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ORIGINAL ARTICLE

Normative tables for the dynamic and isometric judogi chin-up tests for judo athletes

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Abstract
Background No study has elaborated the normative tables to classify judo athletes as to the dynamic and isometric chin-up *judogi* tests.
Purpose To elaborate normative *judogi* chin-up tables to classify judo athletes.
Methods 138 male judo athletes from state, national, and international levels participated in the study. All tests were carried out during the competitive period. The tests can be performed by absolute values or relativized by body mass.
Results Data were distributed as percentile, with absolute values ≤ 10% (very poor ≤ 10 s; ≤ 1 rep), 11 a 25% (poor 11–25 s; 2–6 reps), 26–75% (regular 26–55 s; 7–16 reps), 76–90% (good 56–62 s; 17–19 reps), and > 90% (excellent ≥ 63 s; ≥ 20 reps). The relativized values consist of the following classifications [body mass multiplied per seconds (s) or repetitions (reps)] ≤ 10% (very poor ≤ 1051 kg.s; ≤ 121 kg.rep), 11–25% (poor 1052–2041 kg.s; 122–474 kg.rep), 26–75% (regular 2042–3962 kg.s; 475–1190 kg.rep), 76–90% (good 3963–4008 kg.s; 1191–1463 kg.rep), and > 90% (excellent ≥ 4009 kg.s; ≥ 1464 kg.rep).
Conclusion The normative table can be used as a reference to classify judo athletes as to specific used as a reference to classify judo athletes as to specific dynamic and isometric endurance strength holding the *judogi*, a specific field test which is low cost and can be implemented with the basic equipment.

Keywords Martial arts · Sports performance · Training · Field tests

Introduction

In judo, approximately 50% of the time in senior male combat is spent on grip dispute [1]. In accordance with the present rules of the International Judo Federation [2], the increase in volume of offensive actions can be considered a significant factor in the penalization of the opponent (*shido*) [3]. Similarly, carrying out actions (*shintai*) with a high input of effective strikes to overbalance (*kuzushi*) or throw the opponent, as well as maintaining complete grip control (*kumi-kata*) [3], can be used as relevant tools to defeat opponents in competition. In addition, according to the present rules of the International Judo Federation, the grip cannot be “broken” with both hands, as such, gripping has an important role during the course of competitions, since it is difficult for an athlete to undo a strong grip using only one hand [2]. Therefore, *kumi-kata* plays an important role in the course of judo training and competitions [4, 5].

Moreover, *kumi-kata* has a high level of physical demand on the flexor and extensor muscles of the forearm. These carry out timed endurance strength actions for 5 min, with the possibility of prolongation into extra time (*golden score*) [6]. In view of this, some researchers have proposed a test to evaluate isometric and dynamic endurance strength for handgrip through the gi or *judogi* (uniform used to practice judo) among judo athletes [7, 8]. As

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such, it is undeniable that the forearm muscles play a significant role in combat sports, such as judo. In addition, Franchini et al. [8] noted higher values for the dynamic *judogi* chin-up test among athletes of international level when compared to state-level athletes.

Furthermore, another study [7] investigated performance during the dynamic *judogi* chin-up test among Japanese university students, in which negative correlations were observed between the dynamic *judogi* chin-up, body fat percentage ($r = -0.61$), and body mass ($r = -0.63$), respectively. It can, therefore, be inferred that athletes in lighter categories with lower fat percentage show a better performance in the above-mentioned test, whereas athletes of heavier categories with a higher fat percentage present lower performance. In consequence of the above, and considering the lack of studies investigating these variables, the objective of the present study was the elaboration of normative tables to classify athletes as to specific isometric and dynamic endurance strength by means of *judogi* chin-up test.

Materials and methods

Experimental design

The current study is characterized by the display of a cross-sectional design. After an explanation about all the test procedures, the athletes were submitted to a battery of tests in the following order: (1) stature and body mass test; (2) maximal isometric handgrip test of both hands; (3) isometric *judogi* chin-up test; and (4) dynamic *judogi* chin-up test.

Participants

The study was carried out on 138 judo male athletes from state, national, and international levels (age 25.3 ± 6.1 years; stature 175.8 ± 8.9 cm; body mass 84.1 ± 21.2 kg), recruited from different clubs, associations, and gyms from the State of Sao Paulo. The study included 32% of the athletes of state level, 25% of national level, and 43% of international level and competed in the following body-weight categories <60 kg: 18 athletes, <66 kg: 21 athletes, <73 kg: 18 athletes, <81 kg: 26 athletes, <90 kg: 18 athletes, <100 kg: 18 athletes, and >100 kg: 19 athletes. The sample consisted of the following graduations: 0.7% purple, 14.3% brown, and 85% of black belt.

To participate in this study, athletes were required to: (a) have purple, brown, or black belts; (b) have competed regularly in official competitions; (c) be enrolled in the Sao Paulo Judo Federation; (d) be 18–40 years of age; (e) have been doing specific judo training at least four times per week; (f) have performed strength training at least three times weekly; (g) not be in the process of weight loss; (h) have maintained a consistent eating routine throughout the collection of data; (i) be free of any injuries which might limit the execution of tests proposed by the study; and (j) refrained from any treatment with substances banned by World Anti-Doping Agency (WADA [9]). All measurements were taken during the competitive period. The study was conducted in accordance with the international ethics directives and the Helsinki declaration, and was approved by the Research and Ethics Committee of the State University of Maringá, Paraná, Brazil, under number (57428916.9.0000.0104). Besides, all athletes that participated this study, willingly signed an informed consent.

Body mass and stature

Body mass (kg) and stature (cm) were measured by means of a Filizola® digital scale with stadiometer (with 0.1 kg and 0.1 cm precision, respectively) in accordance with Heyward [10].

Maximal handgrip isometric test

The maximal isometric handgrip test was carried out on both hands. The athletes were required to stand and hold onto the JAMAR® handgrip dynamometer with the right and left hands, and carried out three executions with the duration of 3–5 s each, interspaced by 1 min of passive recovery. The researchers regulated the dynamometer according to standards proposed by the American Society of Hand Therapy [11]. The dynamometer was set in accordance with the hand length and set at the highest rating of measurement (kgf). To avoid possible errors, whenever rates with a ≥10% difference were observed in the three attempts carried out, the athletes were asked to repeat the attempt with the same rest interval (if necessary, the procedure would be halted should the differences be ≤10%). There was, however, no need to repeat the handgrip tests. The maximal isometric handgrip strength was relativized by the body mass (kg) of the athletes. The rates for the left and right hands were also added for statistical analysis = maximal handgrip strength for the left and right hands (MVCL + MVCR). The tests followed the recommendations proposed by Heyward [12]. The mean and standard deviation of MVCL obtained by the athletes were of 50.6 ± 10.1 and for MVCR = 50.6 ± 10.4, respectively.

Measurement of dynamic and isometric strength holding the *judogi*

Two specific bar tests were carried out holding the *judogi*: the first was isometric and the second was dependent on dynamic maximal repetitions. Both tests followed the original recommendations by Franchini et al. [8], following the classifications described in the two topics as follows:

1. Isometric *judogi* chin-up: the athletes were asked to keep their elbows flexed with their chin above the hands for as long as possible and holding time was clocked. The test was interrupted as soon as athletes were unable to maintain the initial isometric position.
2. Dynamic *judogi* chin-up: the athletes were asked to stretch their elbows completely and then flex them until the chin was above the bar and repetitions of the complete exercise were counted.

Only repetitions which were carried out completely were counted, and the test was interrupted as soon as athletes were no longer able to carry out the proposed exercise completely and/or gave up voluntarily. In both tests, athletes were encouraged to maintain the position for as long as possible (for the isometric test) and carry out as many dynamic repetitions as possible under the supervision of the technical committee. Tests were interspaced by 15 min of passive recovery; in other words, athletes did not suffer any exertion between the tests, and the isometric test was carried out before the dynamic test [8].

In addition, it is worth highlighting that the standardization proposed that athletes maintain the same standard of movement for the dynamic test in the concentric and eccentric phases of movement. In isometric testing, the athletes started the movement by maintaining the grip on the *judogi* with bent arms and keeping the chin in line with the hands. The athletes climbed on a bench, and at the command signal, the bench was removed, the test started, and it was timed. From the moment athletes stretched the arms as a sign of fatigue, the test was interrupted and the clock was stopped. In addition, athletes were required to keep the legs extended, and they were not allowed to elevate the knees or bend the trunk to aid the movement during testing. Finally, to relativize the work done by the athletes during the isometric and dynamic tests, body mass was multiplied by time in seconds (for the isometric test) and repetitions (for the dynamic test).

The reproducibility of the tests was evaluated by a previous study, which reported an interclass coefficient that showed a rate of >0.97 for the isometric test and >0.98 for the dynamic test, respectively. Furthermore, the limits of agreement (LOA) for the isometric test was −2.3 s (95% confidence interval: −3.3 to −1.2 s), whereas LOA for the dynamic test was −0.3 rep (95% confidence interval: −0.9−0.3 rep) [13]. Figure 1 shows the *judogi's* isometric and dynamic strength endurance test positions in accordance with Franchini et al. [8].

Statistics

The Kolmogorov–Smirnov test was previously carried out to confirm data normality. After confirmation, the data referent to the bar tests by means of *judogi* (isometric and dynamic) were distributed into five scales of classification, according to normal distribution adapted from Ramirez-Vélez et al. [14], i.e., ≤10% (very poor), 11–25% (poor), 26–75% (regular), 76–90% (good), and >90% (excellent). Pearson's correlation was conducted between all relative and absolute variables in the study. The magnitude of correlation was interpreted according Hopkins et al. [15]: <0.1 (trivial), >0.1 to <0.3 (small), 0.3–0.5 (moderate), >0.5 to 0.7 (large), >0.7 to 0.9 (very large), and >0.9 to 1.0 (almost perfect). Besides, the standard error of the mean (SEM) was calculated for the graphs showed, in accordance with Hopkins et al. [8]. There was a 5% significance for all variables. All analyses were performed by means of the SPSS® version 20.0 statistical package.

Results

Table 1 shows the classification for the isometric and dynamic *judogi* chin-up tests.

Figure 2 shows the correlations between relative and absolute isometric and dynamic *judogi* chin-up tests.

Table 2 shows absolute correlations between maximal sustaining time and maximal repetitions holding the *judogi*, the sum of maximal isometric handgrip strength (right and left), as well as body mass.

Table 3 shows relative correlations between maximal sustaining time and maximal repetitions holding the *judogi* and the sum of maximal isometric handgrip strength (right and left hands).

Discussion

Considering that the main objective of this study was to elaborate normative tables for the dynamic and isometric bar test by means of grip on the *judogi*, the main findings suggest that both tests (isometric and dynamic) can be used as instruments for the classification of judo athletes. The correlations observed between the isometric and dynamic *judogi* chin-up tests suggest an almost perfect correlation among the relative and absolute values [8]. The use of relative values for the normative table can be useful to classify athletes of heavy categories. Considering that the absolute normative table disconsiders body mass, heavy athletes may present poor ratings. Consequently, the coaching staff responsible for the physical fitness of judo

Fig. 1 *A judogi's* isometric position, *B* final phase of the dynamic test, *C* leg position in both tests, *D* apparatus that simulates the judogi's tissue

Table 1 Classification for the isometric and dynamic *judogi* chin-up tests ($n = 138$ athletes)

	Isometric *judogi* chin-up test		Dynamic *judogi* chin-up test	
	Absolute values (s)	Relative values (kg.s)	Absolute values (reps)	Relative values (kg.rep)
Very poor	≤10	≤1051	≤1	≤121
Poor	11–25	1052–2041	2–6	122–474
Regular	26–55	2042–3962	7–16	475–1190
Good	56–62	3963–4008	17–19	1191–1463
Excellent	≥63	≥4009	≥20	≥1464

athletes can choose which method to use for evaluation (absolute or relative values by body mass).

In turn, the maximal isometric handgrip strength showed a moderate positive correlation with body mass and a small negative correlation with the isometric *judogi* chin-up test. In short, the absence of correlations between maximal isometric handgrip strength and dynamic *judogi* chin-up test suggests that maximal isometric handgrip strength is not a good parameter to be used for the association between these variables (maximal isometric strength in generic tests and endurance strength, during a specific test). Furthermore, body mass showed a negative correlation with the bar tests (isometric and dynamic) holding the *judogi*. These results indicate that the heavier athletes have a lower performance in the specific field tests. It should also be noted that the absence of body composition assessment in this study (for checking body fat) could result in the reduction of performance in the specific tests. This may be considered a potential limitation in the present study. However, other tests with judo athletes, involving displacement of body mass, showed that excess fat mass negatively affects performance [16]. On the other hand, the

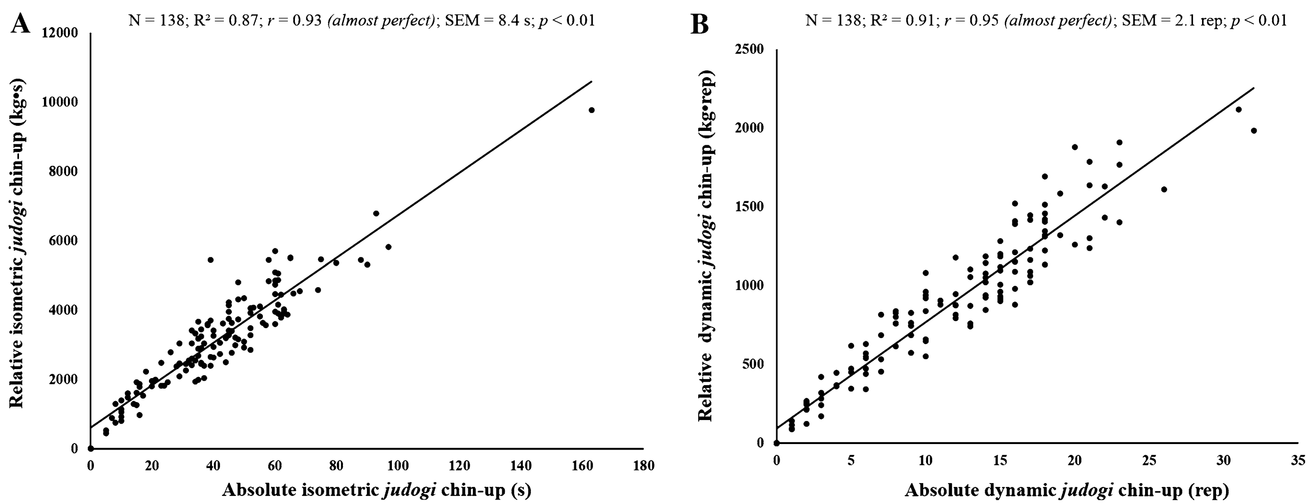

Fig. 2 Correlations between relative and absolute isometric and dynamic *judogi* chin-up tests. **a** Correlations between relative and absolute isometric *judogi* chin-up. **b** Correlations between relative and absolute dynamic *judogi* chin-up

Table 2 Correlations between maximal sustaining and maximal dynamic repetitions holding the *judogi*, sum of maximal isometric handgrip strength, and body mass

	Isometric *judogi* chin-up test (s)	Dynamic *judogi* chin-up test (rep)	Maximal handgrip strength (kgf)
Isometric *judogi* chin-up test (s)	1	repeated data	repeated data
Dynamic *judogi* chin-up test (reps)	0.72**—very large	1	repeated data
Maximal handgrip strength (kgf)	−1.5*—small	−0.9—trivial	1
Body mass (kg)	−0.63**—large	−0.64**—large	0.55**—moderate

To verify the magnitude of correlations, please refer to the "Materials and methods"; * $p < 0.05$; ** $p < 0.01$

Table 3 Correlations between relative values of maximal sustaining and maximal dynamic repetitions holding the *judogi* and sum of maximal handgrip strength

	Isometric *judogi* chin-up test (kg s)	Dynamic *judogi* chin-up (kg rep)
Isometric *judogi* chin-up test (s kg)	1	repeated data
Dynamic *judogi* chin-up (reps kg)	0.68**—large	1
Maximal handgrip strength (kgf/kg)	0.52**—large	0.61**—large

To verify the magnitude of correlations, please refer to the "Materials and methods"; ** $p < 0.01$

use of relativized values for body mass can be relevant for classifying athletes, since they compete within specific bodyweight categories.

The classification of specific dynamic and isometric endurance strengths inferred by the chin-up test could assist coaches in monitoring and verifying the efficiency of the training program in training sessions carried out on the *tatami* and in endurance strength training. It should be highlighted that training for the flexor and extensor muscles of the forearm is of great relevance in sustaining *kumi-kata*, groundwork combat (*ne-waza*), the processes of immobilization, and strangling in grappling combat sports, such as judo [17]. The findings of this study are similar to a previous study by Aruga et al. [7], which indicated that body mass and body fat percentage can be negatively associated with specific performance, inferred by the dynamics bar test holding the *judogi*. On the other hand, in Brazilian jiu-jitsu, the performance inferred from the dynamic and isometric chin-up tests holding the gi differs ($p < 0.05$) between athletes of higher or lower competitive levels (isometric test = 56 ± 11 s for elite athletes and 38 ± 11 s for non-elite athletes, and dynamic test = 15 ± 4 repetitions for elite athletes and 8 ± 3 repetitions for non-elite athletes) [13]. In judo, on the other hand, a difference ($p < 0.05$) was observed only in the dynamic bar test holding the *judogi* (Brazilian judo team = 12 ± 5 repetitions; state-level athletes = 9 ± 4 repetitions) [8].

The differences observed for the isometric endurance strength holding the gi between judo and Brazilian jiu-jitsu athletes can be explained by the fact that time in these sports differs; in other words, the time motion (effort:pause ratio) and the actions carried out in both sports, although similar in some aspects (mainly in the throwing and gripping of the opponent during groundwork combat) are quite distinct as to their effort:pause ratio, i.e., attack/defense time, groundwork combat time, gripping time, pause, and combat time [1, 18–20]. Thus, the differences in performance in the isometric chin-up test by means of the gi in the Brazilian judo athletes are probably due to the characteristic of continued combat evident in Brazilian jiu-jitsu, in other words, with less interruptions, when compared to judo [1, 21]. As such, sustaining the isometric grip to gain points and advantages during groundwork combat is a determining factor for competitive success in Brazilian jiu-jitsu [20]. In addition, Franchini et al. [22] noted that the isometric *judogi* chin-up test adequately indicated the alterations induced by the proposed training, i.e., 8 weeks of strength training using a linear and undulating method, in which distinct exercises were carried out for the flexing and extending of the forearm muscles, executed with the bar.

Finally, the normative table can be used as a reference to classify judo athletes as to specific dynamic and isometric endurance strength holding the *judogi*, a specific field test which is low cost and can be implemented with basic equipment. However, it is still necessary to develop classification tables for female athletes, since this study was carried out on male athletes. It should also be highlighted that the development of normative tables for other performance tests with judo athletes is necessary, since the reference rates for classification of judo athletes are still scarce [23–25]. In addition, new studies with a higher number of samples can be conducted for each weight category, with the aim of determining with more precision the performance in the tests conducted by this study.

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Compliance with ethical standards

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Conflict of interest The authors declare that there are no competing interests.

Ethical approval The study was conducted in accordance with the international ethics directives and the Helsinki declaration, and was approved by the Research and Ethics Committee of the State University of Maringá, Paraná, Brazil, under number (57428916.9.0000.0104).

Informed consent Besides, all athletes that participated this study, willingly signed an informed consent.

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