

Body composition, isometric hand grip and explosive strength leg – similarities and differences between novices and experts in an international competition of Brazilian jiu jitsu

Authors' Contribution:

- A Study Design
- B Data Collection
- C Statistical Analysis
- D Manuscript Preparation
- E Funds Collection

Francisco Javier Diaz-Lara^{1ABCDE}, José Manuel García García^{1ACDE}, Luis Fernandes Monteiro^{2ABD}, Javier Abian-Vicen^{1ABCD}

¹ Sport Training Laboratory, Faculty of Sport Sciences, University of Castilla La Mancha, Spain

² Faculty of Physical Education and Sports, Lusófona University, Lisbon, Portugal

Source of support: Departmental sources

Received: 4 July 2014; **Accepted:** 18 August 2014; **Published online:** 31 August 2014

ICID: 1121905

Abstract

Background & Study Aim: Brazilian jiu jitsu (BJJ) is gaining thousands of practitioners in all countries; however, there is a lack of scientific research related to this sport. We wanted to establish the indicators approached by BJJ athletes to sporting excellence, which is the reason why we divided the subjects into two groups: experts and novices. Additionally, the aim of this study was to knowledge about the body composition, and similarities and differences in the performance of BJJ athletes focusing on two variables: isometric hand grip and explosive strength leg.

Material & Methods: Fifty six BJJ players, who were contestants in the European Open Jiu-Jitsu Championship 2013 in Lisbon (Portugal), took part in this study. Novice group (n=24; age: 29.9±5.8 yrs), Expert group (n=32; age: 30.5±4.7 yrs). Body mass was measured with Bioimpedance, and handgrip strength was measured with a dynamometer. Explosive strength leg was measured from a force platform with the Countermovement Jump (CMJ) test. Differences between experts and novices were established with the t Student's test or Mann-Whitney U test for the parametric and non-parametric variables respectively.

Results: Experts obtained significant differences over novices on isometric hand grip strength in both hands; as for the variables of CMJ, significant differences were found in Height of jump, peak power, velocity at peak power and average power.

Conclusions: BJJ athletes with higher experience, training, and level (expert group) have more adaptations and improvements than the novice group. This can be seen by their higher records in isometric handgrip and the higher explosive strength in their legs.

Keywords: art of defence · combat sports · Countermovement Jump · force platform · sport performance

Author's address: Javier Abian-Vicen, University of Castilla-La Mancha, Avda. Carlos III s/n. Toledo, 45071 Spain; e-mail: javier.abian@uclm.es

Brazilian Jiu Jitsu – is a type of fight in which a uniform or *gi* is used; its main purpose is to project or take your opponent down. Once on the ground, you must seek to control your adversary with different techniques (immobilizations, chokes, joints locks). In the absence of submission at the end of the fight, the winner is declared by the number of points won [3]

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 [9]

Countermovement Jump (CMJ) – is a test of physical performance, which is a dynamic weight bearing movement skill that utilizes multiple muscles and joints of the lower limbs [14]

INTRODUCTION

The Ju-jitsu is believed to have its roots in India. Buddhist monks, who were concerned for their own defence, developed techniques based on the principles of balance, body knowledge, their joint limits, and avoiding the use of arms. This art of defence, together with Buddhism, travelled across Asia, reaching Japan. Once there, it was modified by adapting it to the needs of these people and was called ju-jitsu. In 1914, this Japanese art arrived in Brazil thanks to the teacher Mitsuyo Maeda (Conde Koma), expert in judo and ju-jitsu. He taught Carlos Gracie the techniques he had learned in Japan. Helio Gracie, Carlos's brother, learned this type of fight and modified its techniques, adapting them to their slim and small biotype, with the aim of making it become as effective and efficient as possible. These two brothers created and promoted what is currently known as Brazilian Jiu-Jitsu (BJJ) [1, 2].

Nowadays, sports BJJ is a type of fight in which a uniform or *gi* is used; its main purpose is to project or take your opponent down. Once on the ground, you must seek to control your adversary with different techniques (immobilizations, chokes, joints locks). In the absence of submission at the end of the fight, the winner is declared by the number of points won [3]. Despite BJJ is currently getting thousands of fans and practitioners worldwide, only a few scientific studies are trying to understand the physiological and condition demands required by this sport [4-6].

There are many studies that have used the novice-expert paradigm in different sports since the 1970s. If we focus on combat sports, we can find an investigation by García et al. [7] in judokas. These authors compare different levels of judokas, thanks to some performance tests done to these athletes (maximal isometric strength, VO_2 max. etc.). The purposes were to find nonspecific conditional values that do not have any direct impact in competition, and to delimit the important indicators approached by athletes to sport-excellence.

Body composition is an essential component for the control and definition of the weight categories in combat sports modalities. BJJ athletes have a predominantly mesomorphic component, low fat percentages similar to other combat sports such as wrestling and judo [3, 8].

The 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 [9]. In many sports, it is common to get information about more useful strategies to develop specific training protocols and increase the strength of athletes' hands to prevent injuries due to their sports practice [10, 11]. If we focus on a BJJ fight, the athlete is in contact with the opponent most of the time. During this period of combat, the athlete needs to perform successive grip movements to maintain this grip, to control the opponent or so as to perform new ways of attack, defence, counter-attacks etc. [12]. Then, static and dynamic strength grip, and gripping endurance are vital to competitive success [13].

Countermovement Jump (CMJ), is a test of physical performance, which is a dynamic weight bearing movement skill that utilizes multiple muscles and joints of the lower limbs [14]. It would be interesting to evaluate the explosive movements like CMJ, due to the high-intensity actions performed in BJJ were predominantly short (less than 3 s). Consequently, muscle power exercises should be included in physical training, since the decisive moments of the fight (scores and submissions) require explosive muscle power actions [15]. Moreover, the explosive force manifestation results from the combination of the contractile capacity, that is understood as the concentric action of the agonist muscles without use of the stretch shortening cycle and the capacity to synchronize muscle fibre contraction [16, 17].

The aim of this study was to knowledge about the body composition, and similarities and differences in the performance of BJJ athletes focusing on two variables: isometric hand grip and explosive strength legs.

MATERIAL AND METHODS

Subjects

Fifty-six athletes of BJJ, participants of the European Open Jiu-Jitsu Championship 2013 in Lisbon (Portugal) from 16 different countries, took part voluntarily in this study. They were divided into two groups, novices and experts. The criteria used to divide the groups in our investigation were the experience and level of training at this discipline. Considering experts those who had been more than 4 years training BJJ and had a graduation from purple to black belt; whereas novices were those who had been training for less than 4 years and were graduates from white to blue belt. The novice group consisted of 24 athletes (16 blue belts and 8 white belts). The expert group was formed by 32 athletes (17 black belts, 7 brown belts and 8 purple belts) (Table 1). All

participants were informed about the nature and the purpose of this study, as well as the measurements which were going to be taken. After that, participants signed a consent form to allow the researchers to take the measurements and use their data for scientific purposes. The study was approved by the local Research Ethics Committee in accordance with the latest version of the Declaration of Helsinki [18].

Protocols

The European Open Championship 2013 (IBJJF) was celebrated in Casal Vistoso Pavillion (Lisbon, Portugal). The organization provided us a room near the mat to complete all the tests before the competition started. On arrival, the participants got familiar with the measuring instruments corresponding to the maximum intensity tests (counter movement jump and hand grip strength), signed the informed consent document and filled out another one on information regarding their years of practice, hours of training per week, best result obtained in competition that year, years of practice in BJJ and dominant hand. Then, height (SECA Ltd, Germany with a sensitivity of ± 0.1 cm), body mass (Radwag, Poland with a sensitivity of ± 0.05 kg scale) and body composition with Bioimpedance (BC-418. Tanita Corp, Japan), were measured using established standards to calculate the body fat and the body muscle composition of each subject [19]. All subjects finished all the tests before their first fight and after a specific warm-up of 20 minutes. In the hand grip strength test, the subjects had to grip a manual dynamometer (Takei Scientific Instruments Co, Japan) as hard as possible. Two attempts were made with the elbow extended, the arm parallel to the body and the wrist in neutral position according to the indications of several authors [20-22]. There was a 1 minute break between both attempts and the highest value was chosen for the analysis. In the CMJ test, the participants jumped on a Quattro Jump force platform (Kistler, Switzerland) with their hands on the waist at all times. The angle of knee flexion during the CMJ was freely chosen by the each subject. The highest jump achieved out of three valid attempts with a 1 min rest between them was chosen for the analysis. For the jump test, a leg maximum power output during the jump was determined from ground reaction forces (F). For this calculation, we set the initial vertical velocity of the system at zero. Vertical ground reaction forces were recorded at 500 Hz and were divided by the mass of the system at each time point in order to determine instantaneous acceleration ($a_{inst} = F_{inst} / \text{mass}$). Gravity acceleration was subtracted from the calculated acceleration to ensure that only the acceleration

produced by the participants during the jump was used to determine velocity. The instantaneous vertical velocity (v_{inst}) was integrated from the acceleration. The integration constant was zero because there was no initial movement. Instantaneous power (P_{inst}) was calculated as the product of the velocity and force ($P = F_{inst} \times V_{inst}$) at any given point. The power average from the impulse phase (concentric part of the jump) was used for the statistical analysis. Jump height was determined by the flight time. The flight time is the difference between the first instant of take-off and the first instant of landing, we assume the height of the jumper's centre of mass at the instant of landing is the same as at the instant of take-off, and we used the equation to calculate the jump height proposed by Linthorne [23]. The height of the centre of gravity was calculated by the double integration method (work-energy) of the force-time record based on Linthorne [23]. In total, we evaluated 8 different variables: Jump height (H) calculated from the flight time measured in cm; Position of the centre of gravity at the highest point in the flight phase (Hf) measured in cm; Peak power during the push-off phase normalized for the mass of the player (PP) measured in W/kg; Velocity at peak power (V_{pp}) measured in m/s; Force at peak power (F_{pp}) measured in N; Average Power (AP) measured in W/kg; Vertical path of the centre of gravity between the instants of take-off and first time of the landing (Lr) measured in cm; Second peak vertical force in landing (F2) measured in BW.

Statistical analysis

The SPSS v. 19 program (SPSS Inc., USA) was used to perform the statistical calculations with descriptive and inferential statistical tests. Initially, normality was tested in all variables with the Shapiro-Wilk test. After that, the t Student's test for independent samples was used to establish the differences in the normally distributed variables between groups (experts and novices). For the non-parametric variables differences between experts and novices were established with the Mann-Whitney U test. The criterion for statistical significance was set at $p < 0.05$. All the data are presented as mean \pm standard deviation.

RESULTS

Regarding the characteristics of the subjects, similar results were observed in most variables (age, weight, height, body mass), but significant differences ($p \leq 0.01$) were observed between experts and novices in relation to years of experience and training (hours per week) (Table 1).

Table 1. Characteristics of novices and experts Brazilian Jiu-Jitsu athletes

Variables	Novice (n = 24)	Expert (n = 32)	Δ (%)	P value	Effect Size
Age (years)	29.9 \pm 5.8	30.5 \pm 4.7	1.95	0.341	0.1
Weight (kg)	75.7 \pm 9.3	77.4 \pm 11.3	2.2	0.276	0.2
Height (cm)	177.1 \pm 5.8	175.6 \pm 6.6	-0.8	0.187	-0.2
Body Mass (kg)	69.4 \pm 6.9	70.6 \pm 9.7	1.7	0.307	0.1
% Fat	9.3 \pm 3.7	9.1 \pm 4.6	-2.1	0.432	-0.0
Experience (years)	3 \pm 1.1	9.5 \pm 4.6	217.2	0.000*	2.2
Training (hours per week)	9.4 \pm 2.6	13.1 \pm 3.8	39.3	0.000*	1.1

* Differences at $p < 0.05$

Experts obtained higher values in isometric hand grip strength than novices. Significant differences ($p \leq 0.01$) were found both in right and left hand (Table 2).

Table 2. Isometric strength grip Brazilian Jiu-Jitsu athletes

Variables	Novice (n = 24)	Expert (n = 32)	Δ (%)	P value	Effect Size
Left hand grip (kgf)	43.3 \pm 6.6	49.1 \pm 7.0	13.4	0.001*	0.8
Right hand grip (kgf)	43.6 \pm 7.1	48.6 \pm 6.1	11.4	0.004*	0.7

* Differences at $p < 0.05$

In relation to the variables of (CMJ), significant differences were found between experts and novices in height of jump; position of the centre of gravity at the highest point in the flight phase; peak power; velocity at the peak power; average power and a greater tendency was found in the expert group for vertical path of the centre of gravity. However, no significant differences were observed in force at the moment when the PP was reached (Table 3).

Table 3. Variables Countermovement Jump Brazilian Jiu-Jitsu athletes

Indicators	Novice (n = 24)	Expert (n = 29)	% Dif.	P value	Effect Size
H (cm)	29.7 \pm 5.0	34.2 \pm 5.1	15.2	0.002*	0.9
Hf (cm)	39.2 \pm 4.5	44.6 \pm 4.8	13.8	0.000*	1.1
PP ($W \times kg^{-1}$)	45.2 \pm 4.9	51.6 \pm 7.6	14.0	0.001*	1.0
V _{pp} ($m s^{-1}$)	2.3 \pm 0.2	2.4 \pm 0.2	7.1	0.001*	0.9
F _{pp} (N)	1534.1 \pm 234.3	1575.8 \pm 221.9	2.7	0.512	0.2
AP (W/kg)	23.8 \pm 3.5	26.9 \pm 4.9	13.1	0.014*	0.7
Lr (cm)	-13.5 \pm 7.8	-18.1 \pm 8.7	33.3	0.056	-0.5
F2 (BW)	5.4 \pm 2.0	4.9 \pm 1.8	-10.0	0.318	-0.3

* Differences at $p < 0.05$; H= Height of jump from flight time; Hf = position of the centre of gravity at the highest point in the flight phase; PP = peak power; V_{pp} = velocity of the centre of gravity at which PP was reached; F_{pp} = force at the instant which PP was reached; AP= Power average during the jump; Lr= vertical path of the center of gravity between the instants of take-off landing; F2 = second peak vertical force during landing.

DISCUSSION

Analysing the characteristics of the sample, regarding to body composition (Table 1), as we mentioned before, there are no differences observed in body composition between our experts and novices. In the bibliography, there are two studies that analyse body composition of BJJ fighters. The results of our study are lower than those found by Del Vecchio et al. [3] (9.8 ± 4.2 kg) and Andreato et al. [8] (10.3 ± 2.6 kg). This may be due to the moment of the sports season, in our study athletes were measured just before they had their first combat in an international championship, with everything it entails (competition period, weight adjusted to the maximum in their category, etc.), whereas the other two studies were carried out one during the first preparatory period and the other investigation period is not recorded.

Experts, novices and hand grip strength

Our results may suggest that athletes with some degree of experience, expertise and continuous training in BJJ developed adaptations and improvements related to the isometric handgrip strength. We found significant differences between experts and novices in both hands (right, $p = 0.004$ and left, $p = 0.001$). We have only found three studies in the bibliography in which BJJ expert athletes are compared to lower-level athletes. Borges-Junior et al. [11], analysed the handgrip in 29 men athletes practicing aikido, judo, rowing, BJJ and non-athletes. In this research, only significant differences between BJJ athletes and aikido athletes, and BJJ athletes and non-athletes were found. Oliveira et al. [12], compared 21 athletes graduated as black and brown belts, with 29 graduates from blue to purple belts, these authors finds no significant differences in relation to hand grip strength. While data from their experts are similar, these novices have better results than ours, it may be because their novices have twice as many years of experience (5.8 ± 1.5) [12] versus (3.0 ± 1.1 years) the ones in our study. Although, these authors found no significant differences, they obtained higher values for their expert group (black and brown belts) compared to their non-expert group. Nonetheless, the same authors did find significant differences between BJJ athletes and non-athletes (other 50 subjects were used as a control group) for the left hand. Finally, Corrêa da Silva et al. [24] performed a study with 20 BJJ athletes, we found many parallels with our research. Firstly, in this study, there are differences between elite and non-elite athletes. Secondly, the criterion of differentiation between both groups is

very similar to the one we have established in our research. However, these authors did not measure hand grip strength with a dynamometer because they carried out two specific tests of hand grip. The last similarity between both studies is that these authors also found significant differences between elite and non-elite BJJ athletes.

If we analyse our data of isometric handgrip strength, novices (LHG= 43.3 ± 6.6 kgf; RHG= 43.6 ± 7.1 kgf) and experts (LHG= 49.1 ± 7.0 kgf; RHG= 48.6 ± 6.1 kgf) and compare them with the bibliography, the data obtained from our experts and novices are higher than those obtained by BJJ elite athletes by Andreato et al. [6]. If we only compare the data recorded from our experts, they are above those obtained by BJJ adult athletes in Andreato et al. [15], close to those obtained by BJJ brown and black belts in Oliveira et al. [12], as above mentioned, and lower than those obtained by Franchini et al. [4, 25] in BJJ black belts and BJJ athletes respectively. Moreover, when compared to other similar sports, which have been researched, like judo, the data of both our experts and novices would be close to the data obtained by Franchini et al. [26] from Brazilian national judo. If we only focus on the data from our experts and compare them with judokas, our data are clearly below the senior judokas in Little [27] and the Canadian judo team in Thomas et al. [28].

Most authors who have studied hand grip strength in BJJ have concluded that athletes of this sport do not have high hand grip strength results [4, 6, 12, 15], we agree with this statement, especially if we compare data with high level judokas. However, observing our results, we think that it is very important that BJJ athletes reach minimum values, necessary to compete effectively in high level of this sport. Some authors suggested that the percentage of grip strength loss could be related to the corresponding initial maximum isometric strength [29, 30]. Bonitch-Gongora et al. [31] are in the same line in their study done with judokas elite and non-elite, their findings suggest that elite judokas are able to develop higher levels of hand-grip strength and they also have better strategies to resist successive contractions. Therefore, we can state that having high maximum hand grip strength may be necessary to improve gripping endurance. There is a consensus in the specific bibliography about the importance of this ability (gripping endurance) [4-6, 12, 15], since the more continuous grip actions performed in BJJ, require the higher resistance in maintaining constant levels of force over a longer period of time.

Experts, novices and explosive force

Vertical jumping performance is not described in other studies regarding BJJ athletes. However, observing our results, it seems that the jump performance can be a factor that discriminates between two groups with different levels of training and experience [32, 33].

Thanks to the results obtained in CMJ jump, we observed higher explosive strength in the legs of experts than in novices; this is reflected in the significant differences found in relation to three performance variables in the jump: height of jump (H), peak power (PP), and average power (AP). Furthermore, regarding the moment when the peak power was reached, we observe that there are significant differences in velocity (V_{pp}), but there are not differences in force (F_{pp}). This means that higher records in the variables discussed by experts (height, peak power and average power) are mainly due to their ability to generate more speed in the CMJ, maintaining strength levels.

We are aware that BJJ is a sport in which the manifestations of strength endurance are very important [6, 13]. However, as we have seen in the results of our research, athletes with more expertise and experience also have a good base of explosive strength. This statement is based on authors who explain that the decisive moments, that determine the result of the fight (guard passes, sweeps, submissions etc), require explosive strength and power. Therefore, these skills must be trained specifically in BJJ to improve them [3, 15] and plan your training, not only to improve your abilities but also so that the athlete has no performance losses at any specific period of training [5].

Looking at the three performance variables obtained in CMJ by our experts (H, PP and AP) and compared with other studies found in the literature, our data are very close to those obtained by Spanish students of the Faculty of Sports Science [34], but are clearly below most explosive athletes such as participants of the Spanish National badminton championship [35]. If we compare the data obtained about jumps in combat sports such as judo (due to the lack of evidence in BJJ) to our jump height data, they are below judo athletes [32], but they are very similar to Greek trained judokas [33].

To sum up, BJJ athletes have not achieved very high results in CMJ, especially when compared to highly explosive athletes like badminton players. However, observing our data, which led us to differences between experts and novices, and considering that

the explosive actions often decide the outcome of the fight in BJJ, it would be very interesting to further investigate in this direction, both in the analysis of the explosive strength of legs and arms.

Limitations of the study

Since these athletes performed the tests about an hour before the competition, we selected interesting tests to investigate, which would not affect their subsequent performance during the fight. It would have been interesting to measure the hand gripping endurance and the explosive strength of arms, as well as to perform a test of repeated jumps in different level groups just before an important competition (or at a close stage during the season).

Practical applications

Based on the literature review and the data obtained in our research, BJJ competitors could include exercises of this type within the specific stage: Work to improve the isometric handgrip strength, statically (i.e. sustain grip holding on the *gi* rolled around the bar) and exercises to improve the gripping endurance, dynamically (i.e. with chin ups with *gi* or series of trx with *gi*). Furthermore, they should work the leg power (i.e. box jumps between 80 and 100 cm, repeated sprints, legs power drills).

CONCLUSIONS

BJJ athletes have less fat percentages, which is quite similar to other combat sports such as wrestling and judo.

It is suggested that BJJ athletes with higher experience, training, and level (experts), have adaptations and improvements related to the isometric handgrip strength, if we compare them with other athletes with less training time and lower levels (novices). These results are also interesting because some authors have established a direct relationship between isometric hand grip strength and gripping endurance. The gripping endurance seems a key factor in the performance of BJJ athletes and appears as an essential in the specific literature.

Moreover, it is suggested that expert athletes have more power and explosive strength in their legs than novices because they are able to generate more power and height in the CMJ test. According to the available research bibliography, power actions in BJJ are the ones which often determine the final result of the fight.

ACKNOWLEDGMENTS

We are grateful for the athletes who took part in this study and for the cooperation of the Camilo José Cela University, Federação Portuguesa de Jiu-Jitsu Brasileiro (FPJJB), International Brazilian Jiu Jitsu Federation (IBJJF).

COMPETING INTERESTS

The authors declare that they have no competing

interests.

REFERENCES

- Gracie R, Gracie C. Brazilian Jiu-Jitsu: theory and technique. Montpelier, Vermon: Kid Peligro Publishers; 2000
- Guimaraes F. Jiu-Jitsu Brasileiro. Atlas do esportes no Brasil 2006; 10: 41-4
- Del Vecchio FB, Bianchi S, Hirata SM et al. Análise morfo-funcional de praticantes de brasileiro jiu jitsu e estudo da temporalidade e da quantificação das ações motoras na modalidade. *Movimiento & Percepção* 2007; 7(10): 263-81
- Franchini E, Takito MY, Pereira J. Frequência cardíaca e força de preensão manual durante a luta de jiu-jitsu. *Lecturas Educación Física y Deportes*. [serial online] 2003; 9(65) [accessed 2013 sep 9]. Available from: URL:<http://www.efdeportes.com/efd65/jiujitsu.htm>
- Silva Neto A, Dechechi CJ. Efeito de treinamento de resistência anaeróbica específico para atletas de jiu-jitsu quanto à força de preensão manual e potência muscular. *Revista Hórus*. 2010; 4(2): 188-207
- Andreato LV, Franzoi de Moraes SM, Lopes de Moraes Gomes T et al. Estimated aerobic power, muscular strength and flexibility in elite Brazilian Jiu-Jitsu athletes. *Sci Sport*. 2011; 26: 329-337
- García JM, Navarro F, González JM et al. Paradigma experto-novato: análisis diferencial de la pérdida de consistencia del tokui waza en judo bajo situación específica de fatiga. *Int J Sports Sci* 2007; 3(3): 11-28
- Andreato LV, Franchini E, Franzoi de Moraes SM et al. Morphological profile of Brazilian jiu-jitsu elite athletes. *Rev Bras Med Esporte* 2012;18(1): 46-50
- Koley S, Yadav MK. An association of hand grip strength with some anthropometric variables in Indian cricket players. *Phys Educ Sport* 2009; 7: 113-123
- Visnapuu M, Jürimäe T. Handgrip Strength and Hand Dimensions in Young Handball and Basketball Players. *J Strength Cond Res* 2007; 21(3): 923-929
- Borges-Junior NG, Domenech SC, Silva AC et al. Comparative study of maximum isometric grip strength in different sports. *Rev Bras Cineantropom Desempenho Hum* 2009; 11(3): 292-298
- Oliveira M, Moreira D, Godoy JRP et al. Avaliação da força de preensão palmar em atletas de jiu-jitsu de nível competitivo. *R bras Ci e Mov* 2006; 14(3): 63-70
- Jones NB, Ledford E. Strength and conditioning for Brazilian Jiu-Jitsu. *Strength Cond J* 2012 ;34(2): 60-68
- Bosco C, Cardinale M, Tsarpela O et al. The influence of whole body vibration on jumping performance. *Biol Sport* 1998; 15: 148-156
- Andreato LV, Franchini E, de Moraes SM et al. Physiological and Technical-tactical Analysis in Brazilian Jiu-jitsu Competition. *Asian J Sports Med* 2013; 4(2): 137-143
- Komi PV, Bosco C. Utilization of stores elastic energy in leg extensor muscles by men and women. *Med Sci Sports* 1978; 10(4): 261-265
- Goubel F. Series elastic behavior during the stretch-shortening cycle. *J Appl Biomech* 1997; 13(4): 439-442
- Association WM. Declaration of Helsinki: ethical principles for medical research involving human subjects. *J Postgrad Med* 2002; 48: 206-208
- Moon JR, Smith AE, Tobkin SE et al. Total body water changes after an exercise intervention tracked using bioimpedance spectroscopy: a deuterium oxide comparison. *Clin Nutr* 2009; 28(5): 516-525
- Iglesias E, Clavel I, Dopico J et al. Efecto agudo del esfuerzo específico de judo sobre diferentes manifestaciones de la fuerza y su relación con la frecuencia cardíaca alcanzada durante el enfrentamiento. *Rendimientodeportivo.com* [serial online] 2003; 6 [accessed 2013 nov 14]. Available from: URL:<http://www.rendimientodeportivo.com/N006/Artic027.htm>
- España-Romero V, Ortega FB, Vicente Rodriguez G et al. Elbow position affects handgrip strength in adolescents: validity and reliability of Jamar, DynEx, and TKK dynamometers. *J Strength Cond Res* 2010; 24: 272-277
- Segura-Orti E, Martínez-Olmos FJ. Test-retest reliability and minimal detectable change scores for sit-to-sit test, the six-minute walk test, the one leg heel-rise test, and handgrip strength in people undergoing hemodialysis. *Phys Ther* 2011; 91: 1244-1252
- Linthorne N. Analysis of standing vertical jump using a force platform. *Am J Phys* 2001; 69: 1198-1204
- Corrêa da Silva BV, Moacir Marocolo J, de Moura Simin MA et al. Reliability in kimono grip strength tests and comparison between elite and non-elite Brazilian Jiu-Jitsu players. *Arch Budo* 2012; 8(2): 103-107
- Franchini E, Bezerra P, Oliveira RSF et al. Concentração de lactato sanguíneo, frequência cardíaca e força de preensão manual durante um combate de jiu-jitsu. *Corpoconsciência* 2005; 9(1): 21-29
- Franchini E, Takito MY, Kiss MA et al. Physical fitness and anthropometrical differences between elite and non-elite judo players. *Biol Sport* 2005; 22: 315-328
- Little NG. Physical performance attributes of Junior and Senior women, Juvenile, Junior and Senior men judokas. *J Sport Med Phys Fit* 1991; 31: 510-520
- Thomas SG, Cox MH, Legal YM et al. Physiological profiles of the Canadian National Judo Team. *Can J Sport Sci* 1989; 14(3): 142-147
- Siddiqi T, Walker S, Admunsen L, editors. Measurement of hand grip fatigue. Proceedings of the Annual Conference of the American Physical Therapy Association; 2002
- Yamaji S, Demura S, Nagasawa Y et al. The influence of different target values and measurement times on the decreasing force curve during sustained static J. *Physiol Anthropol* 2006; 25: 23-28
- Bonitch-Gongora JG, Almeida F, Padiá P et al. Maximal isometric handgrip strength and endurance differences between elite and non-elite young judo athletes. *Arch Budo* 2013; 9(4): 239-248
- Fernandes Monteiro L, Massaça LM, García García JM et al. Plyometric muscular action tests in judo- and non-judo athletes. *Isokinet Exerc Sci* 2011; 19: 287-293
- Zaggelidis G, Lazaridis SP, Malkogiorgios A et al. Differences in vertical jumping performance between untrained males and advanced greek judokas. *Arch Budo* 2012; 8(2): 87-90
- Lara AJ, Abian J, Alegre LM et al. Assessment of power output in jump test for applicants to a sports sciences degree. *J Sports Med Phys Fitness* 2006; 46: 419-424
- Abián-Vicén J, Del Coso J, González Millan C et al. Analysis of Dehydration and Strength in Elite Badminton Players. *PLoS One* 2012; 7(5): e37821

Cite this article as: Diaz-Lara FJ, García JMG, Monteiro LF et al. Body composition, isometric hand grip and explosive strength leg – similarities and differences between novices and experts in an international competition of Brazilian jiu jitsu. *Arch Budo* 2014; 10: 211-217