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NEW HUNGARIAN NATIONAL CUT-OFF POINTS OF BMI FOR SCREENING CHILDHOOD UNDERWEIGHT, OVERWEIGHT AND OBESITY

Annamária Zsákai, Kristóf Jakab, Zsolt Karkus, Katalin Tóth, Boglárka Kern, Áron G. Vitályos, Adrienn Lichthammer, Szabina Balázsi and Zsuzsa Gábor

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

Abstract: *Obesity – a nutritional disorder, one of the chronic diseases of developed civilizations, is a major risk factor for several cardio-vascular and other diseases with complications manifested both in childhood and adult age. The prevalence of childhood overweight and obesity has grown to a dangerous extent in the developed societies during the last decades. The question of whether this increase of prevalence is really due to changes in lifestyle and dietary habits or else to some inadequacy of the screening methods still needs consideration.*

The main purposes of this study were 1) to develop the national body mass index (BMI) cut-off points of childhood underweight, overweight and obesity; 2) to estimate the current prevalence of underweight, overweight and obesity in Hungarian children by using the new national BMI cut-off points; and 3) to compare their prevalence estimated by international and national BMI cut-off points.

The subjects (n=24,888, aged 3–18 yrs) were the same as those of the representative cross-sectional study "2nd Hungarian National Growth Survey 2003–2006". Subjects were divided into underweight, overweight and obese subgroups by using international and national BMI cut-off points.

By considering the present economic status of Hungary, the extremely high prevalence of underweight Hungarian children (boys: 7–12%, girls: 13–18%) suggests the need for a revision of the BMI cut-off points used for screening underweight (centile curve crossing 18.5 kg/m^2 at the age of 18 yrs). Although the coincidence of the respective categories (made by using the international and national BMI cut-off points) of overweight (boys: 10–19%, girls: 5–12%) and obesity (boys: 3–5%, girls: 1–3%) was good in both genders, the observations suggested that one should consider methodological implications before inferring prevalence of childhood obesity and overweight.

Keywords: *2nd Hungarian National Growth Survey; BMI cut-off points; Underweight; Overweight; Obesity; Children.*

Introduction

Underweight, overweight and obesity are all abnormalities of nutritional status. Chronic underweight in childhood delays growth and maturation processes and causes serious somatic and mental retardation (Susanne and Bodzsár 2004). More than 1% of children were visually labelled underweight among the subjects of the present sample during the anthropometric investigation. This drew our attention to childhood underweight in present-day Hungary.

To diagnose and treat childhood overweight and obesity is a task as important as that of childhood underweight, not only because obese children tend to become overweight/obese adults, but also because independently of age and gender, as a chronic nutritional disorder, obesity is a major risk factor for many diseases and health complications as well (Gasser et al. 1994, Siervogel et al. 1998, Susanne and Bodzsár 2004). In contrast to overweight, the struggle against obesity needs medical intervention.

There is no doubt that child-age and adult prevalence of overweight and obesity has grown due to changes in lifestyle and dietary habits in the developed European societies including Hungary during the past decades (Bodzsár and Susanne 1998, Gyenis et al. 2004). The question of whether this increase of prevalence is really due to an improvement of these environmental/external factors or else to some inadequacy of the screening methods still needs consideration.

The main purposes of this study were

1. to develop new national body mass index (BMI) cut-off points for screening childhood underweight, overweight and obesity;
2. to estimate the prevalence of childhood underweight, overweight and obesity at the beginning of the 21st century in Hungary by using these new cut-off points; and
3. to compare in the same sample of children the prevalences of childhood overweight and obesity as estimated by the new national cut-off points and the international cut-off points recommended for use in international comparisons (Cole et al. 2000).

Subjects and Methods

The subjects of the present paper were examined in the 2nd Hungarian National Representative Growth Survey 2003–2006 (HNGS, 1% representativeness; Bodzsár 2006), a cross-sectional study to gather data on the biological and psycho-social status of 24,888 children aged 3–18 years living in Hungary (Table 1).

Table 1. Distribution of the subjects by age and gender.

Age (ys)	Boys	Girls	Together
3	527	549	1076
4	582	553	1135
5	712	664	1376
6	730	716	1446
7	726	734	1460
8	837	889	1726
9	867	862	1729
10	823	838	1661
11	840	830	1670
12	849	902	1751
13	778	808	1586
14	718	692	1410
15	820	821	1641
16	850	895	1745
17	865	877	1742
18	872	862	1734
Total	12396	12492	24888

Children were assigned to the BMI categories "underweight", "normal", "overweight" and "obese" by using (1) the age-dependent cut-off points recommended by Cole and his colleagues (Cole et al. 2000) and (2) the new Hungarian BMI cut-off points based on the data of the present representative sample by following Cole and his colleagues' suggestions and method. Cole and his colleagues constructed the age-dependent BMI cut-off points by obtaining data (n=94,851) from six large nationally representative cross sectional surveys on growth from Brazil (1989), Great Britain (1978–1993), Hong Kong (1993), the Netherlands (1980), Singapore (1993) and the USA (1963–1980; Cole et al.

2000). To help researchers providing internationally comparable prevalence rates of overweight and obesity in children Cole and his colleagues proposed BMI cut-off limits using age-dependent trends of BMI and WHO's adult cut-off-points of overweight and obesity by defining centile curves passing through the adult cut-off points of 25 and 30 kg/m^2 resp. at age 18.

The centile curves (3rd, 10th, 25th, 50th, 75th, 90th, 97th and cut-off centiles) were estimated by Cole's LMS method (Cole et al. 2000, Pan and Cole 2004). By this method centile lines can be constructed even for non-normally distributed data. To remove skewness a suitable Box-Cox transformation (1964) was applied in every age group. Using the smoothed curves of the power term (L), the mean (M), and the coefficient of variation (S) at each age, centiles (Ci) could be constructed by using the formulas: if $L \neq 0$: $C_i = M \times (1 + L \times S \times z_i)^{1/L}$, if $L=0$: $C_i = M \times \exp(S \times z_i)$, where z_i is the normal equivalent deviate for the required centile. By using the appropriate formula and the L, M, S values (Table 2) of the studied variable any requested centiles can be calculated.

All differences were tested for significance at the 5% level of random error in the computations by using the SPSS for Windows v. 14.0 software.

Results and Discussion

Changes of BMI by age and gender in Hungarian children aged 3–18 years

The centile distribution of both genders (Fig. 1) demonstrated significant age changes in BMI: after a mild decrease of the median and below-median BMI centiles in early childhood an increase was found from the age of 6 both in the boys and the girls. This strongly supports the use of age-dependent BMI cut-off points for screening abnormalities of the nutritional status in childhood.

By regarding the sexual differences in the centile distribution and age group medians of BMI as well (Figs 1–2, Table 2), it could be stated that 1) till the age of 15 there was no significant sexual difference in BMI, and 2) BMI increased in the boys while did not change in the girls after 15.

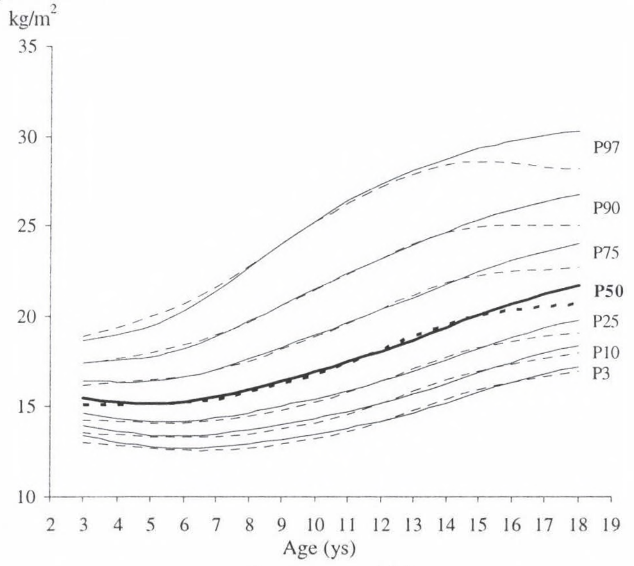

Figure 1: BMI centile pattern of Hungarian children aged 3–18 years.

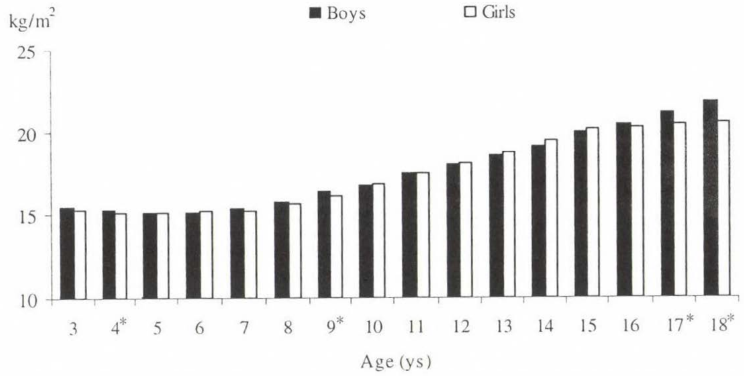

Figure 2: BMI medians of Hungarian children aged 3–18 years (*: Mann–Whitney U-test – significant sexual difference).

Table 2. LMS values for body mass index (kg/m²) in Hungarian children.

	Boys		Age		Girls	
L	M	S	(yrs)	L	M	S
–1.65	15.46	0.09	3.0	–2.02	15.15	0.09
–1.70	15.36	0.09	3.5	–2.01	15.14	0.10
–1.74	15.28	0.10	4.0	–2.00	15.14	0.10
–1.79	15.21	0.10	4.5	–1.99	15.15	0.11
–1.83	15.18	0.11	5.0	–1.97	15.17	0.11
–1.87	15.20	0.11	5.5	–1.96	15.20	0.12
–1.91	15.28	0.12	6.0	–1.94	15.25	0.12
–1.93	15.40	0.12	6.5	–1.92	15.33	0.13
–1.95	15.55	0.13	7.0	–1.89	15.45	0.13
–1.96	15.74	0.13	7.5	–1.87	15.60	0.14
–1.95	15.95	0.14	8.0	–1.84	15.79	0.14
–1.93	16.19	0.14	8.5	–1.81	16.01	0.15
–1.89	16.44	0.14	9.0	–1.77	16.26	0.15
–1.85	16.69	0.15	9.5	–1.73	16.52	0.15
–1.81	16.95	0.15	10.0	–1.68	16.80	0.16
–1.78	17.22	0.15	10.5	–1.64	17.10	0.16
–1.74	17.50	0.16	11.0	–1.60	17.43	0.16
–1.71	17.79	0.16	11.5	–1.57	17.78	0.16
–1.68	18.08	0.16	12.0	–1.55	18.14	0.16
–1.65	18.38	0.16	12.5	–1.54	18.51	0.16
–1.62	18.70	0.16	13.0	–1.53	18.87	0.16
–1.60	19.03	0.16	13.5	–1.53	19.22	0.15
–1.58	19.37	0.16	14.0	–1.54	19.53	0.15
–1.56	19.72	0.15	14.5	–1.55	19.80	0.15
–1.54	20.05	0.15	15.0	–1.56	20.02	0.15
–1.52	20.37	0.15	15.5	–1.59	20.19	0.14
–1.49	20.66	0.15	16.0	–1.61	20.31	0.14
–1.47	20.94	0.15	16.5	–1.65	20.41	0.14
–1.44	21.20	0.15	17.0	–1.70	20.50	0.13
–1.41	21.44	0.14	17.5	–1.75	20.58	0.13
–1.38	21.65	0.14	18.0	–1.82	20.66	0.13

L: Box–Cox power transformation, M: median, S: variation coefficient

The prevalence of underweight, overweight and obesity in Hungarian children aged 3–18 years

BMI cut-off points for underweight, overweight and obesity constructed by using the present sample representative of the Hungarian children aged between 3 and 18 are shown in Table 3. By considering the distributions of subgroups of children having nutritional status abnormalities formed by using these new national cut-off points having, it could be stated that (Fig. 3)

1. 7–12% of boys and 13–18% of girls were underweight; 10–19% of boys and 5–12% of girls were overweight, 3–5% of boys and 1–3% of girls were obese in the present sample.
2. A pubertal increase could be observed in both genders in the prevalence of overweight and obese children.

Table 3. Cut off points for BMI (kg/m^2) for underweight (BMI18,5) overweight (BMI25) and obesity (BMI30) constructed on the basis of the children's data participating in the 2nd HNGS.

	BMI18.5		BMI25		BMI30	
Age (ys)	Boys	Girls	Boys	Girls	Boys	Girls
3.0	14.03	13.92	16.81	17.40	18.56	19.65
3.5	13.87	13.86	16.80	17.52	18.71	19.96
4.0	13.72	13.81	16.80	17.66	18.88	20.30
4.5	13.60	13.77	16.83	17.82	19.08	20.68
5.0	13.50	13.73	16.89	17.99	19.35	21.09
5.5	13.46	13.71	17.02	18.18	19.69	21.54
6.0	13.46	13.70	17.20	18.40	20.12	22.04
6.5	13.51	13.72	17.44	18.66	20.62	22.60
7.0	13.59	13.76	17.72	18.96	21.19	23.22
7.5	13.69	13.84	18.03	19.31	21.80	23.91
8.0	13.81	13.96	18.37	19.70	22.44	24.66
8.5	13.96	14.11	18.74	20.12	23.09	25.43
9.0	14.11	14.27	19.11	20.57	23.73	26.18
9.5	14.27	14.47	19.48	21.02	24.34	26.89
10.0	14.45	14.67	19.86	21.46	24.93	27.53
10.5	14.64	14.91	20.23	21.89	25.50	28.10
11.0	14.84	15.17	20.60	22.33	26.03	28.62
11.5	15.05	15.46	20.97	22.77	26.52	29.10
12.0	15.28	15.78	21.33	23.19	26.97	29.54
12.5	15.53	16.12	21.69	23.60	27.37	29.91
13.0	15.79	16.46	22.05	23.98	27.74	30.23
13.5	16.08	16.79	22.40	24.32	28.08	30.47
14.0	16.39	17.09	22.77	24.59	28.41	30.63
14.5	16.70	17.37	23.12	24.80	28.71	30.70
15.0	17.01	17.61	23.46	24.94	28.99	30.68
15.5	17.30	17.81	23.77	25.02	29.21	30.59
16.0	17.58	17.98	24.06	25.04	29.41	30.45
16.5	17.83	18.12	24.32	25.04	29.59	30.29
17.0	18.08	18.25	24.58	25.02	29.76	30.15
17.5	18.30	18.37	24.80	25.01	29.90	30.04
18.0	18.50	18.50	25.00	25.00	30.00	30.00

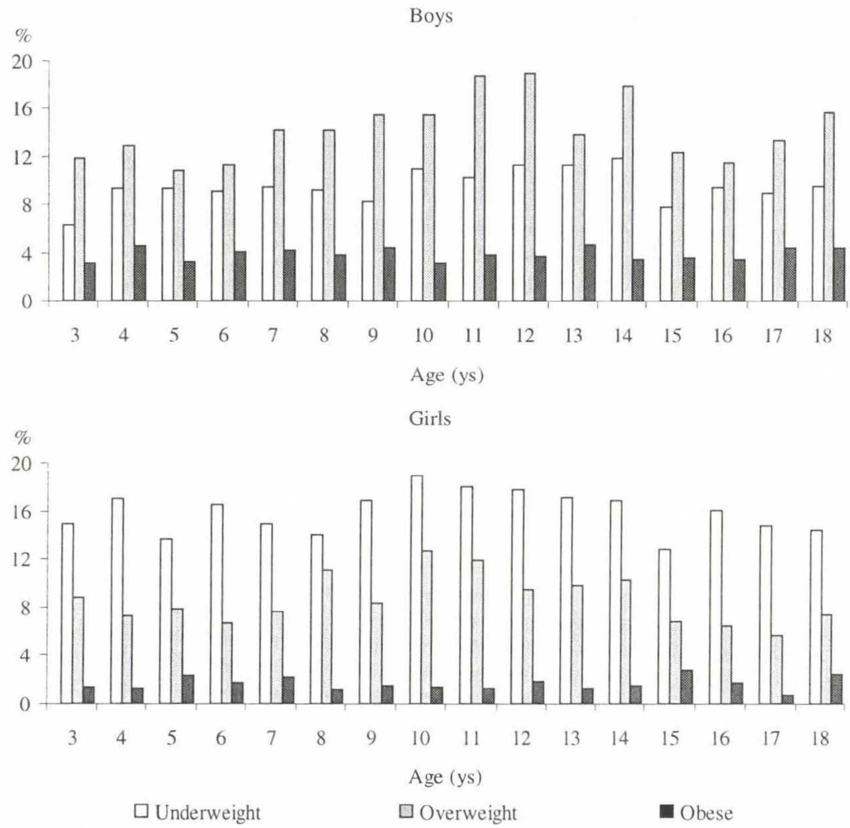

Figure 3: Frequencies of underweight, overweight and obese children.

Since cut-off points for screening childhood underweight were not constructed by Cole and his colleagues, only the national and international cut-off points of overweight and obesity, respectively, and the prevalence of overweight and obesity assessed by using these cut-off points could be compared.

By comparing the BMI cut-off points constructed (1) by Cole and his colleagues (2000) to (2) the present sample the following points could be stated (Fig. 4):

1. The difference between the national and international cut-off points was bigger in the girls than in the boys.
2. The national and international cut-off curves of overweight and obesity ran parallel across the studied age interval after early childhood in the boys. Overweight cut-off curves were not only parallel but differed only in early childhood in the boys, i.e., the international cut-off curve ran higher than the national one; while the national cut-off curve of obesity ran higher than the curve constructed by Cole and his colleagues (2000) with the exception of the age interval of 3–4 in the boys.
3. In contrast to boys, the difference between the national and international curve pairs was bigger in the girls with the exception of the youngest and oldest age groups (this similarity at the age of 18 was due to the similarity of curve construction, centiles had to pass through the 25 and 30 values).

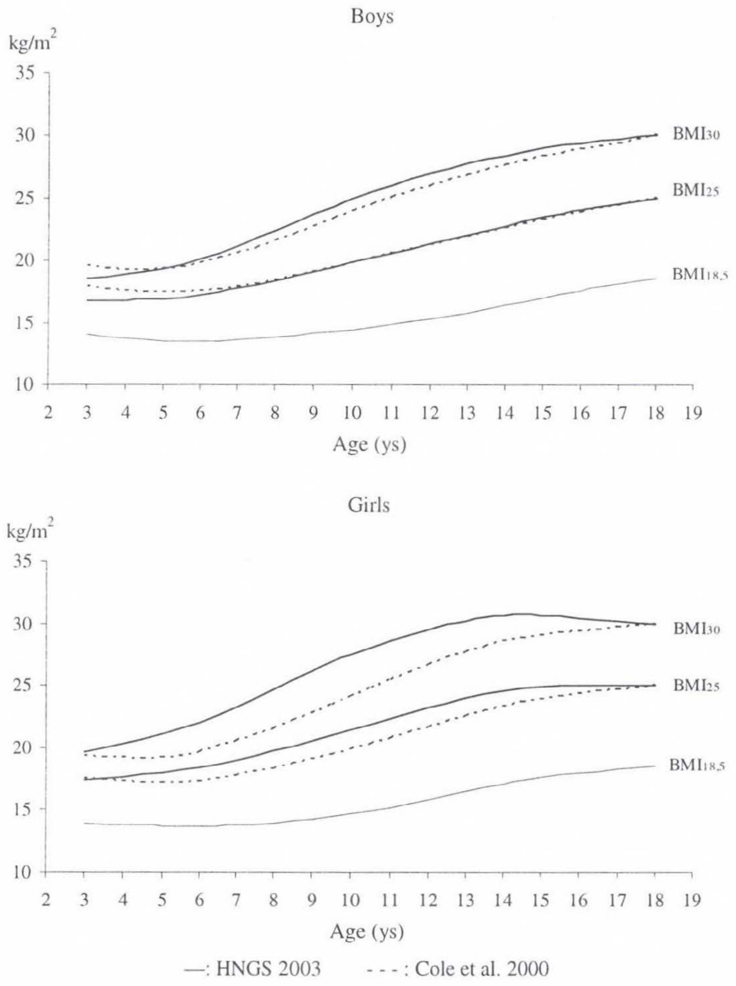

Figure 4: Cut-off point curves (passing through BMI 18.5, 25 and 30 kg/m^2 at age 18 years) for BMI for underweight (BMI18.5) overweight (BMI25) and obesity (BMI30).

To test whether these differences were significant χ^2 homogeneity test was used. Overweight and obese subgroup distributions (Fig. 5), estimated by national, resp. international cut-off points were compared.

The distributions of overweight children did not differ either in the boys or in the girls (χ^2-test – boys: $p>0.05$, girls: $p>0,05$), i.e., almost the same prevalence of overweight were assigned by using the national and international cut-off points. The same tendency was found in the subgroups of obese boys (χ^2-test – $p>0.05$), while the subgroups of obese girls were different in size by using the cut-off point of Cole and his colleagues (2002) and the new Hungarian ones (χ^2-test – $p<0.05$), namely, the prevalence of obesity was smaller by using the national cut-off points than with the international ones.

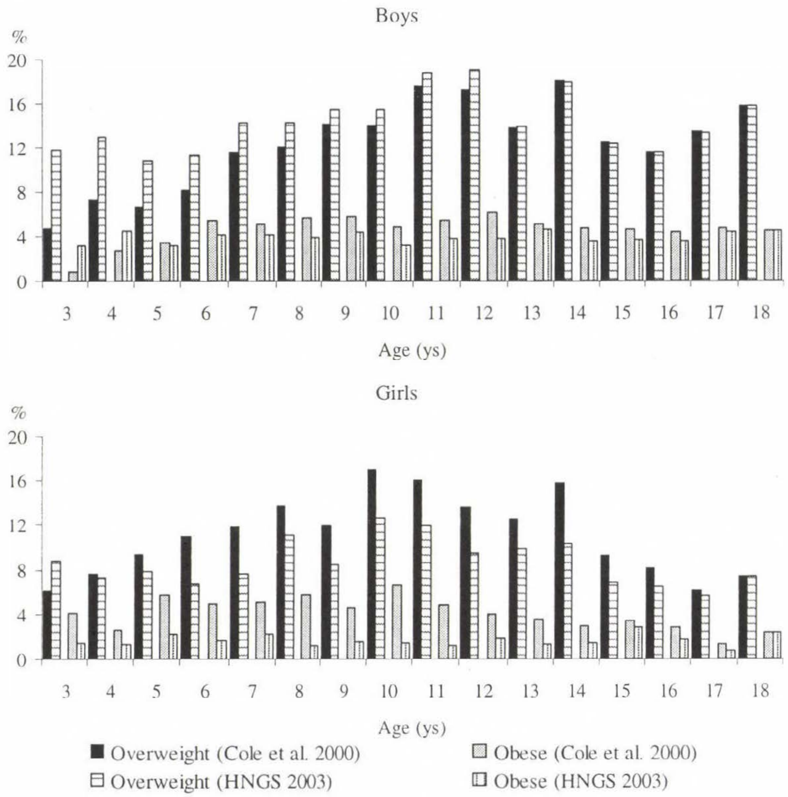

Figure 5: Frequencies of overweight and obese subgroups divided by using BMI cut-off points constructed by Cole and his colleagues (2000) and by using the Hungarian national cut-off points.

Although the subgroup sizes of obese and overweight children estimated by using the national, resp. international BMI cut-off points did not differ significantly, the cross-tabulations of the subgroups (Table 4) revealed that there were individuals who were grouped differently by using the two cut-off point series, namely, 2.2% of the boys and 7.8% of the girls were labelled to belong to different subgroups.

Table 4. Cross-tabulation of the subgroup distributions (%) defined by using the BMI cut-off points of Cole et al. (2000) and the new Hungarian ones.

	Subgroups – HNGS 2003		
Subgroups – Cole et al. 2000	N	Ow	Ob
		Boys	
N	81.5	0.9	0.0
Ow	0.3	12.4	0.1
Ob	0.0	1.0	3.8
		Girls	
N	84.2	0.0	0.0
Ow	5.3	6.4	0.0
Ob	0.0	2.5	1.7

N: normal nutritional status; Ow: overweight; Ob: obese

If a boy was labelled as an overweight one by using one of the cut-off points series, he may have been labelled as one of the other two types of nutritional status, obese or having a normal nutritional status by the other series while, in contrast, a systematic difference was found in the grouping in the girls: in 7.8% of the girls that were subgrouped differently, everybody was overweight or obese by the cut-off points of Cole and his colleagues but was overweight or normal by the new Hungarian cut-off points, resp.

Inferences

Body mass index has been used not only for screening nutritional status disorders in medical and anthropometrical practice as it was originally suggested by the WHO (2000) but for body composition assessment as well. By considering the body dimensions (body mass and stature) built in the index, this adoption of the BMI should be revised.

By using an adequate method for body composition assessment in subjects classified as overweight, it can be stated whether the weight excess originated from fat or musculo-skeletal dominance or both.

However, the reliability of screening for underweight and obesity by the BMI cut-off points is fairly good because of the extremity of the cut-off points of these types of nutritional status disorders – as confirmed by experts studying nutritional status (Susanne and Bodzsár 2004). It has been evidenced by many studies (cf. Susanne and Bodzsár 2004) that adults having BMI values below 18.5 kg/m^2 are really underweight, their relative body mass is very small, while those having BMI values over 30 kg/m^2 are actually obese, they have very large relative body mass.

The age-dependent BMI cut-off points were constructed by using the smoothed centiles passing through the values of 18.5, 25 and 30 kg/m^2 at the age of 18 in the present sample. But the frequency of underweight, overweight and obese subgroups estimated by using these new national centiles in this sample does not only depend on the virtual prevalence of the subgroups but on the centiles chosen to cross the critical BMI values (boys: 11.02, 81.90, 96.70 – girls: 16.50, 90.00, 98.10) as well (e.g. in the sample used for cut-off points construction the 11.02th centile always classifies about 11% of boys as underweight, any differences from this value are caused only by the smoothing technique).

All these considerations and the sexual difference in BMI at the age of 18 should make us suspicious whether it is correct to use the same critical values of BMI at the age of 18.

The prevalence of underweight (>10%) estimated by using the new national cut-off points appears to be problematic – supposing its values are too high in Hungary in the beginning of the 21st century.

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Mailing address: Annamária Zsákai
Eötvös Loránd University
Department of Biological Anthropology
H-1117 Budapest
Pázmány Péter sétány 1/C.
Hungary
zsakaia@elte.hu