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Discriminant and factorial validity of judo-specific tests in female athletes

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Manuscript Preparation
E Funds Collection

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Abstract

Background & Study Aim: To evaluate the state of preparedness of top athletes, specific tests are recommended as the specificity principle is paramount in competitive sports. The main objective of this study was the discriminant and factorial validity of four judo-specific tests in a sample of high-level junior female judokas.

Matherials & Methods: Fourteen Croatian junior female judokas (range 17-19 years of age) took part in the study. They were divided into two groups – seven elite judokas with body mass 71.0 ± 20.8 kg, height 170.9 ± 4.6 cm, judo practice 8 ± 1.2 years and seven sub-elite ones with body mass 72.8 ± 19.7 kg, height 169.3 ± 4.6 cm, judo practice 6 ± 1.4 years. The following judo-specific tests were investigated: the Special Judo Fitness Test (SJFT), the Uchi Komi Fitness Test (UFT), the Santos Test (ST) and the Ten-Station Judo Ability Test (SJA).

Results: The Student's t-test for independent samples indicated statistically significant difference ($p < 0.05$) between the elite and subelite female judokas in SJFT and UFT. The magnitude of the differences between the two groups was large when the performance in the SJFT, UFT and ST are considered and moderate when the SJA is analysed. Moderate-to-high and statistically significant correlation coefficients between all the tests were obtained, and with factor analysis only one significant component has been extracted.

Conclusions: The SJFT and UFT better discriminated the elite from the subelite female judokas and, therefore, are suitable for the evaluation and monitoring of the training status of female high-level junior judo athletes. All four judo-specific tests have a similar measurement objective.

Key words: combat sport • efficacy • metric characteristics • motor-functional abilities

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Metric characteristics – indicate the quality of the test, or its reliability, validity and sensitivity.

Factorial validity – concerns inferences about whether individual item from a multiple-item scale assess the same construct.

Discriminant validity – tests whether concepts or measurements that are supposed to be unrelated are, in fact, unrelated

Judo specific tests – refer to the tests that are structurally very similar to the structure of judo actions.

Motor-functional abilities – abilities that enable realization of all kinds of movements of varying intensity and duration.

Uchi-komi (uchikomi) – repetition of basic technique in kendo and judo training [32].

Introduction

The evaluation of athletes physical fitness is essential in the training process because it provides information about the current athletes performance in specific physical abilities, providing information concerning indicators necessary to be improved to allow athletes to reach their maximal competitive performance [1]. To evaluate the state of preparedness of top athletes, specific tests are recommended as the specificity principle is paramount in competitive sports [2]. Judo is an acyclic sport, in which competitive performance is determined by a combination of many factors, including different physical abilities [3, 4], as well as technical-tactical [5] and psychological aspects [6]. To find an adequate approach to judo training and diagnostic procedures, it is necessary to determine the time structure of a judo fight [4, 7]. For females, the time-limit for a judo fight is 4-min and it is generally constituted by maximal and sub-maximal intensity efforts, with an average work duration of 35 s alternating with a rest period of 6 s [8]. These sequences of effort and pause in judo has been considered to tax aerobic and anaerobic processes to provide energy for the highly physiological demand on the judo athlete [4, 9]. Thus, tests developed to evaluate judo athletes focused on mixed aerobic and anaerobic profile [10-13], although the high-intensity of some of these tests (e.g., SJFT) have been reported to present a predominance of the anaerobic contribution [14]. Some of these tests were reported to be able to properly discriminate athletes from different competitive levels, such as the SJFT [15] and UFT [12]. However, despite the increase in the number of studies presenting different methods of judo athletes' evaluation [3] and the development of judo-specific tests in the last decades, only recently classificatory table was proposed for female athletes [16] and most of the studies conducted using judo-specific tests investigated only male athletes [11, 13, 17].

Thus, there is an evident lack of research that: a) compares the results of specific tests in male or female judokas in terms of the quality of the subjects (discriminant validity); b) determines whether the judo-specific tests studied have a similar objective of measurement (factorial validity); c) provides a general analysis of high-level female judokas in the junior age category.

Therefore, the main objective of this study was the dicriminant and factorial validities of four judo-specific tests in a sample of high-level junior female judokas.

Materials and methods

Participants

The study was conducted with 14 female Croatian judokas (range 17-19 years of age). All athletes gave verbal and written consent, while the parents of athletes under 18 years of age also gave written informed consent. All the subjects were active contestants in weight categories ranging from under 52 kg to +78 kg. To determine the discriminant validity of the tests applied, the participants were divided into two groups based on their competitive success. The first group consisted of seven successfull female judokas (body mass 71.0 ± 20.8 kg, height 170.9 ± 4.6 cm, judo practice 8 ± 1.2 years) who were members of Croatian Junior National Team that won the gold medal in team competition at the European Championship in 2014. The second group consisted of seven less-successfull female competitors (body mass 72.8 ± 19.7 kg, height 169.3 ± 4.6 cm, judo practice 6 ± 1.4years). They participated in the Ceoatian Junior National Championship in 2014, in which they achieved third to seventh places.

This study was approved by the Ethics Committee of the Faculty of Kinesiology (chair person Marko Erceg PhD; NUMBER: 2181-205-02-05-14-002; 13th May 2014).

The sample of variables

The sample of variables consisted of four judo-specific tests that partly differed in their main objective of measurement. In terms of structure, to a greater or lesser extent, the tests simulated the energy and neuromuscular demands of judo training and/or fights.

The Special Judo Fitness Test (SJFT) (index) proposed by Sterkowicz [10]. and described by Franchini et al. [18]. Two judo athletes (*ukes*) with similar height and body mass (same category) of the executor (*tori*) are positioned at 6m distance from one another, while the *tori* is 3m from the judo athletes that will be thrown. The procedure is divided into three periods: 15 s (A), 30 s (B), and 30 s (C) with 10-s intervals among them. During each period, the *tori* throws partners using the *ippon-seoi-nage* technique, as many times as possible. Immediately after and 1 minute after test completion, the athlete's heart rate

is checked. Throws are added and the index is calculated:

Index = final Heart Rate (bpm) + Heart Rate 1min after the end of the test (bpm)/total number of throws.

Thus, the higher the test performance, the lower is the index value. The heart rate was measured with a single monitor Polar Team System (Polar Electro OY, Finland). The index was used as representative of the performance in this test as it is considered an integrative variable expressing both aerobic and anaerobic contributions [10, 14, 18].

The Uchi-komi Fitness Test (UFT) (number of total *uchi-komi*) developed by Almansba et al. [12]. UFT is an intermittent test and last 243 s in total duration. Three judo athletes, two partners to be thrown (*ukes*) and one executant (*tori*) of the same weight category are required to participate in this test. The *tori* must perform 6 sets of *uchi-komi*. The first set lasts 23s and 3s by set is increased for arm static work, interpersed by 4s rest and increase progressively of 2s by set. The *tori* should perform two different sequences of work: (1) arm isometric exercise: the judo athlete grips the sleeve and reverse of a judogi hanging in a high bar during 3s; (2) explosive and dynamic exercise – after going down of the fixed bar, the judo athlete runs toward one of the two *ukes*, executes the *ippon-seoi-nage* and then runs towards the other *uke* and practice the *sode-tsurikomi-goshi* technique. After this, the athlete perform another set of isometric exercise and so on. In this test the distance between the two *ukes* is 4 m.

Santos Test (ST) (total number of unbalances and raises of the opponent) developed by Santos et al. [13]. The test is composed by two phases: an active and a recovery one. The active phase is performed in three bouts, in which the athlete uses his/her preferred technique(s) (used in competition). In the first bout, the judo athlete raises his/her opponent from the ground; in the second one, he/she completely unbalances his/her opponent; and, in the third one, he/she chooses if he/she prefers to raise the opponent from the ground or completely unbalance him/her. Each bout is performed in 40s, and the first one starts with seven repetitions, increasing one repetition at each bout until exhaustion (progressive increase in effort). If the athlete is not able to raise his/her opponent from the ground, unbalance the opponent and/or complete each bout in 40 s, the test is finished. In the recovery phase, two judo athletes move on the tatami gripping their *judogi* (jacket of judo dress) during 15 s, representing the movements that occur during a combat.

This test was designed to determine the aerobic-anaerobic transition zone of judokas but was considered as a maximum effort test in the present study. In other words, the test was carried out precisely according to the described protocol, however, to evaluate the final result we counted the total number of unbalances and raises of the opponent accomplished by the subjects until they do not follow the rules of the test (the judokas do not complete the number of repetitions in stage and/or do not develop judo throwing techniques properly).

The Ten-station Judo Ability Test (SJA) (s) developed by Lidor et al. [11]. The judo-specific ability test is composed of 10 stations. The stations are performed consecutively in a specific order that alternates physical ability and skill components. The 10 components of the test the judo athlete must perform continuously without breaks, as fast as possible. ***First station***: 4x8 m shuttle run; ***2nd station***: *ippon-seoi-nage* throw (two attempts); ***3rd station***: rope climbing (height 3.3m) using only hands; ***4th station***: 10 escape from *kesa-gatame* hold; ***5th station***: 10 side jumps over a bench (height 15cm) with feet together; ***6th station***: *o-uchi-gari* throw (two attempts); ***7th station***: 25 sit-ups performed while lying on the mat, keeping the lower leg on the bench (hips and knees are at 90 degrees angle and hands are held behind the head; one sit-up is counted after the elbows touch the knees and the shoulders return to the mat); ***8th station***: escape from *yoko-shiho-gatame* hold; ***9th station***: 20 push-ups performed with hands on the mat and feet on a bench (hands are placed at shoulder width; one push-up is counted after the chest touches the mat and the elbows return to full extension); ***10th station***: 8 individually selected throws.

The test was designed with the primary objective of identifying talents in judo. However, because the success of the test depends directly on the proper execution of tasks in the shortest time possible, it can also be considered as a maximum effort test.

Experimental design

Testing was done for two days in the pre-competition period of the semi-annual training cycle. All the subjects were healthy and without injuries. During the 24 hours before the measurement, they did not carry out any activities demanding physical effort (except during the actual test) and kept their usual eating habits. The order of the tests were SJFT, UFT, SJA and ST. The break between tests lasted for a minimum of 8 hours, which was estimated to be sufficient for full recovery. The testing was preceded by a 15-minute warm up (5 minutes of easy pace running in circles, 5 minutes of streching exercises, and 5 minutes of moderate-intensity *uchi komi*).

Statistics

The basic descriptive indicators (mean and standard deviation) were calculated for all analysed variables. By using Kolmogorov Smirnov test with Lilliefors correction, all variables were found to be normally distributed ($p>0.05$). To determine the discriminant validity of the tests under analysis Student's t-test for independent was applied to calculate the difference between the elite and subelite judokas and 95% confidence interval for mean differences between groups were also presented. To evaluate the magnitude of differences the Cohen's effect size was calculated. Threshold values to effect size were <0.25 (trivial), 0.25 to 0.50 (small), 0.50 to 1.0 (moderate), >1.0 (large) [19].

To determine factorial validity of the specific judo tests, the intercorrelation matrix of four tests was factorized by using principal components factor analysis. By using Fisher Z transformation, 95% confidence interval for correlations was also calculated. The number of significant components was determined by the Kaiser-Guttman criterion, which retains principal components with eigenvalues of 1.0 or greater. Factorial validity was obtained trough identification of highest structure matrix coefficient (i.e. coefficient of correlation of variable with extracted principal component) [20]. Significance was set at $p\leq0.05$. All data were analysed with the software package STATISTICA version 10.0 (Statsoft, USA).

Results

As shown in Table 1, a statistically significant difference between the elite and subelite female judokas was found in two of the four tests applied (SJFT and UFT), which confirms that these tests can successfully differentiate successful from less-successful female judokas.

The moderate-to-high and statisticaly significant correlation coefficients between all the tests indicate that those tasks, besides the particular test specificity, are measuring similar physical fitness variables (Table 2).

The principal components factor analysis of the four judo-specific tests resulted in the extraction of one significant component, which explained 78.12% of the total variance of all tests (Table 3).

Table 1. Performance in judo-specific tests for female elite and non-elite judo athletes

Variables	M ±SD		t	ES	95% CI
	elite	subelite			
SJFT# (index)	13.6 ±1.4	15.7 ±1.9	2.4[a]	1.3 (large)	−4.0 to −0.2
SJFT (reps)	26.0 ±1.6	22.9 ±2.1	3.1[b]	1.7 (large)	0.8 to 5.2
SJFT# (after) (beats/min)	186.0 ±7.1	187.9 ±10.3	0.4	0.2 (small)	−12.2 to 8.5
SJFT# (1 min) (beats/min)	163.7 ±17.3	168.0 ±13.9	0.5	0.3 (small)	−22.6 to 14.0
UFT (reps)	51 ±5	44 ±6	2.4[a]	1.3 (large)	0.6 to 13.4
ST (reps)	594 ±166	422 ±148	2.1	1.1 (large)	−10.7 to 354.7
ST (s)	1541 ±265	1242 ±292	2.0	1.1 (large)	−26.1 to 623.2
SJA# (s)	127.6 ±21.3	152.3 ±37.6	1.5	0.8 (moderate)	−60.3 to 10.9

Legend: **SJFT** Special Judo Fitness Test; **UFT** Uchi-komi Fitness Test; **ST** Santos Test; **SJA** The Ten-station Judo Ability Test (values are mean and standard deviation); **elite** more successfull female judokas; **subelite** less successful female judokas, **t** Student's test of differences; **ES** effect size, [a]$p<0.05$;[b]$p<0.01$; #reversely scaled variable; **95% CI** confidence interval of 95% for mean differences between groups.

Table 2. Intercorrelation matrix of all specific judo tests

Variables	SJFT	UFT	ST
UFT	−0.55[a] (−0.84 to −0.03)		
ST	−0.77[b] (−0.92 to −0.41)	0.69[b] (0.26 to 0.90)	
SJA	0.73[b] (0.32 to 0.91)	−0.71[b] (−0.90 to −0.30)	−0.78[b] (−0.92 to −0.42)

Legend: **SJFT** Special Judo Fitness Test; **UFT** Uchi-komi Fitness Test; **ST** Santos Test; **SJA** The Ten-station Judo Ability Test; [a]p<0.05; [b]p<0.01, values between parentheis are confidence interval of 95% (95% CI)

Table 3. Eigenvalues (λ) and the percentage of explained variance for all principal components (λ%)

Component	λ	λ %
1*	3.13	78.12
2	0.45	11.36
3	0.23	5.62
4	0.20	4.90

Legend: *significant principal component extracted

All the tests showed extremely high projections onto the first principal component, ranging from 0.83 to 0.92 (Table 4). The ST and SJA had the highest projections onto the factor, the SJFT and UFT showed slightly lower correlations. The results presented in Tables 3 and 4 also indicate that all the tests measured a similar component.

Table 4. Correlation coefficients of all judo-specific tests tests with the extracted principal component

Variables	1. component
SJFT	0.86
UFT	−0.83
ST	−0.92
SJA	0.91

Legend: **SJFT** Special Judo Fitness Test; **UFT** Uchi-komi Fitness Test; **ST** Santos Test; **SJA** The Ten-station Judo Ability Test.

Discussion

The main findings of the present study were that: (a) the SJFT and UFT better discriminated the elite from the subelite female judo athletes; (b) the SJFT and UFT have accetable discriminant validity and therefore are suitable for the evaluation and monitoring of the training status of high-level female junior judo athletes; and (c) all four judo-specific tests measure the same ability, which confirms their factorial validity in the sample of female junior judo athletes; (d) the magnitude of the differences between the two groups were large when the performance in the SJFT, UFT and ST are considered and moderate when the SJA is analysed.

The findings that the SJFT and the UFT tests better discriminated the elite female junior judo athletes from the subelite group and presented acceptable discriminant validity can be explained by the fact that both tests rely heavily on anaerobic processes to meet the physiological demand, but also present a high aerobic demand [12, 14], which has been considered to be a characteristic of judo matches [4].

Previous studies have also shown that the SJFT [15, 21, 22] and UFT [12] successfully discriminated judokas of different qualities. Therefore, the obtained results were as expected. However, it is important to emphasize that based on the factorial validity tested all test seem to measure a similar physical ability or combination of physical abilities, probably due to their maximal effort nature. Thus, coaches and sports scientists are recommended to use preferably the SJFT and the UFT, but they can also consider to use the ST and the SJA when the use of the SJFT or UFT could not be conducted for some reason. Additionally, using different judo-specific tests complementarily to each other can result in more accuracy on the physical and technical level of the evaluated athlete.

When comparing the results from our sample to previous studies, it is important to consider that few studies were conducted with female judo

athletes using these tests and, therefore, a detailed comparison of the present results with previous findings is not possible. The most commonly applied specific judo test is the SJFT. A comparison of the obtained SJFT test index values of the elite female judokas with those reported in previous studies shows, slightly poorer results compared with female judokas of senior age (SJFT index values ranging from 11.3 to 12.6) [21, 23-25] and better results compared with female judokas from 16 to 18 years old (SJFT index value of 14.4) [23 , 26]. When considering the index obtained in the SJFT by the judo athletes of our study according to the classificatory table proposed by Sterkowicz-Przybycień and Fukuda [16] for junior female judo athletes, the elite group is classified as good, while the subelite group is classified as regular.

The successful female judokas had slightly worse results in the UFT compared with the Canadian national team (51.0 versus 53.0 respectively) [27] and significantly poorer results compared with the elite (58.0) and sub-elite (55.0) judokas in the study of Almansba et al. [12].

In the present study, the female judokas in both groups achieved significantly better results in the SJA compared with boys aged 12 to 15 years in the study of Lidor et al. [28] (127.6 s for elite and 152.3 s for subelite judokas versus 173.5 s for the boys).

The judo-specific ST is primarily designed to help determine the aerobic-anaerobic transition zone of judokas, and not as a maximum effort test, as it was used in this study. This is probably why statistically significant differences between the two groups of subjects were not obtained. Although all the applied tests contain specific judo elements that are commonly used in judo training and/or combat, the SJA also includes basic training facilities (shuttle run, push-ups, sit-ups, and side-to-side jumps) that are not judo-specific. Therefore, this test could be characterized as a combined basic-specific test. This is probably the reason why statistically significant differences between the elite and subelite female judokas were not obtained in this study. Basic motor tests are well known to be more appropriate for younger athletes, whereas the importance of specific motor tests and specific motor abilities in general increases with age and the quality of competitors [29]. Even the auhors of the SJA suggested in their study that this test is more appropriate for judokas 12 to 15 years old [28].

Analysing the table of intercorrelation, numerically high and statistically significant correlation coefficient was found between all the applied testsat $p<0.01$, except between the SJFT and UFT which showed a moderate correlation $r = -0.55$ at $p<0.05$. Such a result is interesting because the very same tests best differentiated the elite from the subelite female judokas. However, a comparison of the test structures shows that the SJFT primarily activates the functional capacity of the subjects, whereas the neuromuscular ability of the judokas also plays an important role in the success of the UFT. This probably caused the slightly lower correlation obtained between the two tests. All four tests applied are complex (they evaluate a larger number of abilities and skills) and have partly different main objectives. However, structurally, to a greater or lesser extent they simulate specific situations in judo training and/or combats. Therefore, we aimed to determine their factorial validity through factor analysis. There has been wide discussion of appropriate sample size to number of variables ratio while using factor analysis in scientific research [30, 31].

Altough no exact solution of that problem is found, sample size is a limitation in this study. For further research of this type, bigger sample size is strongly recommended. However, it must be considered that a much large sample size may be difficult to find as elite athletes are, by its own characteristics, a group with a small number of individuals. Although the analysis of the results of principal components factor analysis aims to decrease number of variables, in the present study, at very high factor loads, the principal components factor analysis application was not used for this reduction. The factor analysis extracted only one significant component, which explained 78.12% of the variance of the four judo-specific tests. Because all the tests had high projections onto the extracted factor (from 0.86 to 0.92), and estimated different abilities essential for success in judo, it can be interpreted as a factor of specific judo abilities. Considering that the factorial validity is determined precisely by the correlation of the applied tests with the extracted factor, it is possible to conclude that all four tests are factorially valid. Interestingly, the ST (–0.92) and SJA (0.91) showed the strongest correlation with the resulting factor, whereas the aforementioned

correlation was lower between the SJFT (0.86) and UFT (–0.83). However, due to the specific characteristics of all the tests (they measure a large number of abilities and skills), ranking them according to factorial validity is not reasonable, rather it is more appropriate to determine whether all four tests have a similar measurment objective

Conclusion

According to the results presented and discussed, the following conclusions can be made:

The SJFT and UFT better discriminated the elite from the subelite female judokas.

The SJFT and UFT have accetable discriminant validity and are therefore suitable for the evaluation and monitoring of the training status of female high-level junior judo athletes.

All four specific judo tests have a similiar measurement objective, which confirms their factorial validity in the sample of female junior judo athletes.

When the magnitude of the differences between the two groups are considered large effects were found when the performance in the SJFT, UFT and ST are considered and moderate effect when the SJA is analysed.

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