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TEST AND RE-TEST RELIABILITY OF THE SPECIAL JUDO FITNESS TEST

Miloš Štefanovský, Matej Poliak, Dušana Augustovičová, Stanislav Kraček, Radovan Hadža

Comenius University in Bratislava Faculty of Physical Education and Sports, Slovakia

Summary: Background. When analyzing the available literature, we found differences and considerable variability in the Special Judo Fitness Test (SJFT) reliability methods. **Problems and Aim.** For this reason, we have set our goal to determine the reliability and measurement error of all parameters by SJFT. **Methods.** The research sample consisted of 15 judo athletes (17.13 ± 1.96 years, body height 174.4 ± 10.64 cm, body weight 72 ± 15.37 kg) who trained in judo on average 8.73 ± 2.12 years in two different Slovak judo clubs. The results were processed using interclass correlation analysis and measurement error percentage. **Results.** Our results indicate poor reliability for HR_0 (α= 0.374, *Err* = 4.2 %) and moderate reliability for the following parameters: the number of throws in section A (α = 0.641, *Err* = 5.9 %), section B (α = 0.512, *Err* = 6.0 %), and section C (α = 0.644, *Err* = 5.9 %), respectively. Moderate reliability was also found for the total number of throws (α = 0.687, *Err* = 5.1 %). Good reliability was found for HR_1 (α = 0797, *Err* = 3.5 %) and SJFT index (α = 0.807, *Err* = 4.5 %). **Conclusions.** According to the results of this study, by testing the special level of judo fitness, as well as its changes, we recommend using the HR_1 and SJFT index as good reliable parameters.

Key Words: judo, level of fitness, reliability, measurement error.

Introduction

Due to the multifactorial structure of the sports performance (SSP) in combat sports, as well as the constantly changing conditions in the match, and the resistance of the opponent, it makes the assessment of the athlete's fitness level a very complicated process. Several authors have tried in the past to identify factors of SSP in combat sports, especially by using correlation and regression analysis procedures (Zemková 1999; Feč 2004; Štefanovský 2008). This approach made it possible to test combat sports athletes using a wide range of motor tests, mainly focused on the level of fitness (Matejová et al. 2018; Zemková 2018). However, most

of these tests have a general nature and only marginally cover the special level of fitness. Conventional standardized tests do not take into consideration the opponent´s active resistance, specific movement structures, or decision-making factor. The contemporary trend points to the use of specifically designed tests, which better simulate the competitive load and specific movement (Tabben et al. 2014; Chaabene et al. 2015; Šimenko & Karpljuk 2015; Karimi 2016; Štefanovský et al. 2016; Šiška et al. 2016; Madaiová & Čierna 2018).

To assess the specific level of fitness in judo, Sterkowicz (1995) created a Specific Judo Fitness Test (SJFT). The test was designed to evaluate the specific abilities of judo athletes. SJFT partially respects the time structure of a real judo contest and uses the throwing technique over the shoulder (Ippon-Seoi-Nage). According to Detanico and dos Santos (2012), the SJFT test can be used to identify anaerobic and aerobic capacity, but care should be taken when using recovery HR to infer aerobic capacity. Moreover, the SJFT seems able to induce glycolytic and aerobic demands similar to those of judo combat, being thus an important tool to evaluate the specific performance of the athlete. Currently, the test is used in many countries, where judo is well developed (Štefanovský 2015). More than a hundred scientific papers can be found via Google Scholar, ResearchGate, Scopus, Web of Science, or PubMed databases, in which SJFT has been used to assess the judokas of the different levels. In most scientific papers, the authors refer to the test as a reliable tool, sensitive enough to assess changes in fitness level, with the ability to distinguish judokas by age and sex, and it correlates with the laboratory tests (eg. VO2mox or Wingate) and the number of attacks during a competitive contest (Franchini et al. 2007; Radovanovic et al. 2009; Wolska et al. 2009; Franchini et al. 2011; Detanico et al. 2012). However, in the work of Szmuchrowski et al. (2013), there was no correlation between the Wingate test and SJFT. The authors concluded that the Wingate test of upper and lower limbs is not sensitive enough to adequately assess the anaerobic capacity of judo athletes. Stekowicz (1995) reports that the value of the Spearman correlation coefficient for SJFT is 0.97 ($p \leq 0.01$) when the test is repeated twice. Franchini et al. (1999) report a correlation coefficient value of 0.73 ($p \leq 0.05$) for the parameter total number of throws and 0.89 ($p \leq 0.05$) for the „SJFT index". However, it is important to consider that the Spearman correlation coefficient has been criticized when used to test reliability (Thomas & Nelson 1990; Franchini et al. 2010).

Franchini et al. (1999) report that the performance in SJFT can be improved by a) an increased number of throws, which represents an improvement in speed, anaerobic capacity, and/or technique; b) decreasing the heart rate at the end of the test, indicating higher cardiovascular performance with equal effort (same number of throws); c) decreasing heart rate

1 min after the end of the test, indicating a better recovery, which is due to improved aerobic performance; d) a combination of two or more of the factors.

Iredale (2003), Franchini et al. (1999), and Sterkowicz (1995) in their studies presented only the reliability of some SJFT parameters by using of Pearson Correlation or ICC method. Our work was aimed to assess the reliability and to determine the measurement error of all SJFT parameters in the group of high-performance judo athletes.

Methods

Participants

The research sample consisted of 15 judo athletes (17.13 ± 1.96 years, body height 174.4 ± 10.64 cm, body weight 72 ± 15.37 kg) who trained in judo on average 8.73 ± 2.12 years. The participants were members of two Slovak judo clubs Dukla Banská Bystrica and Slávia Bratislava and their judo technical level was from second Kyu to first Dan. Judo athletes included in this study regularly attended national or international tournaments. All probands, or their legal representatives, signed voluntarily a consent agreement form. The study design received ethical approval from the local Ethics Committee. None of the athletes were engaged in any weight-loss procedures during the testing period and did not take any medicaments.

Procedures

Participants began the testing protocol with warming-up and dynamic stretching. The warm-up consisted of 5 min running around the tatami with low intensity and 10 min of dynamic stretching whereupon, afterward, SJFT was conducted. Immediately after the test, the participants stood still, and the heart rate was monitored. Re-test was realized after seven days, on Monday (after two days of passive recovery), under the same conditions. We did not intervene in the weekly judo training program, which respected the content of the relevant micro-cycle of both judo clubs.

The SJFT was performed in three sections, divided into 15 s section A, 30 s section B, and 30s section C with a 10s break between them. During each section, an athlete throws two equally heavy sparring partners (± 2 kg), placed 6m apart, as many times as possible, using the ippon-seoi-nage technique. The test begins in the middle, at a distance of 3 m apart from both sparring partners. The choice of this technique is based on the following aspects: a) biomechanical – the athlete grasps his partner only with one hand and the turn into the technique allows him to immediately run to the next partner, b) frequency of use in competitions – this technique is one of the most used at the competitions (Adam et al. 2016) and most of the judo

athletes can apply the technique properly, at a high level. Any incorrectly performed throwing technique during the test is not included in the result. Heart rate is recorded immediately after the end of the test (HR_0) as well as 1 min after its end (HR_1). To monitor the heart rate, we used the Sportester POLAR RS800CX G3 (Made in Finland). The judo athlete wears the heart rate monitor during the whole test. From the total number of throws (TT) and HR_0 and HR_1 was calculated SJFT index (Index = HR_0 + HR_1 / TT), while the lower the index value, the better performance in the test, respectively, the more throws, the better performance. Top-level judo athletes (men) can throw more than 30 times and the SJFT index is at 11.20 or below (Ceylan & Balci 2018; Merola et al. 2019).

Statistical analysis

To process the empirical data, we used Cronbach's Alpha method with respective 95 % Confidence Interval (95 % CI). The coefficients of correlation were interpreted according to Koo & Li (2016), where values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values greater than 0.90 indicate excellent reliability. The measurement error (ε) was expressed as the mean percentage error. The level of statistical significance was set at $p \leq .05$.

Results

Our results (Table 1) indicate poor reliability for heart rate (HR_0) immediately after the test (α = 0.374, *Err* = 4.2 %), moderate reliability for the number of throws in section A (α = 0.641, *Err* = 5.9 %), section B (α = 0.512, *Err* = 6.0 %), and section C (α = 0.644, *Err* = 5.9 %), respectively. Moderate reliability was also found for total number (TT) of throws (α = 0.687, *Err* = 5.1 %). Good reliability was confirmed for the heart rate (HR_1) 1 min after the end of the test *(*α = 0797, *Err* = 3.5 %) and SJFT index *(*α = 0.807, *Err* = 4.5 %).

Table 1

Mean values of SJFT parameters and ICC correlation

	Test	**Re-test**	**Cronbach´s Alpha**	**95 % CI**
Section A [n]	5.6 ± 0.63	5.53 ± 0.52	0.641	-0.032 - 0.794
Section B [n]	10.07 ± 0.70	10.13 ± 0.83	0.512	-0.198 - 0.731
Section C [n]	8.87 ± 0.52	9.27 ± 0.70	0.644	-0.050 - 0.740
TT [n]	24.60 ± 1.55	24.93 ± 1.87	0.687	0.046 - 0.813
HR_0 [b/min]	192.33 ± 7.26	192.20 ± 8.50	0.374	-0.331 - 0.668
HR_1 [b/min]	172.13 ± 8.31	169.87 ± 8.55	0.797	0.253 - 0.867
SJFT Index	14.86 ± 1.02	14.59 ± 1.22	0.807	0.280 - 0.875

Section A - number of throws in the 15 s section; section B - number of throws in the 30 s section; section C - number of throws in the last 30 s section; TT – total number of throws; HR_0 - heart rate at the end of the test; HR_1 - heart rate 1 min after the end of the test; SJFT index = $HR_0 + HR_1 / TT$.

Discussion

This research aimed to determine the reliability and percentage measurement error of all SJFT parameters. The research sample was composed of high-performance judo athletes. Although the weekly micro-cycle training content was not uniform among the athletes involved in this work, we assumed that there will be no significant changes in the level of fitness between the test and retest within 7 days.

Surprisingly, only poor reliability with relatively low measurement error was found for the parameter HR_0. Lower HR after the SJFT or a faster HR recovery has been interpreted as an improvement in aerobic fitness.

Our results showed good reliability of parameters HR_1 and SJFT index and their measurement error were quite low. HR_1 indicates a decrease in heart rate after the first min of recovery. The rate of decrease in heart rate during the first min after the exercise is an undemanding, non-invasive, valid, and simple indicator of parasympathetic activity (Lahiri et al. 2008). In judo, the cardiovascular system adapts to a mixture of strength, anaerobic and aerobic load. The decrease in athlete´s HR is due to the chronically increased systolic volume of the heart and two adaptation mechanisms contribute to its increase, which is a) the thickening of the left ventricle wall due to the strength training, and b) an increase of cardiac cavity volume due to aerobic exercise (Hamar & Lipková 1996). A high load of strength appears in judo performance in situations when overcoming the opponent's resistance, as well as in strength and condition training. A faster heart rate recovery can be a significant advantage especially when a repeated high performance during competition day is necessary, caused by interruptions during a match, in overtime situations, or when judo athletes undergo multiphase training units per day (Franchini et al. 2013). Achten, Jeukendrup (2006) report that a decrease in HR during the rapid recovery phase is not only conditioned by the level of aerobic fitness, but also by neural mechanisms associated with motor centers in the cortex. Daanen et al. (2012) in a systematic literature analysis found that the heart rate recovery of well-trained individuals was faster compared to untrained subjects. However, in these two works, no significant differences were found between trained and untrained subjects. The authors concluded that heart rate recovery after exercise can be a valuable tool for monitoring the athlete´s level of fitness. Sterkowicz et al. (1999) found a significant correlation ($r = -0,63$) between VO_2max and HR_1 after SJFT and concluded that heart rate recovery is a good indicator of the aerobic

level of fitness in judo. Franchini et al. (2001) tested female judo athletes 70 and 30 days before the top-level competition. Parameters in SJFT did not change significantly except SJFT index (13.09 ± 1.55 vs. 12.62 ± 1.48; $p \leq .05$). The difference between HR_0 and HR_1 increased from 17 to 21 beats per minute 30 days before the event, which may indicate a slightly (insignificant) improved cardiovascular adaptation to the training load. Significant changes may occur only after a long-term training period. If we consider the measurement error for the HR_1, it was the lowest of all other parameters.

The SJFT index is calculated from the parameters obtained during the test (SJFT = HR_0 + HR_1 / TT). The SJFT index reflects the specific training of the cardiovascular system, the speed of throwing and running between two sparring partners, as well as the ability of the subject to resist fatigue during lactate accumulation. The reliability of the SJFT index using the interclass correlation coefficient method was verified in the work Iredale (2003). She found an ICC value for the SJFT index of 0.84 and the measurement error was 3.4 %. The Cronbach's Alpha coefficient in our work for the same parameter is very similar ($\alpha = 0.807$) and the standard error of measurement was slightly higher, namely 4.5 %. However, with especially well-trained individuals, it might be a problem to detect changes in the HR_1 below 5 %. However, even though it is not a laboratory test with strict standard conditions, we do not consider the measurement error as high.

According to Cronbach's Alpha calculated values for individual sections (A, B, and C), as well as for the total number of throws (TT), we found the moderate reliability of these parameters. These will not be suitable to distinguish judo athlete´s special level of fitness. Measurement error in the range of 5 - 6 % for the throws indicates the inability of the test to detect changes in very well-trained judo athletes. One of the limitations of the SJFT test is the use of the Ippon-seoi-nage (shoulder throw) technique. For example, Sterkowicz & Franchini (2002) found that the SJFT index was significantly lower for those judo athletes who preferred this technique and considered it as a personal throw (tokuj-waza), compared to others. However, in this study, the TT parameter did not differ significantly, regardless of preferred techniques. We can say that the execution quality of each throw and using of different kind of sparing partners (eg different height, limb length, or center of gravity height) can also affect the number of throws in each section as well as the total number of throws. Sometimes, we also noticed a worse quality of throwing execution in some judo athletes. This should be taken into consideration as well. Both the examiner and the test subject must pay attention to the quality of the technical execution during the whole test, and this should meet the basic prescribed standards.

Another limitation of the SJFT is, it does not consider how many times the proband runs the 6 m distance between the two sparring partners. During the test, it happened several times that the athlete runs to the partner, but he does not manage to make the throw due to the end of the time limit. However, the last 6m distance was not included in the performance result.

According to our results, we recommend to coaches and athletes: a) to record a new SJFT parameter – the total number of 6m runs passed, b) to use the HR_1 and SJFT parameter, as good reliable parameters, with low measurement error, when assessing the level of judo athletes fitness, c) to maintain a high level of objectivity of testing, it is important to execute the throwing technique on the highest quality. In future works, the changes in the HR_1 and SJFT index parameters should be monitored during the different periods of the one-year training cycle.

Conclusions

Field test like the Judo fitness test is a good alternative method to measure the fitness of judo athletes without the expense, time, and expertise required for laboratory testing. However, as we found out, not all parameters in this test are suitable and reliable in evaluating the level of fitness. We found low reliability of parameter HR_0. The number of throws in sections A, B, and C, as well as TT, are parameters with moderate reliability and we do not recommend them to assess the level of judo athlete's fitness. Only HR_1 and SJFT index were proven as highly reliable parameters with a relatively low measurement error, and the ability to control the cardiovascular response to a specific load.

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