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Comparison of Selected Body Composition Parameters in Karate Athletes: Matiegka and Bioelectrical Impedance Analysis

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Abstract

The purpose of this study was to compare selected parameters of body composition obtained with two different methods in karate athletes. A cross sectional study was conducted in 23 male karate athletes, mean age 19.78 ± 3.63years. Matiegka protocol (MAT), which is a classic anthropometric method, and bioelectrical impedance analysis (BIA), which is a modern technique, were used to estimate body composition. Body fat percentage obtained by MAT (14.83 ± 1.78%) was statistically insignificantly higher than body fat mass obtained by bioelectrical impedance (13.75 ± 5.31 %). Body fat mass obtained with both methods was also insignificantly different (MAT vs BIA: 11.72± 2.8 kg vs 11.14 ± 5.8 kg). Matiegka's lean body mass (LBM=66.76 ± 10.63 kg) was insignificantly different from BIA's corresponding parameters: fat-free mass, FFM= 69.24 ± 9.59 kg and soft lean mass, SLM = 65.33±9.01 kg. The mean value of the muscle mass obtained by MAT (43.18 ±7.26 kg) was significantly higher than the mean value of the skeletal mass obtained by BIA (38.52 ±5.69 kg). The fat mass and body fat percentage obtained with both methods could be used interchangeably in body composition analysis. The lean body mass parameter, estimated by Matiegka, and Fat-Free Mass and Soft Lean Mass, determined by BIA, are also comparable.

Keywords: body composition, bioelectrical impedance, anthropometry, karate

Introduction

Health care professionals and fitness specialists who work with athletes need accurate, reliable and non-expensive methods to monitor the effectiveness of training and nutritional regime in athletes. The assessment of anthropometric and body composition parameters is especially important in weight class sports, where beside the influence of body components on sports performance, the body weight is an object of adjudication (Ackland, et al., 2012; Torres-Luque, Hernandez-Garcia, Escobar-Molina, Gararyachea, & Nikolaidis, 2016). During the last decades, two types of methods for assessment of body composition parameters have gained popularity in the field of sports anthropometry. These methods are anthropometry and bioelectrical impedance analysis, analytical methods based on different fundaments, various methodologies, different instruments and devices and various equations. In the available literature there are inconsistent reports regarding the comparison of body composition parameters obtained by these two different methods (Torres-Luque, et al., 2016; Marrodan, Gonzalez-Montero, & Morales, 2012; Ostojic, 2006; Malina, 2007). The anthropometric method according to Matiegka protocol, which will be referred further in this article as Matiegka method (MAT), estimates the body composition components by measuring circumferences and skin-folds of the limbs and diameters of the joints (Matiegka,1921; Catrysse, et al., 2002). According to Matiegka body mass is divided in absolute and relative values of three body components: muscle, bone and fat components. According to BIA method, the body is composed of two compartments (fat mass and fat-free mass) which are subdivided into several smaller compartments. The bioelectrical analysis of the body mass is based on the fact that tissues which contain more liquids and electrolytes show lower impedance and therefore conduct electrical current faster and more easily (Kyle, et al., 2004). Both MAT and BIA are indirect field methods as opposed to other laboratory methods. (Heyward, 2001).

This paper discusses the application of these two different methods for body composition analysis in karate athletes. The aim of the study was to identify which body composition parameters could be obtained by each of the two methods and to estimate whether the corresponding parameters could be compared or used interchangeably.

Methods

Sample of subjects: A cross-sectional study was performed in 23 male karate athletes, members of a national karate team from the Republic of Macedonia. Subjects were 15-25 years old with a mean age ± standard deviation (SD) of 19.78 ± 3.63, and had an average 12.71 years of active training regime. Athletes were evaluated at the beginning of the preparation period for participation at the World Junior & Cadet and U21 (Indonesia, 2015). The athletes were examined in the Sports Medicine Laboratory of the Institute of Physiology and Anthropology, at the Medical Faculty in Skopje. All participants completed informed consent statements approved by the respective institutional review boards.

Anthropometric body composition measurements

All anthropometric measurements were made by a highly trained and experienced observer using a standardized procedure. Body weight was measured to the nearest 0.1 kg in fasting subjects, wearing minimal clothing, using an electronic scale (Seca 700 scale, Seca gmbh, Hamburg). Body height was measured to the nearest 0.1 cm using a stadiometer (Holtain ltd., Crymich, UK). Circumferences measurements were taken around the flexed arm, relaxed arm, forearm, thigh, and calf, with aconstant-tension steel tape. Diameters of the elbow, knee, ankle and wrist joints were measured with Vernier caliper (GPMc). Skinfold-thickness sites included biceps, triceps, subscapular, abdominal, suprailiac, anterior thigh, and medial calf. These measurements were taken on the rightside of the body with the Harpenden skinfold caliper (British indicators Ltd, Luton, UK). The values of these measurements were used in the Matiegka protocol equations (Catrysse, et al., 2002) for assessment of body fat (BF%), absolute body fat (BF), relative muscle mass (MM%), absolute muscle mass (MM), bone mass (BM) and relative bone mass (BM%).

BIA assessment of body composition

Body composition was also assessed by the InBody 720, direct multi-frequency (1-1000 kHz) bioelectrical impedance analyzer (BIA). This device makes 30 impedance measurements by using 6 different frequencies (1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, 1000 kHz) at each 5 body segments (right arm, left arm, trunk, right leg, left leg). InBody720 has tetrapolar 8-point tactile electrode system as sensory signal input structure: two are positioned on the palm and the thumb, another two on the front of the foot's heel which enables segmental analysis of the five basic body parts (upper and lower extremities and trunk). Measurements were performed under laboratory conditions according to the user manual instructions. Each subject was lightly dressed (underwear or sports shorts) with bare feet previously wiped with special wet wipes, and standing on the foot pads. Name, age, height, and gender of each subject were recorded before the examination. The subject was asked to stand still while the device captured his/her weight, at which point he/she should place his/her hands around the handgrips. During the exam, which is painless and usually takes no more than 2 minutes, the subject should stand still and breathe normally (Biospace, 2012).

For the purpose of this study we further selected some of the output parameters from both applied methods which we thought could correspond to the same or similar tissues and parts of body mass. The main output parameters from Matiegka anthropometry selected for comparison were absolute muscle mass expressed in kilograms (MM) and relative muscle mass (MM%); absolute bone mass in kilograms (BM) and relative bone mass (BM%); absolute body fat in kilograms (BF) and relative body fat (BF%) and lean body mass (LBM). According to the results sheet of MAT protocol LBM is body weight mass decreased by the value of the fat mass, and it is expressed in kilograms. Selected BIA parameters were protein, osseous and non-osseous mineral, body fat mass, skeletal muscle mass, soft lean mass, fat-free mass, BMI and percentage body fat. The parameter soft lean mass is derived by the sum of total body water and protein. The parameter fat-free mass is derived by the sum of soft lean mass and mineral component.

Statistical analysis

The statistical analysis was performed with the Statistica 7.1 for Windows statistical package. The following methods were applied: in series with numeric parameters descriptive statistics (mean; SD-standard deviation; ±95,00%CI; minimum; maximum) was used; distribution of data was tested with Kolmogorov-Smirnov test; Lilliefors test; Shapiro-Wilks test (p); differences in the mean values of the analyzed parameters were tested with the Student's t–test for independent samples (t) and Mann-Whitney U test (Z/p) depending on the distribution of the data. Statistical significance was considered for $p<0.05$. The data are displayed in tables and graphs.

Results

General data and body composition parameters obtained with standard anthropometric measurements by Matiegka are shown in Table 1.

Table 2 presents the descriptive statistics for body composition parameters obtained with the bioelectrical impedance analyzer.

Table 3 presents the results of the comparison of the mean values of Matiegka's anthropometric and BIA parameters in karate athletes. It is evident that there was a statistically significant difference between the mean values of muscle mass and skeletal muscles and bone mass and osseous (bone) component.

The analysis of the differences between comparable parameters of the body composition obtained by Matiegka anthropometric and BIA method showed that the mean value of the muscle mass (MM) obtained by MAT was significantly higher than the mean value of the skeletal mass obtained by BIA method for $t=2.42$ and $p<0.05$ ($p=0.02$). The mean value of the BM (bone mass) obtained by MAT was significantly higher than the mean value of osseous component obtained by BIA for $Z=5.35$ and $p<0.001$ ($p=0.000$). The mean value of the BM obtained by MAT was also significantly higher than the mean value of the mineral parameter obtained by BIA for $Z=5.81$ and $p<0.001$ ($p=0.000$).

The mean value of the body fat percentage (BF%) obtained by MAT was insignificantly higher than the mean value of the same parameter obtained by BIA for $t=0.92$ and $p>0.05$ ($p=0.36$). The mean value of the body fat parameter (BF) obtained by MAT was insignificantly higher than the mean value of the same parameter obtained by BIA for $Z=0.99$ and $p>0.05$ ($p=0.32$).

The mean value of the LBM (lean body mass) measured by MAT compared to FFM (fat-free mass) obtained by BIA was insignificantly smaller for $Z=-0.99$ and $p>0.05$ ($p=0.32$). The mean value of the LBM measured by MAT was insignificantly higher than the mean value of the SLM (soft lean mass) measured by BIA for $Z=0.47$ and $p>0.05$ ($p=0.64$).

Discussion

The aim of our study was to compare selected variables obtained with the anthropological method used for several decades in our Laboratory of Sports Medicine with several selected variables obtained with a contemporary method - BIA, which is novel in our practice. The comparison of the variables could help us in estimating which of these are interchangeable in order to provide valid and more accurate information regarding the body composition of karate athletes. To our knowledge, our study is the first in the literature, in which the parameters of body composition estimated with the use of one of the oldest anthropometric protocols (by Matiegka), which is currently rarely used have been compared to the results obtained with a contemporary method that is widely and frequently used nowadays.

The mean values of the absolute muscle mass (MM) determined by MAT were significantly higher than the mean values of the skeletal mass (muscles) estimated by BIA. The MAT anthropometric method additionally determines the percentage of the muscle mass within the total body weight, named relative muscle mass (MM%). The relative muscle mass is a very useful parameter which clearly indicates the level of development of the muscle mass in athletes (Nikolić, et al., 2014; Ostojić, 2005). According to Ostojić, the values of muscle mass obtained by Matiegka protocol are lower than those obtained by the anthropometric equation of Martin et al. (Ostojić, 2006). Our results showed that the muscle mass expressed in kilograms had lower values when estimated by BIA and that these two variables are not comparable or interchangeable. Although skeletal muscle makes up the largest fraction of body mass in non-obese adults, especially in athletes, measurement methods that are suitable for field studies are lacking. There are no other data on the comparison of the muscle component between MAT and BIA in the available literature. A practical alternative to modern and costly methods such as computed axial tomography and magnetic resonance imaging (MRI) is anthropometry. Extended Matiegka approach is suggested as a suitable method for determining skeletal muscle mass (Lee, Wang, Heo, Ross & Heymsfield, 2000). The bone mass measured by MAT specifies the fraction of the body weight, which refers to the bone tissue. BIA analyzes two large groups of minerals: osseous and non-osseous. Osseous minerals are found in the bones while non-osseous minerals are found in all parts of the body. Osseous minerals account for about 80% of the body's total minerals. Increase in the weight of the bones will increase the mineral mass. The mean bone mass (BM) values were significantly higher than those of the two potentially comparable components, osseous and mineral, estimated by BIA.

Our results suggest that the parameters which refers to the muscle and bone components obtained by these two methods show statistically significant differences and therefore they could not be used as interchangeable parameters. The question regarding which of these methods more accurately estimates the muscle and/or the bone body component remains unanswered.

The parameters that determine the amount of the fat tissue in the body (the body fat percentage -BF% and the body fat mass - expressed in kilograms) were estimated with both methods. The mean values obtained by BIA were insignificantly higher than those obtained by MAT. Although the results reported for these parameters determined by MAT are frequently higher than the results obtained by other methods (Ostojic, 2006; Pluncevic, Manchevska, Efremova, Todorovska & Nikolic, 2015), our measurements showed insignificantly higher values estimated with MAT than with BIA. Literature reports regarding BIA measurements state that the amount of body fat component has been underestimated by this method (Marrodan, et al., 2012). However, the results of our study obtained very similar results with both methods, a finding that encouraged us to conclude that both methods accurately determined this body component in karate athletes who notably need to maintain the body weight in precise weight limit categories.

The lean body mass (LBM) was measured by Matiegka protocol in our study. Although they are frequently used synonymously, lean body mass is not a synonym for fat-free mass. Fat-free mass (FFM) is body weight minus whole body fat (subcutaneous and essential). Lean body mass is body weight reduced only for subcutaneous adipose tissue, which means it consists of essential fat (Ostojic, 2006). New parameter that defines a similar body fraction is soft lean mass (SLM). According to the result's sheet of InBody720, SLM is a sum of intracellular and extracellular water, protein and non-osseous mineral component. We could calculate SLM if we subtract mineral component from the amount of fat-free mass. Our results showed that LBM (MAT) was insignificantly lower than FFM (BIA) and insignificantly higher than mean values of soft lean mass (BIA).

Many studies have compared the parameters obtained by BIA with anthropometric equations with varying results (Moon, 2013). Ostojic found similar values for body fat percentage obtained with skinfolds and bioelectrical method with high correlation (r=0.96) in athletes of different sports (Ostojic, 2006). Some studies reported that body fat assessed by BIA differs from that obtained by an anthropometric method (Lohman, et al., 2000). Huygens et al. found that BIA is not as accurate as certain anthropometric equations for determining body composition, especially body fat in athletes with predominant muscle mass as in body builders and power athletes (Huygens, et al., 2002). The differences between body fat content determined by BIA and by skinfold method may be a result of the fact that the bioelectrical impedance method measures total body fat while skinfold measurements are associated with subcutaneous adipose tissue only (Silva, Fields, Quitério, & Sardinha, 2009).

Almost twenty years ago Wit et al. stated that the use of diverse methods of determining body components had been criticized because of non-uniformity of the results they extract (Wit, Piechaczek, Blachnio, & Busko, 1998). In their study, comprising a group of healthy adults body fat content estimated with skinfold measurements (SF) was 10.3 kg versus 9.8 kg estimated with bioelectrical (BIA) methods. . Relative body fat content or body fat percentage was 14.3% vs. 13.6% (SF vs. BIA). The lean body mass (LBM in kg) was 62.0 ± 7.7 kg vs 62.5±8.0 kg and water content 63.6 ± 3.1 kg. They concluded that both methods can be used interchangeably.

The estimation of the body components with the BIA devices is based on different equations. In a study conducted in 2007, Marrodan compared the results obtained by direct measurements and the estimation of body composition with an anthropometric method to the results obtained by three different BIA devices (Holtain, Omron and Bscale). The lowest percentage of body fat was obtained by the anthropometric method (15.21%). The results obtained by BIA were as follows: Holtain – 18.69%; Omron - 18.39% and Bscale 24.30%. The absolute values of FFM were 64.62 kg obtained by the anthropometric method and 60.91 kg; 62.69 kg; and 56.21 kg obtained with the aforementioned BIA devices (Marrodan, et al., 2012). A strong correlation between body fat obtained by the sum of skinfold thickness and that assessed by bioelectrical impedance was found in a cross- sectional study including young healthy people (Diniz Araujo, Coelho Cabral, Kruze Grande de Arruda, Siquera Tavares Falcao & Silva Diniz, 2012).

The bioimpedance as a field method has been shown to accurately estimate fat mass and fat-free mass but researchers and practitioners need to take under considerations the development of general athletic and specific athletic BIA equations. BIA is more precise if large variations of body components happen, regardless of fat or fat-free mass component (Moon, 2013; Lukaski, 1987). According to Moon there is a lack of supporting evidence about the validity of BIA in assessing fat mass (FM) and fat-free mass (FFM) of athletes. . Our results suggest that FFM determined by BIA corresponds with the LBM obtained by the anthropometric method. Large variations in FFM hydration have been observed in athletes owing to the large variations in body composition between athletes participating in different sports, as well as within the same sport (Prior, et al., 2001; Moon, et al., 2009).

The appearance of new devices by different manufacturers who offer technological advantages and different software solutions based on different equations contributes to difficult or even impossible comparison and unification of the results obtained by different methods and devices. The results of our study could be useful to athletes and sports experts in gaining information which parameters obtained by the anthropometric and BIA methods could be compared and interchangeable in the estimation of the body composition.

Conclusion

The comparison of data obtained by both techniques (Matiegka anthropometry and BIA) for assessment of body composition in karate athletes showed high correlation between the parameters of fat mass component, whereas parameters referring to specific active components, such as muscle and bone (osseous) mass, were significantly different. These arguments allowed us to conclude that fat mass and body fat percentage obtained with the use of both methods, anthropometric protocol by Matiegka and BIA, could be used interchangeably in body composition analysis. Lean body mass estimated by Matiegka, and FFM and SLM determined by BIA, are also comparable. The parameters referring to muscle and bone body component obtained by different methods could not be compared. Further investigation is needed in order to collect information which of these two methods is more accurate for estimation of active body components in athletes.

Table 1. General data and body composition parameters of Macedonian national team karate athletes obtained with Matiegka protocol

	Mean	SD	Confidence -95.00%	Confidence +95.00%	Minimum	Maximum
Age (year)	19.78	3.63	18.21	21.35	15.00	28.00
Height (cm)	179.28	6.47	176.48	182.08	170.50	191.00
Weight (kg)	78.07	12.75	72.56	83.59	59.00	112.00
BMI	23.14	2.56	22.84	24.65	19.9	29.8
Training experience (year)	12.71	3.31	11.93	14.21	8.00	21.00
MM (kg)	43.18	7.26	40.04	46.32	29.85	59.92
MM %	55.06	3.61	53.50	56.62	46.73	61.10
BM (kg)	13.24	1.82	12.45	14.03	9.62	17.65
BM%	17.03	1.88	16.21	17.84	13.68	21.20
BF (kg)	11.72	2.80	10.51	12.92	8.37	18.34
BF%	14.83	1.78	14.06	15.6	11.84	18.40
LBM (kg)	66.76	10.63	62.17	71.36	50.63	95.69

MM – muscle mass; MM% - muscle mass percentage; BM- bone mass; BM% - bone mass percentage; BF- body fat; BF%- body fat percentage; LBM- lean body mass

Table 2. Body composition parameters of Macedonian national team karate athletes obtained with BIA

BIA variables	Mean	SD	Confidence -95.00%	Confidence +95.00%	Minimum	Maximum
Fat free mass (kg)	69.24	9.59	64.30	74.16	58.00	96.40
Soft lean mass (kg)	65.33	9.01	60.69	69.96	54.70	90.90
Skeletal mass (kg)	38.52	5.69	36.06	40.98	29.40	56.00
Mineral (kg)	4.60	0.70	4.29	4.89	3.43	6.65
Osseous (kg)	3.91	0.59	3.60	4.21	3.31	5.49
Body fat mass (kg)	11.14	5.82	8.61	13.65	5.00	28.90
Body fat percentage (BF%)	13.75	5.31	11.45	16.05	6.60	25.80

Table 3. Comparison of anthropometric and BIA parameters of body composition in Macedonian national team karate athletes

Matiegka vs. BIA variables	Mean MAT	Mean BIA	p-level
Muscle mass vs. Skeletal mass	43.18	38.52	0.02 *
Bone mass vs. mineral	13.24	4.6	0.000 *
Bone mass vs. osseous	13.24	3.91	0.000 *
BF % vs. BF%	14.83%	13.75%	0.36
Body fat vs. body fat mass	11.72	11.14	0.32
LBM vs. FFM	66.76	69.24	0.32
LBM vs. Soft lean mass	66.76	65.33	0.47

*p< 0.05 (statistically significant)

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Conflict of Interest

The authors have not declared any conflicts of interest.

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