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Relationship between Maximum Oxygen Consumption and Lactate Metabolism with Situational Efficiency of Highly Selected Young Judoists

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Abstract

Judo is often referred to as an explosive sport, which requires great anaerobic strength and capacity, with a well-developed aerobic system. Attaining a high level of physical fitness, strength, and fatigue tolerance is essential for achieving success in competition. Fatigue leads to decreased muscle strength, prolonged reaction time, reduced agility, neuromuscular coordination, overall body speed, concentration, and agility. The intensity at which this phenomenon occurs is known as the lactate threshold. The primary objective of the planned research was to establish a link between maximal oxygen consumption (VO_2max), lactate metabolism, and the situational efficiency of selected young judoists. The sample consisted of 30 cadet and junior judo athletes from the national teams of Serbia (average age of 16.43±0.76 years, body height of 176.94±5.15 cm, and body weight of 69.71±10.64 kg). The research employed precisely standardized protocols and modern equipment to determine anthropometric characteristics, and the values of maximal oxygen consumption, lactate thresholds, and the index of a specific judo fitness test among the selected young judo athletes. Based on the obtained results, there was a moderate negative correlation between VO_2max and the index of the special judo fitness test, as well as a low correlation between the first lactate threshold (PLAP) and the second lactate threshold (DLAP) with the index of the special judo fitness test (ISJFT). Additionally, a moderate negative correlation was found between VO_2max and anthropometric parameters, while PLAP and DLAP exhibited low correlations with anthropometric parameters. The research results quantitatively illustrate the physiological adaptation of the top young judo athletes to the physical demands encountered during years of specific training. The proposed battery of tests can be utilized to assess the functional status of competitors more accurately and determine the competition profile for elite judo athletes.

Keywords: *maximal oxygen uptake, VO_2max, aerobic capacity, anaerobic capacity, lactate thresholds, specific judo fitness test, elite judokas*

Introduction

The functional properties of the organism show a direct influence on the size and character of the manifestation of working ability, during physical activity (Heimar & Medved, 1997). There are two general functional properties depending on the biochemical nature of energy processes: aerobic capacity and anaerobic capacity. During physical activity, skeletal muscles utilize the energy created through anaerobic and aerobic processes (Bradarić, 1991).

Anaerobic energy is released through the breakdown of adenosine triphosphate, creatine phosphate, or carbohydrates into pyruvate by the process of glycolysis, whereby lactates are formed.

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In practical terms, the term "anaerobic potency" is used when assessing the alactic and lactic anaerobic capacity of an organism (Radovanović, 2009; Radaković, 2016). Anaerobic power means the energy capacity of an organism, in which energy is created from energetic substances, without the simultaneous consumption of oxygen (Kinderman, Simon & Keul, 1979). With programmed multi-year training, anaerobic capacity parameters exhibit significant improvements (Dopsaj, 2008).

Modern judo demands high intensity and includes a wide range of tactical and technical elements (Franchini & Sterkowicz, 2000; Franchini, Takito, & Bertuzzi, 2005). The increased requirements in modern judo, particularly in the field of periodization, aim to optimize training effects by varying different training parameters, utilizing analytical-diagnostic approaches, and incorporating specific situational training.

Aerobic processes involve the resynthesis of adenosine triphosphate with simultaneous oxygen consumption. Under normal conditions, 90% of the total adenosine triphosphate is resynthesized through aerobic processes with the involvement of enzymes located in mitochondrial cells. The amount of energy created by aerobic processes is 10 times larger than the energy obtained by anaerobic glycolysis (Baxter-Jones, Goldstein & Helms, 1993). During physical activity, in addition to muscle glycogen reserves, liver glycogen, fats, and amino acids can be utilized as energy substrates in skeletal muscle cells. The final products of aerobic reactions are water and carbon dioxide, which are easily eliminated and do not cause significant changes in the body (Baxter-Jones et al., 1993; Radovanović, 2009).

To assess the organism's ability to supply the required amounts of energy through aerobic processes, the term "aerobic power" is used in practice. It represents the maximum level of metabolic processes that occur in the presence of oxygen. This process is primarily limited by the quantity of oxygenated blood that the cardiorespiratory system can deliver to the working muscles and, to a lesser extent, by the muscles' ability to extract the delivered oxygen from the blood (Radovanović, 2009).

In research, during the last century, a decrease in the number of mitochondria in muscles was observed, which were subjected to a program for the development of muscle strength (McDougall, Sale, Moroz, Elder, & Sutton, 1979). Since mitochondria are necessary for aerobic energy production processes, any reduction in mitochondrial numbers theoretically leads to a decrease in muscle oxidative capacity. However, at that time, it was not known that strength training provided other benefits such as injury prevention and relief from exhaustion syndrome. High-intensity endurance training can lead to protein loss from type 1 and 2C muscle fibers, which can result in injury and decreased performance over time (Kraemer, Fleck, & Evans, 1996). During muscle strength training, muscle fibers are stimulated, leading to changes in protein quality and the expression of different types and combinations of myosin ATPase enzymes (Kraemer, Fleck, & Evans, 1996; Tanaka & Swensen, 1998). One of the common reasons why athletes, who compete in endurance-dominated disciplines, avoid training to develop muscle strength is the fear of muscle hypertrophy, and thus weight gain. However, using a force development program (Behm & Sale, 1993; Almasbakk & Hoff, 1996) that incorporates heavy loads and focuses on maximum force mobilization can have a greater impact on muscle coordination and nerve adaptation rather than muscle hypertrophy.

In nearly all studies that have examined concurrent strength and endurance training, no detrimental effects on endurance were observed, and markers of aerobic capacity even increased (Hickson, Dvorak, Gorostiaga, Kurowski, & Foster, 1988).

This indicates that the hypothesis stating that strength training increases body weight and negatively affects performance is not entirely accurate. In almost all studies, which studied simultaneous training for the development of muscle strength and endurance, no negative effects on endurance were observed, and markers of aerobic capacity even increased (Hickson, Dvorak, Gorostiaga, Kurowski, & Foster, 1988). Neurological adaptations, as well as the change of the relationship between the types of muscle fibers, in favor of more oxidative muscle fibers during training for the development of strength, lead to increased economy of performing movements. High-intensity training, with a small number of repetitions and the maximum manifestation of muscle strength in the concentric phase of the movement, is considered the most effective for increasing the economy of movement. It is also recommended to emphasize the rapid manifestation of force. After such training, the greatest improvements were observed in the rate of force development (RFD), maximum force output, and the one-repetition maximum test (1RM; Heggelund, Fimland, Helgerud, & Hoff, 2013). Increased RFD results in shorter contraction times, allowing more time for relaxation during cyclic movements. Longer rest periods also facilitate better blood circulation in the capillaries, thus delaying the onset of fatigue.

Judo is often referred to as an acyclic, explosive sport, which requires great anaerobic strength and capacity, with a well-developed aerobic system (Bratić, Nurkić & Stanković, 2011). From a sports physiology perspective, competitive success largely depends on the ability of a judoist to, within his weight category, reach high values of anaerobic capacity and show great muscle strength, with a quick recovery between consecutive matches. Judoists are characterized by a high level of development in both the anaerobic and aerobic bioenergetic systems (Thomas et al, 1989). However, studies of judo competitors have revealed significant differences in anaerobic capacity and maximum oxygen consumption, which can be partly explained by differences in anthropometric characteristics (Callister, Callister, Fleck, & Dudley, 1991). Skirowski et al. (1987) categorized judoists' activities during a match into four duration categories: 0-10 s, 11-20 s, 21-30 s, and longer than 30 s. Activities lasting 11-20 s have the highest frequency (39%), while resting periods and/or breaks typically last 0-10 s in about 80% of cases. Similar studies (NCCP, 1990) have shown that seizures occur every 10-15 s. Therefore, the anaerobic component of the bioenergetic capacity is predominantly engaged in judoists (Pulkkinen, 2001). A high level of physical fitness and strength, with good fatigue tolerance, are necessary prerequisites for competitive success since judo is characterized by changing activities of maximum intensity with an average duration of 15-30s and rest lasting about 10s (Sterkowich & Frachini, 2000).

Gariod et al. (1994) determined two dominant judo profiles by the analysis of high-energy phosphates, nuclear magnetic resonance spectroscopy, using radioactive 31P: aerobic and anaerobic. The analysis of creatine phosphate dynamics during maximal voluntary contraction revealed a less pronounced decrease in judokas belonging to the aerobic profile, along with faster creatine phosphate resynthesis compared to judokas in the anaerobic profile (Gariod et al., 1994).

Despite the significance of functional abilities in judo athletes and the existing research on this topic, it remains unknown whether studies have established a correlation between maximum oxygen consumption (VO_2max), lactate metabolism, and situational efficiency in young judoists. Therefore, the objective of this research was to investigate the relationship between maximum oxygen consumption, lactic metabolism, anthropometric characteristics, and the situational efficiency of selected young judoists.

Methods

Sample of participants

The research was conducted on a sample of 30 highly selected young judoists, members of a wider list of cadet and junior national teams of Serbia, aged 14 to 18 (average age 16.43±0.76 yrs, body height 176.94±5.15 cm, and body weight 69.71±10.64 kg). The participants were required to meet specific criteria, including being on the list of potential representatives, having no organic or somatic diseases, and falling within the 14 to 18 years age range. Ethical review and approval required for the study on human participants was obtained in accordance with local legislation and institutional requirements. Prior to participation, all participants were informed about the experimental procedures. The research was conducted in accordance with the Helsinki Declaration.

Measurments

Anthropometric Characteristics

Standardized anthropometric instruments were used to measure morphological characteristics. Three variables were measured to assess morphological characteristics: body height (ATVI), body mass (ATMS), and fat tissue percentage (APMT). Body height was measured using the GPM anthropometer (Switzerland) with a measurement accuracy of 0.1 cm. Body mass was measured using the Tefal 6010 electronic scale (France) with a measurement accuracy of 0.1 kg. The ratio of fat and non-fat tissue in the participants was indirectly estimated using the laboratory method of bioelectrical impedance analysis (BIA). For bioelectrical impedance analysis, the Omron BF 300 device (Japan) was employed. The data on the percentage of body fat were recorded from the device's display with an accuracy of 0.1% (Eston & Reilly, 2001).

Cardiorespiratory Endurance

The assessment of cardiorespiratory fitness involved the use of a six-stage maximal protocol test on a manual bicycle ergometer, specifically the maximal multistage test on the Monark Rehab 881 E manual bicycle ergometer (Sweden). Oxygen consumption was measured using the Hans Rudolph mask (Kansas City, USA), and Cosmed's FitMate system. The test aimed to measure maximal oxygen consumption (VO_2max) in ml/kg/min.

Lactate Metabolism

For determining lactate thresholds, data on lactate levels in capillary blood (expressed in mmol/L) were used at the end of each stage of the incremental continuous treadmill test. Capillary blood samples were obtained from the fingertip using specialized test strips. Immediately after sampling, the lactate concentration was enzymatically determined using the Lactate Scout analyzer, EKF SensLab (Germany). The sensitivity and validity of lactate concentration determination using the Lactate Scout analyzer, EKF SensLab, have been scientifically confirmed (McNaughton et al., 2002; Von Duvillard et al., 2005). The assessed parameters included the first lactate threshold (PLAP; mmol/L) and the second lactate threshold (DLAP; mmol/L).

Situational Efficiency of Judoists

The situational efficiency of judoists is determined by the index of the Special Judo Fitness Test (SJFT), which is extensively described in the study by Radovanovic, Bratic, and Milovanovic (2008). The index of the SJFT (ISFJT) is calculated using the following equation:

$$ISFJT = (HReff + HRres) \bullet (A + B + C) -1$$

In the equation, HReff represents the heart rate value immediately after exercise (after performing series A, B, and C), HRres represents the pulse value one minute after the test, and A + B + C represents the total number of throws performed in all three series. A lower index indicates better results.

Statistics

To determine the levels in the manifest space of the examined anthropological dimensions of judoists, the basic statistical parameters will be applied: arithmetic mean (X), standard deviation (SD), minimum (Min) and maximum (Max), range of results (Rang). To determine the normality of the distribution, the following will be calculated: skewness (Skw) for symmetry, kurtosis (Krt) for elongation, and P-P plot graphics. Pearson correlation analysis was applied to determine overall quantitative relationships between groups in the motor, situational motor, and functional space. The strength of correlation was determined according to Cohen (1988), where a weak correlation is defined as r=0.1–0.29, moderate correlation as r=0.3–0.49, and strong correlation as r=0.5–1.0. Data analysis was conducted using the IBM SPSS Statistics program (version 19.0, Armonk, NY: IBM Corp.).

Results

Insight into the basic parameters of the distribution of the applied variables, measured in young judoists (Table 1), reveals that the results are well grouped and normally distributed around the arithmetic mean. Additionally, there is no significant deviation in

Table 1. Basic statistical parameters of applied variables.

	N	Mean	SD	Med	Min	Max	Range	Skw	Kurt
GSTA	30	16.43	0.76	16.50	15.00	17.50	2.50	-0.38	-0.76
ATVI	30	176.94	5.15	178.65	168.30	185.10	16.80	-0.26	-1.23
ATMS	30	69.71	10.64	71.10	52.10	87.70	35.60	-0.08	-1.09
APMT	30	9.18	4.06	7.50	4.00	16.80	12.80	0.68	-0.74
FVO2M	30	41.27	2.67	41.40	35.90	45.90	10.00	-0.35	-0.73
PLAP	30	3.43	0.55	3.50	1.90	4.40	2.50	-0.58	0.95
DLAP	30	6.85	0.67	6.85	5.80	8.90	3.10	1.16	2.62
ISFJT	30	13.63	2.05	13.65	10.60	17.10	6.50	0.03	-1.37

Note: N-number, Mean-arithmetic mean, SD-standard deviation, Med-mediana, Min-minimum, Max-maximum, Skw-skewness, Krt-Kurtkurtozis, GSTA-age, ATVI-body height, ATMS-body mass APMT-fat tissue percentage, FVO2M-maximal oxygen consumption, PLAP-first lactate threshold, DLAP-second lactate threshold, ISFJT-index of the special judo fitness test.

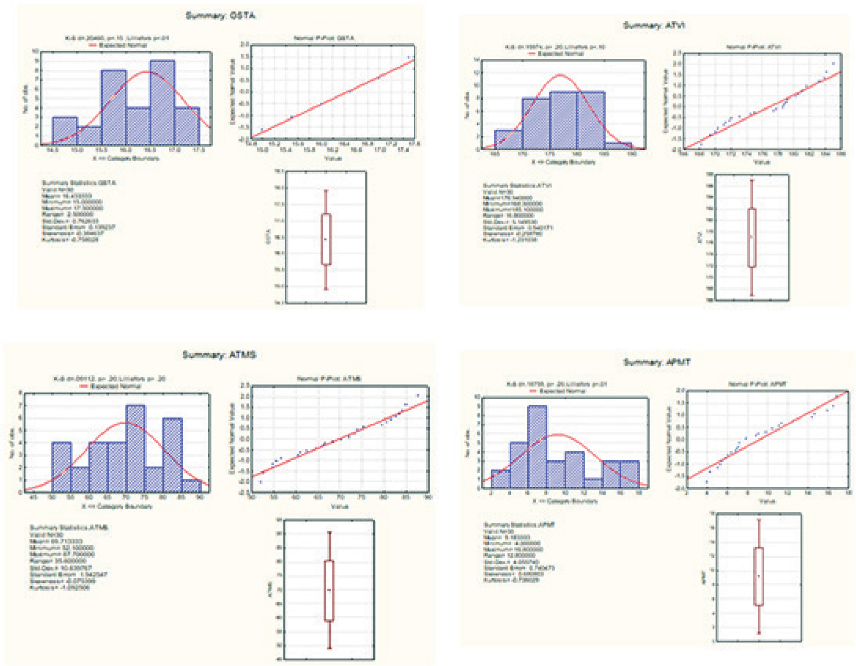

FIGURE 1. Normality of data distribution, skewness and kurtosis, and P-P plot graphs for the variables GSTA, ATVI, ATMS, and APMT.

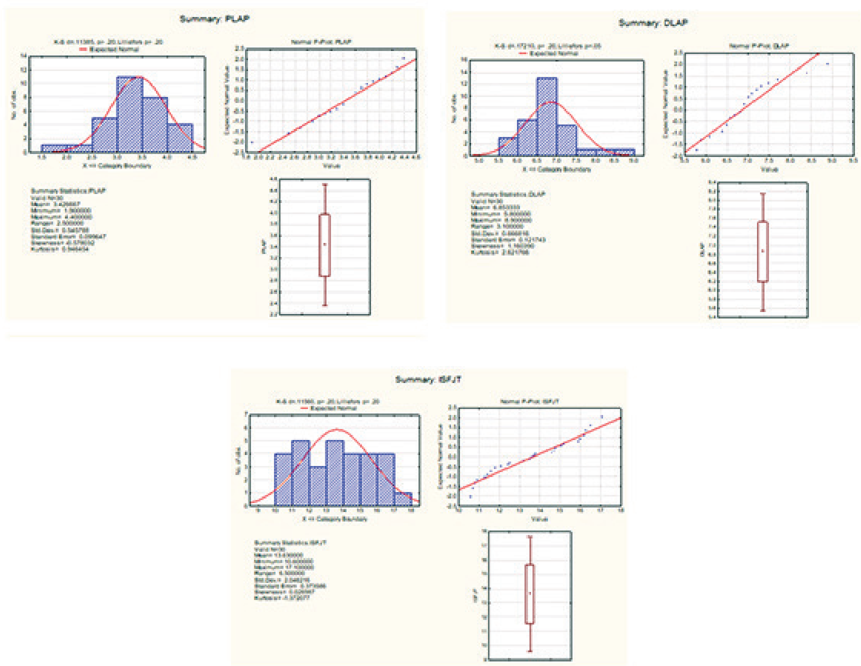

FIGURE 2. Normality of data distribution, skewness and kurtosis, and P-P plot graphs for the variables PLAP, DLAP, and ISFJT

the results (Figure 1 and 2).

Correlations between the analyzed variables are presented in Table 2. Strong correlations were observed between APMT and ATMS (0.90), ATMS and ATVI (0.75), and APMT and ATVI (0.53). On the other hand, VO_2max showed a moderate negative correlation with body composition variables.

Table 2. Correlation matrix between anthropometric characteristics and cardiorespiratory fitness

	GSTA	ATVI	ATMS	APMT
ATVI	0.26			
ATMS	0.32	0.75		
APMT	0.21	0.53	0.90	
FVO2M	-0.21	-0.35	-0.48	-0.49

Note: GSTA-age, ATVI-body height, ATMS-body mass APMT- fat tissue percentage, FVO2M-maximal oxygen consumption.

Table 3. Correlation matrix between anthropometric characteristics and lactate trasholds

	GSTA	ATVI	ATMS	APMT	PLAP
ATVI	0.26				
ATMS	0.32	0.75			
APMT	0.21	0.53	0.90		
PLAP	0.05	-0.16	-0.02	0.01	
DLAP	-0.06	-0.10	0.09	0.01	0.33

Note: GSTA-age, ATVI-body height, ATMS-body mass APMT- fat tissue percentage, DLAP-second lactate threshold, ISFJT-index of the special judo fitness test.

Meanwhile, PLAP and DLAP variables exhibited weak associations with body composition parameters (Table 3).

The analysis of the correlation between the variables of anthropometric characteristics and functional abilities with specific motor tests reveals a moderate negative association between VO_2max and ISFJT (Table 4). However, a weak correlation was found between lactate tolerance and ISFJT variables (Table 5).

Table 4. Correlation between anthropometric characteristics, and cardiorespiratory fitness with situational efficiency

	ISFJT
GSTA	0.21
ATVI	-0.11
ATMS	0.16
APMT	0.34
FVO2M	-0.49

GSTA-age, ATVI-body height, ATMS-body mass APMT-fat tissue percentage, FVO2M-maximal oxygen consumption, ISFJT-index of the special judo fitness test.

Table 5. Correlation between anthropometric characteristics, and lactate trasholds with situational efficiency

	ISFJT
GSTA	0.21
ATVI	-0.11
ATMS	0.16
APMT	0.34
PLAP	0.27
DLAP	-0.21

GSTA-age, ATVI-body height, ATMS-body mass APMT-fat tissue percentage, PLAP-first lactate threshold, DLAP-second lactate threshold, ISFJT-index of the special judo fitness test.

Discussion

Judo is a dynamic and physically demanding sport characterized by high-intensity activity within a short duration. The final outcome in judo is influenced by various variables, including physiological, motor, technical, tactical, and psychological factors (Todorov, 2014). Both anaerobic and aerobic capacities play a role during fights (Thomas et al., 1989). Anaerobic capacity enables intensive, but a short-term manifestation of the maximum muscular strength that characterize this type of sport. The aerobic capacity allows for extended efforts during the potential, five-minute duration of the match. Increasing anaerobic capacity while reducing the percentage of adipose tissue allows for more attacks to be performed during combat while improving aerobic capacity allows for a faster recovery process between fights. Multiple studies have demonstrated the negative impact of adipose tissue percentage on motor skills in judoists, regardless of gender (Nakajima et al., 1998; Frachini et al., 2005). A negative relationship has been observed between adipose tissue percentage and general physical fitness parameters such as isometric strength, flexibility, and balance (Frachini et al., 2005). Similarly, in judoists and other athletes, body weight and adipose tissue percentage have a negative influence on maximum oxygen consumption. It is believed that a lower adipose tissue percentage in elite judoists enables better metabolic adaptation to the diverse technical and tactical demands during matches. The results of the conducted research (Table 2) indicate a strong correlation between body weight and adipose tissue percentage in the subjects. This finding is expected, considering that in the respondents aged 14-18, the chronological age is very close and without significant influence on the body composition. Also, the results of the conducted research confirmed the previously known fact that the percentage of adipose tissue in judoists is higher in competitors of higher weight categories.

To obtain an accurate understanding of the contribution of aerobic metabolism in judoists, it is necessary to measure the consumption of oxygen in combat, which is not possible for technical reasons. Judo matches involve quasi-static positions with raised upper arms, leading to increased heart rate while reducing oxygen consumption (Todorov, Dopsaj, Radovanovic, & Bratic, 2014). Previous research has shown that in static muscle contractions at a certain percentage of maximum heart rate, the percentage of maximum oxygen consumption was lower than the percentage in dynamic contractions (Collins, Cureton, Hill & Ray, 1991). This non-linearity between heart rate and oxygen consumption complicates conclusions regarding energy metabolic pathways during judo. Short periods of high intensity of effort, with even shorter rest intervals, result in a high percentage of lactate anaerobic metabolism. However, the increase in the maximum concentration of lactate in the blood indicates that in high-intensity alternating activities before the onset of fatigue, the largest source of energy is aerobic metabolic processes, while the share of anaerobic is significantly lower. The results of targeted scientific research indicated that during the match there is a need for intensive energy production from glucose because after the fight high levels of lactate concentration in the blood of judoists were registered (Callister, Staron, Fleck, Tesch & Dudley, 1991; Gupta, Goswami, Sadhukhan & Mathur, 1996).

The analysis of the correlation matrix results (Table 4) showed a moderate correlation between VO_2max and Special Judo Fitness Test (SJFT). The SJFT as a field test has less sensitivity and validity compared to the Wingate test, which is performed in laboratory conditions on a hand-held bicycle ergometer. Counting of performed throws during a special judo fitness test gives less precise indicators, but all movements are characteristic of judo. The ability of subjects to maintain a higher intensity, before fatigue and/or test interruption, indicates a higher value of aerobic endurance (Cosgrove, Wilson & Watt, 1999; Bentley, McNaughton & Thompson, 2001). This is particularly important as the metabolic response during non-maximal intensity physical activities can vary depending on the training level of the subject (Baldwin, Snow & Febbraio, 2000). Modification of the multistage progressive test protocol and lactate analysis procedures may affect physiological parameters. These changes can be significant, in terms of interpreting physiological variables in order to monitor the effects of particular training or to predict the level of ability development (Bentley, Newell & Bishop, 2007).

The basic distribution parameters (Table 1.) reveal a wide range of test results for the second lactate threshold (DLAP), indicating the presence of subjects with higher scores. This suggests variations in aerobic metabolism among the subjects included in the study. The correlation matrix showed the lowest correlations between the age and the first lactate threshold (PLAP), which confirmed that chronological age does not affect the level of the first lactate threshold, but it is a consequence of the degree of physical fitness. It is important to highlight that PLAP and DLAP have low correlations with all anthropometric parameters (Table 3), indicating that anthropometric characteristics do not significantly influence lactate threshold. Additionally, the analysis of the correlation matrix between variables (Table 5) shows moderate correlations between the first and second lactate threshold (PLAP) with the judo fitness test variable. Total lactate levels can be increased due to various factors such as decreased glycogen reserves in skeletal muscle cells, low-carbohydrate diets, or previous exhaustive physical activities (Reilly & Woodbridge, 1999). Furthermore, factors like muscle fiber type, activity of glycolytic and lipolytic enzymes, as well as capillary and mitochondrial density, may also influence the blood lactate concentration curve (Midgley, McNaughton, & Jones, 2007). It is important to note that a particular multistage progressive test protocol can vary significantly concerning initial and subsequent load intensity and stage duration.

From a methodological point of view, the place from which the blood sample is obtained to measure lactate concentration (ear shell, fingertip), the type of blood vessel (venous, arterial, capillary), and laboratory methods used (the type of lactate analyzer) also affect the test result. Samples taken from the earlobe showed a lower result of blood lactate concentration than samples taken from the finger. The most accurate approach would be to sample blood from the working muscles (Forsyth & Farrally, 2000). Most published studies on the relationship between the lactate threshold and endurance have shown a strong correlation, meaning that training-induced improvements in cardiorespiratory are significantly associated with improvements in the lactate threshold. Although processes in the central nervous system may have regulatory and decisive effects on endurance (Draper, Brent & Hale, 2006; Noakes, 2007), peripheral metabolic adaptations associated with the lactate threshold are a necessary prerequisite for maintaining aerobic endurance (Midgley, McNaughton, & Jones, 2007). It can be said that there is a large number of evidence (Faude, Kindermann, & Meye, 2009) that the concept of the lactate threshold is of great importance for diagnosis as well as the prediction of aerobic endurance levels. The concept of the aerobic-anaerobic transition can serve as a valuable tool for diagnosing aerobic abilities and guiding training protocols.

Lactate produced in active muscles is subsequently metabolized during high-intensity physical activity in the recovery phase (Westerblad, Allen, & Lannergren, 2002). According to Saltin (1990), there is evidence that a return to values that approximately correspond to the basal values of lactate in the blood can be expected at the earliest 30 to 60 minutes after high-intensity physical activity followed by high lactate accumulation. Since the average accumulation of lactate in the blood after a judo match ranges from 10 to 17 mmol/L, the time interval between matches during tournament competitions, which is typically 15 to 30 minutes, is insufficient for adequate lactate removal. As a consequence, athletes enter the next match in a fatigued state, which may occur earlier than in the previous match. Judo competitors often participate in multiple fights on the same day, sometimes with very short time intervals between them. Therefore, it is highly likely that if lactate accumulation is the cause of muscle fatigue, an athlete who can clear lactate faster will begin the next match with less fatigue and thus have a better chance of achieving a superior competitive result.

The strength of this study lies in the fact that it comprehensively assessed the anthropological status of young elite judo athletes, which has not been done before. The lactate threshold, maximal oxygen consumption in conjunction with anthropometric characteristics, as well as a specific judo test tailored to the judo athletes themselves, were determined. Furthermore, the study established the correlations between the mentioned factors.

However, the limitations of the study are reflected in the relatively small sample size when it comes to correlations, as well as a limited variable system for each individual factor.

Therefore, future research in this field should include a larger sample size, encompassing a broader range of functional and anthropometric variables. Additionally, incorporating precise match analysis would contribute to providing more comprehensive insights.

Conclusion

Improving the ability to recover after a judo fight can have a significant impact on success in multiple fights within the same competition day. Objective measurement data can be used to control, guide, and regulate the training process. The findings of this research can be of great importance for judo schools, clubs, and all experts and coaches involved in judo athlete selection.

In practical terms, one approach could be to incorporate alternating series of high-intensity exercises during training, interspersed with technical actions against opponents, while allowing for short breaks between subsequent series. The theoretical application of the results is evident in the potential for comparing the obtained findings with those of other authors. These findings provide motivation for further research aimed at addressing a wide range of issues related to adaptive changes resulting from long-term training.

Based on the obtained results and the statistical data processing and interpretation, the following conclusions were drawn: There is a moderate negative correlation between VO_2max and the index of the special judo fitness test, as well as a low correlation between PLAP and DLAP with the index of the special judo fitness test. Additionally, a moderate negative correlation between VO_2max and anthropometric parameters was found, while PLAP and DLAP showed a low correlation with anthropometric parameters.

The proposed test battery can be utilized to assess the functional status of competitors and more accurately determine the competitive profile for elite judo. Future studies could be designed to link physiological measurements with precise match analysis, aiming to establish an even stronger relationship between physiological and technical characteristics in judo.

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Conflict of Interest
The author declares that there is no conflict of interest.

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