Weight/Height^2 Indices in Hungarian Youth During The Twentieth Century

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INTRODUCTION

To estimate a relation between stature and body weight goes back to early ages, but by the 19th century scientific approaches appeared. A palpable question seemed to be: how large ratio of body weight falls to the share for one cm height? The greatest Belgian scientist of the 19th century, A. Quetelet, described indices W^2/H^5 and W/H for children and W/H^2 for adults (Quetelet, 1835).

Contrary to height, body weight does not grow on a linear way. As a consequence, out of two persons with the same physique, the taller one has a higher W/H value. To eliminate this problem, the stature was calculated with power. In the space of time over 150 mathematical equations have been developed in order to express biological rules of the process of growth and, for example, to support somatotyping.

Volume is a three-dimensional value. Rohrer (1908) preferred the index weight/height^3, which was proposed already by Buffon (1829). This index is also problematic, because weight does not grow pro rata with the value of stature on the third power. Trunk less participates in growth of height, much more does it the lower extremity with its smaller mass. In W/H^3 increase of weight falls behind the growing height, i. e. the index-value will be too low of a tall person, and too high of a small one, if their width is of the same form (Martin and Saller, 1957). Insufficiency of the Rohrer index came to light after World War I as, while organizing catering for children in poor health during the famine in Germany, tall boys and girls had low values of this index, while small ones had higher values. These findings induced Kaup, a German doctor, to call attention to the use of the W/H^2 index. Although proposed by Quetelet, it was called as Kaup index. Quetelet stated that in adults weight growth pro rata with height on the second power. The index characterises the developmental status of the body.

Martin and Saller (1957) gave "normal" values of the Kaup index as 2.0-2.7. In case of values lower than 2.0, they spoke about unsatisfied broad status and above 2.7 about over-developed broad status. In the pre-computer age, Eiben (1960) has constructed a nomogram to the Kaup index, to make easier the estimation of the index values.

In the Netherlands the term Quetelet index W/H^2 was current till the 1970s. A new term came into fashion in the last third of the twentieth century, the Body Mass Index. BMI = weight in kg x 10,000 / height in cm to the second power. Strictly speaking, weight and mass are not identical. The authors therefore prefer the more exact term W/H^2 index, but because BMI is generally introduced in international both terms are used in this publication.

Tóth and Eiben (2004) have published a book about secular changes of body measurements in Hungary during the twentieth century, according to decades from 1910s to 1990s. The calculated weighted means of the 3-18 year-old boys and girls demonstrate the phenomenon of change of growth, characterising the century. The data were accumulated and compiled on the numerous growth studies carried out in Hungary. Data elaborated, originated from different parts of Hungary and from different ages. Accordingly, one can't exclude some selective effects, like either in advance taller or smaller stature of a local population, differences in urban and rural way of life, including diet and physical activity, or just the educational level of the parents, etc. The presented results were discussed in relation to the changes of the socio-economic circumstances of the Hungarian youth, which may explain causes of the secular growth changes found.

In a discussion between the authors it seemed to be worthy to calculate weighted means, based on the presented height and weight data, of W/H^2. So the present paper can be a valuable supplement to the book in question.

MATERIAL AND METHODS

Basic intention of the book of Tóth and Eiben was to collect all retraceable growth data published in Hungary or abroad about Hungarian children. Although we know growth data in Hungary already from the 1870s, the age of

''schoolchildren" of that time was usually grouped according to school classes, i. e. not according to their chronological age. Consequently, we could not start our data-set earlier than in the decade beginning in 1910.

After co-ordination of the mass of our data, we have ordered those according to decades, and calculated weighted means of all available body measurements for boys and girls per decade. The method was as follows: mean height (weight, etc.) (M) of each age-group of a certain study was multiplied with the number of subjects in its age-group (N), then these part-sums were added up. Thereafter the sum of the means of all studies (according to age-groups, of course) was divided by the sum of all numbers of elements:

The age-specific mean W/H^2 indices (weight in kg x 10,000, height in cm to the second power)

Weighted Mean

$$= \frac{(M_1 \cdot N_1) + (M_2 \cdot N_2) + ... + (M_n \cdot N_n)}{N_1 + N_2 + ... + N_n}$$

of the Hungarian youth are given in table 1. The numbers are rounded upwards to one place of decimals. For some age-groups in the early decades no height and weight data were available. These are indicated with a ''-" sign.

Secular changes and sex differences of W/H^2 in Hungarian youth during the 20th century are analysed. The results are visualized according to age per decade (Figs. 1-8). The post-war secular changes according to age-groups of one year are visualized for the decades 40s-90s (Figs. 9-10).

For a better understanding of the Hungarian data a comparison is made with recent BMI data in the Netherlands. The Dutch 1980 and 1997 data are given in table 2 (Roede et al., 1985; Fredriks et al., 2000). The comparison of the Hungarian and Dutch values are demonstrated in Figures 11 and 12. Note that the projection of the age-points differ half a year as the Hungarian data were calculated for one-year groups and the Dutch ones for age-points X.0.

RESULTS

With exception of the relative extreme values in the 1920s, the published height and weight data are reliable for analysing the course of W/H^2 in Hungary over the twentieth century (Table 1).

During the century the curves according to age develop from irregular to the smooth lines of the 80s and 90s decades (Figs. 1-8). As is found world-wide, the lowest values, 15-15½, occur at pre-school age. For both sexes the impression is that after WW II the age of least values is earlier than before.

At pre-school and school age, W/H^2 values for boys are slightly higher than for girls in the decades 30s-50s and 80s-90s. At puberty, girls show higher values than boys, albeit that the duration differs: from ages 10 to 17 in the 40s, 11-16 years in the 50s and 80s, 12 to over 18 years in the 60s, 13-15 years in the 70s, and 14-15 years in the 90s.

In the course of the century, the Hungarian W/H^2 values changed as follows. In 3-5 year-old boys and 3-4 year-old girls a decreasing tendency occurred, while values in 6-8 year-old boys and girls hardly changed.

In particular the post-war period is of interest. Then the general image is that during puberty a gradual increase took place from decade 50s till decade 90s (Figs. 9-10). For boys the increase is about one unit at ages 9-10, about two units at ages 11-13, and less than one unit at 15-18 year-old. For girls the increase is less than for boys, while at ages 15-18 the curves are about horizontal.

The comparison of the Hungarian and Dutch BMI data in the 1990s is employed at age-points X.0 (Figs. 11-12). At pre-school age, BMI in Dutch boys is minutely greater than in Hungarian boys. At age 8.0-18.0 years, Hungarian boys have higher values than the Dutch ones, with a maximum difference of +1¼ unit at ages 12.0-14.0 years. In Dutch girls somewhat higher values are seen till 9.0 years. At ages 10.0-17.0 years, Hungarian girls have a greater BMI than the Dutch adolescent girls, with a maximum difference of +¼ to ¾ unit at ages 11.0-16.0. Connected with the already mentioned more horizontal course in the post-war period for the eldest Hungarian girls, while the BMI values in the Dutch girls still increase, the curves cross again.

DISCUSSION

There has been a long-time discussion on the significance of mathematical models of the relationship between weight and height, both during the growth period and adulthood (Ross and Eiben, 2002). Two aspects can be discerned: a. the employment for the appreciation of an

Table 1: Age-specific BMI values per decades in the twentieth century in Hungary

Age(year)	*1910s*	*1920s*	*1930s*	*1940s*	*1950s*	*1960s*	*1970s*	*1980s*	*1990s*
Boys									
3	-	-	-	-	16.9	16.3	15.6	15.7	15.6
4	-	-	16.5	15.5	16.7	16.0	15.3	15.5	15.3
5	-	-	16.2	15.6	16.4	15.8	15.0	15.4	15.4
6	-	15.5	15.6	15.3	16.1	15.0	15.1	15.5	15.4
7	-	16.5	16.0	15.6	15.8	15.6	15.4	15.6	15.8
8	-	16.3	15.7	15.9	16.2	16.3	16.3	16.0	16.3
9	-	16.7	16.0	16.5	15.7	15.9	16.2	16.5	16.5
10	19.0	16.7	16.0	16.2	16.4	16.8	17.1	17.1	17.3
11	17.9	16.5	16.7	16.4	16.3	17.3	17.3	17.5	18.3
12	18.4	17.1	17.1	16.7	16.8	17.7	18.1	18.1	18.9
13	18.4	17.5	18.3	17.8	17.5	18.2	18.4	18.8	19.5
14	19.3	-	18.3	18.3	18.5	18.9	18.9	19.6	20.0
15	19.2	-	18.1	18.9	19.5	19.5	20.2	20.3	20.3
16	20.6	-	18.5	20.1	20.3	20.2	20.6	20.9	21.0
17	-	-	19.1	20.7	21.1	20.8	20.8	21.5	21.6
18	-	-	19.5	21.6	21.2	21.4	21.2	21.9	22.1
Girls									
3	-	-	-	-	16.6	16.3	15.7	15.3	15.3
4	-	-	16.1	15.0	16.0	15.6	15.4	15.3	15.2
5	-	-	15.9	15.3	15.6	15.9	15.0	15.3	15.5
6	-	15.8	15.3	15.3	15.3	15.6	15.2	15.4	15.5
7	-	16.8	15.9	15.4	15.5	15.4	15.4	15.5	15.6
8	-	16.6	15.2	15.8	16.0	16.2	15.3	15.8	16.0
9	-	16.7	16.1	16.0	15.9	16.5	16.1	16.3	16.5
10	-	17.2	16.3	16.4	16.2	16.7	16.6	16.9	17.1
11	-	17.7	16.7	17.1	16.6	17.2	17.4	17.6	18.0
12	-	17.8	16.2	17.6	17.6	18.1	17.8	18.4	18.8
13	-	17.9	18.3	19.3	18.2	19.0	19.2	19.3	19.5
14	-	-	20.0	19.6	19.2	19.8	19.6	20.0	20.2
15	-	-	20.7	19.8	20.4	20.6	20.5	20.7	20.8
16	-	-	21.3	20.4	21.0	20.9	20.5	21.0	21.0
17	-	-	21.6	22.0	20.9	21.7	20.9	21.1	20.9
18	-	-	-	21.2	21.3	21.9	20.8	21.2	21.1

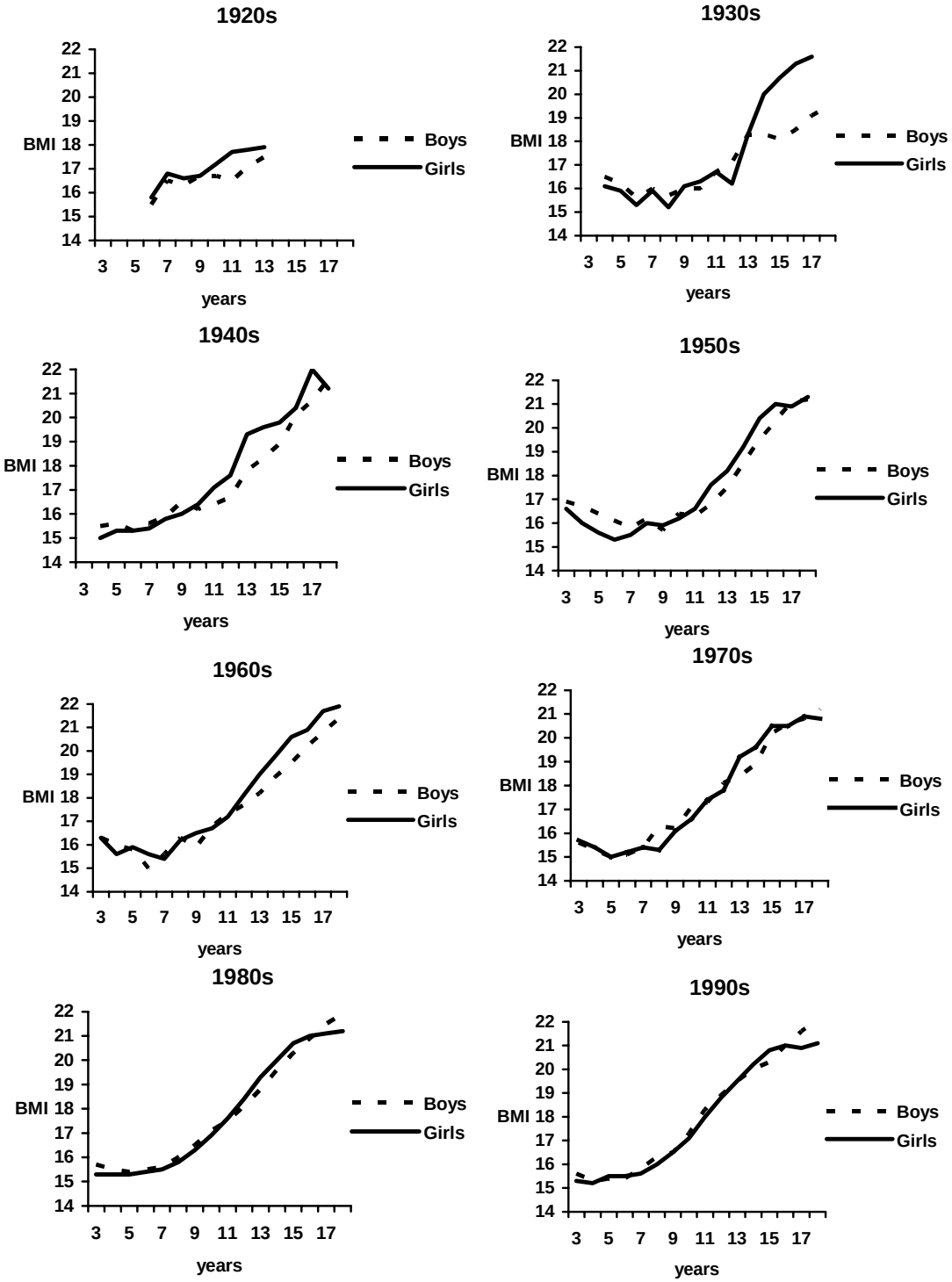
Table 2: Age-specific BMI values in Dutch boys and girls in 1980 (Roede et al., 1985) and 1997 (Frederiks et al., 2000)

Age (year)	*Boys*		*Girls*	
	1980	*1997*	*1980*	*1997*
3	15.9	15.9	15.8	15.7
4	15.6	15.6	15.5	15.5
5	15.4	15.5	15.2	15.4
6	15.2	15.5	15.0	15.5
7	15.3	15.6	15.1	15.7
8	15.4	15.8	15.4	16.0
9	15.7	16.1	15.7	16.3
10	16.0	16.4	16.1	16.7
11	16.4	16.8	16.7	17.2
12	16.7	17.3	17.4	17.8
13	17.3	18.0	18.1	18.5
14	18.2	18.5	19.0	19.2
15	19.0	19.2	19.7	19.8
16	19.6	19.9	20.1	20.3
17	20.2	20.4	20.4	20.8
18	20.7	20.9	20.6	21.2
19	21.2	21.4	20.7	21.5

individuals body build, i.e. in terms of underweight, overweight, and extreme overweight, and b. the epidemiological employment in the study of differences between populations and/or secular changes of growth.

Distribution centiles or standard deviation are necessary for an individual appreciation. Rather new is the proposal by the World Health Organization of the application of "cut-off values" of BMI for children and adolescents (Dietz et al., 1998). BMI values of 20, 25 and 30, used in young adults for the identification of population characteristics like underweight, overweight, and extreme overweight, respectively, can be extrapolated back to the standard deviation values based on growth surveys among children. Critical practise on the Dutch 1997 growth diagrams learned that the cut-off value of 20 for the identification of underweight in American children, is too high for Dutch children, because it would result in a category of over 20% of them with "underweight" (Fredriks et al., 2004).

An individual appreciation may not simply be made on the basis of a comparison with growth



Figs. 1-8. Mean BMI per decade of Hungarian youth in the twentieth century

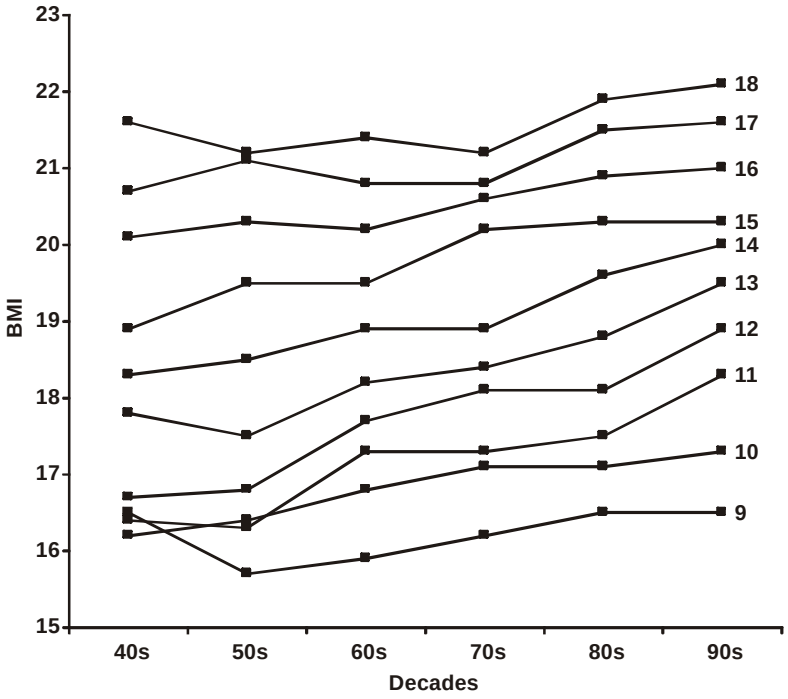


Fig. 9. Post-war courses of BMI, Hungarian boys, 9-18 year-old

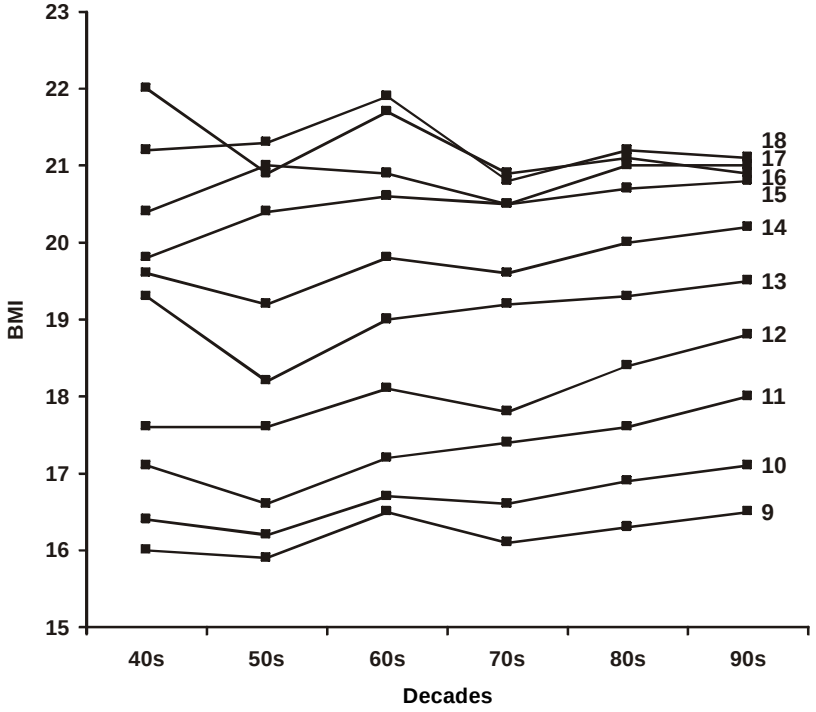


Fig. 10. Post-war courses of BMI, Hungarian girls, 9-18 year-old

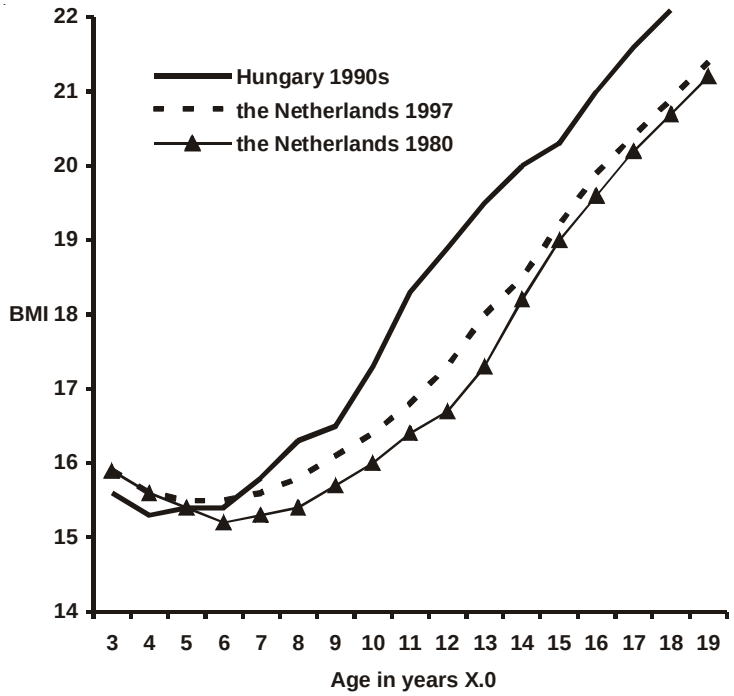


Fig. 11. Mean BMI values of boys, Hungary 1990s, the Netherlands 1997 and 1980

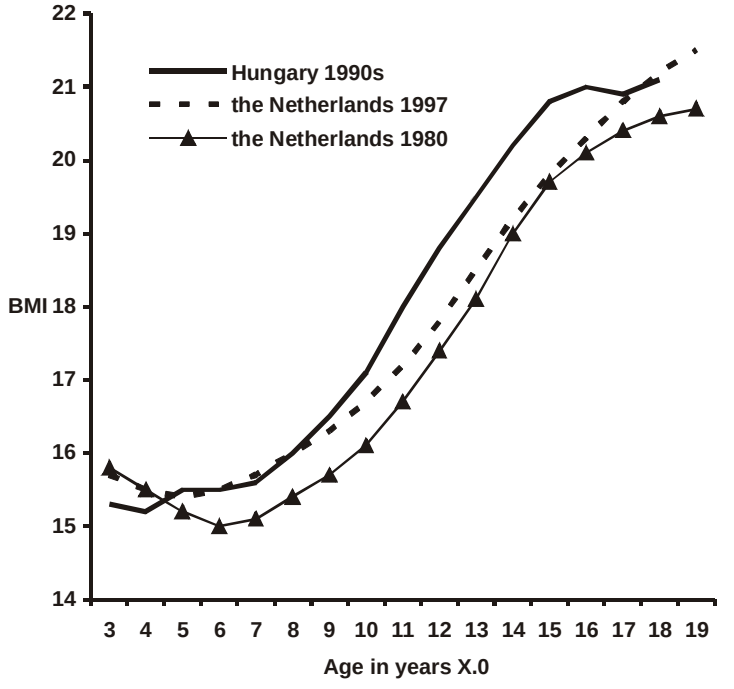


Fig. 12. Mean BMI values of girls, Hungary 1990s, the Netherlands 1997 and 1980

reference data like diagrams or BMI, yes or no cut-off values included. At least an experienced personal observation is required, by preference expanded by specific measurements like skinfold thickness, sitting height, and or waist circumference.

It is clear that mean or median values provide less information than distribution values on the body build of a population. Still, for an epidemiological study of secular changes within a population and differences of body build between (sub) populations mean/median values are useful.

As the distributions of weight and BMI are skewed to the right, it is most likely that a plain secular increase of mean values is brought about more by an increase of the number of individuals with a relative heavy weight than by a decrease of relative lean individuals. The increase of BMI in the Netherlands may serve as proof: the shift upwards in 1980-1997 of P90 is greater than of P10 (Fredriks et al., 2000).

The demonstrated secular increase of mean W/H^2 in Hungarian male and younger female adolescents, and the relative high values compared also to the increased values of their Dutch couterparts, are indicative for a change into the direction of overweight, perhaps for some individuals of extreme overweight. The same process is seen in other parts of the developed world. Connected health risks of adipositas are described: diabetes and cardio-vascular diseases.

Like in all countries with an increase, in some of them extreme, of adiposity in young as well as in older people, it will cost a lot of efforts on different levels to stop and invert this unhealthy process. It claims attention of the governments and asks for general health education programs, information on dietary and eating habits of the population, and co-operation of producers and retailers of nourishment products. The promotion of physical activities of children and youth as well as of adults is exclaimed to be of growing interest (Kemper, 2004).

If the horizontal course of W/H^2 in older Hungarian female adolescents is a sign of a conscious choice, it may be appreciated as an encouraging development.

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KEYWORDS Body Mass Index (BMI). Hungary. The Netherlands

ABSTRACT Together with the late Prof. Dr. O.G. Eiben, one of the authors recently published a book concerning secular changes of 22 body measurements in 3-18 year-old boys and girls in Hungary during the last century. Adding to this, it was intended to study similar data of W/H^2, as derived from the published weighted means of height and weight. The authors prefer the notation W/H^2 as weight and mass are not identical. The results are presented in terms of secular changes and sex differences in the 20th century in Hungary, and by comparison with the recent nation-wide data from the Netherlands. The positive secular change of height in Hungary may be considered as a positive health indication, the post-war increase of weight for height in boys 9-18 year-old as a negative one, and the post-war horizontal course of W/H^2 in 15-18 year-old girls as an encouraging development. In the Netherlands, weight for height in children and youth remained unchanged in the period 1965-1980, and increased clearly in 1980-1997. The

W/H² indices in Dutch boys show in early childhood a little higher, and after 7 years of age lower values than their Hungarian couterparts in the 1990s. In girls, the picture is similar, but the differences are much smaller.

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