Lactate concentration during one-day male judo competition: A case study

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Abstract

Background: The aim of this study was to assess the concentration of blood lactate during the men's judo competition in order to investigate the impact of selected factors (the number and frequency of attacks and other variables) affecting it.

Material/Methods: The study involved one professional judoist from the Sport Club (KS) of the Polish University Sports Association (AZS) Gdańsk University of Physical Education and Sport, Poland (AWFiS) who is also a member of the national junior judo team. To determine the participant's aerobic capacity, the test until exhaustion was performed during the tournament-specific preparation period. Additionally, anaerobic efficiency was measured in the Wingate Anaerobic Test (WAnT). Finally, blood samples were taken during an international junior judo tournament before and after each five fights as a material for the analysis of the concentration of lactate. Additionally, technical and tactical data of the five fights were recorded.

Results: The highest concentration of blood lactate (25.1 mmol·l^{-1}) was observed after the fourth fight, whereas the lowest (9.8 mmol·l^{-1}) value was recorded after the last fight. The technical and tactical data have shown that the subject performed the highest number of attacks (10) in the first and fourth fight.

Conclusions: According to our study, in-competition blood lactate concentration (as measured after each fight) exceeds the concentration obtained through the Wingate effort. This suggests that a single effort exerted during the WAnT is inadequate diagnostic index of glycolytic processes in tournament judo. Further, the frequencies of attacks, numbers attacks, forceful attacks are not the only factors affecting glycolysis process.

Key words: judo competition • blood lactate • anaerobic capacity • aerobic capacity

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Background

Blood lactate level raises with exercise of increasing intensity, closely following the increased glycolytic flux and reliance on muscle glycogenolysis [1]. The lactate can be released by muscle fibres working anaerobically and later taken up and metabolized by other fibres working aerobically [2]. Nevertheless, the lactate is also considered to be an active metabolite, thus playing an important role in muscle glycogen production [3]. Moreover, when lactic acid releases hydrogen ions resulting in a dramatic increase of these protons, and thus muscle fatigue [4,5]. Because all the reports convincingly demonstrating that lactate has diverse metabolic effects, one might conclude that this molecule is a simple worthless metabolite [6].

According to various authors, judo players need to possess an ability to perform extensive physical effort, requiring high efficiency of both non-glycolytic and glycolytic energy processes. Furthermore, athletes must be capable of working in the conditions of growing acidification. Also a relatively high aerobic capacity is required as it enables a

Judo – gentle way.

Lactate – a salt formed from lactic acid.

Lactic acid – is an acid with the chemical formula $C_3H_6O_3$.

Glycolysis – The breakdown of glucose to pyruvic acid.

Anaerobic capacity – the production of energy (ATP) in the absence of oxygen.

Aerobic capacity – the mitochondria that uses oxygen to produce energy (ATP); also known as cellular respiration.

Table 1. Characteristics of the subject.

Variable	N=1
Age (yr)	18.3
Body height (cm)	178.0
Body mass (kg)	79.3
Training (yr)	11
BMI (kg/m^2)	25

judo athlete to perform the exercise more effectively as well as promptly return to the state of a homeostasis [7–10].

For a relatively well developed capacity, a short physical activity causes the blood lactate level to significantly increase after reaching 30–40% of intensity, whereas for highly developed capacity, the intensity of 60–70% of VO_2max must be achieved for the concentration of lactate to raise. During an exercise at maximum intensity, concentration of blood lactate exceeds at least 8 ($mmol \cdot l^{-1}$), yet most frequently it reaches 10–13 ($mmol \cdot l^{-1}$). On the other hand, supra-maximal efforts (for athletes) cause the value of lactate to exceed 16–17 ($mmol \cdot l^{-1}$). During long lasting efforts, blood lactate concentration changes depending on the intensity and duration of the exercise [11]. It is widely known that sport training results in both the increase of the maximum blood lactate concentration and the decrease of the level concentration during exercise of moderate intensity [12].

Therefore, the aim of this study was to evaluate the concentration of blood lactate during the men's judo competition in order to investigate the impact of selected factors (the number and frequency of attacks and other variables) affecting it.

Material and Methods

Participant

The study involved one professional judoist from the Sport Club (KS) of the Polish University Sports Association (AZS) Gdańsk University of Physical Education and Sport, Poland (AWFiS), who is also a member of the national junior judo team (for more information on the subject see Table 1). The procedures of this investigation have been accepted by the Institutional Review Board, and the subject gave his written informed consent prior to the study.

Anthropometric measurements

Body mass (BM) and body composition were estimated using a bioelectrical impedance floor scale (TBF-300 Body Fat Monitor/Scale Analyser, Tanita, Japan) that was calibrated in accordance with manufacturer guidelines prior to each test session. One hour following a light breakfast, the participant voided their bladder and bowels and, clad only in briefs, underwent duplicate measures while in the standing position recommended by the manufacturer guidelines. The average of the two values was used for the final analysis.

Technical and tactical data

All five fights between the study participant (POL-Polish) and his opponents (INT-international) were recorded for technical and tactical elements using the method developed by Adam et al. [13]. Specifically, we analysed the frequency of attacks, numbers of attacks, numbers of forceful attacks, and the effective time of the fights.

Aerobic capacity

Aerobic capacity was determined during VO_2max test. Participant performed a graded cycle ergometry test on an electromagnetically braked, cycle ergometer (ER 900 Jaeger). Immediately following the warm up (5 min with 1.5 $W \cdot kg^{-1}$ BM), the participant began cycling at workloads increased successively by 25 $W \cdot min^{-1}$ until volitional exhaustion. Breath-by-breath pulmonary gas exchange was measured (Oxycon-Pro, Jaeger-Viasys Health Care, Germany) throughout the test [14]. For the analysis, the maximal oxygen consumption (VO_2max) was taken into account, whereas the nonlinear increase in ventilation was used to determine AT (anaerobic threshold).

Anaerobic capacity

Participant performed the WAnT (Wingate Anaerobic Test) on a mechanically braked cycle ergometer (884E Sprint Bike, Monark, Sweden). Anaerobic capacity protocol started with a standard 5 minutes warm up at 1.0 ($W \cdot kg^{-1}$). After the warm up subject performed a 30 s all-out supra-maximal task. Flywheel resistance equalled 0.075 kG per kg of BM (corresponding to 7.5% of the participant's BM). Subject initiated the test from a dead stop. The resistance on the ergometer's friction belt had been preset by the testers immediately before WAnT [15–17]. For the analysis, PP – peak power ($W \cdot kg^{-1}$) and total work – W tot ($J \cdot kg^{-1}$) were taken into the account. All the tests described above were performed in the training phase directly preceding the tournament at similar times in the morning at least 2 hours after a light breakfast.

Blood analysis

Lactate concentration in the capillary blood was assessed right before and 5 minutes after each fight, and before

Table 2. Characteristics of indicators obtained during the test for exhaustion of effort and of indicators obtained during the Wingate Anaerobic Test (WAnT).

Variable	N=1
$\dot{V}O_{2max}$ (ml·kg⁻¹·min⁻¹)	52.7
AT (%$\dot{V}O_{2max}$)	60.0
PP (W·kg⁻¹)	11.4
W tot (J·kg⁻¹)	246.5
LA (mmol·l⁻¹) before WAnT	1.1
LA (mmol·l⁻¹) 5 min after WAnT	13.3
LA (mmol·l⁻¹) 30 min after WAnT	6.5
LA decrease (%)	51.1

and after WAnT and 30 minutes after exercise using LKM 140 Dr Lange kit (Germany). The intra-assay coefficient of variation (CV) for the lactate kit was 2.5%.

Results

The maximal oxygen consumption (VO_2max) of the male judo participant was 52.7 ml·kg^{-1}·min^{-1} and anaerobic threshold was achieved at 60% intensity of VO_2max. Peak power obtained during Wingate Anaerobic Test (WAnT) was 11.4 W·kg^{-1} and, respectively, the total work performed by judokas was 246.5 J·kg^{-1}. Blood lactate concentration measured 5 minutes after WAnT was 13.3 mmol·l. The 30-minute rest after the effort resulted in reducing the blood lactate concentration by about 51% of initial values (Table 2).

Analysis of the technical and tactical data is presented on Figures 1–4. The highest number of attacks (10) by POL occurred during the first and the fourth fight, whereas the highest number of forceful attacks (3 attacks) by POL was performed in the third fight (Figure 1). Only two fights (third and fourth) ended in the allocated time (i.e., 4 minutes) (Figure 2). The highest concentration of blood lactate (25.1 mmol·l^{-1}) was obtained in the fourth fight, while the lowest value was recorded in the last (i.e., fifth) fight (9.8 mmol·l^{-1}) (Figure 3). The highest frequency of attacks of the opponent (INT) was noted (every 18.1s) (Figure 2). The shortest break separated fights 2 and 3 (35 min), whereas the longest was planned between the last qualification fight (i.e., fight 4) and the fight in the finals (i.e., 2 hours and 50 minutes) (Figure 4).

The obtained data indicates that the frequency and number of attacks are not the only factors affecting the glycolysis process. According to the initial assumption, the concentration of the blood lactate tested in the male judoist was growing during the competition from 11.0 (mmol·l^{-1}) after the first, to 25.1 (mmol·l^{-1}) after the fourth fight. However, after a 3-hour rest and the final fight the blood lactate dropped to 9.8 (mmol·l^{-1}) even though the frequency of attacks was similar to the one recorded in previous fights (Figure 3). In our study, we measured the number and frequency of attacks, the amount of forceful attacks and the effective time of the fight. We expected that the repeated workload with each fight will result in an increased concentration of the blood lactate. In contrast to our assumption, we did not observe a correlation between the number and frequency of attacks and the effective time of fight and lactate concentration. The mechanism underlying these

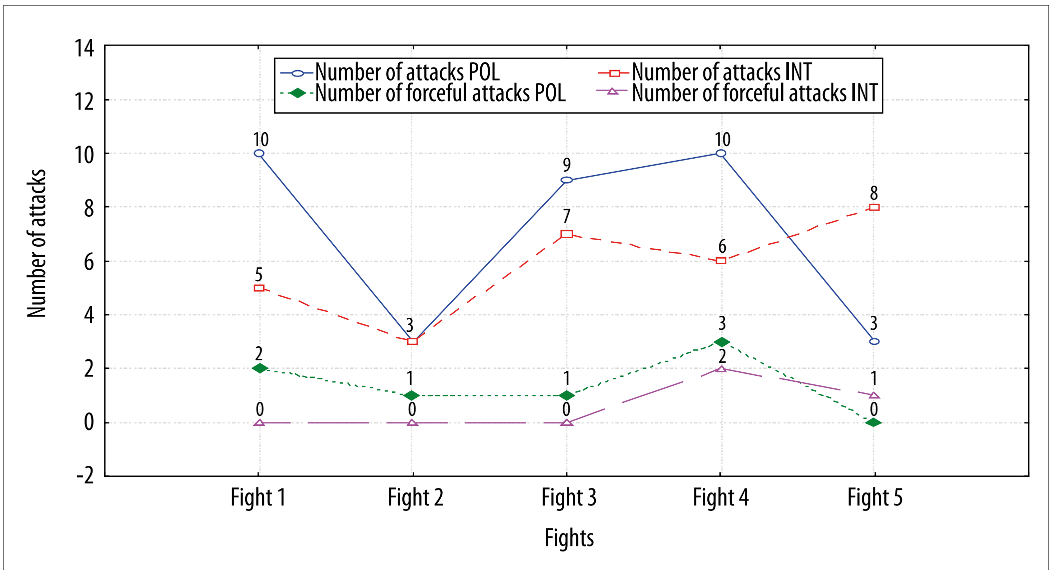

Figure 1. Number of attacks and number of forceful attacks during fights of judo tournament researched POL and opponent INT.

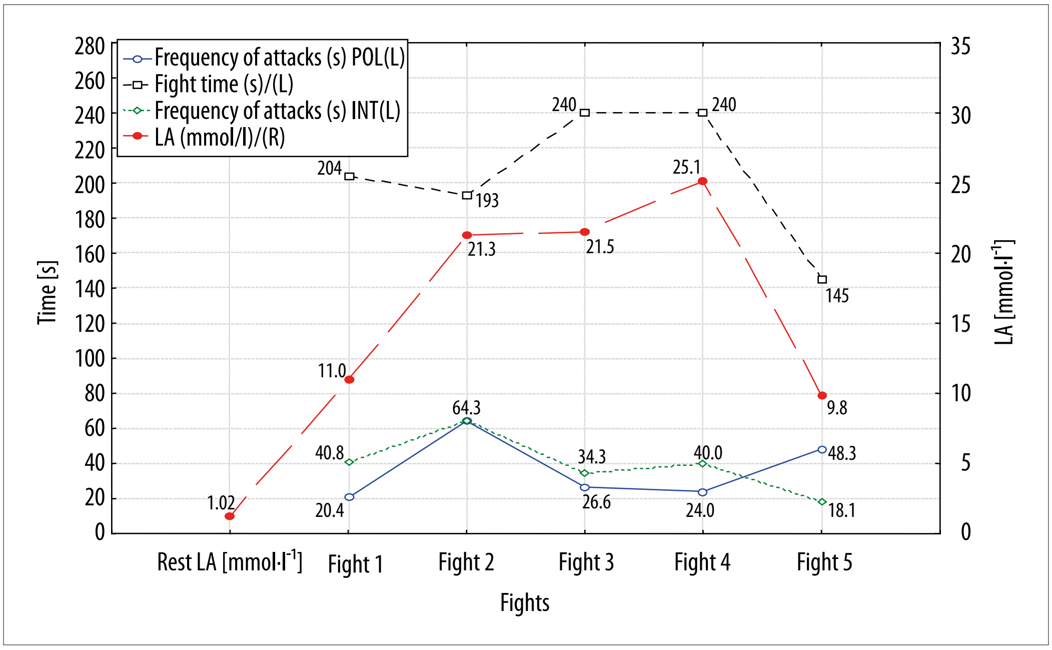

Figure 2. Effective time of individual fight (s) and frequency of attacks (s) researched POL and opponent INT. (L – left axis, R – right axis).

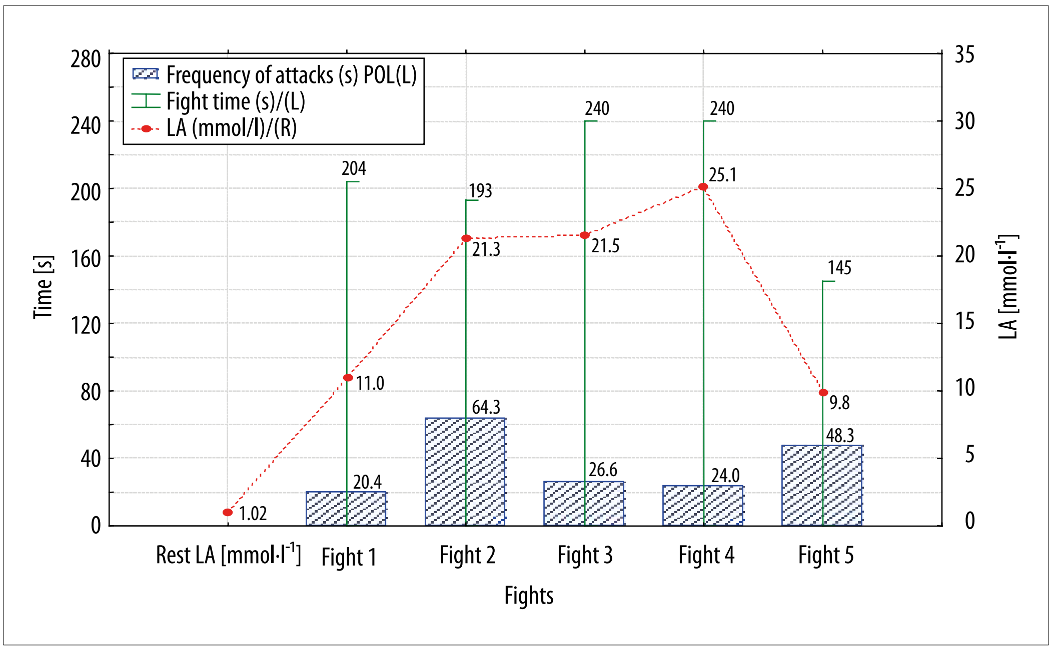

Figure 3. Effective time of individual fight (s) and frequency of attacks (s) during of fights and concentration blood lactate [LA mmol·l⁻¹] after every fights researched POL. (L – left axis, R – right axis).

results is most probably based on either the increasing engagement of the aerobic metabolic system in energy production or the type of Judoist's effort performed in the ischemic conditions.

Discussion

Previous studies have shown that the average effective time of the judo fight is 3.30±0.17 minutes [18]. Our result is similar and indicates a 3.40-minute fight on average. Clearly, this time suggests that an aerobic process may play a significant role in a delivery of energy. Nonetheless, both singular attacks as well as their sequence engage phosphagenic and glycolytic energetic systems. Furthermore, it cannot be neglected that not only the attacks, but also the defensive techniques require a considerable energetic expenditure to sustain a muscle tension with a predominance of isometric contractions.

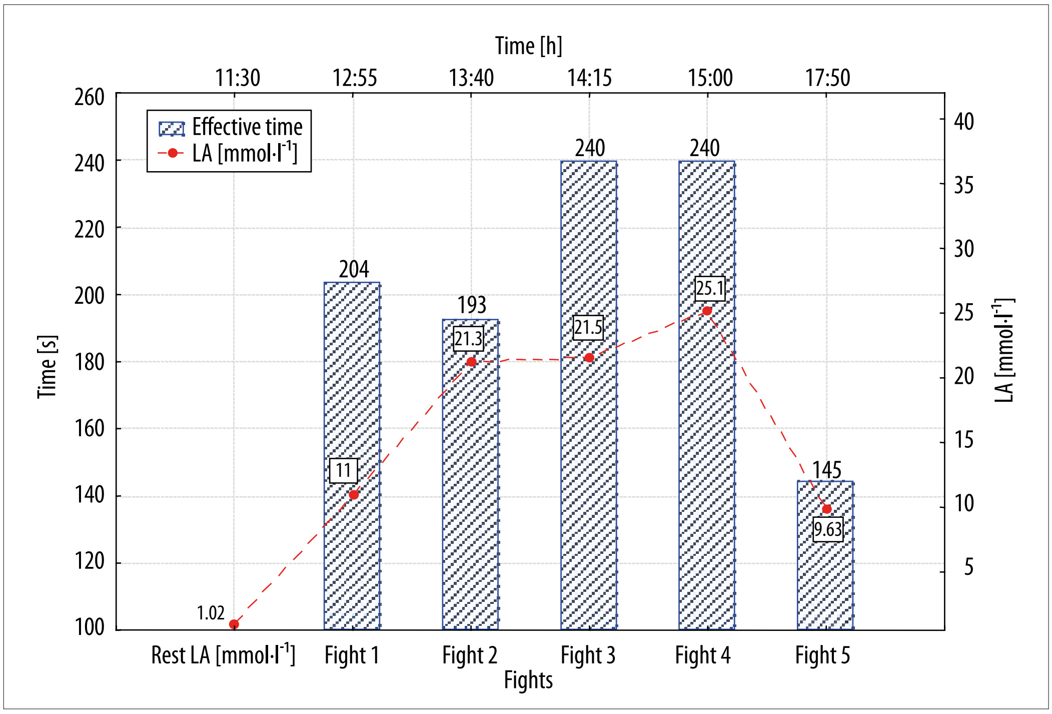

Figure 4. Effective time each fights (s), time to play them each fight and concentration blood lactate [LA mmol·l^{-1}] after every fights researched POL.

This kind of repeated efforts (i.e., attacks and defences) performed in the conditions of insufficient oxygen availability also leads to the greater engagement of anaerobic processes, which are detected in an increased level of blood lactate.

Degoutte et al. [19] showed that the concentration of lactate after a judo fight reaches 12.3 (mmol·l^{-1}), whereas Sbriccoli et al. [9] claimed that the concentration of lactate after judo match equals 9.9 (mmol·l^{-1}). Interestingly, the highest registered value in our participant was twofold bigger than the one suggested by Degoutte et al. [19].

Traditionally, lactate was long considered to simply be a metabolic by product of glycolysis. There are now convincing data that lactate is an important metabolic intermediate element during and after exercise, thus, acting as a substrate for oxidative metabolism in contracting skeletal and cardiac muscle and gluconeogenic precursor [20].

Such an increase of lactate reported in our study may indicate a more intense activity of the enzymes of glycolytic processes and wider tolerance for concentrating hydrogen ions that enables an athlete to perform maximal and supra-maximal efforts [11,21]. It may result from a growing fatigue during the competition as well as from the type of the performed activity characterized by tensing muscles during defence moves and holdings, which are eccentric exercises that cause muscles' ischemia. It is also connected with an isometric tension of skeletal muscle, which causes muscles' hypoxia, accelerating glycolysis and an increase in concentration of lactate of tested judoist. Mostoufi-Moad et al. [22], also discussed the same effect focusing on the adaptation of the organism to conditions caused by the purposeful ischemic training. Similarly, Leppky et al. [23] confirmed more active glycolysis process taking place under ischemic conditions.

Comparing the results of lactate concentration obtained in Wingate test and those obtained directly after judo-fights, the value was higher in competition test. Only in the first and last fight the results were lower than in WAnT. Therefore, it may be deduced that simple effort in WAnT is not appropriate load to diagnostic the actual anaerobic capacities of the judo players.

Sikorski et al. [24] observed that in most judo fights the attack takes place every 15–20 seconds. In our study, the highest frequency of attacks was recorded during the first fight and was 10 attacks within 20.4 seconds (Figure 3). Surprisingly, after this fight the lowest concentration of blood lactate was noted. Hence, it can be concluded for our participant that the attack frequency did not correlate with the lactate concentration.

In terms of training and preparation for competitive season (from a practical standpoint), the regulation of one hour breaks in between fights during a one day championships appears to be worth further investigation (Figure 4). The shortest break separated fights 2 and 3 (35 min), whereas the longest was planned between the last qualification fight (i.e., fight 4) and the fight in the finals (i.e., 2 hours and 50 minutes). We suggest that during the competition-specific preparation period appropriate training methods ought to be applied in order to provide (a) development of the adaptive abilities securing the most efficient functioning of muscles as well as the quickest possible lactate utilization and (b) restoration of lactate rendering between the subsequent fights. However, it is necessary for such training to be linked with an effective oxygen delivery involving its procurement from the environment as well as its efficient distribution and utilization for supplying active muscles with the energy.

Scharhag-Rosenberg et al. [12] and Jones and Carter [25] suggested that the reduction of the maximum concentration of lactate in the blood should be the result of the adaptation to the training. Therefore in preparation phase of training (or pre-season), the anaerobic as well as aerobic capacity plays an important role. The average level of recorded maximal oxygen uptake in high class judo trained man from the USA was 53.2–55.6 $ml \cdot kg^{-1} \cdot min^{-1}$ [26,27]; whereas in Japanese judoists was 49.9 $ml \cdot kg^{-1} \cdot min^{-1}$ [28]; for Canadian, 57.6 $ml \cdot kg^{-1} \cdot min^{-1}$ [29]; and for French, 59.8 $ml \cdot kg^{-1} \cdot min^{-1}$ [30], respectively. According to Franchini et al. [7] typical maximal oxygen uptake values are around 50–55 ($ml \cdot kg \cdot min^{-1}$) for judo male. The value in the present study as recorded from the participant was similar and reached 52.7 $ml \cdot kg^{-1} \cdot min^{-1}$ (Table 2). Sbriccoli et al. [9] observed that anaerobic threshold was achieved by high-class judo players at the level of 80.8% from Italy; whereas for the Japanese judoists it was 57.5% [28]; and for elite French, 63.2% [31]. In our study, the anaerobic threshold was reached at 60% of the maximal oxygen consumption (Table 2). Sbriccoli et al [9] noted the peak power level at 12.1 ($W \cdot kg^{-1}$), Sterkowicz et al. [32] at 11.4 ($W \cdot kg^{-1}$), whereas Frenchs' at 14.6 ($W \cdot kg^{-1}$) [31]. Thus, maximal anaerobic power recorded in our participant was lower than reported previously and this value was only 11.4 ($W \cdot kg^{-1}$) (Table 2).

Summarizing, our participant might not have an ideal profile in high-level judo but he is still a young athlete (junior age category). Also, we can assume that the cause of these high concentrations of lactate during the tournament is a phenomenon, which has some ischemic explanation in the literature [22,23]. Hence the need to establish the causes of muscle fatigue during competitive judo and to take them into consideration in preparation for a tournaments.

Conclusions

According to our study, the blood lactate concentration when tested after tournament fights exceeds the concentration recorded during the Wingate test, thus suggesting that a single effort Wingate test is an inadequate diagnostic tool of glycolytic processes in completive judo. Further, the frequency of attacks, number of attacks, and forceful attacks are not the only factors that affect the developing glycolysis process. We suggest that the preparation for the tournament period ought to include appropriate training methods that would ensure the development of the adaptive abilities resulting in the most efficient functioning of muscles as well as the quickest possible lactate utilization and restoration between the subsequent fights.

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