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THE ESTIMATE OF AGREEMENT BETWEEN THE THREE DIFFERENT CLASSIFICATION SYSTEMS FOR DETERMINING STUDENTS NUTRITIONAL STATUS

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ABSTRACT

The aim of this paper is to determine the agreement in assessing the nutritional status of adolescents using the classification systems of the US Centers for Disease Control and Prevention (CDC), the International Obesity Task Force (IOTF) and the World Health Organization (WHO). Non-experimental observation was performed on a sample of 213 first grade high school students from Banja Luka, Republika Srpska, Bosnia and Herzegovina, with an average age of 15.67 years, of which 89 (41.8%) were male and 124 female (58.2%). Each of the subjects was categorized according to a unique scale, as underweight, normal weight, overweight or obese, using IOTF, CDC and WHO reference values. The Cohen kappa coefficient (k) was used to estimate the agreement of the three classification systems in determining nutritional status. The prevalence of underweight was found to be highest according to IOTF standards in both sexes, while the prevalence of overweight was highest according to WHO references. The differences between analyzed three systems are not large for the obese category, especially in girls. In boys, CDC references show a slightly higher percentage of obese compared to the other two systems. The agreement between the classification systems ranges from 0.83 to 0.86 on the total sample of respondents based on all nutritional status categories, which can be considered a reliable parameter for further monitoring, comparison and prescribing of measures.

Key words: YOUTH NUTRITION STATUS/ BODY MASS INDEX / CLASSIFICATION SYSTEMS / BiH

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INTRODUCTION

The prevalence of childhood obesity has been increasing dramatically around the world, especially in the last three decades. A number of researches have shown a high percentage of obesity among children (UNICEF, WHO & World Bank, 2015; Datar & Chung, 2015; Brown, Halvorson, Cohen, Lazorick & Skelton, 2015). It was found that the prevalence of overweight and obesity varies among different ethnical groups, sexes, and socio-economic categories (Tuan & Nicklas, 2009; Stamatakis, Wardle & Cole, 2010). Nonetheless, the increase in obesity among children and adolescents is a problem because obesity commonly tends to stay present in adulthood as well (Lobstein, Baur & Uauy, 2004). Fats surplus in childhood increases the risk for the development of certain diseases in adulthood (Reilly et al., 2003; Baker, Olsen & Sorensen, 2007), but is also connected to poor health during childhood, including an enhanced risk of developing hypertension (Verma, Chhatwal, & George, 1994), insulin resistance (Marcovecchio, Mohn & Chiarelli, 2010), asthma, (Flaherman, & Rutherford, 2006), and psychosocial issues (Strauss, 2000), diseases that must be treated for many years. Due to the importance of nutritional status in public health, trends in childhood obesity are closely monitored.

Determining adult nutritional status is usually based on the Body Mass Index (BMI) that represents the ratio of body weight to height (weight measured in kilograms divided by the square of height measured in meters). According to these guidelines (WHO expert committee, 1995) adults are classified as underweight (BMI below 18.5 do 25 kg/m2), normal body weight (BMI of 18.5 to 25 kg / m2), overweight (BMI of 25 up to 29.9 kg / m2), or obese (BMI over 30 kg / m2). On the other side, the classification of nutritional status of children and adolescents is problematic due to their rapid growth and development. BMI of children tends to change significantly with years (Rolland-Cachera, et al., 1982).

Several methods have been developed to estimate the nutritional status of children and adolescents. Currently, the three most commonly used classification systems are:

I. Classification system of the International Obesity Task Force (IOTF) recommended in 2000 (Cole, Bellizzi, Flegal & Dietz., 2000). As BMI values related to children's health were not defined, this group recommended references based on extrapolation of adult BMI values of 25 and 30kg/m2. IOTF references for defining nutritional levels of children and adolescents aged 2 to 25 were developed on a sample from five countries (Brazil, Great Britain, Holland, Singapore, and the USA), and one region (Hong Kong).

II. An alternative classification system based on growth curves developed in 2000 by the Centers for Disease Control and Prevention (CDC) (Kuczmarski et al., 2002) and based on research data collected in the United States between 1963. and 1994. The Center's expert committee advised that, based on the established growth curves value from 2000, the children whose BMI is ≥95. percentiles for a certain age group and sex are considered obese, while those with BMI ≥85. percentile, but <95. percentile, are considered overweight children, while children with BMI ≤5. percentile are recognized as underweight (Kuczmarski et al., 2002).

III. The World Health Organization (WHO) system from 2007 for monitoring the growth of children aged 5 to 19(de Onis et al., 2007). Based on the growth curves, WHO recommended that children with a BMI greater than 2 standard deviations (SD) above the mean be considered obese, children with a BMI between 1 and 2 SD overweight, while the underweight category involves those with a Z-score below -2 SD.

Still, the question of the metric characteristics and reliability of these three systems still arises. It's questionable whether the CDC references, designed for the American children, are applicable internationally (Tuan & Nicklas, 2009)? The IOTF references can possibly be more adequate for the nutritional status classification of children internationally by including children from six countries from four continents. However, even in this case, it is uncertain whether the references are suitable for use in countries that were not included in the development of norms or countries with different economic statuses (Hesketh and Ding, 2000). On the other hand, WHO references are based on data collected before the obesity of the epidemic (Shields & Tremblay, 2010). Concerning the aforementioned doubts, certain countries have developed a national references for growth based on national representative sample of children, using a similar methodology (Abdulrazzaq, Moussa & Nagelkerke, 2008; Juliusson et al., 2008; Tambalis et al., 2015).

Whether or not a child is obese may depend on the classification system used for assessment, which often results in classification of nutritional prevalence that differs. All this makes it difficult to follow trends at the national level and compare the results from different studies at the global level. Therefore, studies are needed to analyze data obtained from the most commonly used references (CDC, IOTF, and WHO) to determine the level of agreement between these classification systems, and thus their applicability at the international level. Therefore, the aim of this paper is to assess the agreement of the nutritional status of adolescents from the city of Banja Luka in relation to the reference values of the CDC, IOTF and WHO.

METHODS

Sample

For this research, a sample was selected consisting of 213 first grade students of the Gymnasium from Banja Luka (average age = 15.67), of which 89 (41.8%) were male and 124 female (58.2%). The measurement, that is data collection, was performed in April 2015. Respondents were measured in physical education classes.

Measures and calculations

Body height was measured with an anthropometer with an accuracy of 0.5 cm, while the subject stood upright barefoot on a flat surface.

Bodyweight was determined by measuring on an Omron BF511 Body Composition monitor with an accuracy of 0.1kg, while the subjects were barefoot and wore only light clothing.

BMI was calculated by dividing body weight (kg) by the square of height (m2).

Each of the respondents was categorized as underweight, normal weight, overweight, or obese using IOTF, CDC, and WHO reference values.

The categorization of respondents based on IOTF references was done by entering the value of BMI in free software developed by Dr. Tim Cole - LMS Growth software (http://www.healthforallchildren.com). BMI percentiles according to CDC reference values were calculated using a calculator available at https://www.cdc.gov/healthyweight/bmi/calculator.html.

AnthroPlus (http://www.who.int/growthref/tools/en/) is software published by the WHO and used to calculate BMI Z-scores on a sample of subjects and to determine the nutrition status of each subject in accordance with the standards defined by the WHO in 2007 (de Onis et al., 2007).

Statistical processing and data analysis

The general characteristics of the respondents are presented by arithmetic mean, standard deviation, maximum and minimum results.

Student 's T-test for independent samples was used to determine differences in morphological characteristics in relation to sex.

The nutritional status of the respondents was determined using the reference values of the three classification systems.

The Cohen kappa coefficient (k) was used to estimate the agreement of the three classification systems: IOTF, CDC, and WHO. Agreement of the system is established in relation to the following levels of agreement, namely: weak (k = 0.00-0.20); acceptable (k = 0.21-0.40); moderate (k = 0.41-0.60); very good (k = 0.61-0.80); and almost perfect agreement (k = 0.81-1.00).

The significance level was set at P <0.05 for all comparisons. Data processing was performed by the SPSS (Statistical Package for the Social Sciences) version 20.

RESULTS

Basic descriptive statistics for measures of body height and weight, as well as BMI in relation to gender, are presented in Table 1. The T-test for independent samples showed that boys were statistically significantly both taller and heavier than girls. No statistically significant differences in BMI in relation to gender were found (t = 1.10, p = .274).

Table 1. Morphological characteristics of students

	Sex	N	M	SD	Min.	Max.
Height	Boys	89	181.99[a]	6.66	162.5	197.5
	Girls	124	167.72	6.23	151.0	184.0
Weight	Boys	89	73.21[b]	12.96	52.2	122.4
	Girls	124	60.69	9.38	42.6	100.7
BMI	Boys	89	22.09	3.61	15.6	31.9
	Girls	124	21.58	3.19	16.8	35.3

Legend: N - number of respondents; M - arithmetic mean; SD - standard deviation; Min. - minimum result; Max. - maximum result.
[a] Statistically significant difference between boys and girls in relation to height: t=16.03, p=.000
[b] Statistically significant difference between boys and girls in relation to weight: t=7.76, p=.000.

Student nutritional status according to CDC, WHO, and IOTF reference values is shown in Table 2. The prevalence of underweight was highest according to IOTF standards in both sexes. The prevalence of overweight ranges from 13.6 to 17.8% and is highest according to WHO references. The difference between WHO and IOTF prevalence is generally smaller compared to the difference between WHO and CDC in this category.

The differences between these three systems are not large for the obese category, especially in girls. In boys, CDC references show a slightly higher percentage of obese than the other two. If the categories of overweight and obese are analyzed through three systems, then the WHO scale shows the highest prevalence (23.4%). The percentage of underweight, overweight, and obese was generally higher in boys than in girls.

The agreement among classification systems ranged from 0.83 to 0.86 on the total sample of respondents based on all nutritional status categories, representing an almost perfect agreement (Table 3). The Kappa coefficient was approximately the same between all observed pairs.

Table 2. Nutritional status of students according to different references in relation to gender

	Underweight (%)			Normal weight (%)			Overweight (%)			Obese (%)		
	CDC	WHO	IOTF	CDC	WHO	IOTF	CDC	WHO	IOTF	CDC	WHO	IOTF
Boys	6.7	3.4	7.9	65.2	64.0	62.9	18.0	24.7	21.3	10.1	7.9	7.9
Girls	0.0	0.0	4.8	85.5	83.1	79.0	10.5	12.9	12.9	4.0	4.0	3.2
Total	2.8	1.4	6.1	77.0	75.1	72.3	13.6	17.8	16.4	6.6	5.6	5.2

Table 3. Kappa coefficient and 95% IC confidence interval for nutritional status classification

	kappa	95%IC	p
CDC and WHO	0.86	(0.78; 0.94)	.000
CDC and IOTF	0.85	(0.78; 0.93)	.000
WHO and IOTF	0.83	(0.75; 0.91)	.000

DISCUSSION

Monitoring of the nutritional status is vital in the periods of growth and development of children and young people. The reasons for these monitoring are reflected in the assessment of the child's nutritional status in response to the question of growth, primarily whether the obtained values are characteristic for a certain age and sex and whether there are any deviations. Moreover, the ability to determine the measures for obesity prevention in every country demands precise data on the number of obese children and young people.

In relation to the above, it is extremely important to use an adequate method for the assessment of the nutritional status. This paper aims to determine the level of agreement between the three most commonly used methods for child nutritional status assessment (CDC, IOTF, and WHO). The results of this study indicate that there is an almost perfect agreement between the applied three classification systems, which indirectly suggests the possibility of comparing the prevalence of the nutritional status between countries and regions based on measurements and analysis through these three systems. However, similar studies show different results, depending on the region in which they were conducted (Tuan & Nicklas, 2009) but also other factors, such as socioeconomic (Stamatakis, Wardle & Cole, 2010).

Lee et al. (2016) found an almost perfect agreement between the CDC, WHO, and IOTF references on a sample of students (aged 16 to 19) from the United States, which coincides with the results of this study. There are studies that show somewhat lower coefficients of agreement based within nutrition categories (Banjade, Naik & Narasannavar, 2015; Medehouenou et al., 2015), but in most cases the agreement is very good or almost perfect (k = 0.60-1.00). On the other hand, some studies (Minghelli, Nunes & Oliveira, 2014; Keke et al., 2015;) interpret the kappa coefficient based on only one category (e.g., overweight or obesity). The application of this approach was not possible in this study due to the smaller sample of respondents, which is why it was not possible to make a quality assessment of agreement between the categories of nutritional status and based on only one category of nutritional status.

Although in this paper an almost perfect agreement between the scales and their reference values was established, nevertheless, certain differences in the prevalence of nutritional status have been noticed in relation to the analyzed three classification systems. Percentage of underweight was highest according to IOTF references in both sexes (CDC – 2.8%; WHO – 1.4%; IOTF – 6.1%). Other authors have also found that the prevalence of underweight is highest according to this scale and values (Tuan & Nicklas, 2009; Cole & Lobstein, 2012; Dereń et al., 2018; Milasinovic, Bojanic, Cvorovic & Kukic, 2019). Although there are studies that show otherwise (Ramireza et al., 2017). Based on this research, it can be concluded that IOTF values in the underweight category are systematically higher compared to CDC and WHO, which, on the other hand, leads to conclusions about higher prevalence of underweight when using only this scale and its reference values.

The results of this study results indicate that the most overweight children were according to WHO scale and reference values (CDC – 13.6%; WHO – 17.8%; IOTF – 16.4%). The differences between analyzed three systems are not large for the obese category in the total sample, although the percentage of the obese among boys is somewhat higher according to CDC references. Banjade, Naik & Narasannavar (2015), and Dereń et al., (2018) also determined the highest percentage of the overweight based on WHO scale and reference values. There are authors who agree that IOTF references show the lowest prevalence of obese (Minghelli, Nunes & Oliveira, 2014; Banjade, Naik & Narasannavar, 2015; Nilsen et al., 2016; Dereń et al, 2018), while CDC or WHO classification systems show the highest prevalence of obese. This study indicates that the most overweight and obese together were according to WHO system (23.4%), which agrees with the data of Minghelli, Nunes & Oliveira (2014).

The results of this study generally coincide with the results of Milasinovic, Bojanic, Cvorovic, and Kukic (2019) obtained from a sample of children from Montenegro, which can be explained by factors of nature and nurture of these geographical areas.

Regarding the previously said, it can be concluded that there are certain differences in nutritional status assessment between these three classification systems. That can be explained by the differences of sample of respondents upon which these three classification systems were based. Additionally, there are methods used for the construction of curves and intersection points for a certain nutritional status category. In other words, it is difficult to argue which reference overestimates and which underestimates the level of nutrition of children and adolescents.

Additional studies are necessary to examine the objectivity and reliability of the analyzed classification systems, and the relationship between scales and reference values to health. For that reason, some authors recommend that IOTF system values be used at this time (Monasta, Lobstein, Cole, Vignerová & Cattaneo, 2010), because they are „grossly“ associated with poor health later in life. Namely, as mentioned, the intersection points of the IOTF references are based on BMI values of 25 and 30 kg/m2 in eighteen-year-old boys and girls and those values are associated with poor health in adults (WHO expert committee, 1995). The choice of system may also depend on the purpose of the test. Shields and Tremblay (2010) point out that IOTF references are recommended when examining population nutritional status for descriptive and comparative purposes, while the CDC and WHO systems and their reference values are intended for clinical use in monitoring the growth of children.

However, this study has certain limitations. This primarily refers to a small number of respondents covering only one age group of students. The following studies ought to include a larger number of children and adolescents from all age groups.

Nevertheless, the information obtained through this study are certainly useful and can be used for comparisons at the international level. When we look at the results of this analysis, we came to conclusion that we cannot determine which of the three analyzed classification systems is the most suitable for determining the nutritional status of children from the Western Balkans and the locality of Republika Srpska. Consideration should be given to creating national reference values to better monitor the nutritional levels of children and adolescents and to prevent negative trends. At the international level, on the other hand, it is necessary to continue with the verification of techniques and methods that can most reliably present, monitor and compare nutritional levels.

CONCLUSION

The results of this study indicate that there is an almost perfect agreement between three classification systems (CDC, IOTF and WHO), and their reference values of adolescent nutritional status, which indicates the possibility of objective classification but also comparison of nutritional

prevalence between regions. As the determined Kappa coefficient is approximately the same for all observed pairs of three classification systems, it was not possible to determine which of the systems is the most suitable for determining the nutritional status of children from the area of the city of Banja Luka.

Based on this and similar research, it was found that the IOTF system most often shows the highest prevalence of underweight and the lowest prevalence of obese children compared to the other two systems. The prevalence of overweight is highest according to WHO references. As for obesity, it is, depending on the researches, the highest according to the values of the CDC or the WHO classification system.

This research shows similar conclusions as the research of the analyzed authors. What they have in common is that it is difficult to argue which of the systems overestimates and which underestimates the level of nutritional status of children and adolescents. Therefore, it can be concluded that additional studies are necessary to determine the metrics of classification systems of nutritional status, as well as their relationship with health attributes based on parameters such as adipose tissue percentage, blood pressure, triglyceride levels, cholesterol fractions and blood glucose.

Regardless of the limitations, the results of this paper are certainly useful and informative, and they can be used for comparisons with similar studies and protocols. Future studies on a larger number of children and adolescents from all age groups should provide more reliable answers to the question of agreement between the three classification systems in the assessment of child nutritional status. In addition, it is desirable to consider creating national reference values in order to more objectively monitor the level of nutritional status and the prevalence of negative trends in children and adolescents.

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