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Original research article

THE EFFECTS OF SPECIFIC TRAINING ON CARDIORESPIRATORY ENDURANCE AMONG YOUNG JUDOKAS

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Abstract. *The primary aim of this research was to determine the changes in cardiorespiratory endurance of young judokas during an eight-week specifically designed training program. The research was carried out on a sample of 25 young, highly selected judokas, all members of the extended list of cadet and junior national team members of Serbia, aged 14 to 18. All of the participants were included in a specifically designed training program which lasted for eight weeks, and represented a combination of highly-intense activities of very short duration, specific strength exercises, the improvement of specific judo techniques and judo matches (randori). The results of the analysis indicated that cardiorespiratory endurance among young judokas after an eight-week specifically designed training program had not undergone any statistically significant changes. Furthermore, the value of VO_{2peak} was somewhat elevated at the final measuring. The explanations for these results can be found in the fact that young judokas were not subjected to a rapid reduction in body weight, and instead through increased intensity of the training load were able to decrease their body fat percentage. In addition, we can justifiably assume that the level of training load, during this specifically designed training program, was sufficient for the previously achieved level of cardiorespiratory endurance to be maintained. The results of this research confirm that the basis for daily planning and programming should consist of precisely diagnosed procedures for the evaluation of the characteristics of athletes, since they offer insight into the proper application of training load*.

Key words: *judo, cardiorespiratory endurance, training, adaptation*.

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INTRODUCTION

The general conclusion of the research carried out to date is that the physiological profile of judokas, as an interconnection between aerobic and anaerobic metabolism, cannot be defined precisely (Todorov, Bratić, Nurkić, & Radovanović, 2013). As a result, the successful combination of training depends on a variety of factors such as the genetic potential of the athlete, the length of training experience, the current physical fitness, the intensity and extent of the training, the optimal periodization, diet, supplementation, etc. During concurrent training which aims to increase muscle endurance, muscle fibers are faced with two different types of adaptation. At the same time, the skeletal muscle fiber needs to adapt to the oxidative stimulus and improve aerobic capacity, or to adapt to the stimulus of the program for the development of force and improve the ability to generate force (Radovanović & Ignjatović, 2013). Endurance training increases the activities of aerobic enzymes and the density of mitochondria, while training for the development of muscle strength can lead to the decrease in aerobic enzymes. When applying concurrent training for the development of strength and endurance, the optimal adaptation of the muscle fibers is hindered. It would, however, occur due to the application of only one type of training (Radovanovic, Bratic, Nurkic, Cvetkovic, Ignjatovic, & Aleksandrovic, 2009).

A frequent characteristic of judo training is adherence to the following principle: "*as competition gets closer, work gets shorter but sharper and rest gets longer"* and the decrease in aerobic training during the preparatory period. This approach often begs the question whether focusing of training on the aerobic regimes of load decreases the cardiorespiratory (aerobic) endurance of competitors.

The aim of this research is to determine the changes in the cardiorespiratory endurance of young judokas during an eight-week specifically designed training program.

THE METHOD

The participants

This research was carried out on a sample of 25 young, highly selected judokas, members of the extended list of cadet and junior national team members of Serbia, aged 14 to 18. All of the participants were familiar with the measurement conditions and they voluntarily participated in the study. The research was carried out in accordance with the conditions of the *Declaration of Helsinki: Recommendations Guiding Physicians in Biomedical Research Involving Human Subjects* (http://www.cirp.org/library/ethics/helsinki/), and with the approval and consent of the Ethics Committee of the Faculty of Sport and Physical Education, University of Niš. All of the participants took part in the specifically designed training program for the a period of eight weeks, which represented a combination of highly-intense activities of a short duration, specific strength exercises, the improvement in specific judo techniques and judo matches (*randori*).

Procedures

The measurements of body composition were performed using the bioelectrical impedance analysis (BIA), with the InBody 720 Tetrapolar 8-Point Tactile Electrode

System (Biospace Co., Ltd.). The InBody 720 apparatus utilizes the latest technology of measuring body composition using the method of Direct Segmental Multi-frequency Bioelectrical Impedance Analysis (DSM-BIA). Using the frequency range from 1kHz to 1MHz, the quantity/weight of all four major body components are measured with a high level of accuracy (720 InBody Biospace, 2008).

The manufacturer's recommendations (InBody 720 Biospace, 2008) were followed fully: the measurements were taken in the morning (between 8:30 and 10:00 a.m.); the participants did not eat after 9:00 p.m. the evening before, and on the day of the measurement they neither ate nor drank before the end of the procedure; the participants were not submitted to any great physical exertion during practice 12 hours before the measurement; the participants did not consume alcohol 48 h before the measurement; the participants were asked to empty their bowels and bladder before the measurement; the participants were in the standing position for at least 5 minutes before the measurement to redistribute the tissue fluids; the measurement was performed in a standing position in accordance to the procedure recommended by the manufacturer (hands aside placed 15 cm laterally from the body).

After the body composition measurement, the participants were subjected to a maximal progressive exercise test on the crank arms ergometer Rehab Trainer 881 E (Monark, Sweden). The crank arms were individually adjusted for each participant. The participants were familiarized with the testing procedure. A standardized stepwise continuous test protocol with a 3-min warming at a load of 25 W was used. After that the load was increased by 25 W every 3 min until the end of the exercise test. The workload was set at 50 rpm. The test was performed to volitional exhaustion. At the end of the test, the participants were asked not to stop promptly but to continue at a slow pace for 3 min at a load of 50 W, while all the parameters were monitored.

Oxygen uptake (VO_2) was determined using an automated cardiopulmonary exercise system (FitMate Pro, Cosmed, Italy) which was calibrated prior to data collection. During each test, the participants breathed through a two-way mouthpiece (Hans Rudolph, Kansas City, USA). The validity, reliability, and accuracy of the FitMate gas analyzer were previously reported (Nieman, Austin, Benezra, Pearce, McInnis, & Unick, 2006). We hypothesized that peak oxygen uptake (VO_{2peak}) was reached when at least two criteria proposed by Howley et al. were fulfilled (Howley, Bassett, & Welch, 1995).

Statistical analyses

Standard descriptive statistical procedures were used to determine the mean ± standard deviation (mean ± SD) values. After the distribution was determined to be normal, T-tests were used to evaluate the differences between the means of the two samples. Statistical significance was set at $p \leq 0.05$. SPSS (version 18, SPSS Inc., Chicago, USA) was used to perform the analyses.

RESULTS

Body composition

Comparisons between the initial and the final measurement showed no statistically significant difference in weight and body composition after 8 weeks training period (Table 1).

Table 1 Judokas' main demographic and physical characteristics.

Characteristics	Initial	Final
Age (years)	16.2 ± 1.3	
Judo Training Experience (years)	8.6 ± 1.8	
Height (cm)	176.9 ± 0.9	
Body Weight (kg)	73.4 ± 7.2	73.3 ± 7.6
Body Fat (%)	11.7 ± 3.3	10.9 ± 2.9

Values are mean ± SD

Comparisons between the initial and the final measurement showed no statistically significant difference in cardiorespiratory endurance after an 8-week training period (Table 2).

Table 2 Judokas' cardiorespiratory parameters.

Parameters	Initial	Final
VO_{2peak} ($ml \cdot min^{-1}$)	2.5 ± 0.3	2.6 ± 0.4
VO_{2peak} ($ml \cdot kg^{-1} \cdot min^{-1}$)	34.3 ± 3.6	35.7 ± 2.8
VE_{peak} ($l \cdot min^{-1}$)	94 .1 ± 20.4	95.6 ± 21.5
HR_{peak} ($beats \cdot min^{-1}$)	182.6 ± 10.1	184.3 ± 8.8

Values are mean ± SD. Abbreviations: VO_{2peak} = peak oxygen uptake; VE_{peak} = peak ventilation; HR_{peak} = peak heart rate.

DISCUSSION

The strong link believed to exist between physiological adaptations to training, the quality and quantity of training and the level of technical abilities of the competitors is very difficult to determine, since judo is a sport in which technique is predominant, and the physiological characteristics and their parameters are only the basis on which the judo athlete builds his technique and tactics (Todorov, Bratić, Nurkić, & Radovanović, 2013).

In order to obtain a precise response to the actual development of the aerobic metabolism among judokas, oxygen uptake needs to be measured during a match simulation, which was not possible for obvious technical reasons. What is more, a judo match partially takes place with elevated upper arms in a quasi-static state. This includes the appropriate engagement of the cardiovascular system and an increase in heart rate frequency, with a concurrent decrease in oxygen uptake. Previous research has shown that in the case of static muscle contractions, at a certain percentage of maximum heart rate frequency, the percentage of maximum oxygen uptake would be smaller than the one that exists during dynamic contractions (Collins, Cureton, Hill & Ray, 1991). As a result, there is a loss of linearity between heart rate frequency and oxygen uptake, which

prohibits us from drawing any conclusions related to the metabolic means of generating energy during a judo match. We believe that the applied maximum multi-level hand bicycle-ergometry test is one of the best possible solutions for the evaluation of the cardiorespiratory endurance of judokas, The increase in load intensity during a maximum multi-level hand bicycle-ergometry test was used as a method for achieving maximum oxygen uptake and determining $VO_{2\ peak}$. The ability that the participants possess of maintaining greater intensity prior to the onset of fatigue and/or the end of the test implies a greater value of aerobic endurance (Bentley, McNaughton & Thompson, 2001). The abovementioned claim is of great importance considering the fact that during physical activity of non-maximum intensity, the metabolic response could be different, depending on the degree of the fitness level of the participants (Baldwin, Snow & Febbraio, 2000). The joint methodological limitation in all of the previously published studies is the length of the stages during the multi-level progressive test and the overall duration of the test in question. It is possible that the modification of the protocol of the multi-level progressive test can influence the maximum and sub-maximum physiological parameters (Coyle, 1995). These changes can be significant in terms of the interpretation of the physiological variables, with the aim of monitoring the effects of a certain type of training, or predicting the level of development of abilities (Bentley, Newell, & Bishop, 2007). From the literature that is available, it would seem that the multi-level progressive test, which consists of three-minute phases, enables researchers to obtain the most reliable data for analysis.

Radaković (2011) carried out a study with the aim of determining the connection between maximum oxygen uptake and lactate metabolism with the situational effectiveness of selected young judokas. The average value of maximum oxygen uptake during the continued progressive test on the hand bicycle-ergometer had a value of 41.3 $ml \cdot kg^{-1} \cdot min^{-1}$. Based on the analysis of the obtained results, the author concluded that there is a statistically significant connection between maximum oxygen uptake and the index of the special judo fitness test among selected young judokas, as well as a statistically significant connection between the levels of the lactate thresholds and the index of the special judo fitness of selected young judokas, as well as a statistically significant connection between the levels of lactate thresholds and the index of the special judo fitness of selected young judokas.

In their research, Pocecco, Gatterer, Ruedl, & Burtscher (2012) studied a sample of 8 young judokas, aged 15.3, the average value of maximum oxygen uptake during a continued progressive test on the hand bicycle-ergometer had a value of 35.5 $ml \cdot kg^{-1} \cdot min^{-1}$. Even though the type and kind of test were similar to ours, they were performed using different measuring instruments and following a different protocol, which made it impossible to fully compare the obtained results. In a similar study involving 17 young judokas aged 14, Pocecco & Burtscher (2013) determined that the average value of maximum oxygen uptake during the continued progressive test on the bicycle-ergometer was 38.4 $ml \cdot kg^{-1} \cdot min^{-1}$. In this study as well, the inconsistency between the equipment and the protocol used in this study and the aforementioned ones, made it impossible to compare the obtained results.

A comparison of the results obtained in this study with those of the aforementioned studies indicates that the registered values in both measurements are within the values set for gender, age and type of sport. An analysis of the results in our study indicated that cardiorespiratory endurance among young judokas during an eight-week specifically

designed training program did not undergo statistically significant changes. What is more, not only was there no change in the value of the parameter of cardiorespiratory endurance, but the value of $VO_{2\ peak}$ was somewhat greater at the final measuring. The explanation for these results can be found in the fact that the young judokas were not subjected to a rapid reduction of body weight, and instead through the increased intensity of the training load decreased their percentage of body fat. In addition, we can justifiably assume that the level of training load, during this specifically designed training program was sufficient for the previously achieved cardiorespiratory endurance to be maintained.

CONCLUSION

The results of our research confirm that the diagnostic procedures for the evaluation of the characteristics of athletes should be the basis of any kind planning and programming, since they offer insight into the proper application of the training load. Moreover, these findings may have practical importance and should be considered in evaluating the results from cardiorespiratory testing, especially arm-ergometry testing, as well as in planning the training for young male judo athletes.

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EFEKTI SPECIFIČNOG TRENINGA NA KARDIORESPIRATORNU IZDRŽLJIVOST MLADIH DŽUDISTA

Cilj našeg istraživanja je bio da se utvrde promene kardiorespiratorne izdržljivosti kod mladih džudista tokom osmonedeljnog specifično planiranog treninga. Istraživanje je sprovedeno na uzorku od 25 mladih, visoko selekcionisanih džudista, članova šireg spiska kadetske i juniorske reprezentacije Srbije starosne dobi od 14 do 18 godina. Svi ispitanici su bili uključeni u specifično planirani trening program u trajanju od osam nedelja, koji je predstavljao kombinaciju visoko-intenzivnih aktivnosti kratkog trajanja, specifičnih vežbi snage, usavršavanja specifičnih džudo tehnika i džudo borbi (randori). Analiza rezultata istraživanja je pokazala da kardiorespiratorna izdržljivost kod mladih džudista tokom osmonedeljnog specifično planiranog treninga nije statistički značajno promenjena. Šta više, vrednost VO2 peak je bila nešto veća u finalnom merenju. Objašnjenja za ovakve rezultate nalazimo u činjenici da mladi džudisti nisu bili podvrgnuti rapidnoj redukciji telesne težine već su kroz povećani intezitet trenažnih opterećenja smanjili procenat telesnih masti. Takođe, možemo osnovano predpostaviti da je nivo trenažnih opterećenja, tokom ovog specifično planiranog treninga, bio dovoljan da se prethodno postignuta kardiorespiratorna izdržljivost očuva. Rezultati našeg istraživanja potvrđuju da bazu svakog planiranja i programiranja treba da čine precizni dijagnostički postupci za procenu karakteristika sportista, jer pružaju uvid u pravilnu primenu trenažnih opterećenja.

Ključne reči: *džudo, kardiorespiratorna izdržljivost, trening, adaptacija.*