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review article

# Especific evaluation in judo: a review of methods

## *Avaliação específica no judô: uma revisão de métodos*

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**Abstract** – The aim of this study was to analyze the judo specific tests present in the literature, including the variables obtained from these and their use as performance markers in judo matches. To develop of this study we considered original articles indexed from 1990 to 2011, using electronic data bases Scopus®, SciELO®, ScienceDirect® (Elsevier) and PubMed®. The keywords used for research were: judo, performance, aptitude tests and their combinations. After analyzing the articles deemed eligible, we elected four tests (studies) that considered all criteria: a) Special Judo Fitness Test (SJFT), b) endurance test of Azevedo et al. (2007), c) Uchikomi Fitness Test - UFT and d) Santos Test. All tests have the judo motor skills for the identification of physiological variables, however, its use depends of the researcher's purpose. The SJFT can be used for the identification of anaerobic and aerobic capacity as well as being able to induce glycolytic and aerobic demand similar in the judo match. The Azevedo et al. endurance test needs a validation process based in the gold-standard to maximal lactate steady state to be a reliable tool in the obtain the aerobic capacity. The UFT and the Santos Test reproduce some judo match characteristics, but still need more original studies to be considered as performance markers.

**Key words**: Aptitude tests; Judo; Performance.

**Resumo** – *O objetivo deste estudo foi analisar os testes específicos para o judô presentes na literatura da área, destacando as variáveis obtidas a partir destes e a sua utilização como indicadores de desempenho nos combates. Para o desenvolvimento deste estudo, foram considerados artigos originais indexados no período de 1990 a 2011, utilizando as bases eletrônicas de dado Scopus®, SciELO®, ScienceDirect® (Elsevier) e PubMed®. Os unitermos empregados para a busca foram: judô, desempenho, testes de aptidão e suas combinações. Após a análise dos artigos considerados elegíveis, foram selecionados quatro testes (estudos) que atenderam a todos os critérios: a) Special Judo Fitness Test (SJFT); b) teste de endurance de Azevedo et al. (2007); c) Uchikomi Fitness Test - UFT e d) Santos Test. Todos os testes analisados apresentam a especificidade dos gestos motores do judô para a identificação das variáveis fisiológicas, entretanto, a sua utilização depende do objetivo do pesquisador. O SJFT pode ser utilizado para identificação da capacidade anaeróbia e aeróbia, além de ser capaz de induzir a uma demanda glicolítica e aeróbia semelhante às impostas pelo combate de judô. O teste de endurance de Azevedo et al. necessita de uma processo de validação com base no padrão-ouro para máxima fase estável de lactato, a fim de que possa ser uma ferramenta confiável na obtenção da capacidade aeróbia. O UFT e o Santos Test reproduzem algumas características presentes nos combates, no entanto, ainda precisam de mais estudos para serem considerados como marcadores de desempenho nos combates.*

**Palavras-chave**: *Judô; Desempenho; Testes de aptidão.*

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## INTRODUCTION

Judo is an acyclic sport whose performance is complex to explain, because it may be determined by a combination of different physical abilities, as well as technical, tactical and psychological aspects[1-3]. Considering that a match can last a few seconds or up to eight minutes (5 min of match + 3 min of golden score), the physical condition is difficult to describe by single physiological model that quantifies effort[4]. Thus, there is no consensus in the literature about a marker that could be used as a performance predictor and a variable of training control.

The analysis of temporal aspects of a judo combat we can highlight some characteristics common to most matches that can contribute to the explanation and use of a performance marker. Hernádez-García et al.[5] have analyzed temporal parameters according to the new rules of judo and have observed that the number and the duration of pauses decreased and the duration of work sequences increased when compared to the old rules. These features transformed a judo match into something even more intense, in which some physical abilities, such as aerobic and anaerobic fitness, become extremely important to performance.

Several recent studies[5-9] have shown that lactic anaerobic metabolism has been very demanded during match simulations, evidenced by high concentrations of blood lactate after combats (between 8 and 14 mmol.$L^{-1}$), although these studies did not compute the contributions of the other energetic systems. On the other hand, aerobic capacity and power are considered important, because they were related to a higher blood lactate removal after match[1,10] and to a high number of throws (projections) in a specific test[1]. Moreover, Gariod et al.[11] verified that more aerobically trained judokas had higher phosphocreatinine resynthesis, which could generate higher recovery in the intervals during the match. Aerobic capacity may be considered a determinant of performance in intermittent sports, due to its role in the recovery between high-intensity efforts, as also observed in previous studies[12-14].

In addition to the energy requirement, performance in judo may be attributed to neuromuscular factors. During the combat, constant dynamic changes occur due to athletes' movements, and judoka need a combination of strength and endurance during grip to control the distance between him and his opponent[15]. Moreover, attack actions require high levels of lower limbs muscle power [6,16], mainly in the application of some specific projection techniques.

Considering these aspects, some specific tests that analyze physiological and neuromuscular demand in judo combats have been developed, aiming identify efficient evaluation methods and, based on that, improving physical training methods. Although judo is broadly wide spread all over the world, there is a need of specific tests for this sport, and, among those already developed, many doubts remain regarding the variables measured in each test and what they really represent in the athletes' performance.

Furthermore, can the variables obtained from these tests be considered indicators of performance in the match? Can they be used in the control of training effects?

In an attempt to answer these questions, this study aimed to analyze the judo specific tests present in the literature, highlighting the variables obtained from these tests and their use as performance markers in judo matches.

To develop the present study, we analyzed original articles that approached the subject in a clear and objective manner. A review of indexed articles from 1990 to 2011 was performed, using four electronic databases: Scopus®, SciELO®, ScienceDirect® (Elsevier) e PubMed®. The keywords selected for article research, according to the health science descriptors (DeCS, Health Sciences Descriptors) were: *judo, performance, aptitude tests*. The operator "AND" was employed to combine the descriptors and terms used for tracking publications.

The research on the electronic databases was performed in October 2011. After the first analysis, with the evaluation of the titles, 36 articles were deemed eligible for the second phase of this revision, which consisted of reading the abstracts. After they were evaluated regarding their relevance to the aim of this study, the references that met inclusion criteria were read in full. In the end, four studies met all inclusion criteria. To define which of them would be part of the revision, the following criteria were adopted: a) the study should be original; b) it should present judo specific tests that included validity indices; c) it should have been published between 1990 and 2011; d) it should mention some of the descriptors (keywords) in its title or in its abstract. Abstracts from scientific events were excluded.

## Judo specific tests

The four tests selected for analysis were: a) Special Judo Fitness Test (SJFT), proposed by Sterkowicz[17]; b) endurance test of Azevedo et al.[4]; c) *Uchikomi* Fitness Test (UFT), developed by Almansba et al.[18]; and d) Santos Test, developed by Santos et al.[3].

## Special Judo Fitness Test

The Special Judo Fitness Test (SJFT) was developed by Sterkowicz[17] and described by Franchini et al.[19]. Since then, it has been used in different investigations on judo[1,20-25]. The SJFT consists of a test in which the judoka must project (throw) his opponents as fast as possible and is divided into three periods: 15, 30 and 30 s, with 10-s intervals among them. During each period, the executor throws two partners (6 meters apart from one another) as many times as possible, using the *ippon-seoi-nage* technique. The athlete's heart rate (HR) is recorded immediately after the test and 1 min later. From the number of computed throws, together with HR values, an index is calculated on the basis of the following equation:

$$Index = \frac{HR_{End}(bpm) + HR_{1\ min}(bpm)}{throws(n)}$$

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

The smaller the index, the better the performance in the test. Test performance can be improved by an increase in the number of throws during the periods, which represents an improvement in velocity, anaerobic capacity, and/or efficiency in the execution of the attack; a lower HR at the end of the test, which represents better cardiovascular efficiency for the same effort (equal number of throws); a lower HR one minute after the test, that is, better recovery, which represents an improvement in aerobic capacity; or a combination of two or more of the abovementioned items[25].

It is important to highlight that the SJFT presents higher specificity of movements but less possibility of measurement of physical performance in relation to other less specific but more accurate tests[25]. Even so, according to a validation study of the SJFT[26], the test index was correlated with indices of aerobic and anaerobic fitness. Correlations were observed between the index and maximal oxygen uptake ($VO_2$max) (r = 0.73), running time on the treadmill (r = 0.84), and anaerobic threshold velocity (vAT) (r = 0.66). Regarding anaerobic fitness, the index was correlated with relative total work in the Wingate test (r = 0.71). The number of throws was significantly correlated with relative total work in the Wingate test (r = 0.71), fatigue index (r = -0.52), running time on the treadmill (r = 0.60), and vAT (r = 0.67). HR measured 1 min after the test was correlated with running time on the treadmill (r = -0.69), running distance (r = -0.69), and $VO_2$max (r = -0.63).

The SJFT has classificatory norms concerning the variables measured in the test (HR after the test, HR 1 min after the test, number of throws, and index), as described by Franchini et al.[23] (Table 1). Classification criteria are: very poor, poor, average, good, excellent.

**Table 1**. Classificatory norms from the Special Judo Fitness Test.

| Classification | Variables | | | |
|---|---|---|---|---|
| | Throws (n) | $HR_{end}$ (bpm) | $HR_{1min}$ (bpm) | 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 |

Note: HR – heart rate; Source: Franchini et al.[23]

## Endurance test of Azevedo et al.[4]

Azevedo et al.[4] proposed an endurance test specific for judokas, based on the *uchi-komi* movement (drill of techniques without projection) and an adaptation of the lactate minimum test proposed by Tegtbur et al.[27]. The test consists of an increment in workload, with athletes performing 8 bouts

of 1-minute *uchi-komi* of the *ippon-seoi-nage* technique at intensities corresponding to 8 s, 7 s, 6 s, 5 s, 4 s, 3 s, 2 s e 1 s for each drill. The intensity is controlled by sonorous stimuli. Between each stage, 25 µL of blood sample are collected from the earlobe for analysis of blood lactate concentration. The aim of the test is to evaluate the aerobic capacity of judokas using the lowest blood lactate concentration (lactate minimum).

Based on the results of the study by Azevedo et al.[4], no significant differences were found either between lactate concentrations at lactate minimum threshold (test of Tegtbur et al.[27]) and in the *uchi-komi* test or between HR at lactate minimum thresholds in both tests.

## Uchikomi Fitness Test (UFT)

Almansba et al.[18] developed the UFT with the purpose of evaluating athletes' effort during judo combats in both qualitative (compliance with the several phases observed in matches) and quantitative (effort-pause relationship) terms, providing information on the specific aptitude of the judoka.

During the test, the judo player must complete six levels of *uchi-komi* and traction in a *judogi* attached to a fixed bar. The duration of *uchi-komi* is fixed equal to 20 s, the traction ranges from 6-18 and increasing 3 s per level at breaks that ranges from 4-12 s, with an increase of 2 s per level. The athlete should perform the effort sequence at the maximum possible intensity, maintaining the correct technique of the movement. Work sequences are the following (Figure 1): a) isometric phase of upper limbs (grip): the attacking judo player (*tori*) must remain suspended by a *judogi* (uniform used in judo) stuck on a horizontal bar, with elbows flexed; b) dynamic and explosive phase: the judoka gets down from the horizontal bar and starts to do *uchi-komi* with two opponent players (*uke*) 2 m apart from each other, using two projection techniques, *ippon-seoi-nage* (arm technique) and *sode-tsuri-komi-goshi* (hip technique). The intensity is controlled by sonorous signals. The total number of *uchi-komi* achieved and the number in two better bouts are computed and the athlete's HR is monitored during the test.

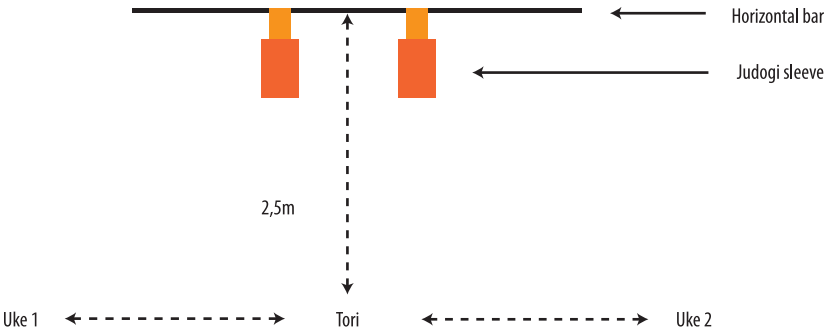


**Figure 1**. Representation of UFT design.

Regarding test validity, a significant correlation was found between muscular power obtained in the vertical jump test (Sargent test) and the

number of *uchi-komi* achieved in the judo test (r = 0.52). Another correlation was found between the number of *uchi-komi* and anaerobic power and capacity obtained in the Australian shuttle test (r = 0.86; r = 0.88, respectively). The strong correlation between HR during the judo test and HRmax obtained in a progressive test (r = 0.88) shows that the proposed test meets the criteria for maximal test.

In another study[28], the reliability of the UFT was performed, comparing the following variables: total number of *uchi-komi*, sum of the number of *uchi-komi* at the two best bouts of the test, HRmax (absolute and relative), and mean HR. The test was performed three times by the same athletes, with 48-h intervals between the tests, and no significant difference was observed in any of the variables. The intraclass correlation index (ICI) was between 0.88-0.99 for the variables investigated, which is considered as high reliability.

## Santos Test

Santos et al.[3] proposed a test that uses actions and conditions specific of a judo combat to determine the aerobic-anaerobic transition zone. To start the test, two judokas in the same weight category should be face to face. The test is composed by two phases: an active and a passive one. The active phase is performed in three bouts, in which the athlete uses his preferred technique(s) (used in competition). In the first bout, the judo player raises his opponent from the ground; in the second one, he completely unbalances his opponent; and, in the third one, he chooses if he prefers to raise his opponent from the ground or completely unbalance the opponent. Each bout is performed in 40 s, 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 opponent from the ground, unbalance the opponent and/or complete each bout in 40 s, the test is finished. In the passive phase, two judokas move on the tatami gripping their *judogi* during 15 s, representing the movements that occur during a combat. The reason for the test being divided into active and passive phase is the intermittent nature of judo combats. In this test, the effort-pause ratio is given as 40-15 s, respectively.

For test validation, variables obtained from a treadmill incremental test were used as reference. In Santos Test, oxygen uptake ($VO_2$) and HR were measured throughout the test, and blood samples were collected before the test, at the intensity relative to the ventilatory threshold (identified in real time with a gas analyzer), and 5 min after the end of the test, in order to measure blood lactate concentrations. No significant differences were found in variables HRmax, HR at the anaerobic threshold, $VO_2$max, and lactate maximum between the Santos Test and the incremental test on a treadmill. As for reliability, no significant differences were found in any of the variables (HRmax, HR at the anaerobic threshold, $VO_2$max, and lactate maximum) between the two evaluations of the test separated by a 7-day interval.

The aim of the Santos Test is to identify the aerobic-anaerobic transition zone, which is considered a key parameter for the improvement of aerobic capacity[3]. In the test, the initial phase of this zone can be obtained by measuring the HR at the moment when the "HR x intensity" curve looses linearity, following the criteria by Conconi et al.[29]. In this phase, there is a fast increase in blood lactate concentrations, which indicates a higher threshold between blood lactate production and removal[30]. Other parameters can also be identified in the test, such as HR at the end of the test (corresponding to aerobic power) and the number of repetitions performed by the athletes in the active phase.

## DISCUSSION

All tests analyzed in this study used specific movements of judo such as *uchi-komi*, throws, displacements, *judogi* grip, among others, to identify the variables that intervene in performance.. However, some tests reproduce only training actions, while others also use actions and characteristics involved in combats.

The SJFTis one of the most used evaluation tests in judo, thus, provides more information on its measured variables. As for the energetic cost involved in the test, Franchini et al.[31] observed greater alactic anaerobic participation (42.3%), followed by anaerobic lactic (29.5%) and oxidative (28.2%) contribution, the last two of which with no statistical difference. The higher alactic contribution, according to the authors, seems to be a consequence of the high-intensity efforts performed during the test and of its intermittent nature, characteristics also reported in previous studies involving intermittent exercises[11-14]. The analysis of blood lactate concentrations after the SJFT and of oxygen uptake during the test shows similarities of these variables to thoseobtained during combats[31]. This points out that the SJFT is able to induce glycolytic and oxidative demands similar to those of a judo combat.

When the variables obtained in the SJFT are analyzed, significant correlations are reported between number of throws and anaerobic capacity indices[26], aerobic power and capacity[1,16,26], and muscular power[1]. This variable has also been associated with specific situations of this sport, such as number of attacks during a combat[21], and is also able to differentiate judokas of different competitive levels[22]. HR obtained 1 minute after the SJFT is significantly correlated with aerobic power markers [26], although it does not seem to be related with aerobic capacity indices (vAT and blood lactate removal after match)[1]. However, special care should be taken when using recovery HR as an aerobic capacity indicator. According to Achten and Jeukendrup[32], the decrease in HR during the rapid recovery phase (1 min) does not seem to be determined by aerobic fitness, but mainly by neural mechanisms related to motor cortex activity.

Moreover, it is important to highlight that the SJFT presents some limitations regarding the neuromuscular demand that occurs during a

combat. In a match, the judoka requests mainly upper limbs compared to lower limbs[31], because he depends on the "grip" on the *judogi* to apply any projection technique, as well as ground immobilizations. On the other hand, in the SJFT the lower limbs have higher neuromuscular demand than upper limbs, since the judo player must move as fast as possible towards the other opponent to project him (6-m distance between the opponents). Thus, in some cases, the athlete can finish the test with strong peripheral fatigue in lower limbs, differently from what happens in combats, when upper limb muscles are the most demanded.

The endurance test of Azevedo et al.[4], adapted from the lactate minimum test of Tegtbur et al.[27], uses increments in workload that are technique drills (*uchi-komi*) to measure anaerobic capacity. Blood lactate response to exercise is widely used in incremental protocols because it is sensitive to training and serves as aerobic performance predictor[1,10,12,26]. However, some limitations should be pointed out in relation to this test, such as the fact that it is not validated as the gold standard for determining maximal lactate steady state. Other methods, such as lactate minimum and anaerobic threshold, present higher variability in lactate individual values, which may not accurately represent the higher intensity between blood lactate production and removal[33]. Other factor that should be considered in the validation of the test of Azevedo et al.[4] is the reduced sample size (six judokas), because, according to Hopkins et al.[34], small samples reduces the power of statistical tests, since they increase typical errors. In this sense, further studies are needed for the test to be used as a reliable tool to measure aerobic capacity through specific actions of the sport.

The UFT reproduces the intermittence, the high intensity and the sequence of actions performed in combats (grip phase and technique drill). Thus, the UFT seems to be a good alternative for obtaining a performance marker for judo, because it is associated with both neuromuscular effort and cardiorespiratory adaptations[28]. However, it is necessary to investigate if energetic cost for the UFT is similar to that for judo combats, and also if there is a relationship between test performance and the number of drills in competitive matches or the winning percentage in these matches. It is important to emphasize that the UFT is not intended to measure intervening physical capacities, but mainly to measure the athletes' physical fitness in similar conditions to those of a real combat. An aspect that must be highlighted is the small sample size (seven judokas) used in the reliability study of the UFT[28], which reduces the power of the inferential tests[34]. Therefore, a new study with a larger sample size would be important to test UFT reliability.

The Santos Test uses a progressive workload sequence to identify the beginning of the aerobic-anaerobic transition zone. The actions performed in the test consist of raising the opponent off the ground and/or unbalance him using a technique of the athlete's preference (the same used in competitions). This stage is called active phase, but the test also has a passive phase, which consists of moving on the tatami gripping the *judogi*.

This characteristic of alternating effort and pause has been observed in judo combats. In male matches, some studies[5,35,36] found periods of 22-24 s of effort, considering standing fight, and 5-7 s of pause. Castarlenas and Planas[37] observed values higher than 35 s of effort and 12 s of pause. In the Santos Test, a ratio of 40-15 s is used, slightly higher than that of the mentioned studies.

Based on specific tasks, such as the number of repetitions obtained in the Santos Test, it is possible to prescribe exercises at the intensity of the anaerobic threshold or of the aerobic power, using variables as simple as HR and blood lactate concentrations. The test was initially designed for the assessment of high-level athletes[3], but it has been observed that this test can be used in any competitive level[38].

Although the Santos Test presents characteristics from judo combats, such as intermittence and effort-pause relationship, it is necessary to carry out studies that ascertain if the energetic cost involved in the test is similar to that of a judo combat. Furthermore, it is important to identify if there is a relationship between the number of repetitions in the test and the number of drills in competitive matches or the winning percentage in these matches. One weakness of the Santos Test is that the procedures are not presented in a totally clear manner, which can hamper the reproduction of the test by others researchers; for example, it is to understand what is performed during passive phase (moving on the tatami). Additionally, the indices presented in the two validation papers[3,38] generate some doubts regarding physical capacities to be evaluated.

Finally, although researchers and coaches seek for specific tests for each modality, in order to increase ecological validity, it is important to emphasize that the more specific a test is, the more difficult is to quantify the effort performed or to determine the physical ability involved. In judo, for example, the higher specificity is related to situations similar to those of a match, but, in this case, the possibility of measuring physical performance is lower, meaning that it is inferred through specific tasks of the modality, such as number of throws, number of *uchi-komi*, among others.

## FINAL REMARKS

All tests analyzed present the judo motor skills for the identification of physiologic variables; however, their use depends on the researcher's aim. The SJFT 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 a judo combat, being thus an important tool to evaluate the specific performance of the athlete. Considering endurance test of Azevedo et al., it needs to be validated on the basis of the gold standard for maximal lactate steady state to be a reliable tool for obtaining aerobic capacity. The UFT and the Santos Test reproduce some characteristics from combats, such as intermittence, high intensity and the actions performed in combats, but

still need more studies to be considered as specific performance markers.

All tests analyzed can be used to evaluate judo athletes and assess training effects; however, the interpretation of the results warrants further caution, since they are indirect markers of physical effort, which may hamper the identification of the physical abilities involved and the training planning. In conclusion, more original studies need to be carried out to test the existing methodologies, observing possible associations with physiological indices and/or situations of competitive match, as well as developing new judo evaluation protocols.

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