Reliability in *kimono* grip strength tests and comparison between elite and non-elite Brazilian Jiu-Jitsu players

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A Study Design
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Abstract

Background and Study Aim: The grip strength endurance is important for Brazilian Jiu-Jitsu (BJJ). Thus, the aims of this study were: a) to test the reliability of two kimono grip strength tests named maximum static lift (MSL) and maximum number of repetitions (MNR) and b) to examine differences between elite and non-elite BJJ players in these tests.

Material/Methods: Thirty BJJ players participated into two phases: "A" to test reliability and "B" to compare elite and non-elite. In phase A, twenty participants performed the MSL and, 15 min later, the MNR in two occasions with 24-h interval. In phase B, ten other BJJ practitioners (non-elite) and ten athletes (elite) performed the same tests. The intraclass correlation coefficient (ICC) two way fixed model (3,1), Bland-Altman plot and the limits of agreement were used to test reliability, correlation between the tests were evaluated by Pearson correlations and independent T test ($P<0.05$) was utilized to compare elite *vs.* non-elite.

Results: The ICC was high for repeated measurements on different days of phase A (MSL: r=0.99 and MNR: r=0.97). Limits of agreement for time of suspension were -6.9 to 2.4-s, with a mean difference of –2.3 s (CI: –3.3 to –1.2-s), while for number of repetitions the limits of agreement were –2.9 to 2.3-rep, with a mean difference of –0.3-rep (CI: –0.9 to 0.3-rep). In phase B, elite presented better performance for both tests ($P<0.05$) compared to non-elite (56±10-s *vs.* 37±11-s in MSL and 15±4-rep *vs.* 8±3-rep in MNR). Moderate correlation were found between MSL and MNR for absolute values during test (r=0.475; p=0.034), and retest phases (r=0.489; p=0.029), while moderate and high correlations in the test (r=0.615; p=0.004) and retest phases (r=0.716; p=0.001) were found for relative values, respectively.

Conclusions: These proposed tests are reliable and both static and dynamic grip strength endurance tests seem to differentiate BJJ athletes from different levels.

Key words: physical assessment • tournament fights • muscle endurance • athletes • exercise movement techniques

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Brazilian Jiu-jitsu – in our article we refer to the combat sport version – derived from the Japanese martial art jujutsu, but developed in Brazil – that focuses on grappling and especially groundwork fighting.

Background

Brazilian Jiu-Jitsu (BJJ) is a sport characterized by high-intensity intermittent efforts separated by low-intensity periods [1]. Muscular strength is considered one of the most important physical components to be developed, in special in upper limbs through dynamic and static actions [2]. Such strength manifestations are vital for

performance in BJJ, in particular to maintain a grip and control the opponent, to perform new attacks, and defense or counter-attack actions [3].

In general, maximal static and dynamic strength are determinants for BJJ performance and are assessed by handgrip dynamometers [4–6]. However, this measure represents only one component of what happens in the fight, because although the region of the forearm is activated to perform isometric action, the trunk and arm are normally executing dynamic actions [7]. Moreover, it has shown to be reported in the literature protocols [8-9] and recommendations [10] the relevance to evaluate different strength manifestations using equipments that are not always accessible to coaches and BJJ athletes (i.e. bench press and free bar for squats) or specific to the sport actions. Furthermore, considering the temporal structure of BJJ matches [11], as well as the rate of perceived exertion reported during fight simulation, which has been elevated in the forearm region [12], it is possible to infer that muscular endurance is more important for performance than maximum strength. Thus, the creation, validation and use of tests easily available and more specific would be useful for the evaluation process of BJJ athletes. In this sense, Franchini et al. [13] evaluated judo athletes in pull up exercise tests, but the grip was made on the uniform of judo (*judogi*) attached to the bar, which produced a greater degree of specificity than the normal contact of hands with the bar. These authors reported high reproducibility (ICC=0.98) and demonstrated that the repetition test was also able to discriminate between athletes from different competitive levels.

Considering that no study has investigated these measures in BJJ athletes and that the test with *kimono* grip is more specific and accessible to all sport's participants, the aims of this study were: a) to test the reliability of two *kimono* grip strength tests (pull-up exercise) named maximum static lift (MSL) and maximum number of repetitions (MNR) and b) to examine differences between these tests in elite and non-elite BJJ athletes. We hypothesized that there would be high reliability between the proposed tests because the grip was very familiar to the practitioners and that these tests could differentiate BJJ practitioners of different levels.

Material and Methods

Subjects and ethical cares

This study was approved by local Ethics Committee (UFTM/Brazil process number 1889) and was performed in accordance with the international ethical standards. Before the research began the volunteers signed an informed consent form. Thirty BJJ male athletes participated voluntarily. The following criteria were considered to include the athlete at the moment the study was conducted: (a) to present age between 20 and 38 years; (b) to be at least 3 years of experience in BJJ; (c), to be graduated from blue to black belt; (d) to be training from 3 to 16 h per week; e) not to present any physical limitations to the tests; f) not being using nutritional supplements or potential ergogenic aids of any kind; g) being familiarized with the exercises.

Table 1 presents the athletes distribution across weight categories for phase B of our study.

Table 1. Weight categories for elite e non-elite BJJ players (n=20).

Categories	Elite (n=10)	Non-elite (n=10)
Feather (up to 70 kg)	1	2
Light (up to 76 kg)	1	3
Middle (up to 79 kg)	4	2
Medium heavy (up to 88.3)	2	1
Heavy (94.3)	1	1
Super heavy (over 105)	1	1

Procedures

This study was divided in phases A and B. Before phase A, all participants undertook familiarization (three different days) with tests, including theoretical instructions and anthropometric measurements. Both in the familiarization and in the days of the tests (phases A and B) the participants were instructed to arrive at the gym in a rested and fully hydrated state, at least 4-hr postprandial, and to avoid strenuous exercise in the previous 24-h. Each subject was tested at the same time of the day (between 4:00 and 6:00 p.m.) with 23°C temperature.

Phase A

Phase A was made in order to test the reliability of two kimono grip strength tests. Twenty BJJ athletes (age: 25.7±5.6 years-old; body mass: 77.6±8.2 kg; height: 1.76±0.05 m) participated in this phase to obtain tests performance (MSL and MNR) in two different days, 24-h apart.

Phase B

This phase occurred one week after phase A and its purpose was to verify if there were performance differences between elite and non-elite BJJ athletes in the proposed tests from phase A. The elite athletes trained five to six times/week, 60 to 120 min/session, had at least one title (state, national or international) and

Table 2. Performance on the maximal static lift (MSL) and maximal number of repetitions (MNR) during test and retest (n=20).

Variables		Test		Retest		
Absolute values	**Mean ±SD**	**Min**	**Max**	**Mean ±SD**	**Min**	**Max**
MSL (s)	51±10	30	66	53±10	35	67
MNR (repetitions)	14±4	10	20	14±4	8	22

SD – standard-deviation.

Table 3. Intraclass coeficient correlation (ICC) for maximal static lift (MSL) and maximal number of repetitions (MNR) between test and retest (n=20).

	ICC	*P*	Confidence Interval 95% (inferior/superior)
MSL	0.971	0.001*	0.927/0.989
MNR	0.987	0.001*	0.966/0.995

* $P<0.05$.

had participated in competitions in the last two years. On the other hand, "non-elite" athletes trained two to five times/week, 60 to 90 min/session, but they did not have any title and did not participate in competitions in the last two years. Thus, ten elite BJJ athletes (age: 25.6±3.6 years-old; body mass: 79.6±9.3 kg; height: 1.76±0.1 m) who already had participated in phase A were selected to be compared to ten non-elite BJJ athletes (age: 30.9±6 years-old; body mass: 78.8±8.3 kg; height: 1.77±0.1 m).

Maximum static lift (MSL)

The participants cycled 5-min on a stationary bicycle (Monark®, 0.5 kp, 60 rpm). Following this warm-up, they did two sets of 5-s of grip holding on *kimono* rolled around the bar, with the elbow joint in maximal flexion, and 1-min of pause between the sets. After 3-min (passive pause), the BJJ athletes were required to sustain this position during the maximal possible time.

Maximum number of repetitions (MNR)

Fifteen minutes after the MSL test, the participants undertook the MNR. Before, however, they cycled 3-min and did two sets of five repetitions with 1-min break. Following 3-min of passive pause, the volunteers performed the MNR from a fully flexed to a fully extended elbow position, with the same grip position applied at MSL.

Statistical analysis

The normality of the data was tested by Kolmogorov-Smirnov test (Medcalc® – Bélgica). Intra-class coefficient of correlation (ICC) based in two way fixed model (3,1), Bland-Altman plot and limits of agreement were used to verify reliability of the two tests (phase A) and descriptive statistics to present the data. Pearson correlation was employed to analyze correlations between tests. The correlation coefficients were interpreted using the scale of magnitudes proposed by Hopkins (www.sportsci.org): ,0.1, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large;.0.9, nearly perfect. Independent Student t test was conducted to compare elite *vs.* non-elite BJJ athletes (phase B) and an a priori power analysis of test was used to identify β error by GPower 3.1.3, and revealed a sample size of 8 participants, sufficient to achieve a power of 0.952 with effect size $\chi^2=0.439$ for MSL and $\chi^2=0.551$ for MNR. The statistical significance was set at $P<0.05$ for all tests. Data were analyzed using SPSS® 17.0 and Stata 10.0.

Results

All data presented normal distribution. Table 2 presents performance during both tests (MSL and MNR) conducted in phase A. There was a moderate correlation between MSL and MNR during test (r=0.475; $P=0.034$) and retest phases (r=0.489; $P=0.029$) for absolute values, while for moderate correlation for test (r=0.615; $P=0.004$) and high correlation (r=0.716; $P=0.001$) for retest phases were found for relative values.

Table 3 presents the ICC for the test-retest values of both tests conducted in phase A.

Figure 1 presents the Bland-Altman plot for the test-retest values of both tests conducted in phase A.

Limits of agreement for time of suspension (MSL) were –6.9 to 2.4-s, with a mean difference of –2.3-s (CI: –3.3 to –1.2-s), while for number of repetitions (MNR) the limits of agreement were –2.9 to 2.3-rep, with a mean difference of –0.3-rep (CI: –0.9 to 0.3-rep).

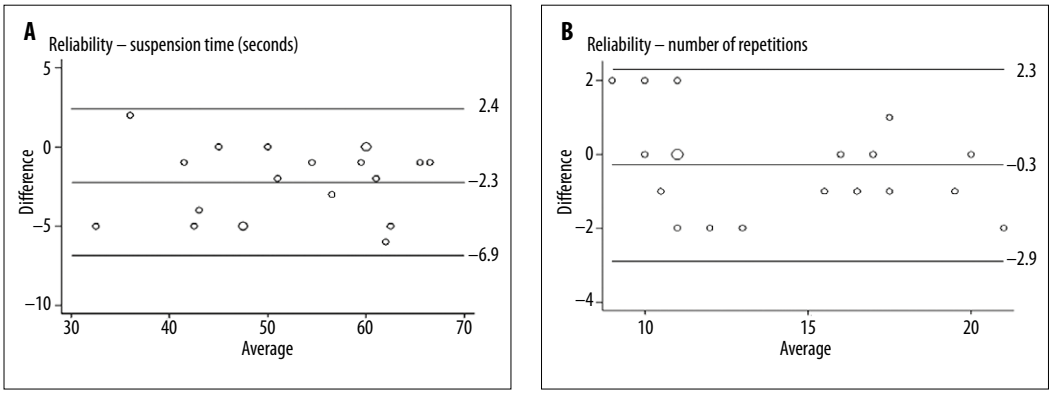

Figure 1. Bland-Altman plot for test-retest performance during maximal static lift (MSL; (**A**)) and maximal number of repetitions (MNR; (**B**)) (n=20).

Table 4. Maximal static lift (MSL) and maximal number of repetitions (MNR) in elite and non-elite Brazilian Jiu-jitsu athletes.

Variables	Elite (n=10)	Non-elite (n=10)
Absolute values		
MSL (s)	56±11	38±11*
MNR (repetitions)	15±4	8±3*

Data are presented as mean ±SD; * $P<0.05$ Non-elite *vs.* elite.

In phase B the elite athletes performed better than non-elite BJJ athletes for both tests (MSL and MNR; $P<0.05$) (Table 4).

Discussion

The major findings of our study were that: a) both tests (MSL and MNR) were highly reliable and b) performance in these tests was able to discriminate between elite and non-elite BJJ athletes. Moreover, it is important to emphasize that such tests are easily conducted and involve the specific grip performed during the BJJ match. Additionally, to our knowledge, this is the first study that has tested specific protocols to evaluate grip **strength endurance** and has compared different levels of BJJ practitioners. Although no similar studies were found with BJJ players, the high reliability reported here (ICC: MSL=0.971 and MNR=0.987) is analogous to that previously reported with judo athletes [7].

The MNR performed by BJJ athletes in our study is similar to those previously observed in national level judo athletes [13]. However, the MSL was higher for our BJJ athletes (phase A ~52 s and phase B ~56 s) than found in judo athletes (~39 s) [13]. Such discrepancy is probably due to the major maintenance of grip holding during BJJ matches [11] when compared to judo matches. Conversely, during judo matches most part of the match involves the grip dispute [14–16], using dynamic actions, which would result in a similar dynamic strength endurance in judo athletes and BJJ athletes.

Some studies have verified the handgrip strength in BJJ practitioners [2,5,6] and other grappling sports [14,17,19], although no difference has been reported in this variable between elite and non-elite judo athletes [17]. These results probably occurred because the grip adopted during the match depends more on other factors as the strength endurance due to the time of maintenance [15,16] and technique [16] than maximum isometric strength [7,14].

Although the methods used here had not been tested in BJJ athletes before, they already were conducted in judo athletes [7,13,20] and have been recommended as a training exercise for mixed martial artists [18,21]. Studies with judo athletes have confirmed the effectiveness of these methods for evaluation and training [7,13]. Franchini et al. [7] found significant values ($P<0.05$) of correlation between both MNR and MSL tests with the following parameters (accounting for body mass): maximal grip static strength, one repetition maximum (1RM) on the rowing exercise and anaerobic power (mean) in the Wingate test for upper limbs. We found moderate correlation between MSL and MNR for absolute values during test and retest phases and moderate and high correlations in the test and retest phases when relative values were considered, suggesting that both tests could be used to evaluate strength endurance in BJJ athletes, especially when relative values are considered.

Regarding the comparison between elite and non-elite BJJ athletes, our results showed better performance for the elite group in the two tests (MSL and MNR). This finding confirmed our initial hypothesis that the tests used here might discriminate recreational practitioners and elite BJJ, in particular because these tests are highly specific. Considering that strength endurance [14,19], as well as the grip on the lapel of the opponent's *kimono* [13] are vital to success in grappling **combat sports**, it seems

Strength endurance – the muscle ability to sustain dynamic actions repeatedly or to maintain an isometric action for as long as possible. In our study the ability to sustain number of repetitions from a fully flexed to a fully extended elbow position while holding the kimono rolled around a bar or to sustain the body mass in an isometric position while holding the kimono rolled around a bar.

Combat sports – "are competitive contact sports where two combatants fight against each other using certain rules of engagement". Cited from The influence of the wrestling technique on contact efficiency of young male team handball players [22].

that these tests can be an important aspect of the physical evaluation of these athletes. In fact our results showed that elite athletes were superior in performance when compared to recreational practitioners of BJJ. At least in part, it corroborates the findings of Franchini et al. [13] because they have found better performance only in a dynamic test. Perhaps these differences from Franchini et al. [13] are due to the specificity of working time which is more static and longer in BJJ than in Judo [11,14–16].

Conclusions

In conclusion, the tests used here are reliable and both static and dynamic grip strength endurance tests (maximal static lift and maximal number of repetitions) seem to differentiate between BJJ athletes from different levels. Thus, these tests can be used for the physical evaluation of Brazilian Jiu-Jitsu athletes because they are highly specific and accessible.

References:

1. Pereira RF, Lopes CR, Dechechi CJ et al: Cinética de remoção de lactato em atletas de Brazilian jiujítsu. Revista Brasileira de Prescrição e Fisiologia do Exercício, 2011; 5(25): 34–44 [in Portuguese]
2. Moreira SR, Andréia Gulak A, Ulanowicz JS et al: Correlação de variáveis antropométricas de membros superiores com a força de preensão manual em praticantes de Jiu-Jitsu. Motriz, 2003; 9(1): 147 [in Portuguese]
3. Oliveira M, Moreira D, Godoy JRP: Avaliação da força de preensão palmar em atletas de jiu-jitsu de nível competitivo. Revista Brasileira de Ciência e Movimento, 2006; 14(3): 63–70 [in Portuguese]
4. Neto AS, Dechechi CJ: Efeito de treinamento de resistência anaeróbica específico para atletas de jiujítsu quanto à força de preensão manual e potência muscular. Revista Hórus, 2010; 4(2): 1–20 [in Portuguese]
5. Franchini E, Campos Pereira JN, Takito MY: Freqüência cardíaca e força de preensão manual durante a luta de jiu-jitsu. Lecturas Educación Física y Deportes, 2003; (65): 9 [in Portuguese]
6. Andreato LV, Franzói de Moraes SM, Lopes de Moraes Gomes T et al: Estimated aerobic power, muscular strength and flexibility in elite Brazilian Jiu-Jitsu athletes. Sci Sports, 2011(26): 329–37
7. Franchini E, de Souza CEB, Urasaki R et al: Teste de resistência de força isométrica e dinâmica na barra com o judogi. Proceeding of III Congreso de La Associasión Espanõla de Ciencias Del Deporte. 2004 [in Portuguese]
8. Campos GE, Luecke TJ, Wendeln HK et al: Muscular adaptations in response to three different resistance-training regimens: specificity of repetition maximum training zones. Eur J Appl Physiol, 2002; 88(1–2): 50–60
9. Goto K, Ishii N, Kizuka T, Takamatsu K: The Impact of Metabolic Stress on Hormonal Responses and Muscular Adaptations. Med Sci Sports Exerc, 2005; 37(6): 955–63
10. Brown LE, Weir JP: ASEP Procedures Recommendation I: Accurate Assessemnt of muscular strength and power. JPE online, 2001; 4(3): 1–21
11. Del Vecchio F, Bianchi S, Hirata S et al: Análise morfo-funcional de praticantes de Brazilian jiu-jitsu e estudo da temporalidade e da quantificação das ações motoras na modalidade. Movimento e Percepção, 2007; 7(10): 263–81 [in Portuguese]
12. Franchini E, Bezerra PL, Oliveira RSF et al: Concentração de lactato sangüíneo, freqüência cardíaca e força de preensão manual durante um combate de jiu-jitsu. Corpoconsciência (São Paulo), 2005; 9: 35–44 [in Portuguese]
13. Franchini E, Miarka B, Matheus L, Del Vecchio FB: Endurance in judogi grip strength tests: Comparison between elite and non-elite judo players. Arch Budo, 2011; 7(1): 1–4
14. Franchini E, Del Vecchio FB, Matsushigue KA, Artioli GG: Physiological profiles of elite judo athletes. Sports Medicine, 2011; 41(2): 147–66
15. Calmet M, Miarka B, Franchini E: Modeling approaches of grasps in judo competition contests. International Journal of Performance Analysis in Sport, 2010; 10: 229–40
16. Marcon G, Franchini E, Jardim JR, Barros Neto TL: Structural Analysis of Action and Time in Sports: Judo. Journal of Quantitative Analysis in Sports, 2010; 6(4): 1–13
17. Franchini E, Takito MY, Kiss MAPDM, Sterkowicz S: Physical fitness and anthropometrical differences between elite and non-elite judo players. Biology of Sport, 2005; 22(4): 315–28
18. Amtmann J, Cotton A: Strength and Conditioning for Judo. Strength and Conditioning Journal, 2005; 27(2): 26–31
19. Krstulovic S, Zuvela F, Katic R: Biomotor Systems in Elite Junior Judoists. Coll Antropol, 2006; 30(4): 845–51
20. Aruga S, Nakanishi H, Yamashita Y et al: A study on the training method for improving judo players'kumite strength – on the judogi chin-up method. Tokai J Sports Med Sci, 2006; 18: 44–53 [in Japanese, English abstract]
21. Santana JC, Fukuda DH: Unconventional methods, techniques, and equipment for strength and conditioning in combat sports. Strength and Conditioning Journal, 2011; 33(6): 64–70
22. Foretić N, Karninčić H, Uljević O: The influence of the wrestling technique on contact efficiency of young male team handball players. Arch Budo, 2011; 7(2): OA87–91