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ORIGINAL ARTICLE

Health-related body composition and muscle strength in Brazilian Jiu-Jitsu practitioners

Daniele Detanico[1] · Rafael Lima Kons[1] · Jorge Nelson da Silva Junior[1] · Diego Luiz Bittencourt[1] · Rodrigo Ghedini Gheller[1]

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Abstract

Purpose This study aimed to analyze the health-related body composition and muscle strength performance in male and female Brazilian Jiu-Jitsu (BJJ) practitioners and to verify the upper and lower limbs bilateral asymmetry in these individuals.

Methods Forty-three BJJ practitioners participated of this study, 20 men and 23 women. The individuals performed anthropometric measurements (body mass, height and body fat), neuromuscular lower limb assessments (countermovement jump—CMJ, squat jump—SJ and sit-and-reach test), and upper limb assessments (handgrip strength test—HGS test and Kimono Grip Strength Test—KGST).

Results The main results demonstrated that most practitioners (both men and women) were classified as normal body fat, regular performance in CMJ and HGS, however, with poor flexibility. Higher performance in neuromuscular tests (CMJ, SJ and HGS) and KGST was reported in men compared to women, while women presented better flexibility and the use of elastic energy during the jump compared to men ($p < 0.05$). Additionally, higher values of HGS in the dominant hand than the non-dominant was observed only in women ($p = 0.001$), and no significant difference was observed in the unilateral CMJ between the limbs for both women ($p = 0.29$) and men ($p = 0.06$).

Conclusion The recreational BJJ practice seems to induce improvements in body composition and muscle strength in the upper and lower limbs, without provoking bilateral asymmetries in the lower limbs. Men presented higher physical performance than women in most neuromuscular tests, but both showed poor flexibility.

Keywords Martial arts · Body fat · Muscle power · Handgrip strength · Asymmetry

Introduction

The health benefits of decreasing body fat and enhancing muscular strength are well established in literature, as it is associated a significantly decrease of several risk factors (e.g. cardiovascular disease events, physical function limitations, and nonfatal diseases) [1]. The sport practice may be an interesting way to improve health-related strength, especially in martial arts or combat sports that require endurance strength and power in upper and lower limbs during the practice [2–4]. In addition, the decrease in body fat may be accentuated due to the aerobic and anaerobic characteristics of most martial arts, mainly the grappling modalities, as judo, Brazilian Jiu-Jitsu (BJJ) and wrestling [3, 5].

In the past decade in particular, there has been a significant rise in the popularity of BJJ, as a grappling sport. BJJ combat is characterized by high-intensity intermittent efforts with few resting periods [6, 7]. In the competitions, athletes are divided

✉ Daniele Detanico
d.detanico@ufsc.br

Rafael Lima Kons
rafakons0310@gmail.com

Jorge Nelson da Silva Junior
jorgenelson17@gmail.com

Diego Luiz Bittencourt
dl.bittencourt@hotmail.com

Rodrigo Ghedini Gheller
rodrigo.gheller@gmail.com

[1] Biomechanics Laboratory, Center of Sports, Federal University of Santa Catarina, Florianópolis, SC 88040-900, Brazil

by age, body weight and belt ranks. The match-time limits vary according to the category, ranging from 5 to 10 min in adults, and the main goal was to achieve the opponent's desistance mainly through the submission (i.e. arm locks, choke or pressure techniques) or through scores by the referee's decision [8]. These characteristics require that the training sessions reproduce the demands of the competitions, generating specific physical, physiological and biochemical adaptations [9].

The BJJ practice requires high levels of isometric handgrip strength and muscle power of the lower limbs to perform takedowns, escapes, holding, and applying submission techniques [10, 11]. Previous investigations have shown that advanced BJJ athletes presented higher performance in upper and lower limb strength assessments (e.g. maximal dynamic strength, maximal isometric handgrip strength and vertical jump) than non-advanced counterparts [12–14], indicating a sport-dependent influence. A recent systematic review showed that BJJ athletes have also great flexibility in the lower limbs and low body fat [3]. Thus, some benefits are also apparent in BJJ practitioners, as shown by Schwartz et al. [15], who identified moderate body fat, high values of maximal handgrip strength, endurance strength (abdominal test), cardiovascular responses and flexibility. In this perspective, Queiroz et al. [4] verified improvements in upper and lower limb strength in elderly men after 12 weeks of BJJ-specific training. Therefore, it seems that the BJJ practice is a good alternative to improve health-related aspects.

The literature on the health-related physical fitness profile in BJJ is limited to men and athletes [4, 14–16], who present different physical and morphological characteristics than women. In addition, studies investigating strength/power parameters did not consider the dominant and non-dominant sides. It is already known that bilateral asymmetries increase the risk of injury [17]. Thus, quantifying and monitoring changes in asymmetry could be deemed important to both maximize physical performance and monitoring neuromuscular rehabilitation programs [18]. Based on this perspective, this study aimed to analyze the health-related body composition and muscle strength performance in male and female BJJ practitioners and to verify the upper and lower limbs bilateral asymmetry in these individuals. We hypothesized that the BJJ practitioners will present good health-related physical fitness (considering health guideline parameters), without inducing bilateral asymmetries in upper and lower limbs.

Methods

Design

This is a cross-sectional study that seeks to describe the body composition and physical profile of BJJ practitioners according to sex. The assessments were performed on two occasions separated by 48 h. On the first day, anthropometric measurements (body mass, height and body fat) and neuromuscular lower limb tests (countermovement jump—CMJ, squat jump—SJ and sit-and-reach test) were conducted; on the second day, upper limb tests (maximal isometric handgrip strength—HGS and Kimono Grip Strength Test—KGST) were performed. Each physical test was separated by a 20-min interval.

Participants

Forty-three recreational BJJ practitioners, 20 males (age: 28.1 ± 7.1 years, range 20–48 years) and 23 females (age: 23.6 ± 5.3 years, range 18–36 years) volunteered and participated in this study. The main characteristics are described in Table 1. The practitioners had participated in at least one year of regular BJJ training, and all had participated in regional ($n = 30$) or state ($n = 13$) tournaments. They were regularly training 2–3 times a week during the evaluation period. The practitioners were white (men $n = 15$, women $n = 21$) and blue belts (men $n = 5$, women $n = 2$), with 4.6 ± 1.2 years of BJJ practice. Some participants reported practicing other physical activities, such as strength training ($n = 31$), surfing ($n = 9$) and dancing ($n = 6$). Participants were instructed not to take alcohol or drugs for at least 24 h before the evaluations and were maintaining normal diets. Ethical approval was obtained by the local university (number 1,957,840) in accordance with the Declaration of Helsinki. All participants signed the informed consent form before the evaluations.

Body composition assessment

To describe the body composition of the practitioners, anthropometric measurements of body mass and height were collected using a Toledo® digital scale with 100 g precision and a stadiometer with 1 mm precision, respectively. The body mass index (BMI) was calculated for male and female individuals. A Cescorf® adipometer with a precision of 1 mm was used to measure the body thickness. Triceps, subscapular, supra iliac and middle calf measurements were collected for men and women and equations proposed by Petroski and Pires-Neto [19] were used to estimate the body density. The Siri equation was used to estimate the body fat percentage [20]. We also calculated the fat-free mass (FFM) and fat-free mass index (FFMI) by the following equations [21]:

$$\text{FFM} = \text{body mass (kg)} \times \left(1 - \frac{\text{body fat (\%)}}{100}\right), \quad (1)$$

$$\text{FFMI} = \frac{\text{FFM (kg)}}{\text{height (m)}^2}. \quad (2)$$

Sit-and-reach test

The flexibility was measured through the sit-and-reach test and was performed in the Wells and Dillon [22]. The individual was in a seated position, with the knees extended, the feet touching the bench, and the hands over-lapping each other. Three attempts were performed, with one-minute interval and the highest value was used as a performance variable. The intraclass correlation coefficient (ICC) showed values of 0.96 between the trials, indicating excellent reliability.

Vertical jump assessments

Before the vertical jump assessments, the participants performed a familiarization/warm-up period involving 30 s of hopping on a trampoline, three series of ten hops on the ground, and five submaximal countermovement vertical jumps. After a 3-min resting period, individuals performed three maximal trials of CMJ and SJ on a piezoelectric force platform (model 9290AD; Kistler, Quattro Jump, Winterthur, Switzerland), which measures the vertical ground reaction sampling at 500 Hz. CMJ and SJ were performed randomly, with 3-minute interval between protocols and 1-minute interval between attempts.

To perform the CMJ protocol (bilateral and unilateral), the individuals started from a static standing position and were instructed to perform a countermovement (descent phase), followed by a rapid and vigorous extension of the lower limb joints (ascent phase). Participants were also asked to flex their knees at 90° in the transition between the eccentric–concentric phases. During the jump, participants were asked to maintain their trunk as vertical as possible, whereas their hands remained on their hips. The individuals were then instructed to jump as high as possible. In the SJ, individuals started the jump from a static position with the knees at an angle of about 90°, the trunk as vertical as possible, and the hands on the waist. The jump was performed without any countermovement, and there was only the concentric action of the agonist muscles involved in the movement. Verbal feedback was provided for the participants during the test to encourage them to maintain a knee angle of approximately 90° and maximum performance until the end of the test. We used the mean value (within the three trials) of the jump height (CMJ_H and SJ_H) and the mean power output normalized by body mass as performance variables. The reliability of the vertical jump variables was tested through three trials of the CMJ and SJ, showing an ICC ranging from 0.97 to 0.99 for the jump height and power output. The pre-stretch augmentation (PSA) index was also calculated to identify the stretch–shortening cycle (SSC) utilization in the lower body muscles using Eq. 3 [23]:

$$\text{PSA} = \left(\frac{\text{CMJ}_\text{H} - \text{SJ}_\text{H}}{\text{SJ}_\text{H}}\right) \times 100. \quad (3)$$

Handgrip strength protocol

Before the assessment, individuals performed familiarization with a handgrip dynamometer (Carci® 225, SH 5001 model) through two submaximal trials. Afterwards, participants were instructed to perform the grip with maximal effort during 5 s for the dominant and non-dominant hand, performed alternately, with one-minute intervals between attempts. The evaluation was performed with participants in a standing position with the shoulder flexed at 90° (in accordance with the gripping phase—*kumi-kata*) and the elbow was fully extended. They performed three trials and the highest value was considered the performance variable. The ICC was calculated with the three trials and showed values of 0.97 and 0.94 for the dominant and non-dominant hand, respectively.

Bilateral asymmetry index

Bilateral asymmetry was quantified as the percentage difference between the stronger and weaker limb for HGS and unilateral CMJ_H through the equation proposed by Impellizzeri et al. [24] (Eq. 4):

$$\text{Bilateral asymmetry} = \left(\frac{\text{Stronger limb} - \text{Weaker limb}}{\text{Stronger limb}}\right) \times 100. \quad (4)$$

Kimono grip strength isometric test (KGST) assessment

The participants were familiarized with the KGST by performing one sustained attempt of 2–3 s grasping a kimono suspended on an elevated horizontal bar. The KGST consisted of sustaining a predefined position of elbow flexion for a maximum time period. Athletes performed only the isometric version of the KGST ($KGST_{ISO}$). The chronometer begins with a verbal command and was stopped when the participants could no longer maintain the original position. The reliability of the KGST has been assessed in a previous study, presenting an ICC of 0.97 [25].

Statistical analysis

Data are reported as the mean, standard deviation (SD) and absolute and relative frequencies. The Shapiro–Wilk test was used to verify data normality. Thus, t-test for independent samples was used to compare the physical variables between male and female practitioners, as well as to compare the dominant and non-dominant limbs. In addition, the effect size (ES) was calculated and the Hopkins [26] criteria was used to classify the ES: 0.0–0.2 trivial, 0.21–0.6 small, 0.61–1.2 moderate, 1.21–2.0 large, and 2.1–4.0 5 very large. 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

Table 1 shows the mean and SD of anthropometric characteristics of male and female BJJ practitioners. The men presented higher body mass, height, BMI, FFM, FFMI and lower body fat compared to women (moderate to very large ES).

The findings in Table 2 shows that jump height and power output in CMJ and SJ (unilateral and bilateral), HGS (dominant and non-dominant hand) and KGST performance were higher in men compared to women (moderate to very large ES). Otherwise, women presented better flexibility and the use of elastic energy (PSA) during the jump compared to men (moderate ES). Higher values were verified in the HGS in the dominant hand compared to the non-dominant for women ($p = 0.001$, ES = 0.49, small), but not for men ($p = 0.23$, ES = 0.10, trivial). However, no significant difference was observed of unilateral CMJ between the limbs for women ($p = 0.29$, ES = 0.11, trivial) and men ($p = 0.06$, ES = 0.22, small).

The Fig. 1 shows the asymmetry index of unilateral CMJ (women: 7.7 ± 5.6%, men: 10.3 ± 9.8%, ES = 0.28, small) and HGS (women: 12.1 ± 8.1%, men: 8.9 ± 7.0%, ES = 0.42, small). No significant differences were observed in both variables between the sexes.

Table 3 summarizes the absolute and relative frequency of classification levels for body composition and physical test performances in men and women. Most women were classified as 'normal' for BMI and men as 'normal' and 'overweight'. Most individuals were classified as 'recommended' range for body fat and as 'needs improvement' for the sit-and-reach test. In addition, most practitioners

Table 1 Body composition characteristics of women and men BJJ practitioners

	Women ($n = 23$)	Men ($n = 20$)	p	ES
Body mass (kg)	61.1 ± 9.1	76.6 ± 10.1	< 0.01	1.61
Height (cm)	165.3 ± 7.4	176.4 ± 7.2	< 0.01	1.52
Body mass index (m kg^{-2})	22.2 ± 1.9	24.6 ± 2.3	< 0.01	1.13
Body fat (%)	23.3 ± 2.9	16.6 ± 5.7	< 0.01	1.48
FFM (kg)	46.7 ± 5.6	63.4 ± 5.8	< 0.01	2.92
FFMI (kg m^{-2})	17.0 ± 0.9	20.4 ± 1.4	< 0.01	2.88

FFM fat-free mass, *FFMI* fat-free mass index, *ES* effect size

Table 2 Physical test performance in upper and lower limbs in women and men BJJ practitioners

	Women ($n = 23$)	Men ($n = 20$)	p	ES
Sit-and-reach test (cm)	29.9 ± 8.3	24.4 ± 9.5	0.05	0.61
CMJ_H (cm)	31.1 ± 4.5	38.5 ± 7.1	< 0.01	1.24
CMJ_P (W kg^{-1})	19.2 ± 3.4	23.2 ± 3.6	< 0.01	1.14
SJ_H (cm)	28.8 ± 4.12	37.8 ± 5.84	< 0.01	1.78
SJ_P (W kg^{-1})	14.9 ± 2.0	19.0 ± 2.4	< 0.01	1.85
PSA index (%)	8.2 ± 4.7	5.4 ± 3.3	0.01	0.68
CMJ_{H_D} (cm)	20.4 ± 2.9	25.5 ± 4.5	< 0.01	1.34
CMJ_{H_ND} (cm)	19.7 ± 3.4	26.0 ± 4.6	< 0.01	1.55
HGS_D (kgf)	27.2 ± 4.94$^{\#}$	43.1 ± 7.13	< 0.01	2.59
HGS_{ND} (kgf)	24.8 ± 4.82	42.3 ± 9.05	< 0.01	2.41
$KGST_{ISO}$ (s)	19.5 ± 12.46	29.4 ± 18.68	0.04	0.62

CMJ_H countermovement jump height, *CMJ_P* countermovement jump power, *SJ_H* squat jump height, *SJ_P* squat jump power, *PSA* pre-stretch augmentation, *HGS_D* handgrip strength of dominant hand, *HGS_{ND}* handgrip strength of non-dominant hand, *$KGST_{ISO}$* Kimono Grip Strength Isometric Test, *ES* effect size. *Significant difference between women and men, $^{\#}$significant difference between dominant and non-dominant hands

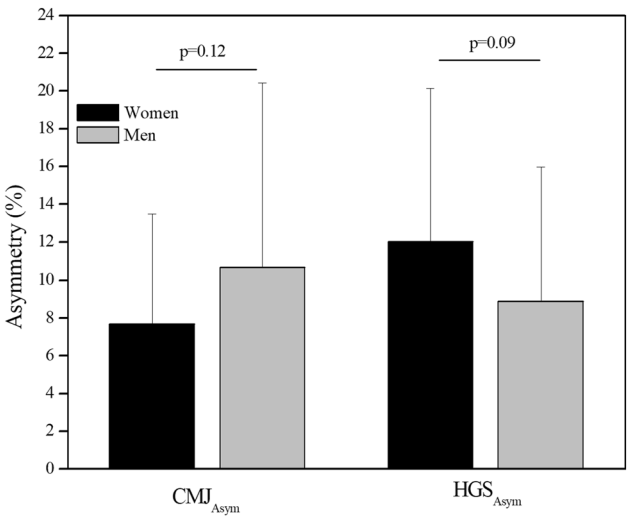

Fig. 1 Asymmetry index of CMJ_H and HGS in women and men BJJ practitioners

Table 3 Absolute and relative (%) classification of body composition and physical tests performance in BJJ practitioners

	Classification	Women	Men
BMI (kg m^{-2})[a]	Underweight	0 (0)	0 (0)
	Normal	22 (95.7)	11 (55)
	Overweight	1 (4.3)	9 (45)
	Obesity	0 (0)	0 (0)
Body fat (%)[a]	Essential	0 (0)	0 (0)
	Low/athletic	3 (13)	0 (0)
	Recommended	20 (87)	18 (90)
	Overfat	0 (0)	1 (5)
	Obese	0 (0)	1 (5)
Sit-and-reach test (cm)[a]	Excellent	3 (13)	1 (5)
	Very good	3 (13)	3 (15)
	Good	2 (8.7)	3 (15)
	Fair	6 (26.1)	3 (15)
	Needs improvement	9 (39.1)	10 (50)
CMJ_H (cm)[b]	Excellent	–	1 (5)
	Good	–	2 (10)
	Regular	–	8 (40)
	Poor	–	5 (25)
	Very poor	–	4 (20)
HGS (kgf)[c]	High	1 (4.3)	2 (10)
	Typical	14 (60.9)	10 (50)
	Low	8 (34.8)	8 (40)

[a]Normative data according to American College of Sports Medicine—guideline for exercise testing and prescription [27]

[b]Branco et al. [28] with correction proposed by Dias et al. [29] for CMJ assessment in force platform

[c]Fukuda [30]

were 'regular' for CMJ_{JH} (only men) and 'typical' for HGS (men and women).

Discussion

The aim of this study was to analyze the health-related body composition and muscle strength performance in male and female BJJ practitioners and to verify the upper and lower limbs' bilateral asymmetry in these individuals. We accept our hypothesis, as the BJJ practitioners present normal values (considering health guideline parameters) of body composition (BMI and body fat) and muscle strength for men and women in upper and lower limbs (with the exception of flexibility). The women showed slight asymmetry in the HGS, but no bilateral asymmetry in the lower limbs (unilateral CMJ) was identified in both men and women.

The anthropometric characteristics showed that men present higher body mass, height, BMI, FFM, FFMI and lower body fat than women. These findings were already expected and possibly, the higher BMI in men was due to the higher FFM compared to women, as the body fat was lower in the men. The use of BMI for individuals who practice sports is not very advisable, as these individuals may have lean mass greater than the general population and result in very high BMI values [31]. Thus, the FFMI has been an interesting alternative, combining the three components—body mass, body fat and height [21]. We could not properly classify our individuals according to the FFMI due to the lack of a normative table in the current literature. The body fat classification showed that most men and women presented values within the 'recommended'. The body fat was similar to what was observed in previous studies with male BJJ [15] and female practitioners [32], but higher compared to BJJ athletes [33, 34].

With regard to the flexibility, the women's scores were better in the sit-and-reach test than men, which is in agreement with the literature [35, 36], as women present different anatomical features mainly related to spine and hip mobility. The men presented values close to another study with BJJ practitioners [15], but lower than BJJ high-level athletes [14]. For most of the men and women, the set-and-reach test performance was classified as 'needs improvement'. The flexibility is considered a very important capacity for BJJ success, as it has been related to specific techniques of attacks or defenses [3], in addition to being an important component of the heath-related physical fitness [27]. In this sense, improvements in the mobility are expected, especially in spine and hip, with the practice BJJ.

Adequate levels of muscle strength and power in upper and lower limbs are important during the adulthood, especially considering the age-specific recommendation for health improvements and quality of life [1, 27]. We observed that men showed higher levels of muscle power in lower limbs (CMJ and SJ performance) compared to women, probably due to morphologic features evidenced in our study (e.g. higher body mass, FFM, FFMI and lower body fat), that are related to greater muscle strength [37]. Most male practitioners were classified as 'regular to excellent' for CMJ height, showing acceptable values of muscle power in lower limbs [28]. In women, it was not possible to analyze this variable due to the lack of normative classification. Although BJJ practice is in most part performed on the ground, high levels of muscle power in lower extremities is important to perform takedowns and escapes, holding, as well as applying submission techniques [10, 11]. An interesting result is that women presented better use of SSC compared to men, despite the worst CMJ performance. Previous studies have already found that the women may be able to utilize a greater portion of the stored elastic energy in jumping activities [37, 38].

The men showed also higher performance in HGS than women, but most of them (men and women) were classified as 'typical', showing acceptable values of maximal isometric

strength in the forearm muscles [30]. The values of HGS obtained for males were similar to those observed in the literature for BJJ practitioners [34]. No data were found in the literature for HGS in BJJ female practitioners or athletes. The KGST is a BJJ-specific endurance strength test and has been widely used to assess BJJ male athletes/practitioners [25, 39, 40], but not yet evidenced in women. The values in males within our study were similar to those observed by Silva et al. [39] for BJJ practitioners. It is worth mentioning the importance of dynamic and isometric strength actions during BJJ matches (e.g. to control the opponent and perform attacks) [41] and for health benefits, as lower risk of developing physical function limitations and cardiovascular diseases [1, 27].

The women in our study presented slightly higher values of HGS in the dominant hand compared to the non-dominant one, with an asymmetry index of 12%. Both men and women did not show differences of unilateral CMJ between the limbs, but the asymmetry index was at the acceptance threshold for men (10.3%). When comparing men and women, no difference in the bilateral asymmetry was identified in upper and lower limbs. It has been reported that values above 10% of asymmetry indicate a possible risk of injury during sports practice [42]. Therefore, although the recreational practice of BJJ does not seem to induce major muscle imbalances, it is recommended that specific actions be performed bilaterally (e.g. takedowns, escapes, holding, submission techniques, etc.) to reduce the asymmetry and consequently the muscle-related disorders.

Finally, it is important to highlight that this is a cross-sectional study that described the health-related body composition and muscle strength parameters in men and women who practiced recreational sessions of BJJ for at least 1 year. We did not control the BJJ training routines of the practitioners, which is a limitation in our study. However, we provided data showing that recreational practice of combat sports may be a strategy to enhance physical fitness and health in men and women. Thus, it is recommend to monitor body composition and physical fitness in BJJ practitioners to verify health-related physical fitness parameters. Additionally, the inclusion of bilateral and especially unilateral assessments (e.g. HGS and unilateral CMJ) may be an important strategy to prevent muscle-related disorders and risk of injuries even in recreational practitioners.

Conclusion

We conclude that the recreational practice of BJJ (2–3 times per week) contributes to improvements in the health-related physical fitness in men and women, particularly in the body composition and muscle strength in upper and lower limbs, with exception to flexibility. In addition, the BJJ practice seems no induce bilateral asymmetries in the lower limbs in women and in the upper and lower limbs in men.

Compliance with ethical standard

Conflict of interest The authors declare no potential conflict of interest.

Ethical approval Ethical approval was obtained from the local Human Research Ethics Committee at the local university, in accordance with the Declaration of Helsinki.

Informed consent All participants signed the informed consent form before the evaluations.

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