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BIOELECTRICAL IMPEDANCE ANALYSIS OF BODY COMPOSITION IN KARATE ATHLETES REGARDING THE PREPARATORY PERIOD

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Abstract: The aim of the paper was to assess changes in body composition using bioelectrical impedance analysis (BIA) methodology in members of national karate team after ten week preparatory training period. The investigation was carried out on 11 male karate contestants, aged 18 to 28 years mean age (21.82 ± 3.58). The body composition was analyzed with In Body 720. The BIA outcomes were divided in 3 group of variables: body fluid and body composition variables, obesity diagnose variables and segmental analysis variables. All BIA variables were insignificantly higher at second measuring ($p > 0.05$). Only Body mass index ($BMI = 24.1$ vs 24.55); mineral (4.69 kg vs 4.77 kg) and osseous (3.85 kg vs 3.92 kg), were significantly higher ($p \leq 0.05$) after preparatory period. Body fat mass ($BFM = 10.34$ kg vs 10.75 kg, $p = 0.329$) and body fat percent ($BF\% = 12.73$ vs 13.22%) insignificantly increased after preparatory period. The skeletal mass has changed from 40.03 kg to 40.55 kg ($p = 0.276$). Body composition analysis, changes in weight, BMI and body fluids are essential for weight categories dependent sports such as karate. Positive changes in body components and in body fluids suggest that the training process during the preparatory period did not show negative effects on body components and the hydration of the karate athletes.

Key words: body composition, bioelectrical impedance, body fluids, karate

ANALIZA TELESNOG SASTAVA KARATISTA BIOELEKTRIČNOM IMPEDANSOM PRE I POSLE PRIPREMNOG PERIODA

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Apstrakt: Cilj ovog rada je da se izvrši analiza promena telesnog sastava kod članova nacionalne karate reprezentacije Republike Makedonije, pomoću bioelektrične impedance (BIA metoda), posle pripremnog perioda od deset (10) sedmica. U istraživanju je učestvovalo 11 članova reprezentacije Republike Makedonije, prosečnog uzrasta 21.82 ± 3.58 godina. Telesni sastav je analiziran pomoću aparata In Body 720. Parametri koji predstavljaju krajnji rezultat ovog aparata su podeljeni u 3 grupe: telesne tečnosti i telesne komponente; parametri dijagnoze gojaznosti i parametri segmentarne analize. Većina BIA parametara su viši, ali statistički neznačajno, pri drugom merenju ($p > 0.05$). Jedino su indeksi telesne uhranjenosti ($BMI = 24.1$ vs 24.55); mineralna masa (4.69 kg vs 4.77 kg) i koštana masa (3.85 kg vs 3.92 kg), bili značajno veći ($p \leq 0.05$) posle pripremnog perioda. Količina telesne masti ($BFM = 10.34$ kg vs 10.75 kg, $p = 0.329$) i procenat telesne masti ($BF\% = 12.73$ vs 13.22%) su neznatno viši posle pripremnog perioda. Skeletna mišićna masa (SMM) se promenila za neznatnih 0.5 kg [40.03 kg do 40.55 kg ($p = 0.276$)]. Analiza telesnog sastava i telesnih tečnosti je od suštinske važnosti za sportske grane kao što je karate, čiji takmičari pripadaju različitim težinskim kategorijama. Naše istraživanje je pokazalo da su sve telesne komponente ostale nepromenjene. Značajno je što nije ustanovljeno smanjenje količine telesnih tečnosti, što ukazuje na to da su sportisti bili dobro hidrirani tokom pripremnog perioda.

Ključne reči: telesni sastav, bioelektrična impedansa, telesne tečnosti, karate

INTRODUCTION

Biomechanical and physiological requirements of karate training regime affect the athlete's body composition, especially musculoskeletal system and body fat mass (Szeligowski, 2010; Imamura, Yoshimura, Uchida, Nishimura, & Nakazawa, 1998). A great number of methods have been used in order to perform accurate evaluation and valid comparison analyzes of different anthropometric indices and body composition in martial arts practitioners (Pieter, Bercades, & Kim, 2006; Amusa & Onyewadume, 2001; Koropanovski et al., 2011).

Bioelectrical impedance analysis (BIA) has potential in the area of sports and exercise as a method for evaluation of body composition in different groups of athletes. However, according to other authors, the BIA method is insufficient in registering small changes in body fat component (BF %) in the subject, which could prove as a great deficiency for its use in athletes. The reports on BIA measurements in athletes, available in the literature suggest that there is a need for rigorous control of the ambient variables (such as hydration, temperature, food intake and the training regime before the measurements) in which the measurements are performed (Dehghan & Merchant, 2008). The data on body fluids that are obtained by BIA method are very useful for athletes who compete in weight categories and who use dehydration methods in order to lose weight as well as for athletes who train and compete in extreme external conditions.

The present study was conducted with an aim to determine body components and other parameters that derive from the BIA measurements in a group of elite karate players in the Republic of Macedonia before and after a preparation period.

METHODS

Study sample

The research was carried out in a group of eleven (11) male elite karate athletes, members of Macedonian national team, aged from 18 to 28 years. All of them had trained karate for more than 8 years, with average 8 ± 2.7 years of experience. None of them reported any medical problems or recent injuries. The study was approved by the Ethical Committee for research on humans of the Medical Faculty, UKIM, Skopje, The Republic of Macedonia. Prior to the measurements all participants received a complete explanation regarding the purpose and procedures of the research. They signed an informed consent document according to the Helsinki Declaration.

Eleven members of the Macedonian karate national team, aged 18 to 28 years, with a mean age of 21.8 ± 3.57 years, were examined on the start and on the end of the preparatory period which lasted ten weeks and was aimed for their participation on the World Karate Championship. The athletes were divided in weight categories:

Assessment of body composition

Body composition was diagnosed by the In Body 720, multi-frequency (1-1000 kHz) bioelectrical impedance analyzer (BIA). According to this method body mass is divided into three components: total body water (TW), fat free mass (FFM) and body fat (BF). In Body 720 employs eight contact electrodes: 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). The measurement was performed under laboratory conditions according the user manual instructions (In Body 720). Time consumption for measurements is between one and two minutes.

The preparatory training period of the athletes was 10 weeks long, including general fitness training and specific fitness training, and lasted from 10th July 2015 to 20th September 2015. The measurements were performed in the morning hours on empty stomach and before training.

The final results of the body composition measurements with the BIA methods could be shown in three groups of parameters.

Body fluid and body component's variables: Intracellular water (ICW); extracellular water (ECW); Total Body water (TBW); protein; mineral; osseous; skeletal muscle; Fat free mass (FFM); soft lean mass (SLM).

Obesity diagnose variables: body mass index (BMI); Body fat mass; body fat percent, waist hip ratio (WHR).

Segmental analysis variables: right arm, left arm; trunk, right leg, left leg.

Statistics: BIA parameters obtained during the first and during the second measurement are presented as central and dispersive statistical parameters: mean values, standard deviation and standard error. The dependent Sample (Paired – Sample) T test was used to test the differences between the variables in two different occasions, before and after training process. The level of significance was set at 0.05. The SPSS statistical software was used, version 20 (Chicago, Illinois, USA).

RESULTS

Basic anthropometric characteristics of the research group are shown in table 1. The age of the subjects varied within the interval of 21.82 ± 3.58 years; $\pm 95.00\%CI$: 19.64-21.70; minimal age being 18 years while maximal age was 28 years.

Table 1. Descriptive statistics of general characteristics of karate athletes

	Mean	Confidence -95.00%	Confidence +95.00%	Minimum	Maximum	Std. Dev.
Age (year)	21.82	19.64	21.70	18	28	3.58
Height (cm)	181.95	176.12	181.97	175.5	191.00	6.59
Weight (kg)	80.21	72.97	84.20	69.00	111.70	11.42

During the first measurements the athletes' average weight was 80.21 ± 11.42 kg, while after the preparatory training regime it was 81.05 ± 11.5 kg. The standard deviation during the two measurements is large because of the wide range of the weight categories in which the athletes compete.

The body fluid and the body components variables of the karate athletes before (1) and after (2) ten weeks preparatory period are shown in table 2. Total body water, as well as its components- intracellular and extracellular water were insignificantly higher after the preparatory period. All body composition components which constitute the active body mass part: protein, skeletal mass, osseous and mineral, were higher after preparatory period, but only osseous and mineral were significantly higher.

The variables of obesity diagnose are shown in table 3. Body fat mass and body fat percent were insignificantly higher after preparatory period. The waist hip ratio was the same at both measurements (0.82). The segmental analysis of extremities and trunk are shown in table 4. Analysis of differences of segmental analysis variables showed that all the changes were inconsistent and insignificant ($p > 0.005$).

Table 2. Body fluid and body components BIA variables of karate athletes before (1) and after (2) ten weeks preparatory period

Body fluid and body components (kg)	Mean	Standard deviation	Std. error mean	Paired differences	Paired correlations
ICW1	32.23	4.33	1.30		$r = 0.995$
ICW2	32.37	4.55	1.37	0.341	$P = 0.000$
ECW1	19.04	2.82	0.85		$r = 0.993$
ECW2	19.2	2.79	0.84	0.540	$P = 0.000$
TBW1	51.27	7.13	2.15		$r = 0.995$
TBW2	51.48	7.33	2.21	0.389	$P = 0.000$
Protein1	13.92	1.89	0.59		$r = 0.995$
Protein 2	13.98	1.98	0.57	0.432	$P = 0.000$
Mineral 1	4.69	0.65	0.20		$r = 0.994$
Mineral 2	4.77	0.69	0.21	0.007*	$P = 0.000$
Osseous 1	3.85	0.55	0.16		$r = 0.995$
Osseous 2	3.92	0.57	0.17	0.003*	$P = 0.000$
FFM 1	69.87	9.65	2.91		$r = 0.995$
FFM2	70.25	9.39	2.83	0.238	$P = 0.000$
Soft Lean Mass 1	66.03	9.12	2.75		$r = 0.995$
Soft Lean Mass 2	66.33	9.39	2.83	0.328	$P = 0.000$
Skeletal mass 1	40.03	5.64	1.70		$r = 0.996$
Skeletal mass 2	40.55	5.96	1.80	0.276	$P = 0.000$

Table 3. Obesity diagnose variables of karate athletes before (1) and after (2) ten weeks preparatory period

Obesity diagnose	Mean	Standard deviation	Std. error mean	Paired differences	Paired correlations
BF mass 1	10.34 kg	4.11	1.24		r= 0.945
BF mass 2	10.75 kg	3.82	1.15	0.329	P= 0.000
BMI 1	24.21	2.21	0.67		r= 0.971
BMI 2	24.55	2.15	0.65	0.05*	P= 0.000
BF % 1	12.73 %	4.39	1.32		r= 0.939
BF % 2	13.22 %	3.98	1.20	0.307	P= 0.000
WHR 1	0.82	0.04	0.01		r= 0.912
WHR 2	0.82	0.05	0.01	0.572	P= 0.000

Table 4. Segmental analysis variables of karate athletes before (1) and after (2) ten weeks preparatory period

Segmental analysis (kg)	Mean	Standard deviation	Std. error mean	Paired differences	Paired correlations
Right arm 1	4.08	0.78	0.24		r= 0.991
Right arm 2	4.06	0.77	0.32	0.591	P= 0.000
Left arm 1	4.01	0.74	0.22		r= 0.979
Left arm 2	4.01	0.73	0.22	0.938	P= 0.000
Trunk 1	28.12	9.5	2.86		r= 0.642
Trunk 2	30.43	4.25	1.28	0.332	P= 0.033
Right leg 1	10.94	4.25	0.45		r= 0.962
Right leg 2	10.95	3.26	0.46	0.341	P= 0.000
Left leg 1	10.94	1.36	0.41		r= 0.992
Left leg 2	10.83	1.39	0.42	0.078	P= 0.000

DISCUSSION

The athletes who compete in weight class sports such as karate, judo wrestling, boxing, and weightlifting are commonly faced with a reduction of body weight. In the available literature, there is a small number of reports on body composition of athletes who compete in these sports, although it is common opinion that the body composition is essential for them. These reports are most needed in order to make an international database which could be used for comparison and evaluation between teams and individuals. To our knowledge, this study obtained the first results regarding the body composition and its changes during the preparatory training regime in Macedonian karate contestants.

There are five weight categories among senior karate male athletes: <60 kg, <67, <75, <84 kg and >84 kg. Within each weight category it is most essential whether the weight of the individual athlete has changed and if it has - how many kilograms. Although it is logical to expect that the athletes' weight would decrease after a relatively long preparatory period (ten weeks), the mean weight of the group increased 0.9 kg. Out of eleven athletes, eight had increased their weight. Most of them (six athletes) had increased their weight for 1.2 kg. Only three athletes had decreased their weight in a range of 0.7 to 2 kg. The reason for this increment of the weight could be the fact that all of those who had increased their weight did not have any difficulties to stay in their category.

One of the advantages of the BIA method is the fact that the content of the body water could be estimated. There was mild non-significant increment of total body water and her components ICW and ECW in karate athletes in our study. This result could be due to the mild increment of the muscle component. This positive change of the body compartments suggests good hydration (euhydration) of Macedonian karate athletes.

There was a small significant increment of the absolute values of the components that comprise the bone tissue (mineral and osseous) after the preparatory period in karate athletes in our study. This result is in accordance with the

reports of other studies that suggest that the sports with high impact increase the density of the bones (Andreoli et al., 2008; Drozdowska et al., 2011).

Mean age of the athletes in our study was 21.8 (3.57) years, while most of them (eight out of eleven) were younger than 23 years. This fact implies that they are still in the phase of growth and development of the skeletal system.

The body mass index (BMI) is a numeric indicator of the nutritional status and the level of obesity of the subject. The BMI could show increased values due to larger muscle mass and consequently higher body weight compared to body height in athletes. Subjects in our study showed similar BMI values compared to data for karate athletes in the literature. Polish male karate athletes with similar general characteristics as our subjects (age 23.5 ± 4.67 years; height 1.80 ± 0.07 m; weight 81.4 ± 11.99 kg) amounted similar values for BMI (24.9 ± 1.74) and FFM (68.5 ± 9.76 kg) and higher body fat percentage (16.8 ± 2.51) (Sterkowicz-Przybycien, 2010). Reports from different study in Poland showed similar BMI values regarding the beginning and the end of the preparatory period (23.1 vs 23.4 kg/m²) in male karate contestants: during 23.5 ± 2.414 kg/m² and the start period 23.44 ± 2.38 kg/m² (Gloc, Plewa, & Nowak, 2012).

Koropanovski et al. (2011) reported an analysis of anthropometrics and physical performance in 31 male karate competitors of the Serbian national karate team. The athletes were at similar age as our subject and had lower BMI compared to our results (24.55 ± 2.1 kg/m²). The mean age of male karate athletes was 21.0 ± 2.8 years and their BMI amounted to 23.5 ± 2.1 kg/m². Kata group in turn, was 20.7 ± 4.4 years of age and their BMI amounted to 23.2 ± 1.8 kg/m².

The body fat is the passive part of body mass and it is usually targeted for decreasing. Body fat may act as ballast in biomechanical terms, but adipose tissues are vital endocrine organ in terms of general health (Ackland et al., 2012). Despite a great methodological and technological advances in measuring of human body composition there is still no gold standard for body fat assessment with accuracy better than 1%. Body fat percent in karate contestants in our study (BF%=12.7% vs 13.22% was similar to values reported by other researchers. The body fat percentage range of top-level karate athletes extends from approximately 10.7 ± 2 for Japanese (Raschka, Bousomnita, & Preiss, 2005), 13.7 ± 4.1 for French, 14.1 ± 3.46 , to the highest values for British $16.5 \pm 4.6\%$ and Polish international level contestants 16.8 ± 2.5 (Imamura et al., 1998; Brozek et al., 1963; Chaabene, Hahcana, Franchini, Mkaouer, & Chamari, 2012). It is noteworthy that adiposity of karate fighters increased in the heavier weight categories (Raschka et al., 2005).

Intensive training regime during the preparatory period could lead to decrement of body fat mass and of the body fat percent in athletes; nevertheless it was not the case in our study. One of the possible explanations of the insignificant increment of these components in our subjects could be the insufficiency of BIA method in detection of small changes in body fat component (Kyle, Bosaeus, De Lorenzo, & Deurenberg, 2004). Furthermore, it is common fact that the athletes who start the training regime during the preparatory period are still in good physical fitness, therefore the values of their body fat components are within referent values for their sport and their age. One of the most undesirable explanations for these results could be that the regimes of nutrition and training haven't been appropriate for the preparatory period.

Although there is a strong agreement about the significance of body composition for those sports such as karate, there is a very small number of reports regarding this issue. Based on the deficit of reports about karate athletes regarding body composition, we will refer to studies which included other fighting sports. The skinfold thickness method was the most frequently used method of body composition measurements in the majority of reported studies (Andreato et al., 2012). Investigation of aerobic and anaerobic endurance after five week preparatory period in elite judo athletes showed insignificant decrement of body mass (85.7 kg to 85.3 kg), decrement of BMI (27.4 to 27.3) and of fat percent (14.6% to 14.2%). Only the fat free mass (FFM) was increased (71.7 kg to 72.6 kg) which was in accordance with the results from our study (Borowiak, Norkowski, Woznika, Keska, & Tkaczyk, 2012).

The segmental analysis showed that there was no statistically significant difference between the values for the right and for the left extremities (right arm/left arm and right leg/left leg) in our subjects. The change of the parts of the extremities regarding the preparatory period is insignificant. Segmental and total bone mineral density were measured by Andreoli et al. (2001) in judo, karate and water-polo athletes, and the study has shown that athletes engaged in high impact sports have significantly higher total bone mass and bone mass density.

CONCLUSION

Positive changes in body components and body fluids are registered in athlete members of the Macedonian karate national team. The training process during the preparatory period does not have negative effect on body components and the level of hydration in karate athletes. The preparatory training regime does not significantly alter athletes' body composition (except for the osseous and the mineral component).

Authorship statement

The authors have contributed equally.

Financial disclosure

We declare that we have no conflicts of interest.

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