Using body mass index for the estimation of the nutritional status of school children – are international standards good enough?

Korišćenje indeksa telesne mase za procenu uhranjenosti školske dece – da li su međunarodni standardi dovoljno dobri?

To the Editor:

Most scientific studies agree that the simplest method for large population studies of the nutritional status of children is to directly measure body mass and body height and calculate body mass index (BMI), out of which nutritional status is estimated using either local (national) norms or international criteria. The most commonly used international norms are those from the International Obesity Task Force (IOTF) [1], the Centers for Disease Control and Prevention (CDC) [2] criteria, and the World Health Organization (WHO) [3] standards. As we do not have national norms in Serbia, there is a dilemma over which of the given norms would be more appropriate to use in our population. Therefore, our objective was to evaluate the differences between the three international norms and find out whether there is a systematic error that can affect the assessment of the nutritional status of school children.

This epidemiological cross-sectional study was approved by the Ethics Committee of the Faculty of Medicine in Belgrade (No. 2650/IV-11, from April 10, 2018). The measurements were carried out from January to June 2018 at the Institute of Medical Physiology "Richard Burjan" of the Faculty of Medicine, University of Belgrade, and the Sports Medicine "Malićević" in Belgrade, as well as within fieldwork in 17 primary schools in each city municipality of Belgrade, Serbia. After receiving information about the research details, written informed consent was given for each subject by one of the parents/guardians for the data to be used in this study. In summary, 7,880 children aged 9–15 years were included in this large study (6.16% of the total of 127,811 children in the Belgrade region).

BMI was calculated out of body mass and body height and expressed in kilograms *per* square meter (kg/m^2). The assessment of the nutritional level from the BMI value was carried out according to the criteria of IOTF [1], WHO [3], and CDC [2].

In our study, we have found the following: according to the CDC [2] definition, the BMI value defines the lowest cases of malnutrition; the WHO [3] criteria from the BMI value defines the fewest children with normal nutritional status; the

Table 1

The prevalence of classes of nutritional status according to different definitions in children aged 9–15 years

Nutritional status	IOTF [1]	CDC [2]	WHO [3]
Girls			
malnutrition	297 (7.7)	121 (3.1)	374 (9.7)
normal	2,473 (64.2)	2,647 (68.7)	2,206 (57.2)
pre-obesity	835 (21.7)	671 (17.4)	733 (19.0)
obesity	249 (6.5)	415 (10.8)	541 (14.0)
total	3,854 (100.0)	3,854 (100.0)	3,854 (100.0)
Boys			
malnutrition	244 (6.1)	149 (3.7)	342 (8.5)
normal	2,357 (58.5)	2,334 (58.0)	1,870 (46.4)
pre-obesity	1,035 (25.7)	801 (19.9)	832 (20.7)
obesity	390 (9.7)	742 (18.4)	982 (24.4)
total	4,026 (100.0)	4,026 (100.0)	4,026 (100.0)
Total children			
malnutrition	541 (6.9)	270 (3.4)	716 (9.1)
normal	4,830 (61.3)	4,981 (63.2)	4,076 (51.7)
pre-obesity	1,870 (23.7)	1,472 (18.7)	1,565 (19.9)
obesity	639 (8.1)	1,157 (14.7)	1,523 (19.3)
total	7,880 (100.0)	7,880 (100.0)	7,880 (100.0)

IOTF – International Obesity Task Force; CDC – Centers for Disease Control and Prevention; WHO – World Health Organization. All values are expressed as numbers (percentages).

Correspondence to: Sead Malićević, College of Sports and Health, Toše Jovanovića 11, 11 000 Belgrade, Serbia.
E-mail: sead.malicevic@vss.edu.rs

Table 2

**Head-to-head comparison of international standards for defining nutritional
status from body mass index values of children**

Parameter	WHO [3]				
	malnutrition	normal	pre-obesity	obesity	total
CDC [2]					
malnutrition	100.0	0.0	0.0	0.0	100.0
normal	9.0	81.8	9.2	0.0	100.0
pre-obesity	0.0	0.0	75.1	24.9	100.0
obesity	0.0	0.0	0.0	100.0	100.0
$\chi^2 = 12.833$ (n = 7,880; df = 9), $p < 0.0001$; $\kappa = 0.733$; V = 0.737					
IOTF [1]					
malnutrition	100.0	0.0	0.0	0.0	100.0
normal	3.6	84.4	12.0	0.0	100.0
pre-obesity	0.0	0.0	52.7	47.3	100.0
obesity	0.0	0.0	0.0	100.0	100.0
$\chi^2 = 13.229$ (n = 7,880; df = 9), $p < 0.0001$; $\kappa = 0.661$; V = 0.748					
	CDC [2]				
	malnutrition	normal	pre-obesity	obesity	total
IOTF [1]					
malnutrition	49.9	50.1	0.0	0.0	100.0
normal	0.0	97.4	2.6	0.0	100.0
pre-obesity	0.0	0.3	72.0	27.7	100.0
obesity	0.0	0.0	0.0	100.0	100.0
$\chi^2 = 14.048$ (n = 7,880; df = 9), $p < 0.0001$; $\kappa = 0.789$; V = 0.771					

χ^2 – chi-squared; κ – coefficient of agreement between definitions of nutritional status; V – Cramer's V coefficient of degree of association; df – degree of freedom; n – total number of participants. For the abbreviations of other terms, see Table 1. All values are expressed as percentages.

application of the IOTF [1] criteria defines the highest prevalence of pre-obesity and the fewest children with obesity (Table 1).

Statistically significant differences were found between the results obtained using all three definitions ($p < 0.0001$). On the other hand, that also confirmed a very good agreement between different definitions of nutritional status, the largest being between the definitions of CDC and IOTF ($\kappa = 0.789$) and the smallest between WHO and IOTF ($\kappa = 0.661$); the degree of association was high (Cramer's V coefficient 0.737–0.771) (Table 2).

Although there were high levels of agreement and association, we have found significant differences in our study between the three standards: nearly a quarter of the subjects classified as obese by the WHO definition were classified into the pre-obese category by the CDC criteria; nearly half of the subjects classified as obese according to the WHO criteria were classified into the pre-obesity category by the IOTF definition; half of the subjects classified as normal by the CDC were classified into the malnutrition category according to the IOTF criteria, while nearly 28% of the subjects

classified as obese by the CDC were classified into the pre-obese category by the IOTF definition.

That fully agrees with the findings of numerous international [4–6] and national studies conducted around the world: the United Kingdom [7], Portugal [8], India [9], Chile [10], Canada [11], Ireland [12], Argentina [13], and France [14].

As there are obvious and significant differences between international standards, developing and using national norms is recommended, which is our main conclusion.

Conflict of interest

The authors of this paper declare no conflict of interest, including financial interests, relationships, and/or affiliations relevant to the subject matter or materials included.

Sead Malićević, Sanja Mazić
College of Sports and Health, Belgrade, Serbia;
University of Belgrade, Faculty of Medicine, Belgrade,
Serbia

R E F E R E N C E S

1. *Cole TJ, Lobstein T*. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatr Obes 2012; 7(4): 284–94.
2. *Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R*, et al. CDC Growth Charts: United States. Adv Data 2000; (314): 1–27.
3. *de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J*. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ 2007; 85(9): 660–7.
4. *Cole TJ, Green PJ*. Smoothing reference centile curves: the LMS method and penalized likelihood. Stat Med 1992; 11(10): 1305–19.

5. *NCD Risk Factor Collaboration (NCD-RisC).* Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. Lancet 2017; 390(10113): 2627–42.

6. *Reilly JJ, Dorosty AR, Emmett PM; Avon Longitudinal Study of Pregnancy and Childhood Study Team.* Identification of the obese child: adequacy of the body mass index for clinical practice and epidemiology. Int J Obes Relat Metab Disord 2000; 24(12): 1623–7.

7. *Chinn S, Rona RJ.* International definitions of overweight and obesity for children: a lasting solution? Ann Hum Biol 2002; 29(3): 306–13.

8. *Minghelli B, Nunes C, Oliveira R.* Body mass index and waist circumference to define thinness, overweight and obesity in Portuguese adolescents: comparison between CDC, IOTF, WHO references. Pediatr Endocrinol Rev 2014; 12(1): 35–41.

9. *Stigler MH, Arora M, Dhavan P, Tripathy V, Shrivastav R, Reddy KS*, et al. Measuring obesity among school-aged youth in India: A comparison of three growth references. Indian Pediatr 2011; 48(2): 105–10.

10. *Kain J, Uauy R, Vio F, Albala C.* Trends in overweight and obesity prevalence in Chilean children: comparison of three definitions. Eur J Clin Nutr 2002; 56(3): 200–4.

11. *Shields M, Tremblay MS.* Canadian childhood obesity estimates based on WHO, IOTF and CDC cut-points. Int J Pediatr Obes 2010; 5(3): 265–73.

12. *O'Neill JL, McCarthy SN, Burke SJ, Hannon EM, Kiely M, Flynn A*, et al. Prevalence of overweight and obesity in Irish school children, using four different definitions. Eur J Clin Nutr 2007; 61(6): 743–51.

13. *Kovalskys I, Rausch Herscovici C, De Gregorio MJ.* Nutritional status of school-aged children of Buenos Aires, Argentina: Data using three references. J Public Health (Oxf) 2011; 33(3): 403–11.

14. *Kêkê LM, Samouda H, Jacobs J, di Pompeo C, Lemdani M, Hubert H*, et al. Body mass index and childhood obesity classification systems: A comparison of the French, International Obesity Task Force (IOTF) and World Health Organization (WHO) references. Rev Epidemiol Sante Publique 2015; 63(3): 173–82.