Serbian Journal of Sports Sciences
2012, 6(4): 117-125
UDC 796.853.23.015.132

ISSN 1820-6301
ID 197150988

Invited Review
Received: 19 Oct 2012
Accepted: 12 Dec 2012

SPECIAL JUDO FITNESS TEST – A REVIEW

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Abstract Judo has been characterized as a high-intensity intermittent combat sport, consisting of many different techniques and actions employed during a match. In judo, diagnostics is performed to gain information in talent identification and selection, to define athletes' current fitness condition, and to monitor training effects. The aim of this paper was to provide an overview of a specific test that is commonly used in judo to evaluate judo-specific performance. Pub med and Web of Science were screened (last search on October 1st 2012) using the following keywords: (Special Judo Fitness Test) and (SJFT). For this purpose, articles, titles and abstracts were screened for relevance. The SJFT showed reliability with a low measurement error, applicability and sensitivity for training monitoring even with high level (elite) judokas. Furthermore, this test identified differences between judokas of various fitness levels, and highly correlated to well-controlled laboratory tests; it was also relevant to attacks during a judo match. As a result of the material collected and presented here, the SJFT was considered as an adequate and comprehensive testing tool in all levels of judo practitioners as well as in athletes doing sports similar to judo.

Key words: SJFT, judo, diagnostics, evaluation

INTRODUCTION

Judo, which means “the gentle way” or “the easy way”, is a sport that developed in Japan in the second half of the nineteenth century thanks to Professor Jigoro Kano, who created a new martial art based on the techniques of jujitsu. The system underlying this combat sport rests on the principles of efficient use of balance, leverage, strength, and movement in the performance of throwing and grappling techniques. Certainly, judo does not involve the use of brute force but rather the ability to defeat the opponent by reversing his or her momentum using skill and speed. Judo belongs to the group of acyclic polystructural sports dominated by acyclic movements, which means that it can be described as an activity of particular complexity, where the goal is to overcome the opponent using symbolic destruction. Judo has been characterized as a high-intensity intermittent combat sport [16, 18], consisting of many different techniques and actions during a match. A judo practitioner tries to throw the opponent on the back or to subdue the opponent during fighting on the floor [2, 9].

Judo is an Olympic sport and besides the Olympic Games, judokas compete in the world- and continental championships and cups. In the previous decade, judo was introduced to grand prix and grand slam competitions, where the best judo athletes have been able to win significant financial rewards. There are 7 weight categories for male and female competitors in judo. International judo organizations organize competitions for age categories of cadets (U18 – Under 18), juniors (U21 – Under 21), seniors, and veterans. The complexity of judo sport analysis is enhanced by multiple weight categories as each category differs in its technical and tactical fighting structure, as well as in physiological demands and morphological characteristics.

The variety of judo techniques compounds the structure of the bout, demanding an appropriate performance of the technique as well as its sequences with the use of full competitor’s potential. The competitor has to be able to apply the adopted technical and tactical stereotypes, instantaneously reorganizing them in an offensive and defensive-counterattacking performance. Each judoka has an innate ability, a certain degree of maturity, previous experience in performing movements, as well as a certain degree of motivation and emotion. Achieving satisfactory performance skills in judokas demands attaining a number of factors (i.e. perceptual-motor skills, maturity level, previous experience in accomplishing movement tasks, achievement motivation, maintenance of optimal emotional level, etc.).

Training motor skills usually means adopting technical and tactical skills. The desired outcome in judo is to win with maximum certainty and minimum expenditure of energy and time [32]. Only the judoka that shows the ability to achieve the goal with a high degree of certainty, without excessive influence of luck, could be taken for skilful. Another quality of successful performance is minimization, and more often energy saving in performance (i.e. reduction and/or removal of unwanted and unnecessary movement). This feature is essential in judo, where necessity to save energy during the match is the key to success up to its last seconds. Moreover, the concept of minimum energy means that skilled judokas are able to organize their actions in a manner of reducing the need for mental tasks. Athletes that perform with a high level of automated techniques are able to focus their thoughts on other relevant activities (i.e. strategy application in competition). The third quality in successful performance of a particular technique in judo is the shortened time needed to achieve the goal (throwing and gaining a point) resulting in more efficient techniques when the movement is accelerated and precise.

In order to be effective, judo techniques should be applied with high preciseness (i.e. the good moment to attack, with strength, force and velocity of the movement). This burst of energy is mostly anaerobic. In contrast, during a match, the phases between throwing attempts and in recovery are dominantly aerobic. Special importance of aerobic metabolism is reflected in the process of recovery between matches [18, 41].

The base for any planning and programming of the training process lies in precise testing procedures for evaluation of the initial characteristics of athletes. Diagnostics is implemented through general and specific procedures and tests, in order to assess motor and functional ability, health status, anthropometric characteristics and psycho-sociological dimensions of athletes [4, 6]. Based on the results given by diagnostic procedures, comparisons to model characteristics can be made and features that need to be developed with future planning and programming can be determined. Moreover, assessing athletes' abilities represents primary information that allows insight in the proper application of training loads. Diagnostics can be described as a series of procedures carried out in order to determine the individual athlete's characteristics through various tests specific to the sport activity. In judo, diagnostics is performed in order to identify talents, to define current athletes' skills, and to monitor the effects of training.

Testing procedures can be performed in laboratory or in the field. Laboratory tests mostly evaluate basic conditioning abilities, whilst field tests can asses both basic skills and specific fitness conditioning.
The aim of this paper was to provide an overview of a specific test that is commonly used in judo for the purpose of evaluation of judo-specific performance. Pubmed and Web of Science were screened (last search on October 1st 2012) using the following keywords: (Special Judo Fitness Test) AND (SJFT). This action resulted in 38 hits; these articles, titles and abstracts were screened for relevance. The retrieved studies were further selected based on their purpose, methodology, and the number and characteristics of the judo athletes evaluated.

SPECIAL JUDO FITNESS TEST (SJFT)

A judo athlete should show a number of various technique actions during a single match, thus the physiological demand of each match is high. Winning a medal on a major competition requires a judoka to have 4 to 7 matches per day, with a single match lasting up to 5 minutes. The most common break between matches in elimination round lasts about 30 minutes. The match automatically ends if one of the judokas throws (or subdues) his opponent for ippon (before the time expires). If time expires and the score is tied, "the golden score" achieved in additional 3 minutes of the match determines the winner. If, by any chance, the score is still tied after "the golden score", judges decide the winner by majority of vote (Hantei). In short, a judo match can end within a few seconds or 5-8 minutes of active fighting, depending on points won by contestants. In order to find an adequate approach to judo training and diagnostic procedures, it is necessary to determine the time structure of a judo match. According to Garcia and Luque [19], a match has an average of 8 to 9 periods of pauses or intervals. The typical time structure is 30 s of activity with a 10 s interval [5, 18, 33]. Marcon et al [25] in their study reported an average of 11 action sequences per match, with 4 being on the ground. Previous studies described the effort-to-pause ratio in high-level judo competitions [5, 24, 33]. Specifically, they identified 20 to 30 seconds of effort interrupted with approximately 10 seconds of pause.

Based on the knowledge that judo represents a high-intensity intermittent sport, a test was constructed that imitates a judo match in its temporal structure. This test was proposed by Prof. Stanislaw Sterkowitz, whereas its metrical characteristics have been measured and validated at the Krakow Academy of Physical Culture.

The test is performed on the tatami with three judo practitioners from approximately the same weight categories needed for the measurements. The athlete who is being tested stands in between the other two athletes, who are positioned 3 m apart from the tested subject on opposite ends (Figure 1).

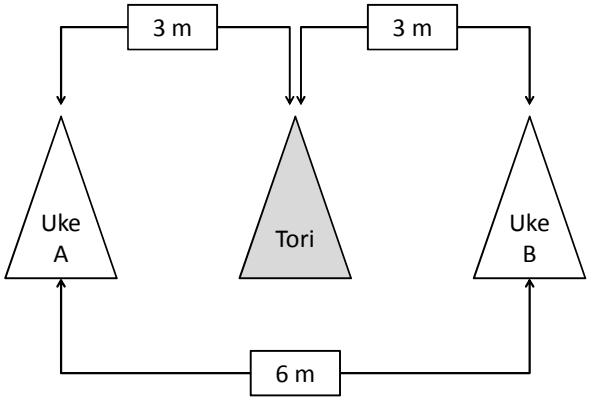

Figure 1. Positioning in the Special Judo Fitness Test

Figure 2. Ipon-seoi-nage

At the '*Hajime*' command, the subject attempts at throwing the two assistants by "Ipon-seoi-nage" (Figure 2) in three separate series: Series 1 lasts 15 seconds, while Series 2 and 3 last 30 seconds each. There are two 10-second breaks between the series. The throws need to be technically sound, and performed at maximum speed. Heart rate is recorded during, immediately following (P1), and 1 minute after the test (P2). These measurements are used to calculate the index presented in the equation:

$$\text{Index} = (P1 + P2)/N$$

where: N represents the total number of tested subjects. It is obvious from this equation that the score is inversely related to the index, i.e. the lower the index, the better the score. Up to date, numerous researches have been published using this testing procedure. This test has been shown to be reliable [20, 35], and with a low measurement error [20].

Sterkowicz et al [36] researched fitness levels of 15 judokas based on laboratory testing and application of the SJFT during preparation period. They reported that number of throws in the SJFT positively correlated with performance in both upper and lower body and the Wingate test. The authors concluded that the SJFT was an appropriate testing procedure in the assessment and evaluation of specific judo abilities, for laboratory testing mainly does not assess parameters needed by judo coaches and competitors.

Sterkowicz and Franchini [37] compared research results between novice and elite, junior and senior, as well as lightweight and heavyweight judokas. The results of this study showed that the SJFT was able to discriminate correctly between judokas according to their performance in competitions.

Franchini et al [13] researched relations between the Wingate test, the SJFT and simulated combat. Blood lactate after the SJFT correlated with blood lactate after combat, indicating similarity of metabolic demands in these events. In addition, this study demonstrated that morphological, physiological, and technical actions during combat were correlated with each others.

Determination of differences between elite and non-elite Brazilian judokas was the aim of a survey conducted by Franchini et al [14]. In the SJFT, the elite athletes presented more anaerobic capacity (inferred from the number of throws). Heart rate did not differ between the groups, suggesting a similar cardiovascular stress

during this test for both groups. The authors interpreted this as a similar aerobic capacity in both groups. The SJFT index was statistically lower with elite judokas, referring to better test results.

Table 1. SJFT results in male judokas

Study	Athlete characteristics; sex	Variables					
		Total of throws	HR after (bpm)	HR 1min after (bmp)	Lactate 3'	Lactate 5'	Index
Sterkowicz et al., 1999 [36]	Male judokas n=15	27.27±2.71	181.6±6.2	150±11.8	-	-	12.29±1.48
Sterkowicz and Franchini, 2001 [37]	Younger n=50	25.8±2.3	185.3±9.4	156.8±15.9	-	-	13.4±1.50
	Older n=30	26.8±3.4	178.6±9.5	149.8±17.2	-	-	12.3±1.70
	Elite n=33	27.7±2.9	180.1±10.0	151.9±18.1	-	-	12.1±1.60
	Novice n=47	25.1±2.2	184.7±9.6	155.8±15.5	-	-	13.6±1.40
	Lighter n=52	26.7±2.8	182.9±9.9	154.4±17.2	-	-	12.8±1.70
	Heavier n=28	25.1±2.4	182.5±10.4	153.7±15.9	-	-	13.5±1.40
Franchini et al., 2005 [13]	Male elite college judokas n=13	28±2	179±6	163±10	10.9±2.5	-	12.28±1.01
Franchini et al., 2005 [14]	Elite judokas n=23	28±2	181±10	162±12	10.9±2.5	-	12.53±1.11
	Non-elite judokas n=53	25±2	186±11	165±13	10.9±2.5	-	14.16±1.52
Franchini et al., 2007 [15]	Male judokas A team n=7	28±3	178±9	151±7	-	-	11.83±1.16
	Male judokas B and C team n=13	27±2	175±9	157±11	-	-	12.21±1.26
Boguszewska et al., 2010 [3]	Junior judokas n=8	25±3.6	187±19.9	129±10.9	-	-	12.71±1.94
Detanico et al., 2012 [7]	Male judokas n=18	27±2	179±10	155±15	10.2±3.1	-	12.5±1.3
Katralli et al., 2012 [22]	Senior judokas ≤ 5 years of training n=20	28.4±2.3	177.3±9	141.7±21.6	-	-	11.3±1.40
	Senior judokas > 5 years of training n=11	28.4±2.0	181.1±5.7	142.9±18.2	-	-	11.4±1.00

Another research by Franchini et al [15] had a purpose to research the differences between Team A and Reserves (Teams B and C). The second purpose of the research was to check the association between morphological and functional variables and between aerobic power and performance on high-intensity intermittent task. In this study no difference was found between Team A and Reserves (Teams B and C), which indicates the same level of development for both groups. A negative correlation between weight and performance in the SJFT appeared, indicating that heavier athletes exerted lower anaerobic power in activity that involved throwing opponents from the same category.

Boguszewska et al [3] compared biomechanical and special methods of control techniques in judo training. In a setting of the results of biomechanical parameters with the SJFT Index, a negative correlation was noted. Detanco et al [7] analyzed the relationship of aerobic, anaerobic and neuromuscular indices with the performance in the SJFT. Authors reported a significant correlation between the number of throws in SJFT and anaerobic threshold velocity.

In a study by Katarelli et al [22] the aim was to define and interpret the possible anthropological determinants and SJFT in Indian judokas. They have reported a non-significant negative correlation between weight and performance in the SJFT. There was a negative correlation of body fat and number of throws in SJFT observed in this study.

Drid et al [8] sought to determine fitness profiles of sixteen elite female judokas of the Serbian national team, in addition to which anthropometric characteristics, motor and physiological abilities separated more successful from less successful athletes. After SJFT data analysis, significant differences between groups were found in the number of throws and lactate concentrations 5 min after exercise. There were no between-group differences in other variables. Authors found significant positive correlation between number of throws on the SJFT and average power on the RAST (Running-based anaerobic sprint test), which means that the SJFT could be used as a specific test of aerobic fitness.

Jagiello et al [21] analyzed correlations between the International Physical Fitness Test (IPFT) and the SJFT in three groups of female judokas. Highly qualified judokas were characterized by a more expressed and diversified immediate relationship between indices of general and special physical preparation when compared with 16-18- and 13-15-year-old counterparts.

Table 2. SJFT results in female judokas

Study	Athlete characteristics; sex	Variables					
		Total of throws	HR after (bpm)	HR 1min after (bmp)	Lactate 3'	Lactate 5'	Index
Drid et al., 2009 [8]	Elite female judokas n=8	29.6±2.1	184±5	150±14	5.8±1.4	6.6±1.3	11.3±1.00
	Non-elite female judokas n=8	26.6±2.9	182±7	148±14	6.2±1.2	8.9±2.0	12.5±1.90
Jagiello et al., 2009 [21]	Female judokas n=11	24.3±1.8	175±7	129±12.9	-	-	12.6±0.69
	16-18-year-old n=15	22.1±1.92	181±10.6	137±10.8	-	-	14.4±1.26
	13-15-year-old n=14	22.9±2.01	191±4.8	153±10.2	-	-	15.2±1.51
Wolska et al., 2009 [42]	Female judokas n=11	24.3±1.8	175±7	129±12.9	-	-	12.6±0.69
Wolska-Paczoska, 2010 [43]	Female judokas aged 16-18 years n=15	22.1±1.92	181±10.6	137±10.8	-	-	14.4±1.26
Smulski et al., 2011 [34]	Female judokas n=11	24.3±1.8	175±7	129±12.9	-	-	12.6±0.69

Table 3. SJFT results after applied training treatment in different conditions

Study	Athlete characteristics; sex		Variables					
			Total of throws	HR after (bpm)	HR 1min after (bmp)	Lactate 3'	Lactate 5'	Index
Radovanovic et al., 2008 [27]	Male judokas (creatine) n=6	Pre-training	23.4±2.1	182.44±8.6	154.66±12.28	-	-	14.61±2.10
		Post-training	24.8±2.8	180.46±6.4	155.24±11.84	-	-	13.95±1.82
	Male judokas (placebo) n=6	Pre-training	24.2±2.5	183.12±7.8	156.36±13.10	-	-	14.18±1.96
		Post-training	25.1±2.9	181.52±8.1	154.74±11.42	-	-	13.52±1.78
Radovanovic et al., 2009 [28]	Male judokas (experimental) n=7	Pre-training	-	-	-	-	-	15.86±2.32
		Post-training						13.24±1.75
	Male judokas (control) n=7	Pre-training	-	-	-	-	-	15.41±2.08
		Post-training						13.58±1.91
Franchini et al., 2009 [16]	Male judokas n=9	Active recovery after match	27±2	-	-	11.36±2.13	11.51±2.42	-
		Passive recovery after match	26±3	-	-	13.66±2.94	14.01±2.70	-

Wolska et al [42] was to determine the correlation between the index of the SJFT and the parameters of aerobic and anaerobic capacities in women judokas during the preparation for the competitive period. The results of the correlation analyses between the somatic indexes and performance in the SJFT suggest that shorter women competitors and with lower FFM (kg) were able to execute more throws in the SJFT. The correlation analysis between aerobic and anaerobic capacities and performance from the SJFT showed significant relations.

Wolska-Paczoska [43] continued previous research with an analysis of exercise-training level for female judokas from 16 to 18 years old. The correlations between aerobic and anaerobic capacities as well as three series of SJFT throws were analyzed and the results showed statistically significant correlations.

Smulski et al [34] completed the survey in this series by analyzing correlation between indices of the general and sport-specific preparation with the age-somatic parameters of elite female judo competitors during the preparation for the competitive period. In conclusion, the authors stated that the highly qualified female judokas who had smaller body height as well as lower absolute content of fat and liquid components in the body demonstrated a higher level of sport-specific preparation in the SJFT.

Radovanovic et el [27], performed the SJFT in order to determine the effect of the two-week creatine monohydrate supplementation and a specially designed training program of aerobic power and body composition in judo athletes. After the applied training program, no statistically significant differences were found between creatine (C) and placebo (P) group in SJFT values. Also, Radovanovic et al [28] used the SJFT to investigate the effect of training on oxidative stress biomarkers in judokas. SJFT index values were statistically significantly lower after 12-weeks preparatory period in control (C) and experimental (E) groups. Authors explained such a result as an improvement in performance of specific judo techniques. During the preparatory period, judokas from E group were involved in strength and endurance training, while C group were involved in the same strength training. Markers of oxidative stress showed that the values of erythrocyte malondialdehyde and plasma catalase in the experimental group statistically significantly increased especially when compared with the control group.

In order to verify that active recovery (AR) after a judo match resulted in a better performance as compared to passive recovery (PR), Franchini et al [16] used four-upper Wingate test (WT), SFJT and another match. In conclusion, authors' results indicated that the minimal recovery time reported in judo competition (15min) was long enough for sufficient recovery in the WT and in a specific high-intensity test (SJFT).

Table 4. SJFT results in sports which have similarities with judo fight

Study	Athlete characteristics; sex	Variables					
		Total of throws	HR after (bpm)	HR 1min after (bmp)	Lactate 3'	Lactate 5'	Index
Trivic, 2008 [29]	Female judokas n=14	29.1±2.3	182.7±6.6	153.2±12.8	6.4±1.5	8.5±2.5	11.5± 0.8
	Female samboist n=27	24.6±2.2	181.1±7.3	150.8±15.5	6.9±1.8	8.9±2.0	13.6± 1.6
Sterkowicz-Przybycien, 2009 [40]	Ju-jitsu coaches (master) n=14	22.7±1.38	179.9±13.6	158.1±13.2	-	-	14.91±1.22

The Special Judo Fitness Test is a recognized tool used also in judo-related disciplines, such as sambo and jujitsu (Table 4). Trivic [29] found statistically significant differences between female judo and sambo elite competitors. Total number of throws was statistically higher in female judokas with lower lactate concentration in third minute of recovery as compared with female sambo athletes. Based on the obtained results in sambo female competitors, the researcher was of an opinion that this test could be applied to evaluate and monitor the training process and progress in sambo competitors.

Sterkowicz-Przybycien [40], investigated special fitness preparation among jujitsu coaches using the SJFT. Results did not reveal any statistically significant correlation between the results of the conducted fitness test and age, training experience and BMI. The researcher concluded that the SJFT was a good indicator for strengths and weaknesses in fitness preparation in jujitsu participants.

Table 5. Classificatory norms for total number of throws, heart rate (after and 1-min after) and index in the Special Judo Fitness Test (n=141) [17]

Classification	Variables			
	Total of throws	HR after (bpm)	HR 1min after (bmp)	Index
Excellent	≥29	≤173	≤143	≤11.73
Good	27-28	174-184	144-161	11.74-13.03
Average	26	185-187	162-165	13.04-13.94
Poor	25	188-195	166-174	13.95-14.84
Very Poor	≤24	≥196	≥175	≥14.85

HR – heart rate

Based on classificatory norms [17] (Table 5), it is possible to classify physical fitness of judo athletes and monitor their training progress which can help both coaches and athletes. In addition, application of these norms could be used in rehabilitation process.

DISCUSSION

Several fitness tests have been developed for judo practitioners that provide both valid and accurate information on the competitor's ability to exert effort [30, 31], but the most popular and best researched is the SJFT. The SJFT showed reliability with a low measurement error [20], applicability and sensitivity in training monitoring [11, 23], even with high-level (elite) judokas [12]. Furthermore, this test showed differences between judokas of different fitness levels [14, 38], in addition to high correlations compared to well-controlled laboratory tests [10, 36]: it was also highly correlated to number of attacks during a judo match [13].

A specific judo fitness test can be important for coaches and athletes to control the performance status and to have an indication of which aspect should be improved. In addition, the SJFT provides important information on competitors' ability to exert effort and allows coaches to compare current to previous results and to other male judokas (Table 1). According to the authors [18], by using the SJFT, coaches evaluate mainly the judokas' anaerobic alactic system. In view of the fact that judo is a sport that highly depends on glycolitic pathway, there is an elevated blood lactate concentration after combat. Artioly et al [1], investigated whether the increase in blood lactate was related to the performance in the SJFT. After the SJFT was completed, the blood was drawn from the fingertip and analyzed immediately for lactate by the procedures of reflectance photometry. The level of blood lactate measured in the third minute after the test was recorded as La3, and the level of lactate measured 5 minutes after the test was recorded as La5.

Miarka and associates [26] compared the acute short-term effect of plyometric exercise, combined strength and plyometric exercise (contrast) and maximum strength performance in the SJFT. Results of their study suggest that contrast and plyometric exercise performed before SJFT can result in improvement in the test index and anaerobic power in judokas.

The Special Judo Fitness Index as an individual judo participant's score may also serve as one of the criteria in the selection of the intensity in his or her individual exercises, in line with the proposition that the lower the SJF Index, the greater the competitor's effort capacity. This test has also been used to determine the fitness profile for female judokas (Table 2). It should therefore become one of the basic instruments of monitoring the training progress especially in highly qualified male and female competitors. On the basis of the previous research data (Table 3), the importance and wide application of the SJFT in different field of research such as supplementation is obvious [39]. Sterkowicz and associates [39] concluded that the results obtained during the SJFT depended not only on energy resources but also on the exercises which improved the technique of performing typical grip-and-throw judo actions despite the ensuing fatigue. The special judo fitness test is suitable not only for judo competitors, but also for a sport similar to judo. In judo-related skills (Table 4), the application of the specific judo fitness test was proved to be useful although the achieved results of the test were weaker in comparison with judoka results. Despite this fact, SJFT could be used in future with new normative data for presented skills related to judo.

Using the SJFT norms (Table 5) the level of judoka preparation can be accessed as excellent to very poor (based on Total of Throws and Index in SJFT). Presented norms can help coaches using the SJFT to classify their athletes and to monitor their physical fitness progress [17], but there is a need for the development of classificatory tables for female judokas as well as for different weight categories.

CONCLUSION AND PRACTICAL APPLICATION

As a result of the SJFT material collected and presented here, the test seems adequate and reasonable for testing all levels of competitors in judo as well as in similar sports. Undoubtedly, the SJFT could be alternatively used to evaluate the effort tolerance in judokas, especially under circumstances where the laboratory facilities are not available. The special Judo Fitness Test provides important information on competitors' ability to exert effort. Therefore, it should become one of the basic instruments in monitoring the training progress of highly qualified competitors.

The Special Judo Fitness Test is suitable not only for competitors in judo but in sports that have similarities with judo as well.

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Serbian Journal of Sports Sciences