A comparative analysis of male judo and Brazilian jiu-jitsu practitioners based on motor performance and body build

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Key words: muscle strength, body composition, anthropometry, martial arts

Summary

Introduction. Particular fighting styles such as jiu-jitsu and judo, despite they have the same roots, differ from each other in technique and fighting dynamics and may involve different physical and functional demands. The aim of the study was to compare selected motor performance and body build variables in a sample of male combat athletes.

Material and methods. An anthropometric and fitness examination involved 23 judo and 43 Brazilian jiu-jitsu practitioners. The study was performed under the auspices of the Polish Ministry of Science and Higher Education under the grant "Development of muscle strength among martial arts and combat sports athletes differentiated by body build" (No. NRSA1 001551).

Results. While the jiu-jitsu group showed better performance in the standing long jump and sit-up test, the judo group attained higher strength values in which the largest difference was in back strength by approximately 20 kG. No significant intra-group differences were found in mean body height and size. Greater subscapular skinfold thickness and smaller forearm girth was found in the jiu-jitsu practitioners; the judo group was better hydrated.

Conclusions. The specificity of Brazilian jiu-jitsu, in that it allows a number of fighting techniques not permissible in judo, is reflected in improved motor performance via strength of the abdomen and lower limbs. The judo practitioners, using techniques that primarily engage the trunk and upper limbs, present strong back and forearm musculature as well as less trunk fat and increased forearm girth.

Introduction

While jiu-jitsu and judo are martial arts that traditionally place an emphasis on mental and spiritual development, a direct fight constitutes their essential element. Today they are largely practiced within the realm of combat sports. Brazilian jiu-jitsu is a Brazilian sport that originated by adapting techniques from traditional Japanese jujutsu [1]. Focus has shifted in these fighting disciplines to the recruitment and selection of athletes and deciding which anthropometric, mechanical, and physiological factors are the most important for competitive success [2-8]. It was proved, that among the others, physical fitness with great muscular strength is important factor of success in combat sports [4,9,10]. Other studies have reported that performance and competitive success in combat sports are influenced by body size and other anthropometric variables [2,4,5,11]. These aspects are intertwined with combat sport training, which also introduces changes in the physical fitness and some elements of body build of its practitioners [12,13]. Franchini et al. [2,14] concluded that in the group of the best athletes, the morphological variables do not discriminate performance, but the higher percent body fat is negatively correlated with performance, especially in activities with body mass locomotion.

Jiu-jitsu and judo both have a lot of elements of fight technique in vertical and horizontal positions, however, in Brazilian jiu-jitsu there are more elements of technique which are not permissible in judo. In judo bouts competitors struggle in vertical (tachi-waza) and horizontal (ne-waza) positions. The fight ends when one judoka (tori) performs the throw (on the large part of back, with power and control) and the referee announces ippon [15]. The amount of time of the fight in tachi-waza and ne-waza depends on the rules [16]. In jiu-jitsu bouts there are 3 phases: fight in distance (striking), fight with grip (throws) and fight in horizontal position – ne-waza [17]. Brazilian jiu-jitsu is considered a predominantly aerobic sport [18] with significantly higher proportion of an effort/ pause (ratio of approximately 10:1) when compared to judo which have presented an effort-pause ratio of approximately 2:1 [19]. Brazilian jiu-jitsu has more longer combat phases than judo [18].
The differences between judo and jiu-jitsu may be reflected in a number of physical and functional characteristics of which the most readily measurable are body build and fitness level. The purpose of this study was to therefore compare and analyze selected elements of motor performance, especially strength, as well as the body build and composition of judo and Brazilian jiu-jitsu practitioners. During judo or jiu-jitsu fight, all strength types are employed, thus stronger judoists are at an advantage over their opponents of comparable technical skills. Although it seems that physical variables of elite athletes have little impact on their success in sport [14], in case of non-elite combat sports practitioners, the presented results may support the direction of different combat sports training.

Material and methods

Sixty-six males aged 19–26 years (body height 177.9 ± 5.3 cm and body mass 80.0 ± 5.5 kg) were recruited in which 23 practiced judo and 43 Brazilian jiu-jitsu. Participants must have met the following inclusion criteria: minimum 2 years training experience, university sports club member, and competing in the middleweight class (73–90 kg in judo and 70–88 kg in jiu-jitsu) in regional and national championships. Both groups represent similar sports level (non-elite, degree above the rank of 3rd kyu and below the rank of 2nd dan). The sample was screened to verify that they were not suffering from any injury or disease that might affect participation in the study and written informed consent was obtained.

Anthropometry was performed using GPM anthropometric instruments (Siber Hegner, Switzerland). Body height was measured with a Martin-type anthropometer accurate to 0.1 cm. A spreading caliper was used to measure humeral and femoral bone breadths. Skinfold thicknesses at the subscapular, forearm, suprailiac, and calf sites were obtained using a Holtain skinfold caliper accurate to 0.2 mm [20]. Flexed arm and calf girths to the nearest 0.1 cm were determined using anthropometric tape [20]. Body mass was assessed with an electronic scale to 0.1 kg. Based on the above measures, body mass index and anthropometric indexes quantifying the body proportions of body musculature, skeletal size, and fat distribution were calculated. Somatotyping following Sheldon’s method as modified by Heath and Carter [21] was used to determine the level of endomorphy, mesomorphy, and ectomorphy. Body composition was also assessed by bioelectrical impedance analysis using a BIA 101 Anniversary Sport Edition and the prepackaged Bodygram 1.3.1 software (Akern, Italy).

Motor performance was assessed on the base of basic motor abilities, required to perform specific movements during judo or jiu-jitsu bout [1,22]: isometric grip strength and back strength, endurance strength (sit-ups test, bent-arm hang test) and the explosive power of the lower limbs (standing long jump test). Right and left handgrip and back strength were measured to the nearest 0.5 kG using an adjustable-grip dynamometer and back dynamometer (Takei Scientific Instruments, Japan). Motoric test were carried out in a gym in standard conditions according to Eurofit [22]. Relative strength to body mass was calculated for the right hand, left hand, and back.

Means and standard deviations were calculated and Levene’s test was used to analyze the homogeneity of variance. Differences between the judo and jiu-jitsu groups for body build and composition and the strength performance tests were analyzed using Student’s t-tests. These statistical tests were performed with the Statistica 9.0 software package (Statsoft, USA). Somatotypes were examined using Somatotype Analysis of Variance (SANOVA) using Somatotype Calculation and Analysis software (Sweat Technologies, Australia).

The study was approved by the Ethics Committee of the University School of Physical Education in Wroclaw, and conducted according to the Declaration of Helsinki. Funding was provided by the Polish Ministry of Science and Higher Education under the grant "Development of muscle strength among martial arts and combat sports athletes differentiated by body build" (No. NRSA1 001551).

Results

Motor performance

The judo practitioners achieved significantly better results than the jiu-jitsu cohort for absolute back strength (by 20 kG) and relative back strength (Table 1). While the judo group was also characterized by greater handgrip strength (by 2 kG), the jiu-jitsu group showed better motor performance in the remaining tests by completing more sit-ups, jumping 10 cm farther, and hanging 2 s longer (Table 1).

Body proportions

The judo and jiu-jitsu groups were characterized by a similar body height (178.0 cm and 178.3 cm, respectively; $t = 0.16$, $p = 0.764$) albeit more variability was observed in the judo

| Tab. 1. Motor performance tests results of the judo and Brazilian jiu-jitsu groups |
|---------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| Motor test                      | Judo      | BJj       | Student’s t-test |
|                                 | Mean SD   | Mean SD   | $t$        | $p$       |
| Right handgrip [kG]             | 49.0 10.3 | 47.4 7.7  | 0.67       | 0.503     |
| Left handgrip [kG]              | 48.9 10.2 | 45.8 7.4  | 1.42       | 0.159     |
| Back strength [kG]              | 146.0 25.6 | 126.7 20.4 | 3.37       | 0.001     |
| Sitt-ups [n]                    | 32.1 4.4  | 34.7 4.5  | -2.13      | 0.037     |
| Bent-arm hang [s]               | 37.9 11.0 | 40.5 10.7 | -0.89      | 0.377     |
| Standing long jump [cm]         | 221.9 17.5 | 233.0 21.1 | -2.03      | 0.046     |

Strength relative to body mass

Hand strength index             | 1.22 0.18 | 1.19 0.20 | 0.71 0.479 |
Back strength index             | 1.84 0.31 | 1.81 0.25 | 3.20 0.002 |
than jiu-jitsu (SD = 6.0 cm) group. As the judo and jiu-jitsu participants were all middleweights, they also shared a similar body mass (80.0 ± 5.3 kg and 79.2 ± 4.1 kg, respectively; t = 0.60, p = 0.548). No significant differences were found in body size. Mean BMI for the judo and jiu-jitsu groups were also similar (25.2 ± 2.4 kg/m² and 24.9 ± 2.3 kg/m², respectively; t = 0.63, p = 0.484).

Although the differences among the absolute measures were minor, a number of significant differences were observed when considering the groups’ body proportions. Judo practitioners were found with shorter lower limbs relative to body height as evidenced by the lower limb index value but a larger trunk relative to body height (Table 2). As a result, this group of judo could be considered to be average-limbed and short-trunked. The jiu-jitsu group consists instead primarily of short-trunked but long-limbed individuals. This difference is due to their proportionally longer thighs as seen by a significantly higher thigh length index compared with the judo group. The judo group was found with greater arm, thigh, and calf musculature as evidenced by the higher Bürger, thigh, and calf index values (Table 2). No differences were noted in terms of relative skeletal size via the humeral robustness and femoral robustness indexes.

Comparisons of the adiposity indexes found that the judo group was characterized by less trunk fatness than the jiu-jitsu group but shared a similar level of limb fatness (Table 2). The calculated fat distribution index shows that subcutaneous fat was more evenly distributed in the judo group, with limb fatness approximately 61% of trunk fatness while limb fatness in jiu-jitsu was about half of trunk fatness.

No significant between-group differences were observed for the shoulder–trunk ratio but a difference was noted for the shoulder–hip ratio (Table 2). A greater disproportion was found between the width of the shoulders and hips among the judokas, which, when considered with trunk circumference index, is indicative of a more masculine body profile in this group.

**Body composition**

Analysis of skinfolds showed that the judo group was characterized by less subcutaneous fat than their jiu-jitsu counterparts, with the difference significant for the subscapular skinfold (Table 3). A similar result was obtained in the body composition measures obtained by bioelectrical impedance analysis, where the judo group was found with less fat but more body water and fat-free mass than the jiu-jitsu group (Table 4). The differences between both groups for total body water, muscle mass, and fat-free mass were approximately 1.5–2%.

**Somatotype**

The mean somatotype of the judo group (1.87–6.57–1.79), like among the jiu-jitsu group (2.21–6.12–1.92), is indicative of high mesomorphy but low endomorphy, resulting in a relatively large body profile. Although the somatotypes were not significantly different (F = 2.1, p = 0.148), the

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**Tab. 2. Body proportion indexes of the judo and Brazilian jiu-jitsu groups**

<table>
<thead>
<tr>
<th>Body proportion</th>
<th>Judo Mean</th>
<th>Judo SD</th>
<th>Judo Student’s t-test</th>
<th>BJJ Mean</th>
<th>BJJ SD</th>
<th>BJJ Student’s t-test</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower limb index (B-sy/B-v) * 100</td>
<td>52.5</td>
<td>0.8</td>
<td>-3.71</td>
<td>53.3</td>
<td>1.0</td>
<td></td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Thigh length index (sy-ti/B-v) * 100</td>
<td>25.2</td>
<td>0.8</td>
<td>-2.09</td>
<td>25.9</td>
<td>1.4</td>
<td></td>
<td>0.041</td>
<td></td>
</tr>
<tr>
<td>Calf length index (ti-iph/B-v) * 100</td>
<td>27.2</td>
<td>0.7</td>
<td>-0.85</td>
<td>27.5</td>
<td>1.2</td>
<td></td>
<td>0.401</td>
<td></td>
</tr>
<tr>
<td>Bürger musculature index ((loxed arm-relaxed arm)relaxed arm) * 100</td>
<td>10.7</td>
<td>2.6</td>
<td></td>
<td>9.4</td>
<td>2.4</td>
<td>1.88</td>
<td>0.064</td>
<td></td>
</tr>
<tr>
<td>Thigh musculature index (thigh girth/sy) * 100</td>
<td>130.3</td>
<td>8.7</td>
<td></td>
<td>127.5</td>
<td>11.4</td>
<td>1.03</td>
<td>0.303</td>
<td></td>
</tr>
<tr>
<td>Calf musculature index (calf girth/b-aph) * 100</td>
<td>93.6</td>
<td>5.4</td>
<td></td>
<td>90.9</td>
<td>6.3</td>
<td>1.74</td>
<td>0.086</td>
<td></td>
</tr>
<tr>
<td>Humeral robustness index (d-cm/B-v) * 100</td>
<td>4.1</td>
<td>0.2</td>
<td></td>
<td>4.0</td>
<td>0.1</td>
<td>1.59</td>
<td>0.116</td>
<td></td>
</tr>
<tr>
<td>Femoral robustness index (ep-opt-B-m/B-v) * 100</td>
<td>5.8</td>
<td>0.3</td>
<td></td>
<td>5.6</td>
<td>0.3</td>
<td>2.23</td>
<td>0.029</td>
<td></td>
</tr>
<tr>
<td>Trunk fatness index (subscapular+calf skinfolds)/B-v*100</td>
<td>8.9</td>
<td>2.7</td>
<td>-2.33</td>
<td>10.5</td>
<td>2.6</td>
<td></td>
<td>0.023</td>
<td></td>
</tr>
<tr>
<td>Limb fatness index (subscapular+calf skinfolds)/B-v*100</td>
<td>5.4</td>
<td>1.9</td>
<td></td>
<td>5.3</td>
<td>1.7</td>
<td>0.10</td>
<td>0.391</td>
<td></td>
</tr>
<tr>
<td>Fat distribution index ((troops+calf skinfolds)/B-v) * 100</td>
<td>60.9</td>
<td>15.3</td>
<td></td>
<td>51.7</td>
<td>15.9</td>
<td>2.28</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td>Trunk length index (sy-sy/B-v) * 100</td>
<td>28.7</td>
<td>0.6</td>
<td></td>
<td>28.1</td>
<td>1.0</td>
<td>2.89</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>Shoulder width index (a-aB-v) * 100</td>
<td>24.3</td>
<td>1.0</td>
<td></td>
<td>23.9</td>
<td>0.8</td>
<td>1.82</td>
<td>0.074</td>
<td></td>
</tr>
<tr>
<td>Hip width index (c-cB-v) * 100</td>
<td>16.0</td>
<td>0.8</td>
<td></td>
<td>16.4</td>
<td>0.7</td>
<td>-1.90</td>
<td>0.062</td>
<td></td>
</tr>
<tr>
<td>Shoulder–trunk index (a-a/sy-sy) * 100</td>
<td>84.6</td>
<td>4.0</td>
<td>-0.58</td>
<td>85.2</td>
<td>4.1</td>
<td></td>
<td>0.562</td>
<td></td>
</tr>
<tr>
<td>Shoulder–hip index (a-a/c-c) * 100</td>
<td>66.1</td>
<td>3.6</td>
<td>-3.40</td>
<td>68.8</td>
<td>3.0</td>
<td></td>
<td>0.001</td>
<td></td>
</tr>
</tbody>
</table>
Individuals with the highest level of mesomorphy were all judo practitioners (Figure 1) while the jiu-jitsu group was characterized by greater endomorphy.

**Discussion**

Both judo and Brazilian jiu-jitsu are martial arts with frequent grappling techniques, but also involve a combination of holds and throws in which participants frequently use isometric strength to submit an opponent [15, 17]. According to many authors, most of judo fights finished before time and the score awarded most often by referees was ippon [23, 24]. Additionally, the victories were most often awarded as a consequence of the throwing techniques rather than the grappling techniques, and hand techniques proved to be dominating [24, 25]. The mentioned facts are reflected in greater strength of judoists. Actual comparisons between the two studied groups indicated that the judo practitioners showed greater absolute and relative (normalized to body mass) back and handgrip strength than the Brazilian jiu-jitsu group. Greater musculatures of the arm, thigh, and calf were also observed in this group even though they shared a similar BMI with the jiu-jitsu group. The increased arm musculature of the judoists explains their ability to generate greater force, as muscle strength is proportional to its cross-sectional area [26] and anthropometric dimensions of arm are crucial for throwing techniques efficient in judo [4-6]. Franchini et al. [11] studied a group of elite and non-elite judo competitors finding right and left handgrip strengths of 51 ± 10 kG and 49 ± 10 kG, respectively, in the elite group, whereas the non-elite group generated slightly lower force at 42 ± 11 kG and 40 ± 10 kG, respectively. In the present study, the non-elite judo practitioners attained si-
miliar values as the elite judokas in Franchini et al. [11], where a right and left handgrip strength of 49.0 ± 10.3 kG and 48.9 ± 10.2 kG was found, respectively. The examined Brazilian jiu-jitsu practitioners were characterized by smaller handgrip strength (47.7 ± 7.7 kG in right and 45.8 ± 7.4 kG in left) in comparison with judoists. According to Andreato et al. [1,19] the elite Brazilian jiu-jitsu athletes did not have high isometric handgrip strength but had excellent abdominal and upper body strength endurance, what was also proved in this study. Jiu-jitsu group showing greater abdominal strength (sit-ups test) and also greater lower limb strength (standing long jump) comparing to judo group. Brazilian jiu-jitsu athletes need high isometric strength endurance, which is used to keep a good hold on an opponent and apply a submission technique [19].

Upper body strength is important because the techniques generally involve extreme contact and do not provide space for dynamic movements [19]. Differences between the judo and jiu-jitsu groups may be also explained by the fact that the judo participants were characterized by shorter lower limb length relative to body height and slightly larger epiphysis of the lower limbs. However, the proportionally longer thighs of the jiu-jitsu groups classifies them as long-limbed and short-trunked, whereas the judoists can be considered short-trunked but average-limbed. Upper limb epiphysis was comparable between both groups. Franchini et al. [11] observed that high-level judo players presented larger circumferences and bone diameters than their amateur counterparts.

No significant differences were found in the results of the bent-arm hang test, although the examined Brazilian jiu-jitsu athletes were able to perform this test approximately 2.5 s longer than the judo group irrespective of the fact that both groups shared a similar weight.

Besides the lack of a significant difference in body mass and height, the groups were similar in terms of shoulder–trunk ratio but not shoulder–hip ratio. In the latter, the judo group presented slightly wider shoulders and narrower hips relative to body mass compared with the jiu-jitsu group, while a smaller difference was noted in the absolute widths of the shoulders and hips. The above characteristics, combined with a greater trunk circumference index, are indicative of a more masculine body profile in the judo group.

In terms of the skinfolds’ measures, the judo group was characterized by 1.5–2.0 mm thinner skinfolds than the Brazilian jiu-jitsu group, with the difference significant for the subscapular skinfold. Franchini et al. [11] noticed that the values of skinfolds thickness were very low for both elite and non-elite judoist, indicating that judo athletes were very lean. A lower level of body fat among the examined judo practitioners was confirmed when analyzing body composition by bioelectrical impedance analysis, which also indicated that this group had greater body water and fat-free mass than the jiu-jitsu group. These differences between both groups for total body water, muscle mass, and fat-free mass were approximately 1.5–2%. It was previously stated that high-level judo players should have low body fat and high arm circumference [4,27,28]. However, body composition differs between weight categories, with higher body fat percentage in half-heavyweight and heavyweight categories compared with lower categories [29].

The calculated fatness indexes indicated that the judo group was characterized by less trunk fatness than the jiu-jitsu participants but shared a similar level of limb fatness. Fat distribution, in turn, was more uniform in the judo group. Low body fat content is known to aid fighting by allowing faster movements as well as quicker defensive reactions, both critical aspects in combat sports [30].

When comparing the group somatotypes, the judo group was similar to the Brazilian jiu-jitsu group in that they represent high mesomorphy and low endomorphy. There was, however, a slightly higher mesomorphic component in the judo group whereas the jiu-jitsu practitioners were slightly more endomorphic. The levels of endomorphy, mesomorphy, and ectomorphy among the judo and jiu-jitsu participants confirm the results of previous studies on the somatotypes of combat athletes [31, 32]. The high mesomorphic component of both groups is indicative of the impact of judo and jiu-jitsu training on the development of muscle mass and muscle hypertrophy as well as skeletal size.

Conclusions

1. The varied combination of fighting techniques in judo and Brazilian jiu-jitsu may influence the motor performance and body build of practitioners.

2. The specificity of Brazilian jiu-jitsu, in that it allows a number of fighting techniques not permissible in judo, is reflected in improved motor performance via strength of the abdomen and lower limbs.

3. Judo practitioners, using techniques that primarily engage the trunk and upper limbs, present strong back and forearm musculature as well as less trunk fat and increased forearm girth.

References


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