



The Relationship Between Postural Stability, Anthropometry Measurements, Body Composition, and Sport Experience in Judokas with Visual Impairment

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Abstract

Background: Postural stability is quite mandatory when practicing high-performance sports. Investigations of postural stability and related variables in judokas with visual impairment can lead to new training plans targeting the improvement of postural stability and ultimately to enhanced performance.

Objectives: To investigate postural stability and its relationship with anthropometric measurements, body composition, and experience in judokas with visual impairment.

Methods: Seventeen judokas (70.6% men) with visual impairment participated in this cross-sectional study. The athletes were grouped based on the functional classification of partial (B2/B3, n = 10) and total visual impairment (B1, n = 7). Postural stability was assessed using the elliptical area of the 95% confidence interval (Area) and the average displacement velocity (V_{avg}) while remaining in a bipedal stance with eyes closed and blindfolded. Body mass, height, circumferences, skinfold thickness and diameters were measured and used to estimate body composition. Between-group comparisons were evaluated using the Mann-Whitney test. Bivariate correlations were determined with Spearman's correlation coefficient with bootstrap analysis and 95% confidence interval (95% CI) from 500 resamplings.

Results: No significant difference was observed between the B1 and B2/B3 groups in relation to postural stability (Area; $P = 1.00$; V_{avg} ; $P = 0.85$). Postural stability (Area but not V_{avg}) correlated positively and moderately ($P < 0.05$) with anthropometric measurements and negatively with judo experience (practice time).

Conclusions: The postural stability of judokas was unrelated to the degree of visual impairment. Postural instability was correlated with anthropometric measurements, mainly body fat and height, and judo experience.

Keywords: Judo, Body Composition, Postural Stability, Visual Impairments, Sport Performance

1. Background

Postural stability is important when performing activities of daily living. However, it is quite mandatory when practicing high-performance sports. In particular, judokas try to knock down their opponents within the competition Area (1) using strategies that provoke the displacement of opponents' center of body mass (CoM) while maintaining their stability (2). To achieve this high performance, a judoka's training promotes the development of tactics that stimulate the integration (3) of sensory i.e., c-visual, somatosensory, vestibular and muscular information to respond to changes in the base of support and its rela-

tionship with the judoka's CoM, such as during an attack-defense situation. In addition, judokas also perform actions using an enlarged base of support, which makes it more difficult to displace their CoM (2). From the biomechanical point of view, postural control is achieved by adjusting the position of the CoM, i.e., the net location of the center of the mass of the body; the CoM is redirected by the displacement of the body's center of pressure (CoP), i.e., the location of the ground reaction forces generated by the muscles in response to the sensory input and its integration (4). Postural instability can be related to the total or partial impairment of one or more of these sensory sys-

tems; visual impairment is particularly compromising in this regard given its dominant association with body displacement stabilization (5-7).

People with total visual impairment report more postural instability than people with normal visual abilities (5). However, they have better postural stability than people with partial visual impairment (6). Therefore, it has been argued that athletes with somatosensory impairments have training experiences that, combined with a reweighted sensory-motor integration (8), enable them to maintain postural stability despite their limited or absent visual input. As far as we know, only one other study evaluated postural stability in visually impaired judo athletes (5), although that study did not analyze the correlation between postural stability and anthropometric measurements or body composition. Investigations of postural stability and related variables in judokas with visual impairment can primarily lead to new training plans targeting the improvement of postural stability and ultimately to enhanced performance in matches. Because judokas are classified by body mass in competition, in this study, we focused on anthropometric factors and factors related to body composition that are known to influence postural control, such as height (9), body mass (10), and fat mass (11).

2. Objectives

This study investigated the relationship between postural stability and anthropometric measurements, body composition, and experience in judokas with visual impairment. We hypothesized that (1) postural stability is related to the degree of vision impairment and (2) postural stability is inversely related to body mass, height, and variables related to body composition.

3. Methods

3.1. Study Design and Ethics

This was a cross-sectional correlational study. The Local Research Ethics Committee approved the study (CAAE: 31778614.0.0000.5235).

3.2. Participants

Seventeen judokas were invited to participate. The inclusion criteria were age ≥ 18 years, partial (functional classification = B2/B3) or total (functional classification = B1) visual impairment, and judo practice for ≥ 6 months. We excluded those who had musculoskeletal and/or intellectual limitations that might impede their ability to perform the evaluations.

3.3. Anthropometric Measurements and Body Composition

Body mass (0.1 kg, scale; Filizola, Brazil), body height (0.1 cm, stadiometer; Filizola), bone diameters (0.1 cm, pachymeter; Sanny PQ5011, Brazil), body circumferences (0.1 cm, metric tape; CESCORF (12) (Brazil) and skinfold thickness (1.0 mm, adipometer; CESCORF, Brazil) were measured. Body composition was estimated by anthropometry (13). The following variables were estimated: fat percentage (14) (%G), the sum of 9 skinfolds ($\sum 9SF$, mm), fat mass (kg), free fat mass (kg), and muscular mass (kg).

3.4. Postural Stability

Postural stability was evaluated using a force platform (AccuSway^{PLUS}, AMTI, USA) under a standard protocol at a sample rate of 100 Hz and task duration of 35 s (the first 5 s of each attempt was discarded from the analysis) (15, 16). The participants were asked to remain standing on the platform with arms relaxed, head in a natural position, and their feet together at the midline of their bodies. The task was performed with eyes closed and blindfolded. This task was repeated three times, with a 2-minute interval. The recorded center of pressure (CoP) signal was filtered (second-order Butterworth low-pass filter with a cutoff frequency of 2.5 Hz, applied in the direct and reverse directions) to remove noisy high-frequency components that were unrelated to the body sway (17). The area of the ellipse for the 95% confidence interval (Area; mm²) and the average displacement velocity (V_{avg} ; mm/s) were analyzed (18); to increase the reliability of the test (19), the average values across the three repetitions were considered for analysis.

3.5. Statistical Analysis

Descriptive analysis involved the calculation of median values (minimum-maximum) or absolute and relative frequencies. Between-group comparisons were performed using the Mann-Whitney U test. Bivariate correlation analysis was determined based on Spearman's correlation coefficient (ρ). The 95% confidence interval (95% CI) for ρ was obtained by the bootstrap method after 500 resamplings. Coefficients between 0.4 and 0.6 were considered "moderate" correlations, and those above 0.7 were considered "strong" correlations (20). Statistical analysis was performed in SPSS V. 20.0 (Armonk, NY: International Business Machines Corporation) ($\alpha = 5\%$).

4. Results

The participants' median age was 24 (18 - 33) years, with the majority being men (70.6%) and having a B2/B3 functional classification (58.8%). The B2/B3 athletes were

younger than the B1 athletes ($P = 0.01$). The participants median years of experience was 7 (2 - 22) years, with a weekly training frequency of 5 (3 - 6) days/week. No differences were observed between the B2/B3 and B1 groups for judo experience ($P = 0.81$), weekly training frequency ($P = 0.89$), or anthropometric and body composition variables (Table 1).

The B1 and B2/B3 athletes were similar in terms of Area [$B1 = 403.0$ (160.1 - 1601.6) mm^2 versus $B2/B3 = 441.3$ (192.0 - 823.6) mm^2 ; $P > 0.99$] and V_{avg} ($B1 = 17.1$ (11.4 - 0.1) mm/s versus $B2/B3 = 17.3$ (12.5 - 23.9) mm/s ; $P = 0.85$). Therefore, both groups were merged ($n = 17$) to perform the correlational analysis.

We observed moderate and significant correlations between Area and body mass; height; arm span; circumferences of the thigh, leg, abdomen and hips; $\sum 9\text{SF}$, and body fat mass, as well as the judo experience time [$\rho = -0.548$ (-0.831 - -0.144); $p = 0.023$]. No anthropometric variable or body composition-related variable was found to be correlated with V_{avg} (Table 2).

5. Discussion

This study investigated the relationship between postural stability and anthropometric measurements, body composition, and experience in judokas with visual impairment. The main findings do not provide evidence in support of the hypothesis of differences in postural stability between judokas with total visual impairment and those with partial visual impairment. However, we did find evidence in support of a relationship between postural stability and anthropometric measurements, body composition, and experience in this population.

Evidence suggests that postural stability is impaired in the absence or insufficiency of vision (5, 6). Under these sensory conditions, the maintenance of the upright posture requires sensory reweighting, involving the information provided by the somatosensory systems. Concerning the degree of visual impairment and postural stability, Juodzbalien and Muckus (6) found that adolescents with partial visual impairment had less postural stability than blind adolescents. Conversely, in our study, we did not find statistical evidence for differences in postural stability between B1 and B2/B3 athletes. This discrepancy in results might stem from the difference in expertise levels, which is known to influence the regulation of postural stability (21). A previous study observed that competitive dancers and judokas without visual impairment had better postural stability (less CoP displacement) than non-athletes when tested with their eyes open, but only judokas maintained their postural stability with their eyes closed (2). These results raise the hypothesis that practicing competi-

itive judo promotes better somatosensory performance in postural stability, arguably via sensory reweighting.

As far as we know, only Almansba et al. (5) evaluated postural stability in judokas with visual impairment; the judokas remained in a single-leg stance test for a similar time as those without visual impairment and for a longer time than non-athletes without visual impairment (5). The authors suggested that chronic adaptations from judo training appear to improve proprioception significantly in people with visual impairment. Our study provides additional evidence in support of these findings since sports experience (time of judo practice) was inversely correlated with the CoP displacement area.

In competitive sports, athlete anthropometric measurements have a direct influence on the development of techniques, athletic movements, and modality-specific motor abilities (1), thereby affecting performance. Inverse associations between body fat and performance have been described by Katralli and Goudar (1); judokas without visual impairment and high body fat percentages performed fewer launches using the *ippon-seoi-nage*-a hand-throwing technique in which the opponent is picked up and thrown over the shoulder onto his/her back- within a specified period than those with low body fat percentages. Franchini et al. (22) found that Brazilian judokas with no visual impairment and a higher fat percentage also performed worse than those with a lower fat percentage on the *Special Judo Fitness Test* and the Cooper test. From these findings, we could expect that postural stability would be associated with larger anthropometric measurements (i.e. body measurements and body fat mass) in judokas.

Russo et al. (23) and Schmid et al. (8) suggest that visual impairment does not necessarily prompt athletes to postural instability. Chiari et al. (9) showed in subjects with preserved vision that anthropometric measurements (e.g., body mass and height) were related to postural stability. Investigating judokas with visual impairment, the present study showed that both anthropometric measurements and body composition correlate positively with the CoP displacement area but not with the CoP velocity. Whereas both CoP position and velocity are informative about the whole body's stability (greater CoP displacements and speeds are associated with greater bodily movements (24)), there is still a debate on which information best represents postural stability (25), and further studies are required in this subject.

In terms of the results found in this study, the relationship between the participants' anthropometric measurements and their postural stability can be understood as an effect of body mass distribution at the level of neuromuscular activity needed to counteract the effects of gravity on the body. Specifically, considering the classic model

Table 1. Anthropometry and Body Composition of the Studied Sample^a

Variables	All Participants (N = 17)	Sports Classification		P Value ^b
		B1 (N = 7)	B2/B3 (N = 10)	
Arm span (cm)	181.9 (154.2 - 201.4)	188.9 (162.1 - 198.3)	179.7 (154.2 - 201.4)	0.53
Abdomen circumference (cm)	87.8 (73.8 - 126.6)	92.1 (83.6 - 126.6)	85.6 (73.8 - 94.6)	0.06
Hips circumference (cm)	99.8 (83.8 - 122.5)	104.0 (95.5 - 122.5)	96.1 (83.8 - 106.4)	0.06
Relaxed arm circumference (cm)	32.7 (27.0 - 43.0)	34.1 (31.4 - 43.0)	31.9 (27.0 - 37.0)	0.11
Contracted arm circumference (cm)	33.4 (27.8 - 43.9)	34.9 (31.8 - 43.9)	32.4 (27.8 - 38.1)	0.08
Thigh circumference (cm)	60.7 (46.1 - 76.4)	61.1 (57.7 - 76.4)	58.2 (46.1 - 64.2)	0.12
Leg circumference (cm)	37.4 (32.3 - 47.8)	37.2 (35.7 - 47.8)	37.4 (32.3 - 41.4)	0.66
Free fat mass (kg)	65.8 (43.5 - 108.2)	67.4 (49.9 - 108.2)	60.7 (43.5 - 77.5)	0.28
Muscular body mass (kg)	35.7 (23.5 - 56.5)	35.7 (27.7 - 56.5)	34.3 (23.5 - 42.5)	0.33
Body fat mass (kg)	14.6 (3.2 - 40.8)	19.3 (10.7 - 40.8)	12.4 (3.2 - 18.0)	0.05
Body fat percentage (%)	17.5 (5.5 - 30.2)	27.1 (15.1 - 30.2)	16.1 (5.5 - 24.5)	0.06
Sum of 9 skinfolds (mm)	145.2 (56.0 - 257.4)	207.6 (118.9 - 257.4)	142.4 (56.0 - 168.9)	0.10

^aValues are expressed as median (range).

^bComparisons between the groups B1 vs. B2/B3, with Mann-Whitney's U Test.

Table 2. Correlations Between Anthropometric Variables, Body Composition and Postural Displacement in the Participants of the Study (N = 17)

Variables	V _{avg} (mm/s), ρ [95%CI] (N = 17)	P Value	Area (mm ²), ρ [95%CI] (N = 17)	P Value
Weight (kg)	0.400 [-0.122 - 0.766]	0.112	0.517 [0.007 - 0.805]	0.034 ^a
Height (cm)	0.466 [-0.113 - 0.864]	0.059	0.484 [-0.075 - 0.873]	0.049 ^a
Arm span (cm)	0.432 [-0.145 - 0.785]	0.084	0.481 [-0.019 - 0.771]	0.051
Thigh circumference (cm)	0.368 [-0.149 - 0.753]	0.146	0.601 [0.153 - 0.786]	0.011 ^a
Leg circumference (cm)	0.455 [-0.012 - 0.731]	0.067	0.666 [0.273 - 0.872]	0.004 ^a
Abdomen circumference (cm)	0.298 [-0.296 - 0.717]	0.245	0.494 [0.073 - 0.753]	0.044 ^a
Hips circumference (cm)	0.310 [-0.204 - 0.690]	0.226	0.565 [0.198 - 0.778]	0.018 ^a
Sum of 9 skinfolds (mm)	0.233 [-0.338 - 0.688]	0.368	0.549 [0.141 - 0.819]	0.022 ^a
Body fat mass (kg)	0.265 [-0.318 - 0.732]	0.305	0.588 [0.171 - 0.887]	0.013 ^a

Abbreviations: Area, area of ellipse for the 95% confidence interval; V_{avg}, average displacement velocity; Spearman's ρ correlation coefficient with 95% confidence intervals.

^aStatistical significance for P < 0.05.

of the inverted pendulum (26), one can suppose that the greater the body mass, the greater the muscle torque that is needed to counteract its movement. This muscle torque, in turn, is reflected in the greater displacement of the CoP, which is proportional to the level of neuromuscular activation (27) and the acceleration of the center of mass (28). This hypothesis is partially corroborated by previous findings (29) that showed a positive relationship between body fat mass (body mass index > 30 kg/m²) and higher CoP displacement area. The observed increases in postural displacement may be due to greater variability in motor control in those individuals with greater anthropometric measurements, as suggested by the biomechanical model (30).

Therefore, we suggest that the postural displacements observed in judokas with visual impairment result from the combination of adaptive postural stability strategies (23) and the characteristics of their body mass distributions (9).

Usually, higher postural displacements are related to lower body stability and greater risk of fall (31). In addition, in athlete populations, changes in postural control are considered risk factors for musculoskeletal injuries (32). Thus, one can argue that athletes with greater body size and fat mass have, at the same time, a higher risk of falling and a higher risk of injury than those with lower body mass. In this case, further research is necessary to in-

investigate whether the incorporation of balance training in this subpopulation of athletes can prevent musculoskeletal injuries in this population.

One limitation of the study is its sample size. However, taking into consideration the proportion of people with visual impairment who practice judo in the city of Rio de Janeiro, Brazil, and who met the inclusion and exclusion criteria established for participation in the study, we believe that we have evaluated a representative sample of this population. Nonetheless, larger studies are required to confirm the findings reported here. Additionally, this study did not include a comparison group of judokas without impairment, which would have allowed us to evaluate the impact of visual impairment on postural stability. Notwithstanding, our results are important for the conceptualization and execution of future analyses that might contribute to planning exercise training for and tracking athletes with visual impairment.

5.1. Conclusions

There was no evidence of differences related to postural stability between judokas with partial visual impairment and those with total visual impairment. Postural stability, as assessed by the area of the ellipse for CoP displacement, was positively correlated with anthropometric measurements, body composition, and judo experience.

Supplementary Material

Supplementary material(s) is available [here](#) [To read supplementary materials, please refer to the journal website and open PDF/HTML].

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Footnotes

Authors' Contribution: Study concept and design: Bruno Ferreira Jeronymo, Thiago Lemos de Carvalho, Patrícia Vigário, Míriam Mainenti, and Lilian Ramiro Felicio; analysis and interpretation of data: Bruno Ferreira Jeronymo, Thiago Lemos de Carvalho, Patrícia Vigário, Míriam Mainenti, Arthur de Sá Ferreira, and Lilian Ramiro Felicio; drafting of the manuscript: Bruno Ferreira Jeronymo, Thiago Lemos de Carvalho, Patrícia Vigário,

Míriam Mainenti, Pablo Rodrigo de Oliveira Silva, and Lilian Ramiro Felicio; critical revision of the manuscript for important intellectual content Arthur de Sá Ferreira, Thiago Lemos de Carvalho, Patrícia Vigário, Míriam Mainenti, Pablo Rodrigo de Oliveira Silva, and Lilian Ramiro Felicio; statistical analysis: Pablo Rodrigo de Oliveira Silva, and Arthur de Sá Ferreira.

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Patient Consent: As the participants had visual impairment, the main researcher of the study read the document. After reading, the place where the consent should be given was indicated.

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