ORIGINAL ARTICLE
SCIENCE OF MARTIAL ARTS

# Can physical tests predict the technical-tactical performance during official judo competitions?

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

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**Received:** 08 August 2017; **Accepted:** 20 October 2017; **Published online:** 27 December 2017

**AoBID:** 11715

## Abstract

**Background & Study Aim:** Judo is an Olympic sport with an intermittent nature due to the large variety of technical-tactical actions and constant interruptions during competition. Technical-tactical analysis of judo matches may be performed using different indicators. This study aimed is the relationship between generic and judo-specific tests and technical-tactical performance in male judo athletes and to identify the physical variables that may explain the technical-tactical performance.

**Materials & Method:** Twenty-two judo athletes were evaluated in two stages. First, physical tests – countermovement jump (CMJ), handgrip strength, Special Judo Fitness Test (SJFT), Judogi Grip Endurance Strength Test isometric ($JGST_{ISO}$) and dynamic ($JGST_{DIN}$) – were performed. Second, matches were recorded during competitions for technical-tactical analysis. Pearson's linear correlation and multiple linear regression analysis were used with the level of significance set at 5%.

**Results:** The main results showed correlation of the effectiveness index with the number of throws in the second series of SJFT ($r = 0.44$, $p = 0.03$) and $JGST_{ISO}$ ($r = 0.43$, $p = 0.04$). The number of attacks was correlated to $JGST_{ISO}$ ($r = 0.45$, $p = 0.03$) and the effective time was correlated with all kinetic indicators in the CMJ ($r = 0.52$ to $0.58$, $p \leq 0.01$). The predictive power and explanation of variance were low for all variables (26-31%).

**Conclusions:** The athletes with higher isometric endurance grip strength ($JGST_{ISO}$) performed a higher number of attacks and showed higher effectiveness in competition. Also, the athletes with higher (SJFT) showed higher effectiveness during the matches, and the judokas with higher muscle power (CMJ performance) showed higher effective time in the combat bouts. Despite this, only a small part of the technical-tactical performance was explained by the physical tests.

**Keywords:** anaerobic capacity • effectiveness • endurance strength • judogi • tori • uke



**Conflict of interest:** Authors have declared that no competing interest exists

**Ethical approval:** The study was approved by the Research Ethics Committee of the Federal University of Santa Catarina (number: 63053516.4.0000.0121)

**Provenance & peer review:** Not commissioned; externally peer reviewed

**Source of support:** Departmental sources

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**Effectiveness** – means the capability of producing an effect, and it is most frequently used in connection with the degree to which something is capable of producing a specific, desired effect.

**Efficiency** – *noun* 1. the ability to make a physical movement with a minimum of unnecessary effort 2. a comparison of the effective or useful output to the total input in any system [38].

**Tactics** – *plural noun* the art of finding and implementing means to achieve immediate or short-term aims [38].

**Technique–** *noun* a way of performing an action [38].

**Combat sports** – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [38].

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

**Judogi** – is the formal Japanese name for the traditional uniform used for judo practice and competition [39].

**Hand grip strength** – is the result of the maximum force that each individual is able to exert under normal mechanic conditions through the voluntary flexion of all finger joints, thumbs, and wrists [40].

**Tori** – the person who applies a technique in *jūdō* training. The receiver of the technique is referred to as *uke* [41].

**Seoi nage –** back throw (belongs to the group *te waza*, i.e. hand throwing techniques).

**Ippon seoi nage –** single back throw.

**Yuko** (**yūkō**) **–** a score in judo competition.

**Ippon** – one point. Achieved through the execution of a valid technique on the opponent [41].

**Muscle strength –** essential and basic physical capacity in combat sports by which the body is moving status is modified [42].

## INTRODUCTION

Judo is an Olympic sport with an intermittent nature due to the large variety of technical-tactical actions and constant interruptions during competition [1]. Technical-tactical analysis of judo matches may be performed using different indicators, such as temporal structure (time actions) [1], technical variety [2, 3] and scores, penalties, or a combination of different elements [4–6]. Some indices have been proposed to evaluate athletes' performance in competitions, such as efficiency and effectiveness indices, which consider the magnitude of scores and the number of matches in the competition [7] and the scores and number of techniques applied during combat bouts [8], respectively.

Good technical-tactical performance during matches depends on the level of physical fitness as the athlete needs to maintain technical efficiency during consecutive matches performed at high intensity. The main physical fitness determinants of judo performance are muscle strength and the power of the upper and lower limbs [9], as well as aerobic and anaerobic aptitude [10]. The upper limbs are engaged in constant pulling and pushing movements to maintain handgrip on the *judogi* and prepare to attack [11], while the lower limbs undergo constant efforts involving power actions (i.e. the stretch-shortening cycle – SSC) [12]. This has been confirmed by previous studies that observed a decrease in handgrip strength [13], external/internal shoulder rotation torque and muscle power in the lower limbs [14] after a simulated tournament. Aerobic power and capacity are also considered relevant in judo performance as they are related to recovery during the short rest periods between efforts (high-intensity intermittent efforts) [15, 16]. Anaerobic power and capacity are also important in the decisive actions, which depend on powerful movements [10].

The neuromuscular or physiological capacities of athletes can be assessed through generic or sport-specific tests. However, the high specificity of tests may make it difficult to quantify effort or determine the physical capacities relevant to performance [16]. Generic tests have been used to classify judo athletes and non-athletes by using, for example, handgrip tests [17], shoulder and elbow isokinetic torque tests [18] and vertical jump tests [19, 20]. Regarding the judo-specific tests, the Special Judo Fitness Test (SJFT) and Judogi Grip Strength Test (JGST) may be highlighted. The SJFT reproduces similar actions to judo combat and estimates aerobic and anaerobic capacities, besides reproducing physiological demands similar to those during matches [21]. The JGST quantifies the isometric and dynamic endurance strength in the upper limbs [11]. Some studies have shown that performance measured in judo-specific tests is correlated to performance measured in generic tests. For example, the number of throws in the SJFT has been found to be correlated with aerobic and anaerobic indices [22, 23], as well as vertical jump performance [12]. The JGST (both isometric and dynamic tests) have been found to be correlated with handgrip strength [24] and elbow isokinetic torque [25].

Few studies have investigated the relationship between generic or judo-specific tests and technical-tactical performance over competitions. Lech et al. [26] found a positive correlation between shoulder, hip, elbow and knee peak torques and the percentage of scores in competition. Another study verified a significant correlation between aerobic indices and effectiveness in judo matches [27] and between technical-tactical actions during simulated combat and total work in the Wingate test and number of throws in the SJFT [23]. However, to the best of our knowledge, no studies have investigated the relationship between technical-tactical performance over competitions and the judo-specific tests widely used, such as SJFT and JGST. In addition, identifying the magnitude with which physical fitness may be related to performance in official competitions is important for technical-tactical planning during the competitive period.

This study aimed is the relationship between generic and judo-specific tests and technical-tactical performance in male judo athletes and to identify the physical variables that may explain the technical-tactical performance.

The main hypothesis of this study is that there will be a higher correlation of technical-tactical performance with judo-specific tests than with generic tests as the former reproduce characteristics close to combat situations.

## MATERIAL AND METHODS

### Participants

Twenty-two male judo athletes (19.08 ±1.09 years age, 74.19 ±15.45 kg of body mass, 177.45 ±9.37 cm of height, 14.26 ±5.16% of body fat) volunteered to participate in this study. The athletes had a practice time of 10.14 ±3.0 years and purple, brown and black belts. They were training regularly (physical, technical and tactical training) 4-5 times a week during the evaluation period. The athletes competed at the state and national levels. Participants were selected based on the following criteria: no reported musculoskeletal disorder or injury that would influence their maximal physical performance, training regularly for the last five years and in the competitive period phase. All participants were older than 18 years and received a detailed verbal explanation of the purpose, methods and potential risks/benefits of the study. They then signed a written informed consent form agreeing to participate in the study.

This study was approved by the Research Ethics Committee of the Federal University of Santa Catarina (number: 63053516.4.0000.0121), in accordance with the Declaration of Helsinki.

### Design

The evaluations of athletes were performed in two stages: 1) anthropometric evaluation, generic and specific tests were conducted; 2) matches were recorded using video during competitions for technical-tactical analysis. In the first session, after the anthropometric evaluation, the participants were submitted to generic tests: countermovement jump (CMJ) and handgrip strength. After 20 minutes of rest, the JGST and SJFT were performed. All assessments were performed over a maximum of two weeks before the official competition (competitive period).

### Anthropometric assessment

Previously data collection, the following anthropometric variables were performed: body mass, height and skinfolds thickness. We used the equation proposed by Petroski et al. [28] to estimate body density, considering the sum of four skinfold thickness (triceps, subscapular, suprailiac and medial calf). Body fat was calculated using the Siri equation [29]. Body mass was measured using digital scale (0.1 kg accuracy), and height was assessed using a stadiometer scale of 0.1 cm accuracy.

### *Vertical jump assessment*

The participants performed a familiarisation/warm-up period involving 30s of hopping on a trampoline, three series of 10 hops on the ground and five submaximal CMJs. Then, participants performed the CMJ protocol, starting from a static standing position (vertical posture) and being instructed to perform a countermovement (descent phase) followed by a rapid and vigorous extension of the lower limb joints (ascent phase). During the jumps, participants were asked to maintain their trunk as vertically as possible, keeping their hands on their hips (akimbo). The athletes were instructed to jump as high as possible. The vertical jumps were performed on a piezoelectric force platform (model 9290AD, Kistler, Quattro Jump, Winterthur, Switzerland), measuring vertical ground reaction sampling at 500 Hz. Each participant performed three maximal jumps with a rest interval of 1 min between them. We took the average (mean) of the three jumps for analysis. From the analysis of the ground reaction force (GRF), the following variables were analysed, as defined in the literature [30]: jump height, calculated using the GRF dual integration method; peak power, i.e. the highest value of the curve obtained from the multiplication of the GRF by the velocity in the concentric phase of the jump, normalized by body mass; mean power, i.e. the mean value of the curve obtained from the multiplication of the GRF by the velocity in the concentric phase of the jump, normalized by body mass; maximum force, identified as the highest value obtained in the concentric phase of the jump, normalized by body mass; peak velocity, i.e. the highest value of the vertical take-off velocity. The reliability of the CMJ variables was calculated for the 3 trials and presented an intraclass correlation coefficient (ICC) ranging from 0.97 to 0.99 for all variables, thus showing high reliability.

### Handgrip strength test

The evaluation of handgrip strength was performed as suggested by Dias et al. [31]. The procedures were the same as those adopted by the American Society of Hand Therapy (ASHT): participants were seated with the spine erect, maintaining a knee flexion angle of 90°. The shoulder was positioned in adduction and neutral rotation, the elbow flexed at 90°, with the forearm in half-pronation and with a neutral grip. The athletes were instructed to hold the handgrip dynamometer (Carci®, SH 5001 model) and perform maximum effort for 3 s with each hand, with a rest period of 30 s between each trial. The highest strength value was used for analyses. The reliability of the handgrip test was first assessed using 3 trials, and the ICC was 0.93 for the right hand and 0.97 for the left hand, respectively.

### *Special Judo Fitness Test (SJFT)*

The judo athletes were submitted to the SJFT. Following a 5-min warm up, three athletes of similar body weight and height performed the test according to the following protocol: two judokas (*uke*) were positioned at a distance of 6 m from each other, while the test executor (*tori*) was positioned 3 m from the judokas to be thrown. The procedure was divided into three periods: 15 s (A); 30 s (B); 30 s (C) with 10-s intervals between them. In each period, the executor threw the opponents using the *ippon-seoi-nage* technique as many times as possible. The performance was determined based on the total throws completed during each of the three periods (A + B + C). The heart rate (HR) was measured immediately after the test and then 1 min later (Polar Vantage NV, Polar Electro Oy, Kempele, Finland). The index was calculated using the following equation:

$$\text{Index}\ (\text{beats.min}^{-1}\cdot\text{throws}^{-1}) = \frac{\text{final HR}\ (\text{beats.min}^{-1}) + \text{HR after 1 min after the test}\ (\text{beats.min}^{-1})}{\text{number of throws}} \quad (1)$$

### *Judogi Grip Endurance Strength Test (JGST)*

The athletes were familiarisation with the test by performing three submaximal repetitions on the *judogi* suspended on the bar. The athletes performed both the dynamic and isometric versions of the JGST. The dynamic evaluation ($JGST_{DIN}$) consists of holding the *judogi* rolled around the bar, with the elbow joint at maximal extension and performing an elbow flexion, moving the chin above the line of the handgrip. The athletes were asked to perform the maximal number of repetitions from a fully extended to a fully flexed elbow position as many times as possible. After a 15-min interval, the athletes performed the isometric test ($JGST_{ISO}$), which consists of sustaining the position (elbow flexion) for the maximal possible time. The chronometer was stopped when the athlete could no longer maintain the original position. The reliability of the JGST has been assessed in previous studies, presenting an ICC higher than 0.98 [11].

### *The technical-tactical analysis in competition*

All combat bouts during state-level competitions were filmed using two cameras (Sony Action Cam AS200), positioned to capture the total combat area and the movements of the athletes without interfering in the event. The videos were stored and separated according to each combat bout of the athletes evaluated. Subsequently, the combat bouts were analysed by a judo expert (black belt, 14 years of experience time) using the *Kinovea* software (0.8.15, ver. 2) to obtain the following variables:

a) Efficiency index: quantification of the points obtained during the competition considering the evaluation of the referees divided by the total matches, according to the following estimation [7].

$$\text{Efficiency} = \frac{(\text{number of ippon} \times 10) + (\text{number of wazari} \times 7) + (\text{number of yuko} \times 5)}{\text{total number of matches}} \quad (2)$$

b) Effectiveness index: relative representation of the use of techniques performed in the competition, calculated by dividing the number of scores obtained and the total number of techniques applied and multiplied by 100 [8].

$$\text{Effectiveness} = \frac{\text{number of scores}}{\text{number of techniques}}\ \text{x100} \quad (3)$$

c) Percentage of wins: number of wins obtained in each competition divided by the total number of matches multiplied by 100.

d) Effective combat time: actual working time of each combat bout.

The technical-tactical data were collected and analysed according to the rules current in 2016, i.e. the *yuko* score was computed over a match time of 5 min for male athletes.

### *Statistical analysis*

Data are reported as means and standard deviations (SDs). The Shapiro–Wilk test was used to verify data normality, and Pearson's linear correlation (normal data) or Spearman correlation (non-normal data) were used to verify the relationships between specific and generic tests and technical-tactical performance. We adopted the criterion of Hopkins [32] to classify the magnitude of effects through r: 0-0.1 (trivial), 0.1-0.3 (small), 0.31-0.5 (moderate), 0.51-0.7 (large), 0.71-0.9 (very large) and 0.91-1.0 (almost perfect). Moreover, multiple linear regression analysis was used with the following dependent variables: efficiency, effectiveness, the percentage of wins, effective time and attacks per match. The independent variables were those that showed a significant correlation

($p<0.05$), except variables correlated with the effective time. For these variables, we chose only the jump height (independent variable) as the other variables exhibited collinearity (power output, maximal force and peak velocity). We used the limits of 0.05 for entry of variables in the model and 0.10 for removal (entry method). The level of significance was set at 5%. These analyses were performed in the Statistical Package for the Social Sciences (IBM SPSS Statistics, USA).

## RESULTS

Tables 1-3 show the means and standard deviation of technical-tactical performance, as well as the generic and specific test performance.

There was a positive correlation of the effectiveness index with a number of throws in the second series of SJFT ($p = 0.038$, moderate effect) and $JGST_{ISO}$ ($p = 0.043$, moderate effect). The number of attacks was also correlated to $JGST_{ISO}$ ($p = 0.033$, moderate effect) (Table 4).

It is apparent that there are correlations between the effective combat time and jump height ($p = 0.009$, large effect), peak power ($p = 0.013$, large effect), mean power ($p = 0.004$, large effect), maximal force ($p = 0.006$, large effect) and peak velocity ($p = 0.004$, large effect). No significant correlations are found between technical-tactical performance and handgrip strength (Table 5).

We performed a multiple linear regression analysis and found a significant model only for effectiveness, effective time and number of attacks. The number of throws in the second series of SJFT ($SJFT_{30a}$) and $JGST_{ISO}$ explained 26% of the variance in effectiveness ($p = 0.05$). $JGST_{ISO}$ explained 29% of the variance in the attacks per match ($p = 0.01$). Moreover, the vertical jump height explained 31% of the variance in effective time ($p = 0.007$).

## DISCUSSION

Based on our results, the hypothesis was rejected as a smaller correlation was found between

**Table 1.** Mean and standard deviation (±) of technical-tactical and performance variables obtained during the competition.

| Technical-tactical variables (indicator) | Mean (±) |
|---|---|
| Efficiency (a.u.) | 9.14 ±4.04 |
| Effectiveness (%) | 26.35 ±13.74 |
| Percentage of wins (%) | 71.21 ±29.29 |
| Effective time (s) | 104.4 ±65.29 |
| Number of attacks per match (n) | 4.93 ±2.91 |

a.u. accepted unit

**Table 2.** Mean and standard deviation (±) of generic tests – CMJ and handgrip strength in male judo athletes.

| Generic tests (indicator) | Mean ± |
|---|---|
| Jump height (cm) | 44.42 ±5.25 |
| Peak power ($W.kg^{-1}$) | 47.32 ±4.91 |
| Mean power ($W.kg^{-1}$) | 26.32 ±3.38 |
| Maximum force ($N.kg^{-1}$) | 23.27 ±2.56 |
| Peak velocity ($m.s^{-1}$) | 2.69 ±0.17 |
| Handgrip right (kgf) | 49.43 ±11.11 |
| Handgrip left (kgf) | 48.41 ±9.40 |

**Table 3.** Mean and standard deviation (±) of specific tests – SJFT and JGST in male judo athletes.

| Specific tests (indicator) | Mean ± |
|---|---|
| $JGST_{ISO}$ (s) | 40.0 ±13.7 |
| $JGST_{DIN}$ (rep) | 14 ±6 |
| $SJFT_{15}$ (n) | 7 ±1 |
| $SJFT_{30a}$ (n) | 11 ±2 |
| $SJFT_{30b}$ (n) | 10 ±1 |
| $SJFT_{TOTAL}$ (n) | 28 ±3 |
| $SJFT_{INDEX}$ (beats.min$^{-1}$.throws$^{-1}$) | 11.7 ±1.5 |

JGSTISO: judogi grip strength isometric test; JGSTDIN: judogi grip strength dynamic test; SJFT: Special Judo Fitness Test.

**Table 4**. Correlations between the performance in specific tests (SJFT and JGST) and the technical-tactical performance.

| Variable (indicator) | Specific tests (indicator) | | | | | | |
|---|---|---|---|---|---|---|---|
| | $SJFT_{15}$ | $SJFT_{30a}$ | $SJFT_{30b}$ | $SJFT_{TOTAL}$ | $SJFT_{INDEX}$ | $JGST_{DIN}$ | $JGST_{ISO}$ |
| Efficiency (a.u.) | 0.08 | 0.02 | 0.01 | 0.07 | −0.21 | 0.36 | 0.06 |
| Effectiveness (%) | 0.09 | **0.44*** | 0.32 | 0.31 | −0.24 | 0.32 | **0.43*** |
| Percentage of wins (%) | 0.28 | 0.21 | −0.10 | 0.03 | −0.05 | 0.24 | 0.21 |
| Effective time (s) | 0.27 | −0.21 | −0.29 | −0.15 | −0.05 | 0.01 | −0.27 |
| Attacks per match (n) | −0.10 | −0.22 | −0.33 | −0.30 | −0.05 | −0.09 | **0.45*** |

*p<0.05; a.u. accepted unit

**Table 5.** Correlations between performance in generic tests (CMJ and handgrip strength) and technical-tactical performance.

| Variable (indicator) | Jump height (cm) | Peak power (W.kg$^{-1}$) | Mean power (W.kg$^{-1}$) | Maximum force (N.kg$^{-1}$) | Peak velocity (m.s$^{-1}$) | Handgrip right (kgf) | Handgrip left (kgf) |
|---|---|---|---|---|---|---|---|
| Efficiency (a.u.) | −0.16 | −0.97 | 0.07 | −0.15 | −0.94 | 0.14 | 0.10 |
| Effectiveness (%) | −0.65 | −0.087 | −0.10 | −0.16 | −0.10 | 0.45 | 0.12 |
| Percentage of wins (%) | -0.12 | 0.31 | 0.04 | 0.02 | −0.10 | 0.15 | 0.19 |
| Effective time (s) | **0.54*** | **0.52*** | **0.58*** | **0.56*** | **0.58*** | 0.21 | 0.19 |
| Attacks per match (n) | 0.10 | 0.22 | 0.22 | 0.19 | 0.15 | 0.35 | 0.54 |

*p<0.05; a.u. accepted unit

technical-tactical performance and judo-specific tests (moderate correlation) than generic tests (large correlation with CMJ performance).

The $JGST_{ISO}$ presented a moderate correlation with effectiveness and the number of attacks per match in competition (Table 4), indicating that athletes who present higher isometric endurance handgrip strength perform a higher number of attacks and show higher effectiveness in combat bouts. Effectiveness is a relative representation of the number of scores using the techniques applied, i.e. better effectiveness indicates higher scores with fewer techniques applied [8]. Isometric endurance grip strength is important during the combat bouts as the athletes should maintain the handgrip on the *judogi* and control the distance from the opponent [10]. The grip control of the opponent allows high balance control and represents an advantage in performing a higher number of throw techniques, especially with more efficiency [33]. No significant correlation was found between $JGST_{DIN}$ performance and technical-tactical variables. In contrast to isometric grip strength, which allows higher control of the opponent, dynamic grip strength is more related to the opponent's approach (pulling and pushing movements) [11]. In this case, athletes may be more unbalanced, presenting difficulties in performing the techniques with high efficiency, which explains the lack of correlation with the technical-tactical variables.

Regarding the performance for SJFT, a correlation was found between performance in the $SJFT_{30a}$ (number of throws) and effectiveness (Table 4), demonstrating that athletes who performed a higher number of throws in the second series of the SJFT were more effective in the competition. Better performance in the SJFT30a requires considerable on the part of the athletes [22]. Recently, Franchini et al. [21] analysed the energetic contribution during the SJFT and verified the higher anaerobic alactic contribution compared with both aerobic and glycolytic contributions. During the combat bouts, the decisive actions (high-intensity efforts) are determined mainly by phosphocreatine resources [34], while the contribution of the aerobic pathway increases over the match, and the glycolytic system seems to maintain a similar contribution over combat bouts [35]. Therefore, considering the findings of this study, it is possible to suggest that, mainly from the energy provided by the anaerobic alactic system, can exert a positive influence on effectiveness during a judo competition. The other SJFT variables ($SJFT_{15}$, $SJFT_{30b}$, $SJFT_{TOTAL}$ and index) showed no significant correlations with technical-tactical performance. We expected correlations between effectiveness and the total number of throws and 15 s and 30 s series but found none.

The effective time measured during the matches was positively correlated with kinetic indicators in the CMJ (jump height, power output, maximum force and peak velocity) (Table 5). The effective time is the actual working time of each combat bout, composed of movements in preparing attacks, handgrips, attacks, contra-attacks, time spent on groundwork, etc. During the matches, the athletes make explosive and powerful efforts with the lower limbs and engage in sudden directional changes for attack or defence [9]. A previous study [12] found a correlation between the number of throws in the SJFT and jump height, probably explained by the specific judo techniques involving the SSC (e.g. *seoi-nage*). Also, Zaggelidis et al. [20] verified that experienced judo athletes present a higher jump height, less contact time during the propulsive phase of the jump and better SSC utilisation than untrained athletes, indicating that these variables can be improved by specific training. Therefore, the correlations of effective time with height, power output and peak velocity in the concentric phase of the jump may be explained by storage optimisation and the reuse of elastic energy and faster transition between the eccentric-concentric phases during SSC activities [12]. This is especially evident in explosive actions, such as throwing techniques, similar to the CMJ technique [19]. The maximum force obtained during the concentric phase was also correlated with effective time. This indicates that the athletes showed good levels of strength in the lower limbs during the combat actions (e.g. throwing techniques and groundwork).

The handgrip strength test did not show correlation with any technical-tactical variable. The maximal isometric handgrip strength is considered to be important during matches to maintain the grip on the *judogi* [10, 11]. A previous study found a reduction in handgrip strength over four simulated judo matches, indicating high isometric neuromuscular demand during the combat bouts [13]. However, the handgrip test measures only the forearm strength, limiting the results. During combat, the athletes often perform pulling and pushing movements to attack or defend, which are dependent on dynamic and isometric actions in the upperbody [14]].

Regression models were used in an attempt to explain technical-tactical performance in relation to effectiveness, the number of attacks per match and effective time as dependent variables. The predictive power and explanation of variance were low for all variables (26-31%). This seems to indicate that performance in generic and specific tests is not able to explain technical-tactical performance under competition conditions. Other factors, such as technical skills, tactical strategy in the face of each opponent and psychological (motivation, anxiety, mood, etc.) and environmental aspects (referee, climate, fans, etc.) may aid in explaining performance in competitions [36, 37]. Although physical tests have been used to analyse training effects and the prescription of training loads, it is important to highlight that they predict or explain only a small part of the performance in competitions. Finally, the main limitation of this study was that not all athletes engaged in the same number of matches due to defeats during the competition, which could affect the results.

## CONCLUSIONS

In summary, the athletes with higher isometric endurance grip strength ($JGST_{ISO}$) performed a higher number of attacks and showed higher effectiveness in competitions. The athletes with higher ($SJFT_{30a}$) showed higher effectiveness during the matches. Also, the judokas with higher muscle power in the lower limbs (CMJ performance) showed higher effective time during the matches. Despite this, only a small part of the technical-tactical performance was explained by the physical tests (generic or specific), indicating that judo combat is a complex task and dependent on several factors.

We encourage judo coaches and physical trainers to continue using physical tests to verify the training effects or load prescriptions (when possible), despite the relatively low explanatory power in competitive performance. Generic or specific tests may be used as a reference to discriminate or classify judo athletes at different training levels, promoting improvements in their physical performance.

## REFERENCES


1. Miarka B, Panissa VL, Julio UF et al. A comparison of time-motion performance between age groups in judo matches. J Sports Sci 2012; 30(9): 899-905
2. Franchini E, Sterkowicz S, Meira CM et al. Technical variation in a sample of high level judo players. Percept Mot Skills 2008; 106(3): 859-869
3. Sterkowicz S, Heinisch HD, Sterkowicz-Przybycień K. Effect of body length, body weight, and sport achievement on points scored by male judo athletes in the Olympic tournament 2012. Arch Budo Sci Martial Art Extreme Sport 2016; 12: 1-9
4. Boguszewski D, Boguszewska K. Dynamics of judo contests performed by finalists of European Championships (Rotterdam 2005). Arch Budo 2006; 2: 40-44
5. Adam M, Wolska B. The general individual technical-tactical profile of the multi-medallist judo athlete Teddy Riner's. Arch Budo Sci Martial Art Extreme Sport 2016; 12: 37-44
6. Challis D, Scruton A, Cole M et al. Time-motion analysis of lightweight women's judo in the 2010 World Championships. Int J Sports Sci Coaching 2015; 10(2-3): 479-486
7. Adam M, Smaruj M, Tyszkowski S. The diagnosis of the technical-tactical preparation of judo competitors during the World Championships (2009 and 2010) in the light of the new judo sport rules. Arch Budo 2011; 7: 5-9
8. Sterkowicz S, Maślej P. An evaluation of the technical and tactical aspects of judo matches at the seniors level. Sport Wyczynowy 1999; 10: 45-53 [in Polish]
9. Franchini E, Artioli GG, Brito CJ. Judo combat: time-motion analysis and physiology. Int J Perform Analysis Sport 2013; 13(3): 624-641
10. Franchini E, Matsushigue KA, Vecchio FB et al. Physiological profiles of elite judo athletes. Sports Med 2011; 41(2): 147-166
11. Franchini E, Miarka B, Matheus L et al. Endurance in judogi grip strength tests: comparison between elite and non-elite judoka. Arch Budo 2011; 7: 1-4
12. Detanico D, Dal Pupo J, Franchini E et al. Relationship of aerobic and neuromuscular indexes with specific actions in judo. Sci Sport 2012; 27(1): 16-22
13. Bonitch-Gongora J, Bonitch-Domınguez JG, Padial P et al. The effect of lactate concentration on the handgrip strength during judo bouts. J Strength Cond Res 2012; 26(7): 1863-1871
14. Detanico D, Dal Pupo J, Franchini et al. Effects of successive judo matches on fatigue and muscle damage markers. J Strength Cond Res 2015; 29(4): 1010-1016
15. Gariod L, Favre-Juvin A, Novel V et al. Energy profile evaluation of judokas in 31P NMR spectroscopy. Sci Sports 1995; 10(4): 201-207 [in French]
16. Detanico D, Santos SG. Specific evaluation in judo: a review of methods. Braz J Kinanthrop Human Perform 2012; 14(6): 738-748
17. Ache Dias J, Wentz M, Kulkamp W et al. Is the handgrip strength performance better in judokas than in non-judokas? Sci Sports 2012; 27(3): e9-e14
18. Ruivo R, Pezarat-Correia P, Carita AI. Elbow and shoulder muscles strength profile in judo athletes. Isok Exerc Sci 2012; 20(1): 41-45
19. Monteiro LF, Massuça LM, García JG et al. Plyometric muscular action tests in judo- and non-judo athletes. Isok Exer Sci 2011; 19(4): 287-293
20. Zaggelidis G, Lazaridis SN, Malkogiorgos A et al. Differences in vertical jumping performance between untrained males and advanced Greek judokas. Arch Budo 2012; 8: 87-90
21. Franchini E, Sterkowicz S, Szmatlan-Gabrys U et al. Energy system contributions to the Special Judo Fitness Test. Int J Sports Physiol Perform 2011; 6(3): 334-343
22. Sterkowicz S, Zuchowicz A, Kubica R. Levels of anaerobic and aerobic capacity indices and results for the Special Judo Fitness Test in judo competitors. J Hum Kinetics 1999; 2(2): 115-135
23. Franchini E, Takito MY, Bertuzzi RCM. Morphological, physiological and technical variables in high-level college judoists. Arch Budo 2005; 1: 1-7
24. Branco BHM, Diniz E, Santos JFSS et al. Normative tables for the dynamic and isometric judogi chin-up tests for judo athletes. Sport Sci Health 2017; 13(1): 47-53
25. Follmer B, Dellagrana RA, Franchini E et al. Relationship of kimono grip strength tests with isokinetic parameters in jiu-jitsu athletes Braz J Kinanthrop Human Perform 2015; 17(5): 575-582
26. Lech G, Chwała W, Ambroży T et al. Muscle Torque and its Relation to Technique, Tactics, Sports Level and Age Group in Judo Contestants. J Hum Kinet 2015; 45: 167-175
27. Lech G, Tyka A, Palka T et al. Effect of physical endurance on fighting and the level of sports performance in junior judokas. Arch Budo 2010; 6: 1-6
28. Validation of equations anthropometric for the estimate of the body density in men. Rev Bras Ativid Fís Saude 1995; 1(3): 5-14

29. Siri WE. Body Body composition from fluid spaces and density: Analysis of methods. In: Brozek J, Henschel A, editors. Techniques for Measuring Body Composition. Washington: National Academy of Science and Natural Resource Council; 1961: 223-244
30. Linthorne NP. Analysis of standing vertical jumps using a force platform. Am J Phys 2001; 69(11): 1198-1204
31. Ache Dias J, Ovando AC, Kulkamp W et al. Hand grip strength: evaluation methods and factors influencing this measure. Braz J Kinanthrop Human Perform 2010; 12(3): 209–216 [in Portuguese]
32. Hopkins WG. Statistical vs clinical or practical significance – Sport science [accessed 2017 May 20]. Available from: URL:http://www.sportsci.org/jour/0201/Statistical_vs_clinical.ppt
33. Calmet M, Miarka B, Franchini E. Modeling of grasps in judo contests. Int J Perform Anal Spor 2010; 10(3): 229-240
34. Bogdanis GC, Nevill ME, Boobis LH. Contribution of phosphocreatine and aerobic metabolism to energy supply during repeated sprint exercise. J Appl Phys 1996; 80(3): 876-884
35. Julio UF, Panissa VLG, Esteves JVDC, et al. Energy system contributions to simulated judo matches. Int J Sports Physiol Perform 2017; 12(5): 676-683
36. Julio UF, MY Takito, L Mazzei et al. Tracking 10-year competitive winning performance of judo athletes across age groups. Percept Mot Skills 2011; 113(1): 139-149
37. Kuvačić G, Krstulović S, Caput PD. Factors determining success in youth judokas. J Hum Kinetics 2017; 56: 207-217
38. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006
39. Santos L, Fernandez-Rio J, Ruiz ML et al. Three-dimensional assessment of the judo throwing techniques frequently used in competition. Arch Budo 2014; 10: 107-115
40. Koley S, Yadav MK. An association of hand grip strength with some anthropometric variables in Indian cricket players. Phys Educ Sport 2009; 7(2): 113-123
41. Budō: The Martial Ways of Japan. Tokyo: Nippon Budokan Foundation; 2009
42. Calvo Rico B, García García JM, Monteiro LF et al. Kinematic indicators in combat sports athletes in a pre-competitive dehydrated status. Arch Budo Sci Martial Art Extreme Sport 2015; 11: 181-188

**Cite this article as:** Kons RL, Ache-Dias J Detanico D. Can physical tests predict the technical-tactical performance during official judo competitions? Arch Budo Sci Martial Art Extreme Sport 2017; 13: 143-151