulder width as well as several of other body proportions assume a stable value already before puberty and tend to stay unchanged even during the growth spurt of puberty. On the other hand, the proportions of shoulder width and bicristal width related both to one another and to trunk length point to an increasing sexual dimorphism with advancing puberty.

While such proportions do reflect the development of body shape, they necessarily refer to one given region of the body alone. The overwhelming majority of the papers that analyzed morphological body build as a whole – and thus body shape – employed the method of the anthropometric somatotype of Heath and Carter (Eiben 1972a,b, 1985, 1988a; Szmodis 1977; Bodzsár 1980, 1984a, b, 1986, 1991a; Pápai and Szabó 1986; Pápai 1992; Pápai et al. 1991, 1992a, b, 1994; Zsákai and Bodzsár 1998). The other possible approach, that of estimating Conrad's anthropometric growth type (Conrad 1963), has been less popular than the former, mainly because of its German origins. Since it provides an independent further estimate on skeleto-muscular robustness, is suitable for demonstrating the course in which child-age physique approaches the adult one and takes account in its particular way also of sexual dimorphism, it has been used in Hungarian and German sports anthropology as a method complementary to somatotyping in athletic subjects (Szmodis 1977; Mészáros 1990).

The main trends in the age-linked changes observed in the anthropometric somatotype can be summarized as follows.

Somatotype has been evidenced to change also in children aged between 3 and 8. This global change involves changes in the thickness of subcutaneous adipose tissue, development of muscle and a relative increase in lower limb length related to trunk length. The change in mean somatotype is slight, if any, between the age of 8 and puberty. With the onset of puberty the somatotype undergoes marked changes again, the reason for which can be found mainly in the sex-linked shift of the proportion between shoulder width and bicristal diameter, in the accumulation of subcutaneous fat in the females and in the more intense growth of muscle in the males.

As age proceeds, the mean somatotype of males may stay unchanged or else it moves from the ectomorphic mesomorph region towards the mesomorphic ectomorph field. The mean somatotype of the females develops by moving from the ectomorphic mesomorph region into the ectomorphic endomorph area. Sexual differences of the mean somatotype become gradually greater with age: although females significantly differ in their somatotype components as early as the age of 7 years from the males, this difference shows a further slight increase until the age of 10, but a much more marked one when the fast fat accumulation of female puberty gives rise to a dominance of endomorphy in the female somatotype. The components of endomorphy and ectomorphy change in opposing directions in the two sexes. By the end of puberty sexual dimorphism is very near to that observed in adults.

In prepuberty the first component of the mean male somatotype shows an increase that lasts until 11 years of age when it becomes constant. Endomorphy shows a monotonous increase in the female except at the age of 10 to 11 years when it does not change. Mean relative fatness of the girls always exceeds that of the boys of the same age. The developmental course of endomorphy corroborates the inferences drawn from the studies on body composition: prepuberty is a phase associated with a gradual and slow fat accumulation while the early period of pubertal changes involve a loss of adipose tissue in both sexes. When puberty ends, the continued accumulation of fat in the girls may be regarded as a secondary sex characteristic.

Mesomorphy (component II) changes little during childhood. In prepuberty both sexes display some decrease in it, although the male mean consistently exceeds the female one at every pertinent age. With the onset of puberty a phase lag develops between the intensity of bone and muscle development. It is the longitudinal growth of limb bones that occurs first (this is associated with an increase in ectomorphy in early puberty). This phase is then followed by that of transversal growth of the same bones, but neither of these phases coincides with a growth of muscles. This is why mesomorphy shows merely a slight increase when habitual physical activity is not sufficiently intense. The relative robustness of the skeleto-muscular system shows no further change in the females after the age of 14; this occurs only after the age of 15 in the boys.

As mentioned above, the more essential changes in component III (ectomorphy or relative linearity of the somatotype) develop during puberty and in this regard the two sexes behave in an opposite way.

The distribution of individual somatotypes in a given age group is more homogeneous before than during puberty. The greatest heterogeneity has been found in the age interval of 11 through 13 years. Females display a broader dispersion of somatotypes than males.

Data about the relationship of male sexual maturation with individual somatotype are scarce and conflicting. Hunt (1966) claim that a dominance of ectomorphy in the somatotype makes one to expect a late but fast maturation while a dominance of endomorphy predicts an early but protracted process of maturation, further that a boy of mesomorphic dominance will be an early maturer, but his maturation rate will be average. The Hungarian samples have not shown such essential difference in the somatotype of the boys who were in the various stages of sexual maturity while there was a well observable relationship in the girls (Pápai 1996; Bodzsár 1999a). Girls of the same chronological age but of a different sexual maturity display marked differences in somatotype. The most conspicuous difference exists between early and late maturers. The stouter the physique and the sturdier the muscle and bones, the younger the age at which sexual maturity will be completed, and vice versa. The somatotype of a post-menarcheal girl differs significantly from that of a pre-menarcheal one. The sharpest difference can be found in the endomorphy component of the somatotype.

When girls are grouped by their stage of secondary sex characteristics, the migratory direction of the somatopoint means in the somatochart points to the fact that a higher stage of sexual maturity is associated with a more marked endomorphy.

The dependence of body composition on age and sex

Researches studying body composition by the two-compartment techniques have evidenced that behind an apparently identical mean body mass of males and females in childhood and prepuberty there is a very dissimilar proportion of fat and lean masses (Bugyi 1972; Bodzsár 1984a, b, 1991a, b, 1996; Bodzsár és Pápai 1989, 1992; Pápai 1992, 1996): boys have more of lean body mass while girls have more of fat. The smallest sexual difference in lean body mass has been observed at 11-12 years of age; this results from the fact that pubertal growth spurt occurs in females at a younger age. Increase in lean body mass is more intense and takes longer in the males; this produces a very important part of sexual dimorphism by the end of puberty.

The sexual difference of the body components, which already exists before puberty, becomes more accentuated by a dissimilar change of the component tissues during puberty. When the pubertal growth spurt of fat-free mass occurs in the boys, the ensuing decrease in fatness is not merely relative, but implies also an absolute loss of fat. This course of events has been termed the negative fat wave, and is followed by a period of very slow increase of body fat content. The fat loss of the girls however, is, only relative, and when the growth spurt of fat-free mass ends the process of fat accumulation becomes more intense.

Frisch and Revelle's hypothesis (1969) concerning a critical body mass, which assumes that menarche would occur in the girls after they had reached or passed a body mass of 47 kg, has met severe criticism, and has got only partial support from the various studies (Bodzsár 1975, 1991a, b; Eiben 1988a; Örley et al. 1980; Farkas és Szekeres 1986; Farkas 1990; Csoknyay 1998).

The studies that observed peer-age children grouped by the occurrence or non-occurrence of menarche, and compared the body composition of these groups have shown a significantly larger and a practically identical relative fat mass in the post-menarcheal girls at every age studied. This means that the smaller the fat percentage, the older the age at which menarche occurs (Bodzsár 1984a, 1984b; Bodzsár and Pápai 1994; Csoknyay 1998).

Post-menarcheal girls significantly exceed their pre-menarcheal peers also in their lean body mass. The analysis of relative body fat has shown beyond doubt that the ratio of lean body mass over fat mass is larger in the pre-menarcheal girls than in the relatively early maturers. In this way the difference of body mass in favour of the more mature ones results from the larger relative fat mass.

Although the relatively early maturing males accumulate less fat, also their absolute amount of lean body mass is consistently larger. The differences in sexual maturity that were found between the subgroups formed on the basis of relative body fat, respectively by the ratio of lean body mass over fat mass have been corroborated by the comparative analysis of maturity stages in the secondary sex characteristics.

Thus, one can make the summary statement that the maturation type of the individual is really reflected by body composition and, conversely, the fat content of the body depends also on the maturation type so that early maturers of either sex contain more fat than late maturers. The increase in the rate of prepubertal fat accumulation occurs at a younger chronological age in the early maturers. Therefore, the standards evolved for the age-dependent changes of body composition can inform us not only about the respective developmental stage of bones, muscle and fat in a child, but give some opportunity to make a short-range prediction about the events to be expected during puberty (Bodzsár and Pápai 1998).

Growth and socio-economic status

The recognition of the fact that marked differences develop between children living under dissimilar socio-economic conditions has already a long history (Villermé 1828; Cowell and Stanway 1833; Quételet 1835). When growth and maturation proceed under unfavourable circumstances, functional well-being as well as expected life span of the adult are likely to suffer. Darányi and Jankovich (1935) were the first who provided exact evidence on an impaired growth and slower development of children that were living under poor social conditions. Hungarian experts became early aware of the need for studying the relationship of socio-economic factors with growth. This fact can be easily proven by referring either to Véli's study about child development during and after the war or to the papers analyzing the question of "acceleration or release from under retardation" (Véli 1953, 1967; Eiben 1967; Rajkai 1967b). Despite this early awareness systematic studies of how body dimensions depended on the various socio-demographic factors started as late as the second half of the 1970s (Bodzsár 1975, 1977, 1984a, b, 1999a, b; Sárkány et al. 1977; Nemeskéri et al. 1983; Pantó and Eiben 1984; Eiben 1985, 1988b, 1989, 1994; Eiben and Pantó 1985; Eiben et al. 1988; Farkas 1986, 1990; Gyenis 1982, 1995, 1997; Gyenis and Szerényiné Pásztor 1984; Joubert 1990).

The findings reported by the studies discussing the relationship of growth with the bio-demographic or socio-economic agents can be summarized as follows.

When the subjects were grouped by parental site of birth, significant differences were found in stature, but not in the other dimensions studied.

The mother's age at delivery has a strong impact on the growth rate of the child. The body dimensions of a child delivered by a mother older than 36 years are mostly smaller; the child's lag in growth is most marked during puberty. There is no clear-cut answer to the question of how paternal age affects child growth.

The higher the order of birth, the smaller the child's dimensions. Differences between peer-age subgroups arranged by sibling numbers grow with an increasing number of brothers or sisters: a single child has consistently larger dimensions.

There are remarkable differences in growth rate that depend on parental profession: the children of white-collar parents are the tallest and heaviest. The same applies to parental education: the higher the level of parental education, the faster the child's growth rate. Growth rate is related also to per-capita income, floor space, community size, and degree of the settlement's urbanization. Dimensional differences between children living in urban or rural areas reflect the complex way in which the mentioned factors exert their effects. Environmental effects often act in combination: education and per-capita income is lower while family size is mostly greater in the rural regions. Also dietary considerations have a role: people living in towns consume a larger volume of vegetables, fruit, meat and dairy products, but less carbohydrate and animal fat. There are not negligible differences in life style, public hygiene or in the access to services.

Life style is strongly influenced by cultural traditions that include also dietary habits. These, however, are often not very closely related to the family's actual socio-economic status. While social status and body fat content were found to be uniformly negatively related in the West European countries, Hungarian data on body composition evidenced the opposite constellation: children living under favourable social conditions were heavier not merely due to their better skeleto-muscular development, but also due to their higher fat content The most likely reason for this discrepancy may be sought in the proportions of carbohydrates, fat and protein in the traditional diet of these countries.

The basic theorem of epidemiological auxology is likely to have been formulated in view of the connexion of environmental (socio-economic) factors with child growth and maturation: the phenotypic response to adverse environmental conditions is a smaller body size and a slowing down of developmental rate. The hypothesis forwarded to explain positive secular changes (namely, why children become taller and heavier and why they grow faster) is: the change in the pattern of growth is elicited by environmental, mainly by socio-demographic factors. Tanner's wording (1986) for this hypothesis is: "Growth is a mirror of conditions in society".

While the social gradient in child growth and development still exists in Hungary, the recent decades have shown its reduction. However, only future studies can clarify the effects on child growth and development exerted by the most recent reshaping of the economic structure.

Why growth studies so important

The first – and natural – reason is to broaden our knowledge about the main properties of human growth pattern, the age-linked particulars of physical development in the child. Efficient somatic and mental education and training as well as legislation concerning child-age problems needs a sound foundation.

Hungarian growth studies as well as those carried out in other countries have provided unanimous evidence for the assumption that – irrespective of sex and ethnicity – every healthy, well-bred and normal child follows the same human paradigm of development from its conception to the completion of its sexual maturation. As soon as this regularity of growth and the observed special characteristics of the growth pattern had been recognized, we became able to estimate the actual developmental stage of the child and to predict its expected final adult dimensions with an acceptable accuracy. The need for this kind of prediction most often arises in connexion with health, career guidance and selection for a particular event of sports.

Most methods of estimation utilize bone development to arrive at a prediction. There are, however, simple techniques that rely on anthropometric dimensions to develop a prognosis. Final adult height can be estimated by the method of Mészáros and Mohácsi (1983) which in the age interval of 7-16 years (most accurately between 11 and 13 years of age) takes actually measured height, weight, shoulder width, forearm and hand circumferences to calculate morphological age, then finds the corresponding percentage of the adult height standard among the tabulated values and extrapolates to 100%. Owing to the dissimilar growth rate of the various dimen-sions, body shape of the growing child is subjected to changes. When the age-dependent population means and variability of the respective absolute and/or relative body dimensions are known and still valid, we can estimate morphological age which is a specific expression of biological age (Mészáros and Mohácsi 1983).

Although the paradigm of growth is very stable, it is merely a potential: in respect of its intensity and duration growth is rather sensitive to environmental agents. The studies referred to before have proven that economic, hygienic and cultural peculiarities of an environment are faithfully reflected by growth data. In this way growth parameters can be used to detect social inequality in a population and are suitable indicators of changes occurring across time in the economic status of certain groups of the population or of the population as a whole. This is why the World Health Organization (1976) regards the growth data of children and youth best suited to describe the nutritional and health status of a community.

To follow up the biological status of individuals or populations one has to compare it repeatedly with the respective standards or norms of growth. Such norms are extremely helpful in medical, hygienic and epidemiological screening as well as in estimating the child's developmental and nutritional status in the paediatric practice to pick out children who need some special medical, educational or social care.

To be applicable, growth standards have to conform to particular requirements. Of these, one of the most essential requirements is that the norms should be derived of the population to which the subject belongs. Another criterion of applicability stems from the fact that growth data depend on the environment: out-of-date standards are of no use, comparison must rely on valid reference values.

We may consider ourselves lucky, because – in addition to several tables of regional norms – we have access to national standards of growth. Joubert (1983) published centile curves for birth length and weight by basing on data of neonates born in 1973-1978. Farkas (1987) published standards of some absolute measurements by basing on his national study. After having measured a sample that was representative for the whole country Eiben and colleagues (1991) developed reference tables for 18 body dimensions and 8 tests of physical abilities and motor skills. Concerning some important body dimensions, the data of the Budapest Longitudinal Growth Study were used to construct the centiles of not only the distance values, but also those of velocity for the age range between 3 and 18 years (Eiben et al. 1992). In 1981 Joubert and associates launched a national representative longitudinal growth study that traced child growth from birth; they have already analyzed and published the distance and velocity centiles of certain body dimensions (Darvay et al. 1991; Joubert et al. 1993, 1996a), and reference ranges that are suitable for obesity screening (Joubert 1996b).

Naturally, the mentioned aspects are far from exhausting the possible applications and uses of growth data. Several of these already exist, and hopefully the forthcoming new generations of anthropologists will find new ones while carrying on the job of recording the necessary dimensions and indices as well as systematically updating and validating growth standards.

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