Is there a rationale for establishing Slovenian body mass index references of school-aged children and adolescents?

Gregor Starc
University of Ljubljana, gregor.starc@fsp.uni-lj.si

Janko Strel
University of Ljubljana, janko.strel@fsp.uni-lj.si

Abstract

This study provides the rationale for construction of first nationally-specific BMI-for-age charts for school-aged children and adolescents in Slovenia. Because nonationally specific BMI cut-off points have been developed in Slovenia so far, international references such as WHO and IOTF BMI-for-age charts have been utilized in research and diagnostics. We tired to establish whether the use of more recent Slovenian data for production of BMI-for-age charts could result in improved accuracy of this tool for defining adipose tissue. We used the data of 4,931 boys and 4,699 girls aged from 6 to 19 years, who were measured in 1993, 1994, 2003 and 2004 for the construction of nationally specific BMI references. Centile curves were constructed using the LMS method. After classifying a sample of Slovenian children and adolescents into underweight, normal, overweight and obese category according to national, WHO and IOTF references, we calculated the correlations of these classifications with the sum of triceps, abdominal and subscapular skinfolds. The results showed strong correlation of all three references with the sum of skinfolds in boys and girls, but the national references achieved the strongest correlations. We conclude that the nationally-specific BMI cut-off points, based on more recent data than international references, would be appropriate for defining underweight, overweight and obesity in Slovenian school-aged population.

KEYWORDS: BMI reference, skinfolds, children, adolescents, Slovenia, LMS

ANTHROPOLOGICAL NOTEBOOKS 17 (3): 89–100.
ISSN 1408-032X

Introduction

Overweight and obesity show growing secular trends of children and adolescent obesity in most European countries (Manios & Costarelli 2011). Recording and understanding the prevalence of obesity can facilitate the effective public health intervention policies but in order to do so, the measures of adiposity, based on obesity-related criteria have to be defined. In recent years, body mass index (BMI) has been increasingly accepted as a valid indirect measure of adipose tissue in children and adolescents (Wang & Lobstein 2006). The BMI cut-off points of 25 and 30 are commonly used to define adult overweight and obesity, respectively, but for children and adolescents their BMI will normally change with age and vary by gender. Thus, age- and gender-specific BMI cut-off points are needed when classifying overweight and obesity in young people (Kuczmarski et al. 2000; Cole et al. 2000). A number of different international BMI references have been developed such as currently most widely used World Health Organisation (WHO) (de Onis et al. 2007) and International Obesity Task Force (IOTF) (Cole et al. 2000; Cole et al. 2007) BMI-for-age charts. While the international references are very useful for gathering internationally comparable data, their practical applications in local settings can be disputable (Kim et al. 2005; Hosseini et al. 1999; Daniels, Khoury & Morrison 1997; Deurenberg 2001; Deurenberg et al. 2003; Duncan, Duncan & Schofield 2009). The diagnostic accuracy when screening for overweight and obesity in specific populations can be improved with the use of nationally specific BMI-for-age charts and the first ones have been constructed in the 1990s for French (Rolland-Cachera et al. 1991), American (Hammer et al. 1991; Must, Dallal & Dietz 1991), British (Cole, Freeman & Preece 1995; White et al. 1995), Swedish (Lindgren et al. 1995), and Hong Kong (Leung et al. 1998) children. Later, nationally specific BMI-for-age charts have been published also for the Netherlands (Fredriks et al. 2000), Dennmark (Nysom et al. 2001), Italy (Cacciari et al. 2002), Turkey (Bundak et al. 2006), New Zealand (Duncan, Duncan & Schofield 2010), Finland (Saari et al. 2011) and other countries.

Although there have been suggestions that older datasets should be used for construction of BMI references from periods when obesity among children and youth was not very common (Cole & Roede 1999), and that BMI charts are less affected by differences in timing of puberty than weight for height charts (Fredriks et al. 2000), we believe that more recent data is better suited for definition of adipose tissue among contemporary generations of children and adolescents. Because of secular trends, BMI charts constructed on old datasets have become progressively outdated (Cacciari et al. 2002) and this can be demonstrated with the comparison of Slovenian data of height and weight of Ljubljana children and adolescents from 1939 (Škerlj 1948) and 2011[1] (Table 1).

It is obvious that the changes in physical growth in the last 70 years have been substantial and while body height of the Ljubljana children and adolescents rose for 7.62 and 5.92% among boys, and girls, respectively, their body mass increased for 32.60 and 21.43%, respectively. Consequently, their BMI increased on average for 14.22 and 7.94%.

[1] Unpublished data from 2011 Sports Educational Chart database.

Table 1: Height, weight and BMI of Ljubljana children and adolescents in 1939 and 2011

	Height (cm)		Weight (kg)		BMI (kg/m2)	
Boys	Year 1939	Year 2011	Year 1939	Year 2011	Year 1939	Year 2011
11 y	139.6	151.1	32.5	44.7	16.7	19.6
12 y	144.4	157.5	35.0	50.0	16.8	20.2
13 y	148.4	165.2	38.4	57.1	17.4	20.9
14 y	154.5	171.6	43.7	63.0	18.3	21.4
15 y	161.8	176.4	50.6	67.9	19.3	21.8
16 y	167.1	178.4	56.2	71.2	20.1	22.4
17 y	169.9	179.9	59.1	73.9	20.5	22.8
18 y	173.7	180.1	64.6	75.4	21.4	23.3
19 y	174.1	180.3	64.7	76.0	21.4	23.4
Girls	Year 1939	Year 2011	Year 1939	Year 2011	Year 1939	Year 2011
11 y	141.3	152.5	33.1	44.8	16.6	19.3
12 y	144.4	158.2	35.7	50.2	17.1	20.0
13 y	150.0	162.5	40.4	54.3	18.0	20.6
14 y	154.8	164.7	46.0	57.2	19.2	21.1
15 y	157.5	166.2	50.1	59.9	20.2	21.7
16 y	159.3	166.4	53.1	60.4	20.9	21.8
17 y	160.7	166.6	55.3	60.8	21.4	21.9
18 y	161.1	166.9	56.6	61.3	21.8	22.0
19 y	161.3	167.4	57.9	61.7	22.3	22.0

From the available data it is impossible to determine, how their body composition changed but the discrepancy between the change in body height and body mass is so large that the BMI charts, based on the 1939 data would surely have a very poor classification power for the contemporary generations of children and youth. Additionally, this data shows that, for example, 11-year-olds from 2011 are taller and heavier than 13-year-olds from 1939, which can be a proof that the maturation processes of contemporary children start 3 years earlier than 70 years ago. This accelerated timing of puberty probably has greater influence on weight and growth charts but also the effect on BMI charts would be too large to be ignored.

How and what to compare?

Before we started thinking about substituting the established international standards with new national standards, we had to check how international BMI-for-age charts correlated to other anthropometric indicators of body mass of Slovenian children and youth, and construct our own national BMI-for-age charts. In order to do that, we had to decide what data to use. Unfortunately, our largest national data base Sports Educational Chart (Strel et al. 1997) with up-to-date data on weight and height of almost entire school-going population could not be used for this purpose because it only included triceps skinfold for comparison. Instead, we decided to use our data from the longest on-going Slovenian study on children's physical and motor development, entitled *Analysis of developmental trends of motor abilities and physical characteristics, and their relations with other spaces of psychomotor status of Slovenian children between 6 and 14 years of age in the periods*

1970 – 1983 – 1993/94 – 2003/04 (Šturm, Strel & Kovač 2002). Because this research has been gathering data separately for primary and secondary school in two consecutive years,we used the data of the primary-school children from 1993 and 2003 and the data of the secondary-school youth from 1994 and 2004. These measurements have been organised every ten years in September and have always included a nationally representative sample of schools from different Slovenian regions.

Sample and methods

The measurements have included a number of motor tests from the EUROFIT and SLOFIT test battery and various anthropometric measurements (height, weight, circumferences, diameters, lengths and skinfolds). All measurements have been conducted by a team of trained technicians according to the standard protocol. Weight has been measured with a pre-calibrated scale to the nearest 0.1 kg, height with the Sieber-Hagnerstadiometer to the nearest mm and skinfolds with the Tanner/Whitehouse calliper to the nearest mm. All measurements of skinfolds have been repeated twice and the mean value has been calculated. Goran et al. (1998) showed that abdominal, subscapular and triceps skinfolds strongly correlated with intra-abdominal and subcutaneous fat tissue – both being related to various health risks already in childhood (Goran & Gower 1999) – and we decided to use the sum of these skinfolds for establishing correlations of WHO, IOTF and Slovenian national cut-off points for defining underweight, normal weight, overweight and obesity (SLOBMI) with body fat. The use of adipose tissue as a comparative criteria was based on the fact that BMI curves are predominantly used for diagnosing underweight, overweight and obese, which means those children and youth, who have an excess or deficiency of adipose tissue.

Table 2: Number of included boys and girls according to age and year of measurement

Age (y)	Year	Boys (n)	Girls (n)	Age	Year	Boys (n)	Girls (n)
6	1993	12	15	14	1993	195	172
	2003	175	68		2003	218	202
7	1993	165	158	15	1993	11	6
	2003	222	217		1994	92	93
8	1993	208	209		2003	1	0
	2003	189	221		2004	169	140
9	1993	200	213	16	1993	1	1
	2003	203	225		1994	172	161
10	1993	198	224		2004	216	163
	2003	209	236	17	1994	184	213
11	1993	185	190		2004	205	148
	2003	224	221	18	1994	194	181
12	1993	188	206		2004	184	158
	2003	217	205	19	1994	19	19
13	1993	194	210		2004	52	38
	2003	229	186		Total	4,931	4,699

The whole sample included 10,439 children and youth between 6 and 20 years of age. We excluded 809 children because they had missing data and their BMI could not be calculated or they had extreme BMI values. For the calculation of BMI-to-age centile curves we included 4,931 boys and 4,699 girls aged from 6 to 19 years (Table 2).

For the construction of the centile curves we used the LMS Chart Maker Pro version 2.3 software (The Institute of Child Health, London), which fitted smooth centile curves to reference data (Cole & Green 1992). This method summarizes centiles at each age based on the power of age-specific Box-Cox power transformations, which is used to normalize data. The final curves of centiles were produced by three smooth curves (Table 3) representing L (skewness), M (median), and S (coefficient of variation).

Table 3: Fitted LMS curves for SLOBMI by age and sex

	Boys			Girls		
Age (y)	**L**	**M**	**S**	**L**	**M**	**S**
6	-2.95	15.89	0.09	-2.41	16.18	0.11
6.5	-2.86	15.99	0.10	-2.29	16.07	0.11
7	-2.76	16.11	0.10	-2.18	16.03	0.12
7.5	-2.67	16.26	0.11	-2.06	16.10	0.12
8	-2.58	16.44	0.11	-1.94	16.25	0.12
8.5	-2.49	16.64	0.12	-1.82	16.47	0.13
9	-2.40	16.84	0.12	-1.70	16.73	0.13
9.5	-2.30	17.04	0.13	-1.58	16.98	0.14
10	-2.21	17.25	0.13	-1.46	17.25	0.14
10.5	-2.12	17.47	0.13	-1.35	17.56	0.14
11	-2.03	17.70	0.13	-1.24	17.89	0.14
11.5	-1.93	17.96	0.13	-1.13	18.23	0.14
12	-1.84	18.25	0.13	-1.03	18.56	0.14
12.5	-1.75	18.57	0.13	-0.95	18.91	0.14
13	-1.66	18.91	0.13	-0.87	19.30	0.13
13.5	-1.56	19.27	0.13	-0.81	19.68	0.13
14	-1.47	19.62	0.13	-0.76	19.98	0.13
14.5	-1.38	19.96	0.12	-0.73	20.21	0.12
15	-1.28	20.30	0.12	-0.71	20.39	0.12
15.5	-1.19	20.61	0.12	-0.70	20.59	0.12
16	-1.10	20.92	0.12	-0.71	20.78	0.11
16.5	-1.00	21.22	0.11	-0.72	20.96	0.11
17	-0.91	21.51	0.11	-0.73	21.07	0.11
17.5	-0.82	21.80	0.11	-0.75	21.13	0.11
18	-0.72	22.10	0.11	-0.77	21.14	0.10
18.5	-0.63	22.41	0.11	-0.79	21.13	0.10
19	-0.54	22.71	0.11	-0.81	21.12	0.10

We calculated 3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th, 97th and 99th smoothed centiles (Tables 4 and 5) of BMI by age and gender and produced the centile curves for boys and girls aged 6 to19 years in 6-month intervals. We then calculated the correlation coefficients between the WHO, IOTF and SLOBMI classifications of underweight, normal weight, overweight and obesity, and the sum of abdominal, subscapular and triceps skinfolds – denominating adipose tissue – separately for boys and girls (Table 6).

Table 4: Smoothed 3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th, 97th and 99th centiles for boys

Age (y)	3P	5P	10P	25P	50P	75P	85P	90P	95P	97P	99P
6	13.85	14.05	14.39	15.02	15.89	16.99	17.72	18.30	19.31	20.10	22.03
6.5	13.82	14.04	14.39	15.07	15.99	17.18	17.97	18.61	19.72	20.61	22.81
7	13.82	14.04	14.41	15.13	16.11	17.38	18.25	18.93	20.16	21.15	23.65
7.5	13.83	14.07	14.46	15.22	16.26	17.62	18.55	19.30	20.64	21.73	24.54
8	13.88	14.13	14.54	15.34	16.44	17.89	18.89	19.69	21.15	22.34	25.44
8.5	13.95	14.21	14.64	15.48	16.64	18.17	19.23	20.09	21.65	22.93	26.30
9	14.03	14.30	14.75	15.62	16.84	18.45	19.57	20.47	22.12	23.47	27.05
9.5	14.11	14.39	14.86	15.77	17.04	18.72	19.89	20.83	22.54	23.95	27.64
10	14.21	14.50	14.99	15.93	17.25	18.99	20.19	21.16	22.92	24.35	28.09
10.5	14.34	14.64	15.14	16.11	17.47	19.25	20.48	21.47	23.25	24.69	28.40
11	14.48	14.79	15.31	16.31	17.70	19.53	20.78	21.78	23.56	24.99	28.61
11.5	14.65	14.97	15.50	16.54	17.96	19.82	21.08	22.08	23.85	25.26	28.75
12	14.86	15.19	15.74	16.80	18.25	20.13	21.39	22.38	24.14	25.50	28.83
12.5	15.10	15.44	16.01	17.09	18.57	20.46	21.72	22.70	24.41	25.73	28.87
13	15.38	15.73	16.31	17.42	18.91	20.81	22.05	23.02	24.68	25.95	28.89
13.5	15.68	16.04	16.63	17.76	19.27	21.15	22.38	23.33	24.93	26.14	28.88
14	16.00	16.36	16.96	18.10	19.62	21.49	22.70	23.61	25.15	26.30	28.85
14.5	16.31	16.69	17.30	18.45	19.96	21.82	22.99	23.88	25.35	26.43	28.81
15	16.63	17.00	17.62	18.78	20.30	22.12	23.26	24.12	25.53	26.55	28.76
15.5	16.93	17.31	17.94	19.10	20.61	22.41	23.52	24.35	25.70	26.67	28.74
16	17.22	17.61	18.24	19.41	20.92	22.69	23.78	24.58	25.88	26.81	28.75
16.5	17.50	17.89	18.53	19.72	21.22	22.97	24.04	24.82	26.08	26.96	28.81
17	17.76	18.16	18.81	20.00	21.51	23.25	24.30	25.07	26.29	27.14	28.91
17.5	18.01	18.42	19.08	20.29	21.80	23.53	24.57	25.32	26.51	27.34	29.04
18	18.27	18.68	19.36	20.58	22.10	23.83	24.85	25.59	26.76	27.57	29.21
18.5	18.52	18.95	19.64	20.87	22.41	24.14	25.15	25.88	27.03	27.82	29.42
19	18.78	19.21	19.91	21.16	22.71	24.44	25.45	26.17	27.30	28.07	29.63

Table 5: Smoothed 3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th, 97th and 99th centiles for girls

Age (y)	3P	5P	10P	25P	50P	75P	85P	90P	95P	97P	99P
6	13.75	13.99	14.39	15.15	16.18	17.50	18.39	19.08	20.30	21.25	23.55
6.5	13.55	13.80	14.21	15.00	16.07	17.45	18.37	19.09	20.36	21.35	23.76
7	13.41	13.67	14.10	14.91	16.03	17.46	18.42	19.17	20.49	21.52	24.03
7.5	13.37	13.63	14.08	14.93	16.10	17.59	18.59	19.37	20.75	21.82	24.42
8	13.39	13.67	14.13	15.03	16.25	17.81	18.85	19.67	21.10	22.21	24.88
8.5	13.48	13.77	14.26	15.20	16.47	18.10	19.19	20.04	21.52	22.66	25.38
9	13.60	13.90	14.42	15.40	16.73	18.43	19.56	20.43	21.95	23.12	25.86
9.5	13.71	14.04	14.57	15.59	16.98	18.74	19.89	20.79	22.33	23.50	26.23
10	13.86	14.19	14.75	15.81	17.25	19.05	20.23	21.14	22.69	23.86	26.53
10.5	14.04	14.39	14.97	16.08	17.56	19.40	20.60	21.51	23.06	24.21	26.81
11	14.26	14.62	15.23	16.37	17.89	19.77	20.97	21.89	23.42	24.56	27.07
11.5	14.50	14.87	15.50	16.67	18.23	20.13	21.33	22.24	23.75	24.85	27.27
12	14.75	15.14	15.78	16.99	18.56	20.47	21.67	22.56	24.04	25.11	27.41
12.5	15.04	15.44	16.09	17.32	18.91	20.82	22.00	22.88	24.31	25.34	27.54
13	15.38	15.79	16.46	17.70	19.30	21.19	22.36	23.22	24.62	25.61	27.70
13.5	15.74	16.15	16.83	18.08	19.68	21.55	22.69	23.53	24.88	25.84	27.83
14	16.06	16.47	17.15	18.39	19.98	21.82	22.94	23.75	25.05	25.97	27.87
14.5	16.32	16.74	17.41	18.65	20.21	22.01	23.09	23.88	25.13	26.01	27.82
15	16.57	16.98	17.64	18.86	20.39	22.15	23.20	23.96	25.17	26.02	27.75
15.5	16.82	17.22	17.88	19.08	20.59	22.30	23.33	24.07	25.25	26.06	27.73
16	17.07	17.47	18.12	19.30	20.78	22.47	23.47	24.20	25.34	26.13	27.76
16.5	17.29	17.69	18.33	19.50	20.96	22.62	23.60	24.31	25.43	26.21	27.79
17	17.46	17.85	18.49	19.64	21.07	22.70	23.66	24.36	25.46	26.22	27.76
17.5	17.57	17.96	18.59	19.72	21.13	22.73	23.67	24.35	25.43	26.17	27.68
18	17.64	18.02	18.64	19.75	21.14	22.70	23.63	24.30	25.35	26.07	27.55
18.5	17.70	18.08	18.68	19.77	21.13	22.66	23.57	24.22	25.24	25.95	27.39
19	17.76	18.12	18.72	19.79	21.12	22.61	23.50	24.14	25.14	25.83	27.24

Results

Overall, SLOBMI curves of 85th and 95th centile from our study had a somewhat different shape to the WHO and IOTF curves. In boys, the shape of the SLOBMI curves did not resemble the WHO and IOTF curves, especially in the age span from 6 to 14 years. The shape of the 85th centile of SLOBMI resembled the shape of the 85th IOTF centile, although the 85th IOTF centile was aligned to 87th centile of SLOBMI. The WHO 85th centile was much more skewed than SLOBMI and IOTF in this age span and the 85th centile of WHO was better aligned to the 84th centile of SLOBMI. In the 14 to 19 years age, the 85th SLOBMI centile for boys was lower than the corresponding WHO and IOTF centiles. The SLOBMI 95th centile was similar to WHO 95th centile while IOTF 95th centile was much higher.

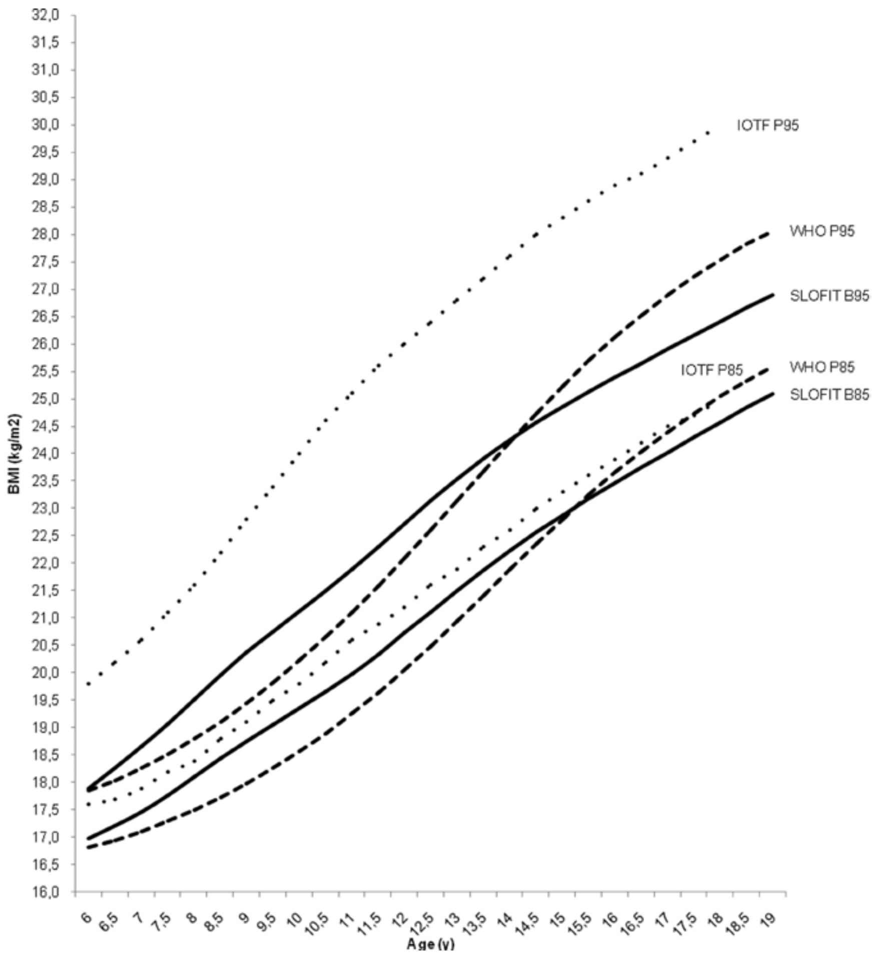

Figure 1: Comparison between WHO, IOTF and SLOBMI 85th and 95th BMI centile cuves for boys

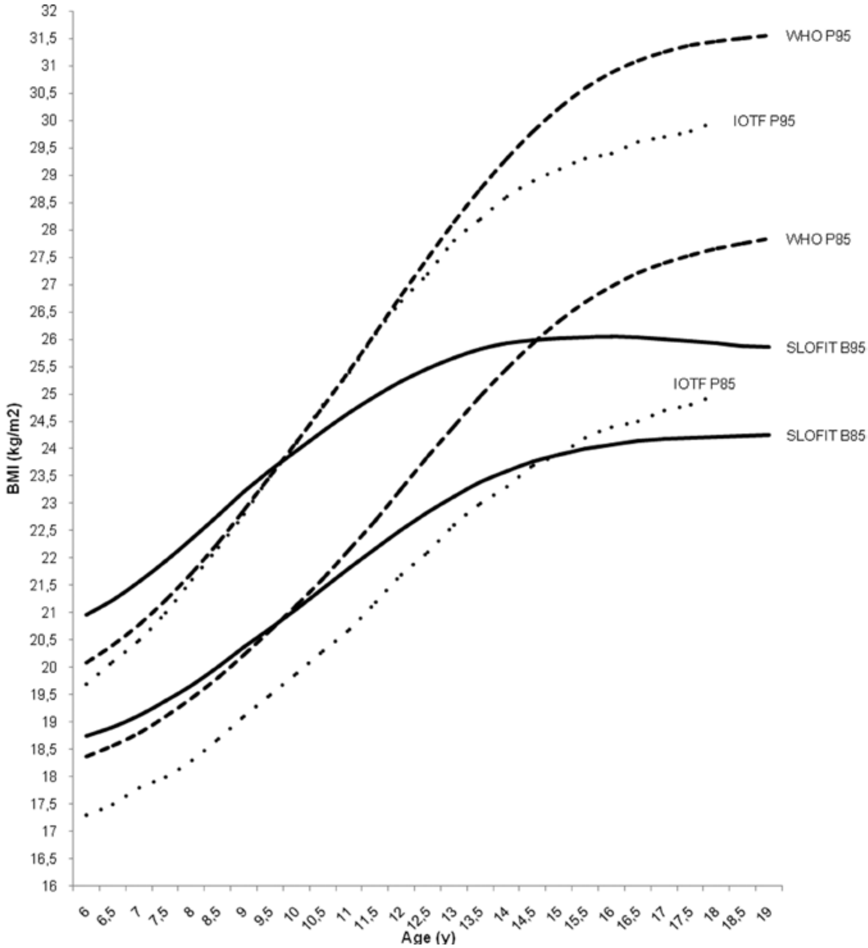

Figure 2: Comparison between WHO, IOTF and SLOBMI 85th and 95th BMI centile cuves for girls

The 85th centile of the SLOBMI distribution for girls is noticeably higher than IOTF 85th centile until age 14 and lower afterwards, while the WHO distribution resembles SLOBMI distribution until age 10 but it is considerably higher from 10 to 19 years of age. The 95th centile of the SLOBMI distribution for girls is better aligned to 93rd centile of WHO and IOTF until age of 10 but is much lower between 10 and 19 years of age.

In order to establish the correlations between the WHO, IOTF and SLOBMI classifications of underweight, normal, overweight and obese with adipose tissue (sum of triceps, abdominal and subscapular skinfold), we calculated the correlation coefficients on the 2003 and 2004 data (Table 6). We included only subjects with complete data on skinfolds and all three classifications.

Table 6: Correlations of adipose tissue with SLOBMI, WHO and IOTF classifications of underweight, normal, overweight and obese

	Boys (n = 2,818)		Girls (n = 2,487)	
	p	r	p	r
SLOBMI	.721	<.001	.691	<.001
WHO	.718	<.001	.634	<.001
IOTF	.714	<.001	.641	<.001

In boys, all three classifications showed strong correlation (p > .06) with adipose tissue although WHO and IOTF classifications showed a bit weaker predictive strength. In girls, the overall correlations were a bit lower, although still strong. The SLOBMI classification again showed the greatest predictive strength.

Conclusions

Possible secular trends of overweight and obesity have been suggested by numerous recent studies (Armstrong, Lambert & Lambert 2011; Godina 2011; Garnett, Baur & Cowell 2011; Khang & Lynch 2011; Sjoberg & Hulthen 2011; Vuorela, Saha & Salo 2011) and there is little doubt that the extensive change in people's lifestyles and the use of modern technology influence also the physical development of children and youth. The introduction of television and telephone decades ago has undoubtedly influenced the everyday practices of physical activity of the entire Slovenian population (Pušnik & Starc 2008; Pušnik 2007; 2008). The changed attitudes of Slovenian children towards physical activity certainly influenced their physical development as well (Jurak & Kovač 2011), and the somewhat expanding role of physical practices in Slovenia moving from physical fitness also towards social communication (Pušnik & Sicherl 2010) could lead to further changes of their physical status.

Therefore, we expected SLOBMI curves to be higher than IOTF and WHO curves because of more recent Slovenian data and a secular upward trend of body mass, but this was not the case. It seems that the more recent Slovenian populations of children and youth differed from the populations, whose data was used for the construction of WHO and IOTF BMI-for-age curves. The SLOBMI curves should be further developed and we are planning to validate their use after our next data gathering on the nationally representative sample of children and youth in 2013 and 2014. There seems to be strong enough rationale to establish our own national BMI-for-age growth curves because it is obviously possible to achieve higher correlations with actual measures of risk-enhancing adipose tissue than the existing international standards do.

Bibliography

Armstrong, Marcy E. G., Mike I. Lambert & Estelle V. Lambert. 2011. Secular trends in the prevalence of stunting, overweight and obesity among South African children (1994–2004). *European Journal of Clinical Nutrition* 65(7): 835–40.

Bundak, Ruveyde, Andrzey Furman, Hulya Gunoz, Feyza Darendeliler, Firdevs Bas & Olcay Neyzi. 2006. Body mass index references for Turkish children. *Acta Paediatrica* 95(2): 194–8.

Cacciari, Emanuele, Silvani Milani, Antonio Balsamo, Franco Dammacco, Filomena De Luca, Francesco Chiarelli, Anna Maria Pasquino, Giuseppe Tonini & Maurizio Vanelli. 2002. Italian cross-sectional growth charts for height, weight and BMI (6-20 y). *European Journal of Clinical Nutrition* 56(2): 171–80.

Cole, Timothy J., Mary C. Bellizzi, Katherine M. Flegal & William H. Dietz. 2000. Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal* 320(7244): 1240–3.

Cole, Timothy J., Katherine M. Flegal, Dasha Nicholls & Alan A. Jackson. 2007. Body mass index cut offs to define thinness in children and adolescents: international survey. *British Medical Journal* 335(7612): 194–7.

Cole, Timothy J. & Pamela J. Green. 1992. Smoothing Reference Centile Curves – the LMS Method and Penalized Likelihood. *Statistics in Medicine* 11(10): 1305–19.

Cole, Timothy J., Jennifer V. Freeman & Michael A. Preece. 1995. Body mass index reference curves for the UK, 1990. *Archives of Disease in Childhood* 73(1): 25–9.

Cole, Timothy J. & Machteld J. Roede. 1999. Centiles of body mass index for Dutch children aged 0-20 years in 1980-a baseline to assess recent trends in obesity. *Annals of Human Biology* 26(4): 303–8.

Daniels, Stephen R., Philip R. Khoury & John A. Morrison. 1997. The utility of body mass index as a measure of body fatness in children and adolescents: Differences by race and gender. *Pediatrics* 99(6): 804–7.

deOnis, Mercedes, Adelheid W. Onyango, Elaine Borghi, Amani Siyam, Chizuru Nishida & Jonathan Siekmann. 2007. Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization* 85(9): 660–7.

Deurenberg, Paul. 2001. Universal cut-off BMI points for obesity are not appropriate. *British Journal of Nutrition* 85 (2): 135–6.

Deurenberg, Paul, Mabel Deurenberg-Yap, L. F. Foo, G. Schmidt & J. Wang. 2003. Differences in body composition between Singapore Chinese and Dutch children. *European Journal of Clinical Nutrition* 57(3): 405–9.

Duncan, J. Scott, Elizabeth K. Duncan & Grant Schofield. 2009. Accuracy of body mass index (BMI) thresholds for predicting excess body fat in girls from five ethnicities. *Asia Pacific Journal of Clinical Nutrition* 18(3): 404–11.

Duncan, J. Scott, Elizabeth K. Duncan & Grant Schofield. 2010. Ethnic-specific body mass index cut-off points for overweight and obesity in girls. *Journal of the New Zealand Medical Association* 123(1311): 22–9.

Fredriks, A. Miranda, Stef van Buuren, Jan M. Wit & Pauline S. Verloove-Vanhorick. 2000. Body index measurements in 1996-7 compared with 1980. *Archives of Disease in Childhood* 82(2): 107–12.

Garnett, Sarah P., Louise A. Baur & Chris T. Cowell. 2011. The prevalence of increased central adiposity in Australian school children 1985 to 2007. *Obesity Reviews* 12(11): 887–96.

Godina, Elena Z. 2011. Secular trends in some Russian populations. *Anthropologischer Anzeiger* 68(4): 367–77.

Goran, Michael I. & Barbara A. Gower. 1999. Relation between visceral fat and disease risk in children and adolescents. *American Journal of Clinical Nutrition* 70(1): 149S–56S.

Goran, Michael I., Barbara A. Gower, Margarita Treuth & Tim R. Nagy. 1998. Prediction of intra-abdominal and subcutaneous abdominal adipose tissue in healthy pre-pubertal children. *International Journal of Obesity* 22(6): 549–58.

Hammer, Lawrence D., Helena C. Kraemer, Donna M. Wilson, Philip L. Ritter & Sanford M. Dornbusch. 1991. Standardized percentile curves of body-mass index for children and adolescents. *Archives of Pediatrics and Adolescent Medicine* 145(3): 259–63.

Hosseini, Majid, Robert G. Carpenter, Kazem Mohammad & Michael E. Jones. 1999. Standardized percentile curves of body mass index of Iranian children compared to the US population reference. *International Journal of Obesity* 23(8): 783–6.

Jurak, Gregor & Marjeta Kovač. 2011. Frequency and characteristics of excuses given by students attending special sports classes of secondary school to avoid participating in physical education class. *Zdravstveno Varstvo* 50(2): 95–105.

Khang, Young-Ho & John W. Lynch. 2011. Exploring Determinants of Secular Decreases in Childhood Blood Pressure and Hypertension. *Circulation* 124(4): 397–405.

Kim, Eugene, Ji-Yun Hwang, Eun-kyung Woo, Seung Soo Kim, Sangmee Ahn Jo & Inho Jo. 2005. Body mass index cutoffs for underweight, overweight, and obesity in South Korean schoolgirls. *Obesity Research* 13(9): 1510–4.

Kuczmarski, Robert J., Cynthia L. Ogden, Lawrence M. Grummer-Strawn, Katherine M. Flegal, Shumei S.Guo, Rong Wei, Zuguo Mei, Lester R. Curtin, Alex F. Roche & Clifford L. Johnson. 2000. CDC growth charts: United States. *Advance data* (314): 1–27.

Leung, Sophie S. F., Tim J. Cole, L. Y. Tse & J. T. F. Lau. 1998. Body mass index reference curves for Chinese children. *Annals of Human Biology* 25(2): 169–74.

Lindgren, Gunilla, Annika Strandell, Tim J. Cole, Marin Healy & Judith Tanner. 1995. Swedish population reference standards for height, weight and body mass index attained at 6 to 16 years (girls) or 19 years (boys). *Acta Paediatrica* 84(9): 1019–28.

Manios, Yannis & Vassiliki Costarelli. 2011. Childhood Obesity in the WHO European Region. *Epidemiology of Obesity in Children and Adolescents* 2(1): 43–68.

Must, Aviva, Gerard E. Dallal & William H. Dietz. 1991. Reference data for obesity: 85^{th} and 95^{th} percentiles of body mass index (wt/ht2) and triceps skinfold thickness. *The American journal of clinical nutrition* 53(4): 839–46.

Nysom, Karsen, Christian Molgaard, Barry Hutchings & Kim F. Michaelsen. 2001. Body mass index of 0 to 45-y-old Danes: reference values and comparison with published European reference values. *International Journal of Obesity* 25(2): 177–184.

Pušnik, Maruša & Kristina Sicherl. 2010. Relocating and personalising salsa in Slovenia: To dance is to communicate. *Anthropological Notebooks* 16(3): 107–23.

Pušnik, Maruša & Gregor Starc. 2008. An entertaining (r)evolution: the rise of television in socialist Slovenia. *Media, Culture & Society* 30(6): 777–93.

Pušnik, Maruša. 2007. Call-up People: Telephone Uses in a Historical Perspective. *Javnost-The Public* 14(5): 19–38.

Pušnik, Maruša. 2008. Domestication of television in Slovenia: Private and public uses of television in a historical perspective. *Javnost-The Public* 15(5): 113–32.

Rolland-Cachera, Marie F., Tim J. Cole, Michel Sempe, Jean Tichet, Claude Rossignol & A. Charraud. 1991. Body Mass Index variations: centiles from birth to 87 years. *European Journal of Clinical Nutrition* 45 (1): 13–21.

Saari, Antti, Ulla Sankilampi, Marja-Leena. Hannila, Vesa Kiviniemi, Kari Kesseli & Leo Dunkel. 2011. New Finnish growth references for children and adolescents aged 0 to 20 years: Length/height-for-age, weight-for-length/height, and body mass index-for-age. *Annals of Medicine* 43(3): 235–48.

Sjoberg, Agneta & Lena Hulthen. 2011. Anthropometric changes in Sweden during the obesity epidemic – increased overweight among adolescents of non-Nordic origin. *Acta Paediatrica* 100(8): 1119–26.

Škerlj, Božo. 1948. *Splošna antropologija v osnovnih potezah*: Državna založba Slovenije.

Strel, Janko, Franci Ambrožič, Miran Kondrič, Marjeta Kovač, Bojan Leskošek & Jože Štihec. 1997. *Športno-vzgojni karton*. Ljubljana: Ministrstvo za šolstvo in šport.

Šturm, Jože, Janko Strel & Marjeta Kovač. 2002. *Gibalni in telesni razvoj osnovnošolcev Slovenije v obdobju 1970/71-1983*. Ljubljana: Fakulteta za Šport.

Vuorela, Nina, Marja-Terttu Saha & Matti K. Salo. 2011. Change in prevalence of overweight and obesity in Finnish children - comparison between 1974 and 2001. *Acta Paediatrica* 100(1): 109–15.

Wang, Youfa & Tim Lobstein. 2006. Worldwide trends in childhood overweight and obesity. *International Journal of Pediatric Obesity* 1(1): 11–25.

White, E. M., Andrea C. Wilson, Stephen A. Greene, Colin McCowan, Giles E. Thomas, Alistair Y. Cairns & Ian W. Ricketts. 1995. Body mass index centile charts to assess fatness of British children. *Archives of Disease in Childhood* 72(1): 38–41.

POVZETEK

Študija preverja smiselnost izdelave nacionalno specifičnih tabel indeksa telesne mase za šolske otroke in mladino. Ker do sedaj v Sloveniji takšne tabele še niso bile izdelane, se v raziskavah in diagnostiki v Sloveniji uporabljajo mednarodne referenčne tabele kakršni sta tabeli WHO in IOTF. Skušali smo ugotoviti, ali bi uporaba novejših slovenskih podatkov izboljšala natančnost tega orodja pri določanju deleža adipoznega tkiva. Za izdelavo nacionalno specifičnih referenčnih tabel indeksa telesne mase smo uporabili podatke 4.931 fantov in 4.699 deklet, ki so bili izmerjeni v letih 1993, 1994, 2003 in 2004. Centilne krivulje smo izdelali z metodo LMS. Po tem, ko smo vzorec Slovenskih otrok in mladine razvrstili v kategorije podpovprečno prehranjenih, normalno prehranjenih, prekomerno prehranjenih in debelih glede na nacionalne reference ter reference WHO in IOTF, smo izračunali korelacije vseh treh razvrstitev z vsoto kožnih gub nadlahti, trebuha in hrbta. Rezultati so pokazali na močno povezanost vseh treh referenc z vsoto kožnih gub pri fantih in dekletih, vendar pa so nacionalne referenčne vrednosti dosegale najvišjo povezanost. Sklepamo, da je izdelava in rabanacionalno specifičnih referenc indeksa telesne mase, ki temeljijo na novejših podatkih kot mednarodne reference, smiselna za diagnosticiranje podpovprečne prehranjenosti, nadpovprečne prehranjenosti in debelosti med slovensko šolsko populacijo.

KLJUČNE BESEDE: indeks telesne mase, kožne gube, otroci, adolescenti, Slovenija, LMS

CORRESPONDENCE: GREGOR STARC, University of Ljubljana, Faculty of Sport, Gortanova 22, SI-1000 Ljubljana. E-mail: gregor.starc@fsp.uni-lj.si.