Physiological profiles of cadet Serbian judokas

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Abstract

The purpose of this study was to determine: 1) physiological profiles of cadet male judokas of the Serbian national team, and, 2) which motor and physiological abilities separate more successful from less successful athletes.

The sample used for this research consisted of the best cadet judokas from the territory of Serbia divided in two groups according to their past results in competitions (groups A and B) which consisted of 16 examinees. The finalists in the Serbian championship were members of the group A, bronze medal winners were members of the group B. Physiological fitness values were measured in all subject.

The structure of discriminant functions clearly indicates that the highest discriminant value in the set of applied variables belongs to the variables agility T-Test, running sideways 20m and Relative Peak power in Wingate test (W/kg). It was concluded that there were statistically significant differences for the variables 10 m sprint from flying start, Running sideways 20 m, Agility T-Test, Continous jump, Shuttle run and Relative Peak power in Wingate test (W/kg) at the level of evaluation which was $p < 0{,}01$. In all cases the differences go in favour of the team A, which means that the examinees from this national team had significantly better results in the above mentioned variables than the ones from the team B.

The structure of being in good shape in judo, which is defined by success, can be labeled as invaluable from the point of view of science and practice. The results obtain in this research can offer coaches the information about the aspects that require more attention in order to make up for the results which are under average, in comparison to the model.

Key words: Physiological profiles, cadet, judokas.

Introduction

Every judoka has to express a large number of actions during one match, so physiological demands of every match are very high (Franchini et al., 2011). A judoka tries to recognize the right moment for using the opponent's weakness and reacts quickly, powerfully and explosively. Quick and powerful techniques of throwing or strong counteraction are mostly supported by anaerobic metabolism. As opposed to that, well-developed aerobic mechanisms of energy recovery are necessary throughout a match, including the breaks (Franchini et al., 2003; Drid et al.; 2008, Drid et al., 2009). Aerobic metabolism is especially important for the process of recovery between matches (Franchini et al., 2009). Many authors describe judo as an explosive sport, with large resources of anaerobic capacities, supported by well-developed aerobic characteristics (Callister et al., 1991; Takahashi, 1992). Anaerobic system allows short, fast, explosive demonstration of strength in a match, while aerobic system enables a judoka do endure an effort during fight and recover during short periods of reduced effort. The structure of movements in this sport is considered to be very demanding for most muscle groups (Thomas et al., 1989; Franchini et al., 2005). To be successful in judo, it is necessary to have a high level of various types of strength, speed and flexibility (Banović, 2001; Franchini et al., 2001a; Franchini et al., 2001b; Monteiro et al., 2001; Radjo et al., 2011) and it can be concluded that there are three motor-functional abilities vital for success in judo: strength, coordination and aerobic-anaerobic endurance.

When selection for judo is taking place, it is necessary to focus on those characteristics and abilities which are vital for sports performance (result), as well as those which are predominantly genetic. In the evaluation of the training process itself, the parameters of the state of fitness allow us to follow the abilities which can be altered under the influence of training (e.g. abilities sensitive to the influence of surroundings, specific physical activities, such as programmed training), which have a strong influence on the result.

Therefore, the purpose of this study was to determine: 1) physiological profiles of cadet male judokas of the Serbian national team, and, 2) which motor and physiological abilities separate more successful from less successful athletes.

Method

Sample of examinees

The sample used for this research consisted of the best cadet judokas from the territory of Serbia (N=32) divided in two groups according to their past results in competitions (groups A and B) which consisted of 16 examinees. The finalists in the Serbian championship were members of the group A (16.54±0.53 years, 179.28±9.46 cm, 84.35±22.56 kg). Bronze medal winners were members of the group B (16.59±0.47 year, 177.50±9.62 cm, 84.14±21 kg).

Sample of measuring instruments

For evaluation of motor abilities the following tests were used: speed: 10 m sprint, 10 m sprint from flying start, 20 m sprint; agility: agility T-Test, running sideways 20 m; explosive power: squat jump, counter movement jump; flexibility: over-arm flip, sit-and-reach; endurance: Shuttle run, continuous jump.

Evaluation of aerobic abilities was done by using the following tests: Absolute maximal oxygen uptake - VO_{2max} in a treadmill test (l/min), Relative maximal oxygen uptake - VO_{2max} in a treadmill test (ml·kg-1·min-1).

Evaluation of anaerobic abilities was done by using the following tests: Peak power in Wingate test (W), Relative Peak power in Wingate test (W/kg).

Protocol of testing and description of tests

Testing for the purpose of this research was done by the educated diagnostic experts. Testing of judokas took place at the Faculty of Sport and Physical Education and Department of Physiology at the Faculty of Medicine.

Speed tests

An examinee starts from a standing position at the starting line and at the sign of a person in charge of measuring runs as fast as possible to the finishing line. The result of the test is the time during which an examinee runs for 10 and 20 m, expressed in hundredths of a second. The test is repeated three times with pauses (up to 10 minutes) and the best result is processed. Examinees are tested for 10 m from a flying start.

Tests of agility

Agility T-test. This test requires four marks in the shape of a letter T, in a way that the second (2) mark is nine meters away from the first one (1), while the third (3) and fourth (4) are to its left side and at the distance of 4.5 meters. The task of an examinee is to run straight from the mark 1 to the mark 2 which should be touched, after that they use a sliding hop-step technique to reach the mark 3. When the mark 3 is touched, the same movements are repeated until the mark 4 is reached and after touching it the sliding technique is used again to return to the mark 2. After touching the mark 2 an examinee starts moving backwards, turning their back to the initial position. The time is stopped when any part of their body crosses the mark. Any avoidance of the given principles should result in interruption of the performance. Otherwise, the results are inadequate for the interpretation. In order to achieve objective results, the testing should be done twice and only a better result should be analyzed.

Running sideways for 20 m. Running sideways with hop-steps. The time is measured in seconds from the starting to the finishing line.

Explosive strength tests

As opposed to other methods used for evaluation of parameters of vertical jumps, Quattro Jump (Kistler Quattro Jump, Switzerland) measures exactly the segment which is of great interest. Explosive strength tests of vertical jumps were measured using the QUATTRO JUMP (Kistler, Switzerland) platform for measuring the force. The result of vertical jump was the height of the jump measured in centimeters (cm). Namely, the tests are used to evaluate the explosive power of legs in concentric (SJ), slow excentric-concentric (CMJ) pattern of muscle force and continuous jumps (CJs).

Tests of flexibility

Over-arm flip. During the over-arm flip test an examinee is standing and holding a pole with his/her arms stretched. Following that, they raise their hands over the head. The person in charge of measuring keeps the record of centimeters measured during this exercise.

Sit-and-reach. An examinee sits on the floor with his/her legs apart forming the angle of 45°. A meter is placed on the floor, between their hips. The examinee puts his/her hands together and tries to reach as far as he/she can bending their back. The result is represented by the reached value expressed in centimeters. The test is repeated several times with pauses between (15 seconds) and the best result is used for data processing.

Test of endurance

Shuttle run. Aerobic fitness was determined using maximal multistage 20-m shuttle-run test (Leger & Lambert, 1982).

Aerobic capacity

The following protocols for determination of the subject's functional abilities were applied: 1) Absolute oxygen uptake (VO_2, ml/min); 2) Relative oxygen uptake (VO_2, ml/min/kg).

Aerobic capacity was assessed with a treadmill (COSMED model T-170-Italy), and the data were collected with a gas analyzer (CPET breath-by-breath method). Briefly, expiratory airflow was measured by gas turbine with a mask and expired gases were analyzed for O_2 with a parametric analyzer and for CO_2 with an infrared analyzer. Before each test, the volume was calibrated by five inspiratory and expiratory strokes at different flows with a three-liter pump; the gas analyzer was calibrated with two mixtures of gases of known oxygen and carbon dioxide concentrations (20.9% O_2, 0.03% CO_2, and then 16.0% O_2, 5.0% CO_2). The FSPE1 protocol itself included measurements of ventilator and metabolic parameters during pauses for one minute, and then for one minute at the speed of 3 km/h. Afterwards, subjects took progressive increments of workload at the rate of 0.5 km/h every 30 seconds (started to run at 7km/h) until exhaustion. The inclination was constant at 2%. The test was considered completed when the VO_2 reached plateau, and respiratory and ventilator quotient reached reference values, while the subjective state of each participant was monitored during the protocol. During the test, subjects had to show the level of rating perceived exertion (RPE) on the modified Borg's Scale where 0 was extremely easy and 13 was extremely hard without capability of proceeding the test (the end of testing).

Anaerobic capacity

Anaerobic capacity was determined by Wingate test (WAnT) and the examination was performed in the Laboratory of functional diagnostics at the Department of Physiology, Faculty of Medicine, Novi Sad. WAnT is a cycle ergometer "all-out" test which lasts 30s. Maximal workload is achieved by turning flywheel with installed blades, previously calibrated by an engine of the adequate power against air resistance (Dotan and Bar-Or, 1983). Testing was performed on a cycle ergometer under the same microclimate conditions. All tests were done by using the same experimental procedure.

Workload was registered directly by the computer which had a module for measuring the number of rotations of the flywheel on a cycle ergometer. A set of programmes which enabled graphic recordings of workload during 30 s, as well as data collection, enabled a software support. Those methods allowed direct monitoring of the testing and a fast analysis of basic indicators of anaerobic capabilities (Peak Power, Peak Power/ body mass, index of fatigue and increase) (MacIntosh et al., 2003). Besides that, programmed support also offered the data about qualitative values of anaerobic energy during any period of time from the 1^{st} to the 30^{th} second of maximal force, together with the automatic evaluation of the absolute and relative values of both registered parameters, as well as a cumulative evaluation of total anaerobic capacity of energy.

Before the test started all examinees were told to warm up by turning pedals of cycle ergometer. That lasted 10 minutes. The goal of warming up was achieving the adaptation of physiological parameters of a body to a higher level which accounted for top results (Bar-Or, 1987).

The test began with a sound signal from a computer which marked the beginning of registration of workload, after which the examinees used their maximal power to move the pedals of cycle ergometer for 30s (Reiser et al., 2002). The height of the saddle was adjusted to the demands of every examinee before the test started. The conventional length of a crank is 16.5 cm. In our laboratory, as well as in many others, this length was used for all examinees, irrelevant of their height and length of their legs. Compulsory equipment of cycle ergometer also included shoe clips (Capmal and Vandewalle, 1997).

Statistical analysis

All statistical analyses were performed by the SPSS 17.0 software (SPSS Inc., USA). Results are presented as arithmetical means with standard deviation (mean ± SD). Student t-test for small independent samples was applied to determine between-group differences in fitness indicators. Differences between groups were also analyzed by the canonic discriminative analysis. Differences were considered statistically significant at $p<0.05$.

Results

Comparative analysis of two analyzed subsamples of examinees was done using the Discriminant analysis, in order to detect qualitative characteristics of the differences, besides the analysis of the quantitative differences between the groups.

Taking into account that there were two groups of the examinees, one discriminant function was defined (Table 1). The isolated discriminant function was statistically significant at the level of evaluation p=0.003. That way it can be concluded that there is a statistically significant difference between the analyzed groups in the field of the applied variables.

The structure of discriminant functions (Table 2) clearly indicates that the highest discriminant value in the set of applied variables belongs to the variables agility T-Test, running sideways 20 m and Relative Peak power in Wingate test (W/kg). Other variables have significantly weaker correlations with the isolated discriminant function. First two variables, agility T-Test and running sideways 20 m, have negative coefficients of correlation with discriminant function, but in fact those are logically positive correlations, taking into account that for those variables lower values indicated qualitatively better results. That is the reason why the values of centroids of analyzed groups must be interpreted taking that into account.

That means that the examinees from the team A have statistically significantly better values of the mentioned variables than the examinees from the team B. The same conclusion can be drawn for the results of the variables Relative Peak power in Wingate test (W/kg) where higher values represented qualitatively better results. That is also indicated by the value of the centroid belonging to the team A which is positive.

Table 2. Structure of discriminant function

Variables	Function
Agility T-Test	**-0.524**
Running sideways 20 m	**-0.493**
Peak power in Wingate test (W/kg)	**0.437**
Shuttle run	0.241
Continuous jump	0.226
10 m sprint from flying start	-0.208
Counter movement jump	0.183
20 m sprint	-0.178
VO_{2max} in a treadmill test (ml·kg-1·min-1)	0.176
Squat jump	0.173
10 m sprint	-0.172
Peak power in Wingate test (W)	0.171
Sit-and-reach	0.084
Maximum oxygen uptake	-0.038
Over-arm flip	-0.029
Centroids of groups	
A team	2.651
B team	-2.461

Analysis of quantitative differences in certain variables between two groups of cadets (Table 3) showed the existence of statistically significant differences in a large number of analysed variables.

It was concluded that there were statistically significant differences for the variables 10 m sprint incuding flying start, Running sideways 20 m, Agility T-Test, Continous jump, Shuttle run and Relative Peak power in Wingate test (W/kg) at the level of evaluation which was $p < 0.01$.

In all cases the differences go in favour of the team A, which means that the examinees from this

Table 1. Discriminant function and its significance

Typical root	R_C	Wilks λ	χ^2	df	p
7.045	0.936	0.124	35.447	16	0.003

Table 3. Analysis of the variance between the teams A and B

Variables	A team	B team	F	p
	Mean (SD)	Mean (SD)		
10 m sprint (s)	1.82 (0.08)	1.91 (0.12)	5.21	0.03
10 m sprint from flying start (s)	1.31 (0.06)	1.40 (0.09)	7.60	**0.01**
20 m sprint (s)	3.15 (0.13)	3.31 (0.21)	5.58	0.03
Running sideways 20 m (s)	5.97 (0.33)	6.76 (0.31)	42.75	**0.00**
Agility T-Test (s)	10.68 (0.37)	11.70 (0.40)	48.36	**0.00**
Squat jump (cm)	31.61 (4.28)	27.86 (4.17)	5.29	0.03
Counter movement jump (cm)	36.65 (6.52)	31.34 (8.71)	3.18	0.09
Continuous jump (cm)	34.35 (3.44)	29.20 (5.23)	8.99	**0.01**
Shuttle run (km)	2.05 (0.16)	1.67 (0.40)	10.21	**0.00**
Over-arm flip (cm)	79.23 (13.39)	81.64 (18.37)	0.15	0.70
Sit-and-reach (cm)	22.50 (5.10)	19.93 (6.68)	1.25	0.27
VO_{2max} in a treadmill test (l/min)	3.44 (0.51)	3.57 (0.77)	0.26	0.62
VO_{2max} in a treadmill test (ml·kg-1·min-1)	47.11 (3.93)	42.63 (5.77)	5.45	0.03
Peak power in Wingate test (W)	785.85 (104.49)	668.79 (156.25)	5.15	0.03
Peak power in Wingate test (W/kg)	10.86 (1.72)	7.92 (0.78)	33.59	**0.00**

national team had significantly better results in the above mentioned variables than the ones from the team B. Significant differences at the level $p<0.05$ were noticed for the variables 10 m sprint, 20 m sprint, Squat jump, Relative VO_{2max} in a treadmill test and Peak power in Wingate test (W).

Discussion

During fight, continuously changing dynamic situations, the fighters need to possess well-acquired technical-tactical stereotypes which they apply, the ability of immediate reorganization of those stereotypes, as well as constant creation of new defensive, attacking and counter-attacking programmes of acting.

The notion of agility cannot be easily defined since it represents the synthesis of almost all physical abilities of one athlete. When it is integrated with coordination, agility enables an athlete to react to a stimulus in a fast and efficient way, move in a desirable direction and be ready to change the direction or stop immediately in order to do a competitive action in a fast, skillful and efficient way. An athlete who has a high level of agility can expect to gain an advantage over other competitors. Having an optimal agility reduces the possibility of injuries, improves sports accomplishment and neutralization of an opponent, which means avoiding contact by quick movements.

Dynamic nature and complexity of making movements in judo fights is represented by movements and actions on tatami, which are performed by maximal power and speed. Actions include a variety of motions the purpose of which is to disturb an opponent's balance, make a protection, as well as throw the opponent in a standing position. On the mat, various rolling movements finally bring about remaining in one position which allows the techniques of a lever, strangling and buttock. If all above mentioned actions and movements in a direct fight with an opponent are taken into account, in constantly changing conditions, it can be noticed that the complexity of technical elements is increased several times. Muscle exertion during fights has both dynamic and static character, but dynamic repetitive strains and explosive movements are dominant.

It is recommendable that sport-specific exercises in judo, such as throwing, pinning, and submission techniques, are restrained to technique drills or actual fighting scenarios on the mat where the desired competitive movement, both in relation to structure and time sequence, can be properly practiced (Henry, 2011).

It is necessary to have a high level of various coordination skills in order to adjust movements to opponent's actions in time and space and apply very complex technical-tactical elements. In order to perform motor tasks in judo in an appropriate way it is important to have agility and capability of changing directions fast. In a judo fight the whole body is included at all times and motor tasks must be performed fast in order to be efficient. Combinations in attacks and defense require timely reactions in changing directions of attacks and defense. Agility is expressed not only in moving on the mat at the maximum speed and power, using techniques of fighting, but also in a variety of other movements the purpose of which is regaining balance, disturbing the opponent's balance, making falling easier, etc.

The results of the analysis of variance show that the group A was able to achieve statistically significantly better results in both tests of agility. The ability of changing directions fast has a strong influence on making combinations in the attack, where in most cases the opponent's reaction causes a fast shift of direction or the shift of force direction.

The speed of doing complex motor tasks is invaluable since without a certain speed of implementing techniques there is no necessary efficiency in judo, no matter how well-coordinated a judoka is. Group A also achieved better results of maximum speed than group B. On balance, taking into account the existing research, it seems like agility is a discriminant component among the groups with more significant differences of competitive level.

Certain authors (Borkowsky et al., 2001; Franchini et al., 2005) found no significant differences in VO_{2max} among elite and non-elite judokas, while some results (Muramatsu et al., 1994; Gariod et al., 1995) show that aerobic capacity has a positive influence on the exercises with interruptions in high intensity. Although aerobic power and capacity are considered relevant to judo performance, the available data do not present differences among judo athletes from different competitive levels. Typical maximal oxygen uptake values are around 50-55 mL/kg/min for male and 40-45 mL/kg/min for female judo athletes (Trivic et al., 2009; Franchini et al., 2011). Observing two groups of Serbian cadet judokas and some of their functional capabilities, it can be concluded that there are some positive statistically significant differences in the maximal oxygen uptake (estimated by *Shuttle run* test), as well as relative maximal oxygen uptake, which indicates that higher results in the achieved VO_{2max} of the judokas from the group A show that they have better functional abilities in comparison to the judokas from the group B. There is some evidence that the judokas who normally get points in the key moments of a fight have a higher value of maximal oxygen uptake (VO2 max) and they are more capable of faster resynthesizing creatine phosphate of the muscle gastrocnemius in comparison to others who get points earlier in the match and have a better performance in the Wingate test for lower body parts (Gariod et al., 1995). This can be important when the structure of judo fights is considered. It has been established (Muramatsu et al., 1994; Castarlenas and Planas, 1997) that judokas with higher VO_2max are in advance in the period of a fight with maximal length (5 min) because the same absolute supermaximal effort has a lower relative intensity in comparison to an athlete who has a lower VO_2max. Changes of the dynamic function of lungs can be used as an indicator of functional fitness even in the activities which are dominantly anaerobic (Radovanovic et al., 2011). Our research has proved that there is a statistically significant difference between the groups of judokas with respect to functional abilities, which includes relative values of maximal oxygen uptake.

The level of general anaerobic endurance depends in the first place on the amount of anaerobic sources of energy (ATP, CP and muscle glycogen), their efficient use (enzyme efficiency) and buffer abilities. Aerobic capacity (oxygen transport system) has no significant influence on the general anaerobic endurance, even though it can be concluded that a higher aerobic capacity ensures longer anaerobic workload since lactic acid is decomposed in the presence of oxygen (1 g of lactic acid requires about 50 ml O_2).

Development of aerobic power and aerobic capacity, as well as muscle power, may be important to some intermittent specific tasks in judo (Detanico et al., 2011). Comparing judokas in the tests of anaerobic capacity, this research proved the existence of certain statistically significant differences, but their value was relative, so it can be concluded that there are some differences in anaerobic capacity between the groups of judokas.

Wingate test for evaluation of anaerobic capacity of judokas was mostly used (Sbriccoli et al., 2007). Comparing different age groups by means of Wingate tests for the upper part of a body showed that cadet judokas have lower absolute maximal and submaximal power than juniors and seniors, as well as lower relative maximal power than senior judokas. These differences are most likely connected to the aspects of growing up. When the performances of the lower body part are compared by using the Wingate test on the athletes belonging to different competitive levels, it can be concluded that higher maximal and submaximal power was measured on top (state and international medalists) than on other athletes (without medals) (Franchini et al., 2005). Greater maximal power and more efficient use of the muscles of the shoulders, arms and legs, results in lower risk of injury and has a positive effect on athletic performance in terms of speed, agility, power and aerobic endurance (Bratic et al., 2012).

Conclusion

Improved performance of motor functions is typical of a top-quality athlete, while movements represent the essence of sport. Athletes are born with a talent which they can develop by training. Being successful in achieving that goal depends, of course, on athletes themselves. First of all, they should realize that motor functions can be learned. Every step they take in that direction is very important for the improvement of their skills. They become successful in sport only if they insist on perfect technique. Maximum achievement is obtained by the means of perfect training practice, which includes the development of the multi-sensory system of feedback information which enables athletes to learn fast by making attempts and mistakes. It should be pointed out that athletes learn efficiently by means of non-verbal and non-auditory signals. The result of acquiring general and specific motor skills is a reduced risk of injuries, improved general physical condition and joining the efficient motor programmes to the goal of producing efficient, top and specific movements.

Improvement of the dynamic balance is the essence of the development of agility. Athletes should develop all physical qualities, including the central stability, mobility, speed, flexibility, strength, force and energy systems. That way they achieve the exquisite technique which enables them to win in the most important game in a competition – the achievement of their sport potential. In that exciting process of learning and advancing athletes are encouraged to become the people with fully developed motor functions (techniques of movement).

In the process of making selection of athletes for judo, the attention must be paid to those characteristics and skills which have the most important influence on sports performance (result), as well as those which are mostly dominated by genetic factors. During the evaluation of the training process the parameters which show the level of being in good shape allow observation of the variables which are under the influence of training (e.g. abilities susceptible to the influence of the environment; specific physical activities, such as programmed training) which affect the result to a great extent.

The structure of being in good shape in judo, which is defined by success, can be labeled as invaluable from the point of view of science and practice. The results obtain in this research can offer coaches the information about the aspects that require more attention in order to make up for the results which are under average, in comparison to the model.

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