



Trabajo Original

Valoración nutricional

Sensitivity of body mass index as a current criterion of nutrition: new body mass index redefinition for young adults

Sensibilidad del índice de masa corporal como criterio actual de nutrición: nueva redefinición del índice de masa corporal para adultos jóvenes

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Abstract

Introduction: obesity during university studies is becoming a growing problem. In order to recognize health risks in the young population as early as possible, it is important to define objective criteria for obesity. Body mass index (BMI) and percentage of body fat (PBF) are the most common parameters for assessing obesity.

Objective: the aim of this research is to determine the criteria of BMI for young university students as a young adult population based on PBF criteria.

Methods: this study included 1272 university students, divided by gender (675 females and 597 males). PBF was measured using multichannel bioelectrical impedance analysis InBody 720.

Results: percentile distribution was used to establish obesity criteria for PBF based in four categories: athlete, fit, normally nourished and overweight. The results for female showed that the BMI cut-off value for the athlete criterion is 21.97 kg/m², for the fit criterion is 22.01 kg/m², for the normally nourished 23.18 kg/m² and for the overweight 27.29 kg/m². The results for male showed that for the athlete criterion the cut-off value for BMI was 23.70 kg/m², for the fit criterion 25.66 kg/m², for the normally nourished 26.63 kg/m² and for the overweight 29.60 kg/m².

Conclusion: the existing standard BMI criteria for young adults are not specifically accurate regarding obesity. We propose to redefine BMI nutritional status criteria based on PBF for young adult subjects.

Keywords:

Cut-off values. Body fat. Obesity. Students.

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SENSITIVITY OF BODY MASS INDEX AS A CURRENT CRITERION OF NUTRITION: NEW BODY MASS INDEX REDEFINITION FOR YOUNG ADULTS

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Resumen

Introducción: la obesidad durante los estudios universitarios se está convirtiendo en un problema creciente. Para reconocer los riesgos de salud de la población joven lo antes posible, es importante definir criterios objetivos para la obesidad. El índice de masa corporal (IMC) y el porcentaje de grasa corporal (PGC) son los parámetros más comunes para evaluar la obesidad.

Objetivo: el objetivo de esta investigación es determinar los criterios del IMC para los estudiantes universitarios jóvenes, como población de adultos jóvenes, basados en los criterios del PGC.

Métodos: este estudio incluyó a 1272 estudiantes universitarios, divididos por género (675 mujeres y 597 hombres). El PGC se midió utilizando el análisis de impedancia bioeléctrica multicanal InBody 720.

Resultados: se utilizó la distribución percentil para establecer los criterios de obesidad del PGC en cuatro categorías: deportista, en forma, normalmente nutrido y con sobrepeso. Los resultados de las mujeres mostraron que el valor de corte del IMC para el criterio de deportista es de 21,97 kg/m², para el criterio de en forma es de 22,01 kg/m², para el de normalmente nutrido es de 23,18 kg/m² y para el de sobrepeso es de 27,29 kg/m². Los resultados de los hombres mostraron que, para el criterio de deportista, el valor de corte del IMC fue de 23,70 kg/m², para el de en forma de 25,66 kg/m², para el de normalmente nutrido de 26,63 kg/m² y para el de sobrepeso de 29,60 kg/m².

Conclusión: los criterios estándar existentes del IMC para adultos jóvenes no son específicamente precisos en cuanto a la obesidad. Proponemos redefinir los criterios del estado nutricional del IMC basándonos en el PGC de los sujetos adultos jóvenes.

Palabras clave:

Valores de corte. Grasa corporal. Obesidad. Estudiantes.

INTRODUCTION

Obesity is defined as an abnormal or excessive accumulation of body fat that can affect health (1). According to a World Health Organization (WHO) report, in 2022, 2.5 billion adults (18 years and older) were overweight. Of these, 890 million were living with obesity (2). The accumulation of excess body fat can contribute to the development of risk factors for cardiovascular disease such as high blood pressure, insulin resistance and diabetes, which can also lead to stroke (3,4).

It is generally known that the body mass index (BMI) is the main and universally accepted criterion for determining obesity, but it is not an accurate measure of body fat content as it does not differentiate between lean mass and fat mass (5). In addition to the BMI, there are studies that indicate that the percentage of body fat (PBF) is a better indicator of obesity and a better predictor of cardiovascular risks (6,7). The BMI is the weight in kilograms divided by the height in meters squared, while the PBF indicates the amount of body fat as a percentage of total body weight. Men and women have different PBF, and the reasons for this are physiological (8). To measure PBF, appropriate equipment is required, which is often not accessible or too expensive (9). Therefore, most people still use BMI as a criterion for body nutritional status, including obesity.

There are studies that have examined and established cut-off values for PBF based on predefined BMI criteria for different age groups and populations (10,11), as well as studies that have examined cut-off values for PBF in the context of metabolic syndrome and cardiovascular disease (12,13). The age range of participants in these studies ranged from 18 to 92 years. Studies have shown that the normal body fat percentage is between 25 % and 35 % in women and between 13 % and 23 % in men (14), while women, aged 20 to 39, with a PBF of over 39 % and men of the same age with over 25 % are considered obese (10). Behera et al. and Wang et al. analyzed and standardized the BMI cut-off values in Indian and Chinese students taking PBF into account (15,16).

Therefore, it is necessary to conduct more studies on university student populations and to establish more age group sensitive BMI cut-off values. To our knowledge, there are no studies that have established BMI cut-off values criteria in college students determined by PBF values. Therefore, the aim of this research is to determine the criteria of BMI for young university students as a young adult population based on PBF criteria. These findings may have the potential to impact some public health standards, the classification of good physical fitness and to highlight potential health risks among the student population.

MATERIALS AND METHODS

PARTICIPANTS

The study was conducted with a total sample of 1272 subjects (students), of which 675 were females and 597 were males. The criterion for inclusion in the study was that they were healthy and university students of the Republic of Serbia. All students had to complete a questionnaire in order to gain access to the tests and be informed about the aim of the study.

TESTING PROCEDURES

The height was measured using an anthropometer (GSM, Swiss-made) according to the Martin protocol and according to the predetermined procedure (8). Body composition was determined using multichannel bioelectrical impedance InBody 720 (Biospace Co., Seoul, Korea) according to a standardized procedure (17,18). The research was conducted by the same team from the same laboratory institutions, on the same equipment (InBody 720). The measurements were carried out between 8 a.m. and 4 p.m. by experienced measurers employed in the laboratory.

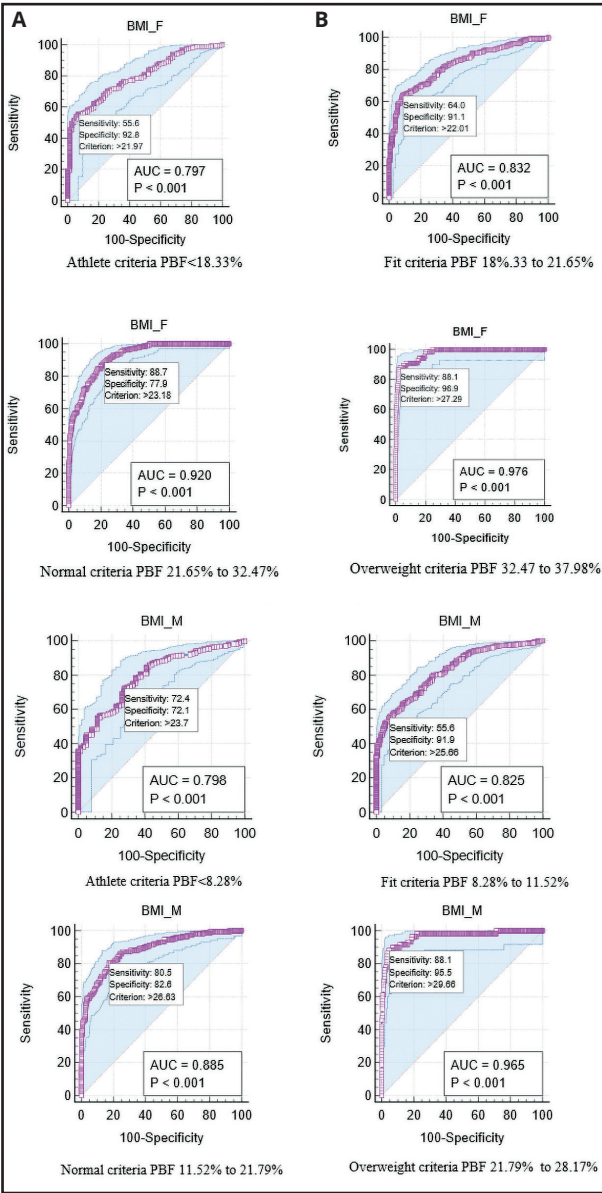


Figure 1. ROC curves for females (A) and males (B) and given cut-off BMI values based on PBF for all four categories.

VARIABLES

For the purposes of this study, two variables directly related to body composition were used to establish criteria for the nutritional status of university students: BMI, expressed in kg/m^2 , and PBF, expressed in %. The values of both variables for each participant are obtained immediately after using multichannel bioelectrical impedance.

STATISTICAL ANALYSIS

Based on the percentile distribution (P), the criteria for PBF were formed as a function of methodological standards cut-off,

which were used to form groups: $< P_{10}$ are athletes; P_{10} to P_{25} are fit; P_{25} to P_{75} are normal nutrition; P_{75} to P_{90} are overweight; and $> P_{90}$ are obese (19). Descriptive statistics were used to calculate the mean value (Mean), standard deviation (SD), coefficient of variation (CoV), minimum (Min), maximum (Max) and upper and lower confidence intervals. Receiver Operating Characteristics (ROC) and the area under the ROC curve (AUC) were applied to determine cut-off values for BMI (20) (Table II and Table III). All statistical analyses were performed using IBM SPSS 25 (IBM Corp., 2017) and Microsoft Excel (Microsoft Corp., 2018). Cut-off values were determined using MedCalc software (Acaciaaan, Ostend, Belgium).

ETHICAL APPROVAL

For the purposes of this study a non-experimental design under laboratory conditions was used. The study was conducted in accordance with the postulates of the Declaration of Helsinki (21) and with the approval of the Ethics Committee of the Faculty of Sport and Physical Education of the University of Belgrade (Ethics Committee approval number 484-2).

RESULTS

Table I shows the descriptive statistics in relation to sex, and gender. The results showed that all CoV % values are relatively low, i.e. within the limits of high homogeneity (from 3.79 % for BH in the sample of males to 21.09 % for BM in the sample of females) (Table I), and that the basic anthropometric indicators in accordance with previous data for a healthy university population in the Republic of Serbia (8).

Based on the obtained results for females, it is observed that for the criterion athlete (PBF = 18.33 %), the cut-off value for BMI is 21.97 kg/m^2 , for the criterion fit (PBF = 18.33 % to 21.65 %), it is 22.01 kg/m^2 , for the criterion normal nutrition (PBF = 21.65 % to 32.47 %) it is 23.18 kg/m^2 and finally, for the criterion overweight (PBF = 32.47 % to 37.98 %) the cut-off value for BMI is 27.29 kg/m^2 (Table II).

Based on the obtained results for males, it is observed that for the criterion athlete (PBF = 8.28 %), the cut-off value for BMI is 23.70 kg/m^2 , for the criterion fit (PBF = 8.28 % to 11.52 %), it is 25.66 kg/m^2 , for the criterion normal nutrition (PBF = 11.52 % to 21.79 %) it is 26.63 kg/m^2 and finally, for the criterion overweight (PBF = 21.79 % to 28.17 %) the cut-off value for BMI is 29.66 kg/m^2 (Table III).

DISCUSSION

Based on the descriptive results of our study, PBF and BMI are higher in female compared to male, which is expected physiologically and supported by numerous studies (11).

Table I. Descriptive statistics for females and males

Female							
	Mean	SD	CoV %	Min	Max	95 % Conf. Int. Lower Upper	
Age (yrs.)	22.56	2.10	9.31	17.8	32.2	22.35	22.77
BM (kg)	64.98	13.70	21.09	40.7	143.7	63.94	66.01
BH (cm)	168.58	6.47	3.84	150.1	191.8	168.09	169.07
BMI (kg/m^2)	22.85	4.45	19.48	14.43	48.63	22.51	23.19
Male							
Age (yrs.)	23.93	3.27	13.67	17.90	41.70	23.61	24.26
BM (kg)	84.96	16.26	19.14	49.9	178.9	83.65	86.27
BH (cm)	181.96	6.89	3.79	162.0	199.6	181.40	182.51
BMI (kg/m^2)	25.62	4.45	17.39	15.89	53.75	25.26	25.98

BM: body mass; BH: body height.

Table II. Results for females for all four criteria

Criteria	Sensitivity (%)	Specificity (%)	Cut-off (kg/m^2)	Standard error	95 % confidence interval	Youden index J	AUC	p
Athlete: PBF < 18.33 %	55.6	92.8	21.97	0.023	0.765 to 0.827	0.484	0.797	0.001
Fit: PBF 18.33 % to 21.65 %	64.0	91.1	22.01	0.016	0.801 to 0.859	0.552	0.832	0.001
Normal: PBF 21.65 % to 32.47 %	88.7	77.9	23.18	0.011	0.897 to 0.939	0.666	0.920	0.001
Overweight: PBF 32.47 % to 37.98 %	88.1	96.9	27.29	0.007	0.962 to 0.986	0.849	0.976	0.001

Table III. Results for males for all four criteria

Criteria	Sensitivity (%)	Specificity (%)	Cut-off (kg/m^2)	Standard error	95 % confidence interval	Youden index J	AUC	p
Athlete: PBF < 8.28 %	72.4	72.1	23.70	0.026	0.764 to 0.830	0.445	0.798	0.001
Fit: PBF 8.28 % to 11.52 %	55.6	91.9	25.66	0.018	0.792 to 0.855	0.475	0.825	0.001
Normal: PBF 11.52 % to 21.79 %	80.5	82.6	26.63	0.017	0.857 to 0.910	0.631	0.885	0.001
Overweight: PBF 21.79 % to 28.17 %	88.1	95.5	29.66	0.014	0.947 to 0.978	0.837	0.965	0.001

After determining the BMI criteria for university students using the PBF criteria, it seems that the standard criteria used in modern fitness and health practice and used by the WHO do not match the results obtained in this study considering to young adults.

According to our study results, for female, the BMI cut-off for the athlete criterion is 21.97 kg/m² (sensitivity 55.6 % and specificity 92.8 %), for the fit criterion the BMI cut-off is 22.01 kg/m² (sensitivity 64 % and specificity 91.1 %), for normal nutrition status the BMI cut-off is 23.18 kg/m² (sensitivity 88.7 % and specificity 77.9 %), and for overweight the BMI cut-off is 27.29 kg/m² (sensitivity 88.1 % and specificity 96.9 %). Those results imply that young adults University age group adult female with a BMI of 27.30 kg/m² or higher should belong to into the obese category.

For male, the BMI cut-off for the athlete criterion is 23.70 kg/m² (sensitivity 72.4 % and specificity 72.1 %), for the fit criterion the BMI cut-off is 25.66 kg/m² (sensitivity 55.6 % and specificity 91.9 %), for normal nutrition status the BMI cut-off is 26.63 kg/m² (sensitivity 80.5 % and specificity 82.6 %) and for overweight the BMI cut-off is 29.66 kg/m² (sensitivity 88.1 % and specificity 95.5 %). Also, those results imply that young adult University age group male with a BMI of 29.67 kg/m² or higher belong to into the obese category. It was established that all defined cut-off values, both for females and for males, are highly statistically significant at the *p* level of < 0.001 for all data.

Behera et al. conducted a study aimed at analyzing and standardizing BMI cut-off values in the young population in India, considering PBF (15). Their results indicate that the cut-off value for obesity is 22.09 kg/m² for men and 23.73 kg/m² for female in the young adult population (15). Wang et al. found that the BMI cut-off for obesity among Chinese students is 23.53 kg/m² for male and 23.41 kg/m² for females (16). Comparing the BM and BH from these two studies with the results of our study, the sample of our subjects differs considerably in these two variables. Specifically, the mean BM and BH values in our study are 64.98 kg and 168.58 cm for females and 84.96 kg and 181.96 cm for males, whereas Indian students had values of 58 kg and 156 cm for females and 66 kg and 168 cm for males (15). Chinese students had average BM and BH values of 52 kg and 160 cm (females) and 65 kg and 173 cm (males) (16). It is evident that their cut-off values for obesity, BM and BH are significantly lower compared to the results of our study. Reasons for this difference most probably could include dietary habits, as well as high carbohydrate intake, lower level of red meat consumption, place and climate of living, cultural influences, living conditions, and physical activity levels. It is obvious that we may conclude therefore, BMI should be adjusted according to ethnicity and different age groups, and that the existence of a universal standard can only be accepted conditionally, that is, from a professional and scientific point of view, the current standard is an outdated category.

Based on the results of this study, there is a very small difference in BMI cut-off values for female between the first two criteria (athlete and fit), 21.97 kg/m² versus 22.01 kg/m². One possible explanation is that in the population of young adult female,

there are subjects those who are active athletes (athlete criterion) and those who regularly exercise for health and physical fitness (fit criterion). Therefore, some train to achieve competitive results (body composition and appearance are secondary outcomes of their training), while others train to be physically fit (and body composition and appearance should be primary outcomes of their training). If we compare the BMI values of this study with the study of Hogstrom et al. the results are the same for the category of athletes (22). Their female athletes (cross-country skiers and alpine skiers) have a BMI of 21.97 kg/m² (PBF = 24.85 %), just like our first category (athletes), while the control group has a BMI of 21.01 kg/m² but a PBF of even 32.9 %, which would be classified as overweight according to our PBF criteria (22). Furthermore, Dopsaj et al. found that elite swimmers have a BMI of 20.88 kg/m², which corresponds to our cut-off for the athlete criterion (23). The results of our study suggest that nutritional status, especially PBF, better identifies normal and overweight individuals, and only for obese category do our BMI standards differ significantly from the WHO global standards. Thus, normally nourished females are not up to 25.00 kg/m², but up to 23.18 kg/m², and those with a BMI of 25 kg/m² are already considered overweight. The new, actually suggested, criterion for overweight is a BMI range of 23.19 to 27.29 kg/m², and those with a BMI of 27.30 kg/m² or higher are already considered obese, not just at 30.00 kg/m².

Comparing the results for males, Dopsaj et al. reported that the BMI of elite swimmers is 23.73 kg/m², which is very similar (almost the same) to the results of our study (23.70 kg/m²) (23). Unlike females, in this study, similar BMI values for males shift to one category higher, with very small boundaries between the fit and normally nourished categories (25.66 kg/m² versus 26.63 kg/m²). Males who do not participate in sports are not lean (BMI less than 23.70 kg/m², many sports do not require large mass but lean bodies). Those who exercise aim for a muscular body and train for greater body mass, distinguishing them from athletes. However, with that mass, due to exercise and a lower fat percentage, they are similar in BMI to normally nourished individuals. Although statistically significant, the AUC is slightly less explained (0.798 for the athlete criterion and 0.825 for the fit criterion). The results showed that the BMI value of a normally nourished young male is up to 26.63 kg/m², those who are overweight have a BMI from 26.63 kg/m² to 29.66 kg/m², and those who are obese have a precisely defined cut-off (AUC = 0.965 for the overweight criterion) at a BMI level of over 29.67 kg/m² (which is very close to WHO's generally accepted standards).

Based on the obtained results, the existing classification is less suitable for the young adult female population and is much more erroneous, while for young males, the existing classification is most erroneous in the normally nourished and overweight categories, and less so for the obese category. The results of this study indicate differences in BMI compared to universal criteria recommended by WHO. Future research is needed to determine the most effective strategies for the prevention and treatment of obesity, taking into account the specific needs and characteristics of different population groups. One limitation of this study

may be the lack of detailed data on diet, physical activity, and other lifestyle habits of the participants to better understand BMI as an indicator of nutritional status cut-off values for defining different body classes on young university students. This data could help identify specific causes of obesity.

CONCLUSION

In this study, BMI cut-off values in young adults University students were determined based on standardized percentile distribution of PBF. The results showed that in young adults university females the BMI cut-off value for the athlete criterion was 21.97 kg/m², for the fit criterion 22.01 kg/m², for normal nutrition 23.18 kg/m², for overweight 27.29 kg/m², and for obese above 27.30 kg/m². For men, the results show that the BMI cut-off value for the athlete criterion is 23.70 kg/m², for the fit criterion 25.66 kg/m², for normal nutrition 26.63 kg/m², for overweight 29.66 kg/m², and for obese above 29.67 kg/m². The results of this study can serve as an initial point for new criteria reference for BMI classification, and assessing the metabolic risks associated with obesity.

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