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Morphological, physiological and technical variables in high-level college judoists

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Summary

Background: To establish the relations between the following variables: (1) morphological – body weight (BW) and percent body fat (%BF); (2) physiological – performance and blood lactate (LA) after two upper body Wingate tests (2WT), performance and LA after the Special Judo Fitness Test (SJFT), LA before and after a 5-min judo combat simulation; (3) technique and tactic actions – number of attacks (NA), type of techniques, number of different techniques applied and time structure.

Material/methods: Thirteen elite college male judoists took part in the study. They were subjected to two bouts of arm Wingate test, a Special Judo Fitness Test (SJFT) and to a simulated combat. Conventional performance variables and numbers of specific actions were recorded. Body fat percentage was determined by skinfold technique.

Results: Relative total work output in two arm Wingate tests, numbers of throws executed in SJFT and numbers of attacks in a combat were significantly, negatively correlated with body fat percentage ($r = -0.87 \div -0.70$). Many performance variables were also significantly intercorrelated and correlated with blood lactate.

Conclusions: The arm technique was correlated with blood lactate after combat, suggesting a higher physiological requirement of this type of technique. Morphological and physiological variables, and technical actions during combat, were intercorrelated. Thus, it seems that improving any of these variables could help to improve the other ones.

Key words: **Judo • Blood lactate • Wingate test • Special Judo Fitness Test**

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Introduction

Judo is a complex sport where many variables (tactical, technical, physiological, psychological) determine the final result. Some researchers studied morphological [2], physiological [22] and technical variables [18] of high-level judoists in an attempt to understand the requirements to achieve top level in judo competition. Recently, studies have focused on the relationships among these variables in specific sport situations [19,20].

Sugiyama [20] observed that executing *te-waza* (arm techniques; *seoi-nague* and *kata-guruma*) resulted in higher oxygen uptake compared to *ashi-waza* (leg techniques; *o-uchi-gari*), suggesting that some actions can be physiologically more efficient compared to others. Gariod et al. [6] identified two profiles of judo athletes by video analysis: (1) aerobic, represented by athletes who win in the final moments of fight; (2) anaerobic, represented by athletes who win at the beginning of fight. Laboratory tests (‡O_2max and Wingate test) confirmed these profiles. Then, the athletes were submitted to plantar flexion exercise, performed at graded fractions of maximal voluntary contraction (MVC). They observed that the decrease in phosphocreatine induced by exertion equal to 80% of MVC was smaller in the muscles of judoists with the aerobic profile than in those with the anaerobic one. Furthermore, the phosphocreatine resynthesis was faster in judoists with aerobic profile, indicating that metabolic and physiological aspects could influence fight styles. Thus, different physiological backgrounds seem to influence technical and tactical actions.

Considering these issues, the present study aimed to describe the results of high-level college judoists in different tests and to verify the relationships between the following variables: (1) morphological – body mass (BM) and percent body fat; (2) physiological – performance and blood lactate (LA) after two upper body Wingate tests (2WT), performance and LA after the Special Judo Fitness Test (SJFT), LA before and after (1, 3, 5, 10 and 15-min) a 5-min judo combat simulation; (3) isometric strength – right and left handgrip (HG); (4) technical and tactical actions – number of attacks (NA), type of techniques (*ashi, koshi, te, sutemi, ossae, shime* and *kansetsu* (i.e., leg, hip, arm, sacrifice, pinning, choke and joint lock, respectively), number of different techniques applied and time structure (interval, time spent on standing and ground work) in the simulated combat.

Material and Methods

Subjects: Thirteen male judoists, including 7 members of Brazil University Team (2nd place in Team Competition in Malaga'2000 World University Championship) and 6 reserves, participated in the study after having submitted their written consents. The procedures were approved by the local ethics committee. The subjects were examined on two consecutive days, with more than 3-h interval between tests or measurements. The order of tests and measurements was as follows: Day 1: Morning – anthropometric measurements, isometric strength; Afternoon – Special Judo Fitness Test; Day 2: Morning – upper body Wingate test; Afternoon – combat simulation.

Anthropometric measurements: After having recorded the body mass and height, breadth and circumference measurements and skinfold thickness (at least 3 times per site, using a Harpenden calliper) were taken at sites defined by Drinkwater and Ross [3]. Body fat and muscle mass percentages were calculated as proposed by these authors. All anthropometric measurements were done by an experienced evaluator.

Arm Wingate test: This test was performed on a Monark cycle ergometer adapted for arm work (load of 0.05 kg per kg of body mass). Power was recorded every second by the "Wingate Test" software (Cefise, Brasil), the following variables being computed: mean and peak power outputs, time to attain the peak power and relative total work during the two bouts. Each subject performed two bouts separated by a 3-min interval. Blood samples were taken to determine lactate concentration before Test 1, 1 min after Test 1, 1 and 3 min after Test 2.

Special judo fitness test: The test was performed in 3 series of 15, 30 and 30 s separated by 10-s intervals. During the test, the athlete was to throw two other judoists (6 m apart from one another) as many times as possible, using the *ippon-seoi-nague* technique. Heart rate was recorded immediately after the test and 1 min later. From the total number of executed throws the performance index (I) was calculated:

$$I = HR_0 + HR_1 / NT,$$

where HR_0 and HR_1 are heart rates immediately after and 1 min after the test and NT is the total number of throws [5,16]. The smaller the index, the better is the test performance. Heart rate was recorded by using a Polar™ Vantage NV Sport-tester (Polar Electro Oy, Finland). Three minutes after the last bout a blood sample was taken to determine lactate concentration.

Post-combat lactate: The combat duration was 5 min. The difference in body mass between the opponents did not exceed 10%. After combat, judo athletes had

a passive 15-min rest, the heart rate being monitored. Blood samples were collected before and 1, 3, 5, 10 and 15 min after the combat.

Isometric strength: Static grip strength of the right and left hands was determined by a Takey Kogi (Japan) dynamometer. Each athlete performed three trials for each hand. The best result was recorded.

Blood lactate analysis: Blood was sampled from the earlobes after having applied a vasodilator pomade Filnalgon™ (Germany) and analysed using the Yellow Springs Sport 1500 device (Yellow Springs Co., USA).

Technical and tactical actions: Numbers of attacks (NA), types of technique (*ashi, koshi, te, sutemi, ossae, shime* and *kansetsu*), numbers of techniques applied and time structure (intervals, standing and ground work durations) in a simulated combat were determined by video analysis in a similar way to that presented by Salvador et al. [11].

Table 1. Somatic characteristics and handgrip strength of elite college judoists (n = 13).

Variable	Mean ± SD
Body height (cm)	180 ± 8
Body mass (kg)	89 ± 16
Body fat content (%)	13.7 ± 5.2
Muscle mass (%)	45.2 ± 3.2
Handgrip, right (kgf)	54.3 ± 8.3
Handgrip, left (kgf)	53.2 ± 7.4

Table 3. Mean values (±SD) of variables recorded for the Wingate test (arm work) in elite college judoists (n = 13).

Variable	Test 1	Test 2
Peak power W1 (W/kg)	8.13 ± 0.75	7.50 ± 0.92*
Mean power W1 (W/kg)	6.24 ± 0.71	5.39 ± 0.91*
T_{att} for peak power W1 (s)	6 ± 2	5 ± 1
Relative total work (J/kg)	349 ± 47	
LA before W1 (mmol/L)	0.7 ± 0.4	
LA 1 min after W1 (mmol/L)	5.6 ± 1.5	8.2 ± 2.2*
LA 3 min after W2 (mmol./L)	13.0 ± 3.7	

LA – Blood lactate; * Significantly different from the respective value in Test 1

Data analysis: Apart from conventional statistical measures, ANOVA with repeated measures followed by Tukey's test was applied to compare data recorded at various time points, the level of $p \leq 0.05$ being considered significant.

RESULTS

Group profile: The somatic characteristics of subjects, the results of tests they performed and their exercise-induced responses are presented in Tables 1–5.

Table 2. Numbers of throws in three bouts of exercise and the corresponding physiological responses in elite college judoists (n = 13).

Variable		Means ± SD
Throws in Bout A (15 s)		6 ± 0
Throws in Bout B (30 s)		11 ± 1
Throws in Bout C (30 s)		11 ± 1
	Total	28 ± 2
HR post-test (bpm)		179 ± 6
HR 1 min post-test (bpm)		163 ± 10
Performance index		12.28 ± 1.01
LA pre-test ($mmol.L^{-1}$)		1.5 ± 1.0
LA 3 min post-test ($mmol.L^{-1}$)		10.9 ± 2.5

LA – Blood lactate

Table 4. Time structure of a simulated combat performed by elite college judoists (n = 13).

Variable	Means ± SD
Number of sequences *Tachi-waza*	12 ± 2
Number of sequences *Ne-waza*	6 ± 3
Time in *Tachi-waza* / sequence (s)	21 ± 7
Time in *Ne-waza* / sequence (s)	11 ± 4
Interval time / sequence (s)	7 ± 1
Total time in *Tachi-waza* (s)	236 ± 36
Total time in *Ne-waza* (s)	54 ± 23
Total interval time (s)	69 ± 19
Total time (s)	360 ± 12

Tachi-waza – standing combat; *Ne-waza* – groundwork combat.

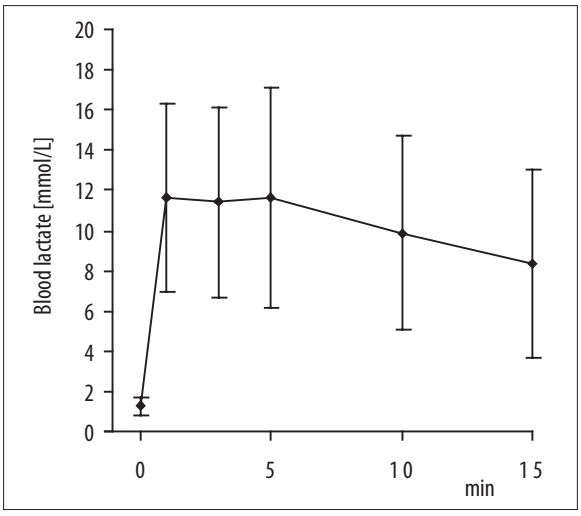

Figure 1. Mean values (±SD) of blood lactate recorded post-fight in elite college judoists (n = 13).

Mean power and peak power significantly decreased from W1 to W2 by 14 ± 8% ($p<0.001$) and 8 ± 9% ($p<0.01$), respectively. Blood lactate was significantly ($p = 0.007$) higher after the Wingate test 2 compared with Test 1 one min post-test and increased further 3 min post-test.

Blood lactate values recorded after the fight are presented in Fig. 1. The decrease in mean blood lactate over the 15 min of post-fight rest was slight but significant ($p<0.05$).

No significant differences in blood lactate were found between the Wingate test 2, SJFT and simulated combat 3 min post-event.

Technical actions used by elite college judoists during a simulated combat are presented in Table 5. The numbers of *shime-waza* (choke techniques), *ossae-waza* (holds/immobilisation) and *kansetsu-waza* (arm lock) are not presented because they were applied at most once per combat.

Table 5. Technical actions during simulated combat performed by elite college judoists (n = 13).

Variable	Means ± SD
Number of attacks	15 ± 5
Different techniques used	8 ± 3
Ashi-waza (%)	61.2 ± 26.1
Koshi-waza (%)	4.9 ± 9.5
Te-waza (%)	28.8 ± 21.7
Sutemi-waza (%)	5.1 ± 5.5

Ashi-waza – leg techniques; *Koshi-waza* – hip techniques; *Te-waza* – arm techniques; *Sutemi-waza* – sacrifice techniques.

Body fat and performance: As shown in Table 6, several performance variables were significantly, negatively correlated with body fat percentage. It should be remembered that the performance index was inversely oriented, hence positive correlation.

Correlations with blood lactate: As shown in Table 7, blood lactate post-event values were in several cases significantly correlated with each other.

Correlations with performance: As shown in Table 8, several performance variables were significantly inter-correlated. No performance variable, however, was significantly correlated with handgrip strength.

Discussion

The performance in the Special Judo Fitness Test reflected by the total number of throws (28) was slightly better than observed in Polish elite judoists (27 throws), but heart rate recovery was slower than in this study (163 bpm) compared with Polish elite judoists

Table 6. Coefficients of correlation between body fat percentage and performance variables in elite college judoists.

Variable	n	r
Relative total work	12	–0.87***
No. of throws (SJFT)	13	–0.70**
Performance index (SJFT)	13	0.72**
No. of attacks	10	–0.76*

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

Table 7. Coefficients of correlation between blood lactate values recorded after various tests in elite college judoists.

Correlated variables	n	r
Combat – No. of *te-waza* actions	10	0.85**
Wingate test 2 – Combat	10	0.69*
Combat – SJFT	10	0.82**
SJFT – Wingate test 2	11	0.65*

SJFT – Special judo fitness test; * $p<0.05$; ** $p<0.01$

(130 bpm) studied by Sterkowicz [17]. Consequently, the index (12.28) in this test was a little worse than that presented by the Polish group (11.57), indicating a lower anaerobic-aerobic conditioning in a sport-specific exercise. Mean blood lactate after the Special Judo Fitness Test (10.9 mmol/L) was very similar to that reported in another study (10.7 mmol/L) with adults [5] and was not different from that found after the simulated judo combat (11.7 mmol/L) by this group.

Peak and mean power decreased from Wingate one to test two. This result is similar to that found in an intermittent leg exercise [7,8,15]. In those studies, authors found a 15–20% decrease in these variables from bout one to bout two.

Performance in the first arm Wingate test was lower than that observed in other elite judoists. In the Canadian Team, relative mean power was 8.66 ± 1.17 W/kg, relative peak power 11.3 ± 0.8 W/kg [23] and in the British Team 8.50 ± 0.50 and 10.6 ± 0.8 W/kg, respectively [12], indicating a need of improvement in that respect for judoists studied by us. Blood lactate after the two bouts of Wingate test was not significantly different from that after judo combat. This result is similar to that found by Obmiński et al. [10]. who observed that blood lactate after the leg Wingate test was very similar to that found after a judo combat (11.6 ± 1.6 and 10.4 ± 4.4 mmol/L, respectively), suggesting a similarity of glycolysis requirements in both activities. Furthermore, we found a moderate correlation ($r = 0.69$; $p<0.05$) between blood lactate after two bouts of arm Wingate test and after a judo combat in this group, confirming the similarity between both activities in terms of metabolic demand. The post-fight blood lactate was slightly lower than after a real competition, but similar to that observed after a simulated judo combat (Table 9).

Table 8. Coefficients of correlation between performance variables recorded in various tests in elite college judoists.

Correlated variables	n	r
RTW – No. of throws (SJFT)	11	0.72*
RTW – No. of attacks (combat)	10	0.76**
RTW – Groundwork time (combat)	10	0.67*
No. of throws (SJFT) – No. of attacks (combat)	10	0.68*

Judo is an intermittent sport, because during combat there are many breaks. Studies on the time structure of judo combat [1,14] revealed that the periods of activity last 15–30 s with approximately 10-s breaks between them. In the present study, the time of activity was very similar, but the interval time was slightly lower. This can be explained by the changes in rules introduced in the last years or by the fact that in a simulated combat, judo athletes spent less time on recovery. The total time spent on ne-waza was the same to that found by Castarlenas and Planas (54 s;

Table 9. Blood lactate (means ± SD) values recorded after simulated judo combats or after competition.

Authors	Subjects	Numbers of combats analysed	Lactate (mmol/L)
Obminski et al. (1999)	20 Polish elite – competition	1	10.4 ± 4.4
Sikorski et al. (1987)	Polish elite – competing at Matsumae Cup (numbers of judoists not reported)	1 2 3 4	10.3 ± 4.7 13.3 ± 2.0 15.9 ± 1.4 17.2 ± 1.9
Sikorski et al. (1987)	Polish elite – competing in different tournaments (numbers of judoists not reported)	1 (n = 51) 2 (n = 15) 3 (n = 22) 4 (n = 5) 5 (n = 15)	13.6 ± 2.3 13.9 ± 2.9 13.2 ± 2.5 13.3 ± 1.0 13.2 ± 1.6
Sikorski & Mickiewicz (1991)	Polish elite – competition	203	16.2 ± 2.6
Thomas, Goubault & Beau (1990)	12 French – simulated combat	1 2 3	9.87 ± 2.01 9.79 ± 2.10 9.27 ± 1.38
Tumilty et al. (1986)	4 Australians – simulated combat	1 2	7.1 ± 2.0 7.9 ± 2.5

[1]) and the time spent on tachi-waza was also very similar (21 s). However, the number of sequences of combat on ne-waza and on tachi-waza was higher in the present study compared to that from Castarlenas and Planas [1] (3 and 8 sequences, respectively). This can be related to the fact that in Castarlenas and Planas'study, the fight had a lower duration (2 min 55 s) compared to the present protocol (5-min judo combat).

Sterkowicz and Franchini [18] studied the techniques used by judoists during World and Olympic Tournaments in the years 1995–1999 and found a higher percentage of *ashi-waza*, followed by *te-waza*, *koshi-waza* and *sutemi-waza* actions. This result is very similar to that presented by judoists from the present study, indicating that the techniques applied in elite judo combat tend to follow this order of preference.

Body fat percentage found in this study was similar to other reports that included heavy-weight athletes: Farmosi [4] reported 14.0 ± 7.3% for the Hungarian Team, Taylor & Brassard [21] – 12.3 ± 3.9% for the 1979 Canadian Team, Thomas et al. [23] – 9.3 ± 2.1% for the 1989 Canadian Team. No reports were found regarding muscle mass percentage in elite judoists.

The negative influence of body fat on motor performance observed in the present study was similar to that found by Nakajima et al. [9] in a study on female judoists. They found a negative influence on isometric strength, flexibility, balance and aerobic power. Thus, it can be concluded that judoists should avoid an excess of body fat in order to maintain their physical abilities.

The correlations found in the present study seem to indicate that judoists with lower body fat percentage, higher anaerobic performance in two bouts of arm Wingate test and in the Special Judo Fitness Test, tend to execute more attacks during combat, probably due to a better metabolic adaptation to combat requirements. Other important point is that the te-waza (arm technique) was correlated with blood lactate after combat, confirming partially the view of Sugiyama [20] about the higher physiological demand of some te-waza (e.g., *seoi-nague* and *kata-guruma*) compared to *ashi-waza* (leg technique; e.g. *de-ashi-barai* and *ko-uchi-gari*).

Blood lactate after general (arm Wingate test) and specific (Special Judo Fitness Test) tests were correlated with blood lactate after combat, indicating the similarity of metabolic demands in these events. Thus, it can be recommended to adopt these tests as a means of training control.

In conclusion, this study demonstrated that morphological, physiological and technical actions during combat were correlated with each other. Thus, it seems that improving any of these variables could help to improve the other ones (e.g., low body fat could be associated with higher anaerobic capacity and increased number of attacks during combat). However, longitudinal studies should be conducted to clarify these suggestions.

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