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The Comparison of Judo-Specific Tests

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Abstract

Background. There are some *judo*-specific performance tests developed in recent years. It has been reported that these tests present the same physiological results as aerobic and anaerobic power measurements carried out in laboratories. Measurements carried out by using judo-specific exercises are important to control the development of the training.

Problem and aim. The aim of this study was to determine whether 3 different judo-specific tests could discriminate judo athletes from different levels and present the same physiological results as simulated judo match.

Methods. Eight male judo athletes who have competed in international competitions in the recent year and 7 male judo athletes who have competed in national competitions in the recent year voluntarily participated in this study. During the selection process, some criteria such as at least 4-year judo background, attending trainings regularly and no injuries in the recent year which adversely affected athletes' training program were taken into consideration. Athletes carried out 4 different practices (tests): Special Judo Fitness Test (SJFT), Uchikomi Fitness Test (UFT), Santos Test (ST) and Simulated Judo Match (SJM). Tests were carried out randomly at the same time of the day with at least 2, at most 3 days intervals. Rest values of hearth rate (HR) and lactate (LA) were measured before tests and at 1st, 5th, 10th, 15th, 30th minutes of the recovery period. Paired comparisons of the variables were tested with independent sample t-test, changes in HR and LA values in both groups were tested with the three-factor mixed-design analysis of variance with repeated measurement.

Results. Elite and non-elite athletes were found to have the same physical characteristics except body fat percentage. Time of measurement ($F=187.57$) and tests ($F=21.05$) significantly affected the level of lactate ($p<0.05$), the interaction effect between test and time factors was also found significant ($F=8.80$; $p<0.05$). Contrarily, changes of the lactate concentration during the tests were similar in elite and non-elite judo athletes ($F=0.82$; $p<0.05$).

Conclusion. Despite similar changes in HR and LA only SJFT and ST discriminated elite and non-elite judo athletes in terms of number of throws and test-specific evaluations while UFT did not discriminate the levels of the athletes.

Introduction

Judo is an Olympic combat sport which has been exposed to many changes due to the recent rules changes. These changes include decreased pause durations and frequencies and increased active phases. These changes have led to a need for reevaluation of performance adaptations and aerobic and anaerobic needs of the judo athletes [Hernandez-Garcia *et al*. 2009].

Many judo specific tests have been developed to evaluate performance of the judo athletes and it was claimed that these tests could reflect the real match performance [Franchini *et al*. 2005a; Franchini *et al*. 2005b; Franchini *et al*. 2009; Almansba *et al*. 2011]. Being one of the most commonly used performance tests in the literature, Special Judo Fitness Test (SJFT) comprised of high intensity intervals and thus contribution of alactic anaerobic metabolism is high [Gaitanos *et al*. 1993]. The blood lactate and oxygen consumption values after the test were similar to those evaluated after judo match [Franchini *et al*. 2009]. When SJFT variables were analyzed, a significant correlation was found between throw numbers, anaerobic capacity indexes [Sterkowicz *et al*. 1999], aerobic power and capacity [Arazi *et al*. 2017; Sterkowicz *et al*. 1999; Franchini *et al*. 2011; Detanico *et al*. 2012] and muscular power [Detanico *et al*. 2012]. Franchini *et al*. [2005a, 2005b] stated that these variables were related to judo specific situations such as attack numbers at a judo competition and this test could show the difference between athletes from different levels. SJFT has some limitations in terms of neuromuscular needs during a judo match. Judo athletes request mainly

upper limbs compared to lower limbs during judo match [Franchini *et al*. 2011b] because athletes rely mostly on the grip in order to control their opponents during both standing position and groundwork. On the other hand, lower limb is exposed to neuromuscular activity during SJFT because the executor runs very fast and throws two partners 6 meters apart from each other. This situation can be accepted as the biggest difference between a judo match and SJFT. Uchikomi Fitness Test (UFT) was developed by reproducing the high intensity and the sequence of actions performed in a judo match (grip phase and technique drill) [Detanico, Santos 2012]. Therefore, UFT seems to be a good performance marker for judo because it is related to both neuromuscular effort and cardiorespiratory adaptations [Almansba *et al*. 2011]. UFT was designed to measure the athletes' physical fitness in the same conditions as those of a real judo match instead of just measuring intervening physical capacities [Detanico, Santos 2012]. Santos Test (ST) was developed by Santos *et al*. [2010] in order to identify the beginning of the aerobic-anaerobic transition zone with a progressive workload sequence. They suggested that ST could be adapted according to physical characteristics of the judo athletes and thus it would determine individual and special anaerobic threshold. Though the aim of ST was to determine anaerobic threshold, it was considered as a maximum effort test as suggested by Tavra *et al*. [2016] and its variables were used to discriminate elite and non-elite judokas.

Even though judo is a worldwide sport there has still been a need for more judo specific tests. All judo specific tests developed until today have suspicions in terms of to what extent they evaluate the performance in relation to measured variables [Detanico, Santos 2012]. There is still a big question related to which of the judo specific tests whose validity and reliability was proven with laboratory tests can reflect a real match performance. Besides, whether there is any change in relationship between match performance and judo specific tests after recent rule changes has not been investigated yet. Therefore, in this study whether some judo specific tests can physiologically reflect a judo match and discriminate elite and non-elite judo athletes were investigated. This study has two hypothesis; 1- Investigated judo tests have some characteristics to discriminate athletes from different levels, 2- Physiological results obtained from judo specific tests are the same as those obtained from simulated judo match.

Method

Participants

Eight male judo athletes who have competed in international competitions in the recent year and 7 male judo athletes who have competed in national competitions in the recent year voluntarily participated in this study. Athletes' ages ranged from 18 to 26. During the selection process, some criteria such as at least 4-year judo background, attending trainings regularly and no injuries in the recent year which adversely affected athletes' training program were taken into consideration. Physical characteristics of the participants were given in Table 1.

Table 1. Physical characteristics of elite and non-elite judokas

	Elite (n=8)	Non-elite (n=7)
Variables	Mean ± SD	Mean ± SD
Age (years)	21.3 ± 3.1	19.6 ± 2.1
Body height (cm)	172.5 ± 8.0	174.7 ± 5.4
Body mass (kg)	69.0 ± 7.4	71.3 ± 6.3
BMI (kg/m^2)	23.2 ± 1.5	23.3 ± 0.9
Body fat (%)	9.6 ± 1.6	11.3 ± 1.2*

* $p<0.05$ difference between the groups

Because weight class and anthropometric characteristics affect judo performance [Franchini *et al*. 2011a] we paid attention to chose athletes from the similar weight classes. Athletes were informed about the procedures in detail and signed a free and informed consent form, as approved by Sport Sciences Faculty Ethic Committee of Selcuk University.

General Design

After anthropometric measurements were carried out, athletes were informed about the judo specific tests in detail. Judo specific tests and simulated judo match (5 mins) were randomly implemented by the athletes at the same time of the day on different days with 2 or 3 days intervals. Before each application blood lactate concentration and heart rate were measured. 1, 5, 10, 15, 30 minutes after the tests recovery lactate concentration and heart rate were observed.

Tests and Measurements

Anthropometric Measurements: After body height (cm) and body mass (kg) were measured body mass index (BMI) of the athletes were calculated as follow: body mass (kg) / height (m)^2. To determine body fat percentage four skinfold measurements (triceps, biceps, subscapula, suprailiac) were taken on the dominant side of the athletes and body density was calculated according to Durnin and Womersley [1974] formula.

Special Judo Fitness Test: The judo athlete executing the test threw his opponents as fast as possible and the test was divided into three periods: 15, 30, 30 s with 10 s intervals. During each period, the executor threw two partners (6 meters apart from each other) as many as possible with *ippon-seoi-nage* technique. The athlete's HR was recorded immediately after the test and 1 min

later. With the help of conducted throws and HR values, an index [Franchini *et al*. 2009] was calculated according to the following equation:

$$Index = \frac{HRend\ (bpm) + HR1\ \text{min}\ (bpm)}{throws\ (n)}$$

HR_{end}: heart rate immediately after the test
HR_{1min}: heart rate 1 minute after the test
Throws: number of throws completed in the test

Uchikomi Fitness Test: UFT which was developed by Almansba *et al*. [2007] with the aim of evaluating athletes' effort during a judo match in both qualitative (having relevance to the phases observed in matches) and quantitative (effort-pause relationship) terms was conducted to all athletes. During the test, the judo athlete completed six levels of *uchi-komi* and traction in a *judogi* attached to a fixed bar. Duration of *uchi-komi* was fixed to 20 s, the traction ranged from 6-18 s, increasing 3 s per level at breaks that ranged from 4-12 s with an increase of 2 s per level. The athlete was expected to perform the test in a maximum effort and carry out the techniques in a proper way. Work sequences were as followed: (a) isometric phase of upper limbs (grip); performer remained suspended by a judo uniform fixed on a horizontal bar with elbows flexed and (b) dynamic and explosive phase; the judoka got down from the horizontal bar and started to do *uchikomi* with two opponents 2 m apart from each other, using an arm (*ippon-seoi-nage*) and a hip technique (*sode-tsuri-komi-goshi*). The total number of *uchi-komi* executed by the athlete and the number in two better bouts were recorded and athlete's HR was monitored during the whole test.

Santos Test: To start ST suggested by Santos *et al*. [2010] in order to determine the aerobic-anaerobic transition zone, two judokas in the same weight category stood face to face. The test included two phases; active and passive. During the active phase, judo athlete performed his preferred technique(s) in three bouts: In the first bout, the athlete raised his opponent from the ground. In the second one, he completely unbalanced his opponent and in the third one, he preferably raised his opponent or completely unbalanced him. Each bout lasted for 40 s and the first one started with 7 repetitions with an increase of 1 repetition until exhaustion, which brought the test its progressive characteristic. As long as the athlete could raise his opponent from the ground or unbalanced his opponent and complete the bout in 40 s, the test went on. Otherwise, the test was finished. In the passive phase, two judo athletes moved on the tatami gripping their *judogi*s during 15 s which represented movements occurring during a judo match. Active and passive phases of the test represented intermittent nature of a judo match.

Simulated Judo Match: Each simulated judo match (SJM) lasted for 5 min with a maximum effort. Athletes competed against someone from the same weight category and level and matches were refereed by a formal referee according to European Judo Union match rules.

Statistical Analyses:
Statistical analyses were performed using SPSS version 16.0. The data were tested for normal distribution with the Kolmogorov-Smirnov test and for homogeneity of variances with Levene's test. An unpaired Student's t-test was used to determine physical, UFT, SJFT, ST and SJM differences between the groups. A three-way (6 time×4 test×2 group) split-plot ANOVA (mixed ANOVA) with repeated measures was used to test the effects of tests and performance levels on blood lactate and HR. When the repeated measures effect was significant via split-plot ANOVA, one-way repeated measures analysis of variance with the post hoc Bonferroni test was applied to identify applied to identify whether the tests and/or measurement times were responsible for the differences. The relationship between 1 min after lactate concentrations and hearth rates in the SJM and in the tests were *tested by Pearson's* correlation coefficient, also the effect size (ES) was determined for the correlations (r: 0,10 small effect, 0,30 medium effect, 0,50 large effect) (Cohen 1992). The ES was calculated using Cohen's d for the independent t test, which was classified according to Rhea (2004): d < .25 = trivial; .25 ≤ d < .50 = small; .50 ≤ d > 1 = moderate and, d ≥ 1 = large. Statistical significance was set at a level of $p<0.05$, and data were expressed as the means± standard deviation (SD).

Results

Table 2 shows SJFT test variables and post-test lactate concentration in both groups. SJFT indexes (*d=1.30,* [large]) and HR 1 min after (*d=1.35,* [large]) the test of elite athletes were found significantly lower than non-elite athletes ($p<0.05$).

Table 2. Comparison of Special judo fitness test variables of elite and non-elite judo athletes

	Elite (n=8)	Non-elite (n=7)
Variables	Mean ± SD	Mean ± SD
15 s HR (bpm)	158 ± 15	162 ± 23
30 s HR (bpm)	171 ± 14	178 ± 10
30 s HR (bpm)	176 ± 10	180 ± 10
1min after HR (bpm)	125 ± 15	148 ± 20*
15 s throws (number)	6 ± 1	5 ± 1
30 s throws (number)	11 ± 1	11 ± 1
30 s throws (number)	10 ± 1	10 ± 1
Total throw (number)	27 ± 2	26 ± 2
Index (point)	11.2 ± 0.9	12.6 ± 1.1*
Post-test lactate (mmol/l)	14.2 ± 3.2	14.4 ± 2.8

*$p<0.05$; significant difference between the groups. HR= Heart Rate.

However, it was investigated that throw numbers at each phase, HR and post-test lactate concentrations were similar in both groups (p>0.05) (Table 2).

Table 3. HR, Uchikomi (UK) numbers and post-test lactate concentrations of elite and non-elite judo athletes after Uchikomi Fitness Tests

	Elite (n=8)	Non-elite (n=7)
Variables	Mean ± SD	Mean ± SD
1. phase HR (bpm)	127 ± 2	157 ± 19*
2. phase HR (bpm)	164 ± 7	165 ± 10
3. phase HR (bpm)	168 ± 9	169 ± 10
4. phase HR (bpm)	171 ± 8	178 ± 15
5. phase HR (bpm)	171 ± 12	177 ± 15
6. phase HR (bpm)	175 ± 11	178 ± 15
1.phase UK (number)	9 ± 1	9 ± 2
2. phase UK (number)	9 ± 1	8 ± 1
3. phase UK (number)	9 ± 1	8 ± 1
4. phase UK (number)	9 ± 1	8 ± 1
5. phase UK (number)	9 ± 1	8 ± 1*
6. phase UK (number)	9 ± 1	9 ± 0
Total UK (number)	54 ± 3	50 ± 5
Post-test lactate (mmol/l)	11.8 ± 3.7	12.9 ± 4.8

*p<0.05; significant difference between groups. HR=Heart Rate.

UK test variables and post-lactate concentration for elite and non-elite judo athletes were given in Table 3. While there was significant difference between HR after the first phase (*d=2.22,* [large]) and uchi-komi numbers at the fifth phase (*d=1.00,* [moderate]) (p<0.05), there was no significant difference between groups in HR and uchi-komi numbers of other phases and lactate concentrations (p>0.05).

Table 4. Phase numbers, test durations, uchikomi (UK) numbers and lactate concentrations of elite and non-elite judo athletes during Santos Test

	Elite (n=8)	Non-elite (n=7)
Variables	Mean ± SD	Mean ± SD
Phases (number)	21 ± 3	17 ± 2*
Total UK (number)	348 ± 83	264 ± 54*
Test duration (sec)	1156 ± 143	936 ± 122*
Post-test HR (bpm)	175 ± 12	185 ± 11
Post-test lactate (mmol/l)	7.1 ± 2.8	8.9 ± 2.4

*p<0.05; Significant difference between the groups. HR=Heart Rate.

When phase numbers (*d=1.57,* [large]), test duration (*d=1.66,* [large]) related with phases carried out and uchi-komi numbers (*d=1.19,* [large]) are compared, elite athletes presented higher values than non-elite athletes (p<0.05). Despite these differences HR and lactate concentrations after the test were found similar for both group (p>0.05) (Table 4).

The changes in lactate concentrations during the test were given in the Table 5. Interaction effects of test and time factors were significant (F=8.80; p<0.05), in other words, changes in lactate concentrations at measurement times differed during each exercise. Test significantly affected lactate concentrations (F=21.05; p<0.05) (Table 6). When tests were compared for each test time, it was investigated that pre-test lactate concentrations were similar (F=1.60; p>0.05) and 1, 5, 10, 15 and 30th min post-test lactate concentrations differed significantly. It was determined that when lactate concentrations were measured 1 min after the tests SJFT was found to cause

Table 5. Lactate concentrations (mmol/L) of the judo athletes pre and post Uchikomi Fitness Test (UFT), Special Judo Fitness Test (SJFT), Santos Test (ST) and Simulated judo match (SJM) (n=15).

	UFT	SJFT	ST	SJM
Measurements	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Pre	1.5 ± 0.4	1.6 ± 0.4	1.5 ± 0.4	1.7 ± 0.4
1 min after	12.3 ± 4.3	14.3 ± 2.7	7.9 ± 2.7	10.4 ± 3.5
5 min after	11.3 ± 3.9	12.6 ± 2.3	6.5 ± 2.7	8.8 ± 3.1
10 min after	8.8 ± 2.7	11.9 ± 2.7	5.5 ± 2.3	6.8 ± 2.7
15 min after	7.5 ± 2.7	10.1 ± 2.7	4.8 ± 2.3	5.9 ± 2.7
30 min after	5.0 ± 2.3	6.3 ± 1.9	3.0 ± 1.9	4.0 ± 2.7

Table 6. Heart rate (bpm) of the judo athletes before and after Uchikomi Fitness Test (UFT), Special Judo Fitness Test (SJFT), Santos Test (ST) and Simulated judo match (SJM) (n=15).

	UFT	SJFT	ST	SJM
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Pre-test	68 ± 10	69 ± 11	67 ± 9	63 ± 7
1 min after	119 ± 14	136 ± 21	122 ± 24	136 ± 22
5 min after	103 ± 11	106 ± 17	105 ± 13	104 ± 16
10 min after	97 ± 3	102 ± 5	99 ± 3	95 ± 3
15 min after	94 ± 2	97 ± 3	94 ± 3	88 ± 3
30 min after	85 ± 3	91 ± 3	86 ± 3	78 ± 3

more lactate accumulation than ST and SJM ($p<0.05$), there was no significant difference between SJFT and UFT ($p>0.05$). While SJFT resulted in the highest lactate accumulation, and UFT, SJM and ST followed it, respectively. Similar significant differences were observed at the other measurement times.

Measurement times significantly affected the lactate concentrations, which means that lactate concentration changes in the measurement times significantly differed as expected ($F=187.57$; $p<0.05$). The lactate concentrations after all test except ST were found higher than pre-test lactate values ($p<0.05$). Especially lactate concentrations 1 min after the tests were found almost similar to those 5 min after the tests and lactate concentrations at 10, 15 and 30 min after the tests significantly differ ($p<0.05$). Despite separately significant main effects and interactions of test and time factors on lactate concentrations, changes of lactate concentrations throughout the tests were not different between the groups ($F=0.82$; $p>0.05$). There was no correlation between lactate concentrations and HR in the SJM and the tests ($p>0,05$).

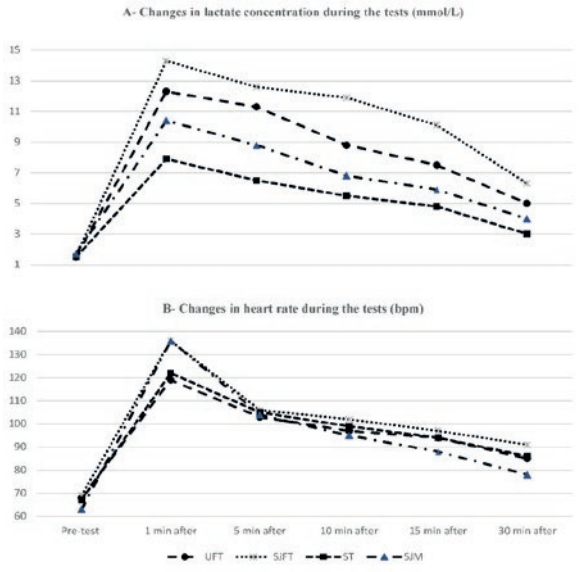

Figure1. Changes in lactate concentrations (A) and heart rate (B) during the tests n=15. UFT=Uchikomi Fitness Test, SJFT=Special Judo Fitness Test, ST= Santos Test, SJM= Simulated judo match.

The changes in HR during the tests were given in the Table 6. The main effect of time on HR was important ($F=174.59$; $p<0.05$). Changes in HR before and after the tests significantly differed. Test ($F=2.29$) and group factor ($F=0.60$) were concluded not to have effects on HR alone ($p>0.05$). However, interaction effects of time-group factors on HR was significant ($F=5.15$; $p<0.05$). When changes in mean values were compared by ignoring differences in tests, HR 1 min after the tests of the elite judo athletes were found lower than non-elites. When exercises were investigated separately, elite athletes' HR 1 min after SJFT and SJM were significantly lower than non-elite athletes ($p<0.05$). Furthermore, time-test factors were also found important ($F=4.42$; $p<0.05$). Changes in HR values of both group differed among all exercises. While the highest values were measured after SJFT and SJM, the lowest values were measured after UFT and ST. Nevertheless, when groups were evaluated separately mean HR values did not differ between tests for all measurement times. Despite above-mentioned effects/interactions, time-test-group interaction was not significant, thus HR changes were similar in elite and non-elite athletes for the tests ($F=1.05$; $p>0.05$).

Discussion

This study was conducted to investigate whether judo specific tests could discriminate elite and non-elite judo athletes and would give the same physiological answers as simulated judo matches. The most important findings of the study were that there were some distinctive variables especially in the SJFT but the changes in lactate concentrations and HR values during the applications were similar in elite and non-elite athletes. Moreover, no significant correlation was found in lactate concentrations and HRs between SJM and other tests one minute after the applications.

It was reported that national level athletes have more body fat percentage than international level athletes [Kubo *et al.* 2006; Fukuda *et al.* 2013]. As expected, it was observed in our study that elite athletes had less body fat percentage than non-elite athletes despite similarity in body mass, body mass index and weight class variables.

Measurement of HR and lactate concentration helps control aerobic and anaerobic capacities and exercise intensity [Torres-Luque *et al.* 2016]. Blood lactate measurement is a better performance determinant than maximal oxygen uptake measurement and it is also known to show exercise intensity better than heart rate [Goodwin *et al.* 2007]. Some researchers [Branco *et al.* 2013; Laskowski *et al.* 2012; Obminski *et al.* 2010] found lactate accumulation during a judo match was found as 8.0±2.6, 11.0 mmol/L and 11.6±2.2 mmol/L, respectively. After simulated judo matches, the lactate concentrations ranged from 7 to 13 mmol/L [Deogutte *et al.* 2003; Franchini *et al.* 2005; Sbriccoli *et al.* 2007; Hernandez-Garcia *et al.* 2009]. In this study, lactate concentration and changes in lactate concentrations after exercise of elite (11.3 mmol/L) and non-elite (9.5 mmol/L) athletes were found similar following simulated judo match. Franchini *et al.* [2005] found the same lactate values for athletes from different levels after judo matches and explained this situation stating that aerobic fitness of the athletes which plays an important role in lactate removal were similar.

In this study aerobic performances of the athletes were not evaluated, but the similarity in lactate concen-

trations may suggest that elite and non-elite athletes have almost the same aerobic capacities. Because there was no effect of athletes' levels on lactate concentration, all the athletes were evaluated as one group while differences among applications were interpreted. The highest lactate concentration resulted from SJFT (14.3±2.7 mmol/L) followed by UFT (12.3±4.3 mmol/L). This shows that SJFT and UFT include more alactic anaerobic efforts than SJM (10.4±3.5 mmol/L). The lowest level of lactate concentration was observed after ST due to its content and duration.

SJFT is known to provide information concerning performance abilities of the judo athletes and help coaches to compare their athletes by using its specific index [Drid *et al.* 2012; Garbouj *et al.* 2016]. Franchini *et al.* [2011b] stated that SJFT is useful for evaluating alactic anaerobic systems of the judo athletes. In a study where elite and non-elite judo athletes were compared, Franchini *et al.* [2005] found that elite athletes performed more throws (28 throws) than non-elite athletes (25 throws) and in another study, Franchini *et al.* [2009] stated that elite athletes were classified as "good" whereas non-elite athletes were classified as "bad". It was stated that elite athletes had a better anaerobic capacity regarding to higher throw numbers during the test. There was no difference between groups in terms of HR, which shows that both group experienced the same cardiovascular stress. In a study applied to medalist and non-medalist judo athletes in Polish Championship, Sterkowicz *et al.* [1999] stated that medalist athletes had more throw numbers and better indexes than non-medalist athletes. Furthermore, HR of the medalist athletes 1 minute after the test decreased faster than non-medalists, which indicated that recovery time after the test is an important element in terms of distinguishing elite and non-elite athletes. In another study, significant difference was found between elite and non-elite athletes in throw numbers and elite athletes presented lower HR after the test, thus it was suggested that SJFT can discriminate athletes from different levels and can be used to evaluate training levels of the judo athletes and to identify talented athletes [Sterkowicz, Franchini 2001]. However, Katralli *et al.* [2012] stated that the throw numbers, HR and index were not different between elite and non-elite judo athletes. Besides, Casals *et al.* [2017] suggested no difference between athletes from different levels. In parallel with above-mentioned studies, post-test HR values and throw numbers were found the same but when HR values 1 minute after the test were taken into consideration elite athletes had a faster recovery than non-elite athletes. Given that Franchini *et al.* [2005] stated that recovery time can discriminate athletes from different levels, HR values 1 minute after the test discriminated elite and non-elite athletes in our study. Considering these HR values, elite athletes were classified as 'excellent' while non-elite athletes were classified as 'good' according to SJFT index [Franchini *et al.* 2009]. Post-test lactate value in our study (14.3 mmol/L) was found higher than those in the previous studies [Franchini *et al.* 2016 (8.23±2.11 mmol/L); Franchini *et al.* 1998 (10.7±2.3 mmol/L)]. Garbouj *et al.* [2016] stated that lactate concentration after SJFT reached at high levels but it was not related to SJFT performance and consequently suggested there was no casual relationship between high lactate accumulation and SJFT performance. Indexes of elite and non-elite athletes were found statistically different but groups were not discriminated upon looking at the classificatory table.

UFT was suggested to be a valid and reliable test to evaluate judo athletes and meet cardiovascular adaptations and muscle power specific to judo [Almansba *et al.* 2011]. However, Tavra *et al.* [2016] stated that UFT is discriminative only when athletes are evaluated with technique repetition numbers. Moreover, although UFT contains high intensity intermittent nature of a judo match and techniques applied during a judo match [Almansba *et al.* 2007], we did not witness any significant difference except HR in the first stage and technique repetition numbers in the fifth stage. In addition, there was no significant difference in the study of Almansba *et al.* [2007] where they compared elite and non-elite athletes in terms of total technique repetition numbers and repetition numbers in the best two stages in parallel with our study. Besides these, lactate changes were the same for both groups in this study and lactate concentrations after UFT were different from those after simulated judo match; lactate concentrations of the athletes after UFT was found higher than after a simulated judo match. The reason of this phenomenon may be explained with a maximum effort presented by the athletes during UFT while athletes' performance went through decreases and increases during a match.

ST was developed by Santos *et al.* [2010] to determine aerobic-anaerobic transition zone of the judo athletes. This test allows coaches to prepare training programs to improve their athletes' aerobic and anaerobic developments [Santos *et al.* 2010]. In this study we used technique repetitions, test duration, hearth rate values after the test as Tavra *et al.* [2016] used instead of determining aerobic-anaerobic transition zones of the athletes. Due to the lack of enough previous studies about this test we had difficulty to compare our results to others. Tavra *et al.* [2016] found that elite athletes had more repetition numbers than non-elites (594±166 and 422±148, respectively), and thus test lasted longer. In our study, we investigated that elite athletes had significantly more test stages, repetitions and test duration than non-elite athletes. However, there was no significant difference in terms of heart rate and lactate concentrations between both groups. As mentioned before, Tavra *et al.* [2016] found a difference between elite and non-elite athletes but stated that ST was less discriminant compared to SJFT and UFT.

This study had some limitations; performance measurements are affected by many factors. Measurements were carried out during the competition period. Athletes were told to refrain from strenuous exercises, rest enough and pay attention to their nutrition but they were not monitored personally. Because SJM were not recorded content analysis could not be carried out. This situation hindered us from analyzing attack numbers and rest intervals during the competition. Therefore, it was difficult to interpret causes of changes/differences in lactate accumulations and HR. The study was implemented to 15 male athletes, so in order to increase statistical power of the study more athletes can be included. Moreover, when this study was carried out match duration was 5 minutes for male athletes. Thus, this situation makes it difficult for us to compare our result to those carried out after the current rule change with which match duration for males is limited to 4 minutes. In addition, Calmet *et al*. [2017] stated that there were not important changes in match duration after current rule change despite increase in percentage of golden score.

It can be stated that judo specific tests and simulated judo match investigated in this study did not discriminate elite and non-elite athletes in terms of HR and lactate changes. However, it can be concluded that SJFT and ST can discriminate athletes from different levels in terms of SJFT index and ST stages performed, thus test duration and *uchi-komi* numbers.

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Porównanie testów specjalistycznych przeznaczonych dla judo

Słowa kluczowe: judo, tętno, mleczan, testy wydajności

Streszczenie

Tło. W ostatnich latach opracowano specjalne testy wydajności w judo. Stwierdzono, że testy te przedstawiają takie same wyniki fizjologiczne jak pomiary aerobowe i anaerobowe uzyskane w testach laboratoryjnych. Pomiary przeprowadzone przy użyciu ćwiczeń przeznaczonych specjalnie dla judo są ważne dla kontroli postępów szkolenia.

Problem i cel: Celem niniejszego badania było ustalenie, czy 3 różne testy przeznaczone dla judo mogą faworyzować zawodników judo z różnych poziomów i przedstawiać te same wyniki fizjologiczne, co w czasie symulowanej walki judo.

Metody. W badaniu dobrowolnie brało udział ośmiu zawodników judo, którzy startowali w międzynarodowych zawodach w ostatnim roku i 7 zawodników, którzy wzięli udział w zawodach krajowych w ostatnim roku. Podczas selekcji brano pod uwagę kryteria takie jak: co najmniej 4-letnia praktyka judo, regularne szkolenia i brak kontuzji w ciągu ostatniego roku, które negatywnie wpłynęły na program treningowy sportowców. Zawodnicy judo przeprowadzili 4 różne treningi (testy): Specjalny Test Sprawnościowy Judo (SJFT), Test Sprawnościowy Uchikomi (UFT), Santos Test (ST) i Symulowana Walka Judo (SJM). Testy przeprowadzono losowo o tej samej porze dnia z co najmniej 2, co najwyżej 3 dniowymi przerwami. Pozostałe wskaźniki: pracy serca (HR) i mleczanu (LA) zostały zmierzone przed badaniami oraz w 1, 5, 10, 15 i 30 minucie okresu odpoczynku po wysiłku. Powiązane porównania zmiennych przetestowano za pomocą niezależnego *t-testu*, zmiany war-

tości tętna i mleczanu w obu grupach testowano za pomocą wariancji trójskładnikowej analizy mieszanej z powtarzanym pomiarem.

Wyniki. Uznano, że zawodnicy judo o najwyższym i niższym poziomie sportowym mają takie same właściwości fizyczne, z wyjątkiem procentu tkanki tłuszczowej. Czas pomiaru ($F = 187.57$) i testy ($F = 21.05$) znacząco wpłynęły na poziom mleczanu ($p < 0,05$), stwierdzono także istotny wpływ interakcji między testem a czynnikami czasowymi ($F = 8,80$; $p < 0,05$). Natomiast zmiany stężenia mleczanu podczas testów były podobne u judoków o różnych poziomach zaawansowania ($F = 0,82$, $p < 0,05$).

Wnioski. Pomimo podobnych zmian w wartościach tętna i mleczanu, tylko testy SJFT i ST wykazały różnicę wśród zawodników judo o różnym poziomie zaawansowania pod względem liczby rzutów i ocen specyficznych dla testów, podczas gdy test UFT nie faworyzował sportowców ze względu na poziom.