

THE EFFECTS OF THE SIX-WEEK TRAINING ON THE INDICATORS OF BODY COMPOSITION AND PHYSIOLOGICAL CHARACTERISTICS IN ELITE KARATE FIGHTERS

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Abstract

In this study, we investigated whether the six weeks of training leads to differences in the body composition and physiological characteristics in elite karate athletes. On the sample of ten elite karate fighters (average age 21.00 ± 2.58), the members of the senior Macedonian national team, we conducted anthropometric and ergometric. All the participants of the research were male, of an average age of 21.00 ± 2.58 years, of medium body height 177.93 ± 7.62 cm and body mass 74.35 ± 8.85 kg. After the six-week training with the national karate team, we observed significant changes in the national team members regarding the body composition. The increase of values is particularly obvious when observing the total body mass, primarily on the raised level of active body components – muscle and bone mass. All of the analyzed physiological parameters have shown statistically significant difference between the first and the second measuring. The values of the heart frequencies have shown the greatest deviations which can be observed throughout the weight load testing. The obtained results are due to the fact that in the mentioned period the athletes had no other physical activity other than a training process, and their age here indicates that the human development curve is going into a stage of stagnation, which means that the natural development factor is negligible.

Key words: national team, ergometric, anthropometric

Introduction

Karate, as youngest Olympic sport that will be presented for the first time at the 2020th Tokyo Olympics, takes a significant place in today's modern sport. Though classified as a high intensity event (Baker, Bell, 1990), there is an evident disagreement as to whether aerobic or anaerobic metabolism is the predominant source of energy, though key actions (attack and defense techniques) are performed thanks to anaerobic lactate system (Beneke, et al. 2004, Tabben, et al. 2013). The nomenclature of karate techniques includes more technical groups, where the domineering ones are arms and legs kicks. Dominancy of these techniques lies in the fact that they are unique point techniques, i.e. they are uniquely evaluated in the total points when deciding on the winner (Kostovski et al. 2014). The efficient performance in karate, in addition to acquiring complex technical skills, demands a substantial level of physical, psychological and tactical preparation. Namely, it has been established that elite karate fighters must have high fitness level (Chaabene et al. 2012). By this, we can say that physiological/functional abilities in athletes have an irreplaceable role in

creating conditions to achieve desirable results. Fitness components usually refer to cardio-respiratory endurance, body composition, muscle strength and flexibility (Vanhees, et al. 2005), where special focus is on cardio-respiratory endurance and body composition. Functional ability of the cardiovascular and respiratory system, which is in charge of oxygen supply, determines the adaption to a certain size and type of muscle performance. On the other hand, body composition (the quantity of adipose tissue, muscles and bones) in every athlete is extremely important. Body mass increase, i.e. adipose tissue increase, may create a significant problem particularly in sports with weight categories (such as karate) and greatly influence on the sport success. The purpose of this paper is to examine the influence of the six-week training process on the functional capacity of the cardiovascular system and body composition in senior karate fighters, members of the Macedonian national team.

Methods

To determine the sample size, a power analysis was performed (Faulet al.2007). In similar studies of the effects on physiological and morphometric variables as a function of 6-8 week training (Nalcakan2014, GIST 2014), small to very large effect sizes (0.3 – 1.9; 95% CI) have been observed. Thus, using a conservative effect size of $d = .90$ $\alpha < .05$, power $(1 - \beta) = .80$, no centrality parameter $\delta = 2.85$ and critical $t = 1.83$ with two repeated measures, we estimated a sample size = 10. On the sample of ten elite karate fighters, male, of an average age of 21.00 ± 2.58 years, of medium body height 177.93 ± 7.62 cm and body mass 74.35 ± 8.85 kg, we conducted anthropometric and ergo metric tests with the main purpose of studying the changes in body composition and in the indicators of the cardiovascular system functioning in elite karate fighters after a six-week preparation period. Based on the purpose of the research, we proposed hypothesis that the karate athletes will have differences in the body composition indicators after the preparation period, as well as higher quantity of muscle mass without any significant increase of adipose tissue and also better results on the ergometric testing after Bruce protocol. All the participants of the research had the following parameters measured:

- general anthropometric characteristics (height, weight, diameters on four joints: elbow, wrist, knee, ankle; circumference of four extremities: upper arm, forearm, thigh, calf; skinfold girth in seven parts: upper arm, stomach, forearm, subscapular, thigh, calf, suprailiac)
- body components (relative and absolute muscle mass, bone mass and adipose tissue mass)
- cardiovascular parameters (testing time, maximum oxygen usage, general endurance, Bruce pulse curve)

During the research, all the participants have had very good general medical condition and they all gave their permission to participate in the study. The research was conducted during the preparation period from March to April, before participation at the European karate championship in Budapest in 2013. Anthropometric and ergometric testing of the athletes was conducted in the Laboratory of Sports Medicine at the Physiology Institute of the Medical Faculty in Skopje. Height and weight were measured by stadiometer (SECA, Leicester, UK) and by an electronic scale (HD-351, Tanita, Illinois, USA). Skinfold girth was measured by Vernier sliding outside caliper (GPMc).

To assess body composition, we applied classical anthropometric method after Matiegka which gives data on relative body components (muscle mass – MMkg, bone mass – MTkg and adipose tissue mass FMkg) revealing how many kilos out of the total body mass relates to the certain component and relative body components (MM%, MT% and FM%), and they are expressed in percentages (Cattrysse et al. 2002). Ergometric testing on a treadmill after

Bruce protocol is sub maximum multiple-degree testing where each participant has his EKG result registered during weight loading. The test has six levels, each lasting for 3 minutes (regardless of the recovery period after the test). If the respondent is feeling subjectively well, the test is done to the point of achieving individual sub maximum pulse, determined before the beginning of testing according to the respondent's age. The results of the Bruce stress testing, in addition to the EKG parameters analysis under strain, give indirect assessment of the oxygen usage and general and specific endurance (Bozinovska et al. 2003). The obtained values of the measured variables, characteristics and the size of the chosen sample have determined the mode of the basic data processing. Central and dispersive parameters have been presented as medium values and standard deviations. We calculated the degree of the curve - Skew as well as curvature degree of the curve - Kurt. Distribution normality of the results was tested by Kolmogorov-Smirnov method. The differences were revealed after the six-week continuous training were established by t-test for small dependent samples. Effect sizes (Cohen's d) were computed to display means' differences where effects reached accepted significance level. We set the significance level threshold at $p = .05$. Statistic data processing was done by statistic package SPSS for Windows, Release 15, 0; SPSS, CHICAGO, IL, USA.

Results and discussion

The six-week training process was conducted on ten senior karate Macedonian national team members, immediately before the European karate championship in Budapest in 2013. Basic characteristics and anthropometric parameters of the participants are presented in Table 1.

Table 1 - Basic characteristics and anthropometric parameters of the participants (arithmetic mean and standard deviation)

Parameter	MEAN \pm SD
Age	21.00 \pm 2.58
Body height (cm)	177.93 \pm 7.62
Body mass (kg)	74.35 \pm 8.85
Leg length (cm)	93.52 \pm 4.75
Arm length (cm)	71.00 \pm 4.70
Wrist diameter (cm)	5.39 \pm 0.31
Elbow diameter (cm)	8.41 \pm 0.58
Knee diameter (cm)	10.22 \pm 0.42
Ankle diameter (cm)	6.92 \pm 0.58
Upper arm circumference (cm)	28.45 \pm 2.34
Forearm circumference (cm)	26.45 \pm 2.35
Thigh circumference (cm)	57.70 \pm 3.34
Calf circumference (cm)	36.40 \pm 2.48
Upper arm skinfold girth (mm)	5.44 \pm 1.84
Abdomen skinfold girth (mm)	10.84 \pm 2.68
Forearm skinfold girth (mm)	14.35 \pm 3.62

Sub scapular skin fold girth(mm)	13.28±3.42
Thigh skinfold girth(mm)	17.95±5.71

Calf skinfold girth(mm)	15.11±3.59
Suprailiac skinfold girth(mm)	12.01±5.12

After the six-week training, we observed significant changes in the national team members regarding the body composition. The increase of values is particularly obvious when observing the total body mass, primarily on the raised level of active body components – muscle and bone mass (Table 2).

Table 2 - Body composition of the participants before and after the preparation

Parameter	Before preparations	After preparations	p	d
Body mass (kg)	74.35±8.85	75.47±9.86	<0.01	.379
BMI (kg/m ²)	23.45±2.08	23.83±2.03	<0.01	.585
Muscle mass (kg)	39.21±5.52	39.91±7.01	<0.01	.353
Muscle mass (%)	52.65±2.93	52.76±4.52	<0.01	.093
Adipose tissue (kg)	11.78±2.16	11.93±2.28	<0.05	.214
Adipose tissue (%)	15.80±1.95	15.75±1.97	<0.05	-.081
Bone tissue (kg)	13,36±1,03	12,80±1,66	<0.01	-1.317
Bone tissue (%)	16,99±1,73	17,43±1,05	<0.01	1.001

All the analyzed physiological parameters have shown statistically significant differences between the first and the second measuring (Table 3). Effect sizes, as measured by Cohen's d, were in accordance with those found in similar recent studies (Nalcakan2014, Gist2014). The values of the heart frequencies have shown the greatest deviations which can be observed throughout the weight load testing (Figure 1).

Table 3 - Physiological indicators in participants before and after sport preparation

Parameter	Before preparations period	After preparation period	p	d
Er (10 ⁶ /mm ³)	5.31±1.28	5.40±0.76	<0.01	.279
Hg (g/dl)	14.61±2.08	15.16±0.76	<0.01	1.225
HR	88.30±15.64	81.30±8.77	<0.01	-1.814
Testing time (min)	11,72±2.15	12.10±1.15	<0.01	.728
VO ₂ max (ml/kg/min)	43.40±5.44	45.10±4.46	<0.01	1.086
General endurance (GE)	3.70±0.68	3.90±0.32	<0.01	1.265

Er – Erythrocyte, Hg – hemoglobin, HR – heart rate, VO₂max – maximal oxygen usage

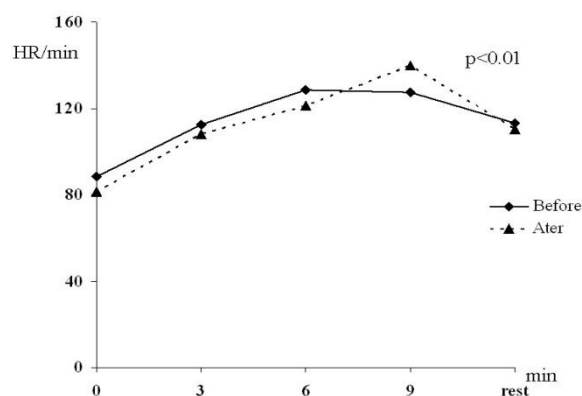


Fig. - 1 Heart frequency rates during weight load testing, before and after six-week training period

Table 4 presents data on comparing the components of body composition and ergometric test results to the results of ergometric test in the first and second measuring. The analysis of these data shows that in both measuring we noticed positive correlations of muscle components (relative and absolute) with testing time, general endurance, oxygen usage.

Table 4 - Pearson coefficient of correlation between body components and cardio physiologic parameters, for the first and second testing

	ET ¹	ET ²	GE ¹	GE ²	Vo2max ¹	Vo2max ²	1	2	HRrest _{t1}	HRrest _{t2}
MM (kg)	0.1	0.084	0.227	-0.149	0.104	0.29	-0.392	-0.029	0.318	-0.550
MM (%)	0.365	0.366	0.336	0.392	0.348	0.640	-0.247	0.047	0.559	-0.315
MT(kg)	0.253	0.270	0.116	-0.197	0.200	-0.142	-0.062	0.151	0.008	-0.311
MT(%)	0.1	0.081	0.223	0.020	0.037	-0.161	0.249	0.265	-0.013	0.033
HR	-0.554	0.551	-0.401	0.172	-0.529	-0.223	1	1	-0.445	-0.134
HRrest	-0.479	-0.38	0.588	-0.214	0.445	-0.440	0.736	-0.134	1	1
ET(min)	1	1	0.833	0.864	0.992	0.586	-0.554	0.551	-0.479	-0.378
VO2max (ml/kg/min)	0.992	0.586	0.853	0.717	1	1	-0.529	-0.223	-0.445	-0.440
VO2 (kg)	0.63	0.419	0.659	0.522	0.622	0.502	-0.078	0.005	-0.078	0.124
GE	0.833	0.864	1	1	0.853	0.522	-0.401	0.172	-0.588	-0.214

(1 first measuring; 2 second measuring) MM - muscle mass, MT - bone mass, HR - heart rate, ET - exercise time, VO2max - maximal oxygen usage, GE - general endurance

In this paper we studied whether six-week preparations lead to the improvement of body composition and physiological characteristics in elite karate fighters. The main results of the study conducted on ten karate Macedonian national team members reveal that the six-week training period resulted in: a) the improvement of the body composition components - primarily of the muscle and bone mass, b) the improvement of physiological characteristics and c) positive correlation between muscle mass and testing time, general endurance and oxygen usage. Morphological characteristics of the athletes have a great influence on achieving desired results in all sports, thus in karate as well. Among these characteristics, a special attention is drawn to body composition, particularly if bearing in mind karate is a sport with weight categories. The changes in body composition may lead to the change of the athlete's category, which can strongly influence his performance, particularly if the changes refer to the increase of adipose tissue (Silva et. al. 2010).

The results of our study have shown that after the six-week preparation period body mass increases, primarily in the aspect of muscle mass and bone mass. Although these are relatively small differences in numbers, they are statistically different, but it must be cleared

that they did not cause the change in weight categories. On the other hand, when discussing the

increase of the muscle mass, it most certainly involves the increase of muscle power, and it is well-known that muscle power is one of the key factors determining success in a karate athlete (Giampietro et. al. 2003, Katić et. al. 2010). Furthermore, by analyzing the values of adipose tissue in our participant, we observed they do not exceed the limits formerly registered in various studies, and they reach from 7.5% in Japanese karate fighters, over 13.7% in French karate fighters to 16.8% in Polish karate fighters (Katić et. al. 2013, Imamura et al. 1997). In a research conducted on elite karate fighters in Bosnia and Herzegovina referring to fat quantity (FAT %), the authors established that it is 8.15% on average. Based on the results obtained from the previous researches, it has been established that the selection of technical actions in elite karate fighters during a fight is connected to the body constitution and proportion. The research conducted on elite karate athletes in Bosnia and Herzegovina revealed that karate fighters with lower values of body height, arm length, total fat weight and body mass index have achieved better results in performing two-point technique (NIHON) (Kostovski et. al. 2013).

The body fat percentage of elite male karate competitors range from 7.5% in Japanese athletes to 16.8% for Polish elite –level karate competitors (Katić et al. 2010, Katić et al. 2013). Data for Indian judo fighters showed that body fat has negative correlation ($r = -0.690$, $p < 0.05$) with performance (Sterkowicz-Przybycien KL. (2010). Mere was using BIA method in senior judo fighters from Austrian National Team showed they have $BMI = 24.8 \pm 2.7$ and body fat 12.9 ± 5.8 (height 174.4 ± 5.1 cm; weight $= 62.8 \pm 4.4$ kg) (Imamura et al. 1997). The average value of body mass index (BMI) established in some researches is higher than the upper limit for this index in normal population ($18.9 - 25$ kg/m²). Data we obtained for this parameter (BMI) for our studied sample (23.5 ± 2.1 kg/m²) is within limits of normal weight for general population. Ubeda supplied data on BMI in elite Spanish judo fighters similar to ours, 24.3 kg/m², while in another study Franchini et al. reported a higher value in Spanish judo fighters, 25.4 kg/m² in senior fighters and 26.1 kg/m² in junior fighters (Úbeda et al. 2010, Franchini et al. 2005). A high BMI in athletes is the result of high muscle mass, i.e. high body muscle component. Although other authors give data on karate fighters having a lower fat component than general population (Santos et al. 2010, Imamura et al. 1997), the athletes in our studied sample had an average fat mass value of 15.8% which, according to the applied method (Matiegka), meets the lower limit of normal values for this parameter in general population. Wide range of BMI in our participant (from 19.84 to 26.79 kg/m²) is the result of the different weight categories they belong to. Relatively small changes in body composition of our studied sample are the consequence of relatively short preparation period. It is not realistic to expect that during six-week preparation period one will significantly increase muscle mass since, based on previous studies, it is realistic to expect that muscle hypertrophy will occur after 8-10 weeks of exercising with weight load. Our assumption is that the reason for a small change in the fat component lies in the fact that our participants already had good physical condition, i.e. the quantity of their adipose tissue was not so high to drastically decrease during the preparation period.

Comparison of cardio-physiological parameters in the studied karate fighters between two ergonomic tests showed a statistically significant difference in favor of the second measuring. The final result of Bruce test, exercise time (ET) was better after preparation period (11.7 vs. 12.1 min) which results even in the better mark of general endurance (3.7 vs. 3.9). Indirect parameter of aerobic capacity, maximum oxygen usage was significantly improved after preparation period (43.4 ml/kg/min vs. 45.1 ml/kg/min). The analysis of heart frequency during ergonomic test reveals that adaption of cardiovascular system during ergometric test was improved after the preparation period. Heart rate at rest (HRR) is significantly reduced (88.3 beats/min vs. 81.3 beats/min). Pulse curve obtained during second measuring, which consists

of pulse frequencies at rest, at the end of every minute and from the frequency in the third minute of the recovery period, has lower values and is under the pulse curve of the first measuring in the graph. The change in the cardio-vascular physiological parameters shows better function of cardio-vascular system in the athletes after the preparation period.

Studied correlations between body components and cardio-physiological parameters have shown similar values in both measuring. Relative muscle mass (%) has shown in both cases moderate positive correlation with testing time and general endurance. Medium strong correlation was registered between muscle mass and maximum oxygen usage ($r = 0.64$). Fat component has not shown significant correlation with any of the parameters, but the weak positive correlation with heart frequency at rest ($r = 0.25$), which leads to an assumption that participant with the greater quantity of adipose tissue have higher HRR. Testing time showed extremely high positive connection with general endurance ($r_1 = 0.833$; $r_2 = 0.864$) and with maximum oxygen usage ($r_1 = 0.992$; $r_2 = 0.586$) which is logical since calculation of general endurance and oxygen usage is the result of testing time. Testing time was negatively connected with HRR and SF3, which means that participant with better (longer) time in Bruce test have better cardiovascular functions (lower frequency at rest and faster decrease of frequency in recovery period). Maximum oxygen usage, in addition to being positively connected to ET and GE (general endurance), was negatively connected to HRR and HRRec ($r = -0.529$; $r = -0.445$). It is the same case with general endurance. Thus, the participant who have higher heart frequency at rest have lower result in Bruce test, and their heart in the recovery period returns to baseline frequency more slowly. When studying body composition (by BIA method) and power changes in elite karate fighters, during the period before and after the preparations, we established a change in the quantity of body water, but without any significant changes in body composition (Silva et al. 2010).

Comparing body composition and aerobic capacity in elite judo fighters, regarding their weight category, shows that weight category increases as well as the relative oxygen usage ($r = -0.63$), in addition to body fat ($r = 0.79$) (Katralli J, Goudar SS. (2010). There are several limitations in this research. Though we determined muscle mass by the formula where the greatest influence has the circumference of upper and lower extremities, we did not determine muscle power directly. Our assumption (speculation) was that greater muscle mass means greater muscle power. Further studies on the distribution of muscle mass are necessary, e.g. arm/leg relation, to establish which extremities are more developed in karate athletes, which would help to explain which muscle groups participate more during a fight.

Conclusion

The research was carried out without the presence of a control group because it is about selected top athletes who were in the preparatory period and in a relatively good shape. They are all with an average age of 21 years, which points to the fact that the human development curve is going into a stage of stagnation, and in the mentioned period the athletes had no other physical activity other than a training process. These data are sufficient confirmation that the changes in the athletes are the result of the training process.

The increase of the total and percentage presence of muscles in karate fighters during the preparation period and the decrease of the adipose tissue shows a positive influence of the training process on the body composition of the athletes. The changes are small in quantity, which is the result of a relatively short analyzed period and the fact that the participants were previously in good physical condition. Cardio-physiological parameters, the results of Bruce ergonomic test were significantly improved after the preparation period. The testing of the cardio-vascular system (CVS) after the preparations shows the improvement in CVS adaptation in conditions of increased physical strain.

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UČINCI ŠESTOTJEDNOG TRENINGA NA POKAZATELJE SASTAVA TIJELA I FIZIOLOŠKE KARAKTERISTIKE VRHUNSKIH KARATISTA

Sažetak

U ovoj studiji istražili smo je li šest tjedana treninga dovodi do razlika u sastavu tijela i fiziološkim karakteristikama kod vrhunskih karatista. Na uzorku od deset elitnih boraca karatea (prosječna dob $21,00 \pm 2,58$), članova seniorskog makedonskog nacionalnog tima, obavljena su antropometrijska i ergometrijska mjerenja. Svi sudionici istraživanja bili su muškarci prosječne dobi od $21,00 \pm 2,58$ godina, srednje visine tijela $177,93 \pm 7,62$ cm i tjelesne mase $74,35 \pm 8,85$ kg. Nakon šest tjedana treninga s nacionalnim karate timom uočili smo značajne promjene članova nacionalne reprezentacije u sastavu tijela. Povećanje vrijednosti posebno je očigledno prilikom promatranja ukupne tjelesne mase, prvenstveno na povišenoj razini aktivnih tjelesnih komponenti - mišića i koštane mase. Svi analizirani fiziološki parametri pokazali su statistički značajnu razliku između prvog i drugog mjerenja. Vrijednosti srčanih frekvencija pokazale su najveća odstupanja koja se mogu promatrati tijekom testiranja utega. Dobiveni rezultati rezultat su činjenice da u navedenom razdoblju sportaši nisu imali drugu tjelesnu aktivnost osim procesa obuke, a njihovo doba ukazuje na to da krivulja ljudskog razvoja ide u fazu stagnacije što znači da je faktor prirodnog razvoja bio zanemariv.

Ključne riječi: national team, ergometric, anthropometric.

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