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Physical Performance, Body Composition and Somatotype in Colombian Judo Athletes

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Abstract

Background. Judo is a grappling sport that requires a combination of powerful actions (e.g., throwing techniques) and aerobic capacity. Physical performance, body composition and somatotype influences athletes' performance.

Problem and aim. Analyze the physical performance, body composition and somatotype of elite Colombian judokas and compare them with athletes from other countries. In addition, to investigate the correlation between body composition and physical performance.

Methods. Fifteen judoists, eight women (21 ± 4.7 years) and seven men (20.5 ± 3.9 years), participated in the present study. The athletes were black belt and had international and national competition experience, winning medals in the Pan-American Games, Central and South American Championships. Squat jumps (SJ) and countermovement jumps (CMJ) on a contact platform were performed to evaluate lower limbs power. The maximum oxygen uptake (VO_{2max}) was estimated using the multistage 20-m shuttle run test. The Anthropometric measurements were taken for body fat and skeletal muscle mass estimation. Pearson correlation was performed between body composition and physical performance variables.

Results. In summary, lower physical performance, and higher body fat percentages were observed in Colombian judoists compared to elite judoists. In other countries Moderate negative correlation was observed between aerobic power and body fat percentage ($r = -0.67$), and the endomorph characteristic ($r = -0.69$). In addition, the skeletal muscle mass presented a very large correlation with power from both SJ ($r = 0.88$) and CMJ ($r = 0.89$) ($p < 0.05$).

Conclusion. Elite Colombian judokas presented lower physical performance, and higher body fat percentage than other elite judokas. The somatotype was adequate and in accordance with that reported at the elite level.

Introduction

Judo is a combat sport characterized by techniques of grappling, throwing, and controlling the opponent on the ground [Miarka *et al.* 2012]. Besides technical and tactical aspects, physical fitness has been demonstrated as a determinant factor in Judo performance [Franchini *et al.* 2011]. Thus, athletes must achieve an excellent level of various physical aspects such as muscle and aerobic power as well as body composition [Franchini *et al.* 2011, Kons *et al.* 2017a]. The assessment of these varia-

bles might be useful for a diagnosis of current physical fitness status, training prescription, and comparison with elite athletes [Callister *et al.* 1991, Franchini *et al.* 2007, Koral and Dosseville 2009, Monteiro *et al.* 2014].

High level of muscle power is required for fight's decisive moments, such as throwing and counterattack techniques, with the goal to score points (i.e., *wazari*) or to finish the combat (i.e., *ippon*) [Miarka *et al.* 2012]. Moreover, the muscle power is related to throw efficiency and also a determinant of the numbers of throws performed in Judo [Detanico *et al.* 2012a]. Since elite judokas

presented higher values of lower limb muscle power [Boguszewska and Boguszewski 2010, Monteiro *et al.* 2011, Detanico *et al.* 2012b], some studies suggest that this variable is related to athlete's level and training load [Busko and Nowak 2008]. In addition, the muscle-tendon unit stretch-shortening cycle optimizes muscle power [Komi 2000], which could lead to increased movement efficiency in a variety of throwing techniques (e.g., *seoinage*, *o-goshi*, *koshi-guruma*) [Detanico *et al.* 2012a].

An official Judo match is characterized by 20 to 30 s of effort periods and 5 to 10 s of pauses [Franchini *et al.* 2018, Castarlenas and Planas 1997, Malderen *et al.* 2006]. Thus, the aerobic capability is responsible for the recovery processes between efforts and matches and it represents an important physical aspect for elite judo athletes since a high cardiovascular demand is observed in this modality [Franchini *et al.* 2013]. Although this variable has great importance in delaying fatigue and on performance maintenance, Franchini *et al.* [Franchini *et al.* 2005b] did not observe differences between elite and non-elite athletes in both aerobic power (i.e., maximal oxygen uptake – VO_2max) and aerobic capacity (i.e., anaerobic threshold velocity). Nonetheless, VO_2max values between 50 and 55 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ and 40-45 $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ are typically observed for male and female judo athletes, respectively [Franchini *et al.* 2011].

Besides the physical abilities aforementioned, several investigations evaluated the relevance of anthropometric variables in judo performance [Franchini *et al.* 2005a, 2005b, 2011, 2014a, Koral and Dosseville 2009]. The body structure is related to accomplish the elite level in judo and it may influence the type of techniques applied during a match [Franchini *et al.* 2005b, 2014b]. For instance, the low body fat content is associated with higher anaerobic capacity and quantity of attacks [Franchini *et al.* 2005a], improving physical performance and competition results [Mello and Fernandes Filho 2004]. In this sense, male athletes with less than 10% of body fat were liable to obtain better results, except the heavyweights [Franchini *et al.* 2011]. Although the somatotype varies between different weight categories [Franchini *et al.* 2014b], elite judo athlete has a profile related to the mesomorphic characteristics [Franchini *et al.* 2014b]. Moreover, female judokas presented endomorphic component values near to the mesomorphic [Franchini *et al.* 2011].

Even though the recent success in the last Olympics in Rio, little is known concerning physical aspects of athletes from countries with less tradition of success in judo, as the South Americans but Brazilians. For instance, judokas from Argentina and Colombia obtained relevant results in the last Olympics in Rio, as one gold (women under 48 kg) and one silver (women under 70 kg) medals, respectively. The growing database concerning elite judo athletes may allow the comparison of the physical condition of athletes from countries with less expres-

sion in the modality with those belonging to countries of recognized success. Thus, the aim of this study is to describe and analyze the physical performance, the body composition and somatotype from elite Colombian judokas and compare it with elite athletes from traditionally successful countries in the modality.

Methods

Subjects

Fifteen judo players, (♀, $n=8$; $21.0\pm 4.7\text{y}$; ♂, $n=7$; $20.5\pm 3.9\text{y}$), participated in the present study. The athletes were black belt and had international and national competition experience, winning medals in the Pan-American Games, Central and South American Championships. Data collection was performed on two separate days in the same week. In the first day participants underwent anthropometric assessments, whereas muscle and aerobic power were measured in the second visit. All participants were informed about the nature and possible risks of the experimental procedures prior to the tests. All volunteers gave written informed consent, as the study was approved by the biomedical committee of the Santander Sports Institute (INDERSANTANDER) and all procedures were performed in accordance with the declaration of Helsinki.

Muscle power

Participants' lower body muscle power was assessed performing the squat jump (SJ) and the counter movement jump (CMJ) on a contact platform (Axon Jump, Buenos Aires, Argentina). The data were processed in the software Axon Jump 4.02. (Axon Jump, Buenos Aires, Argentina). After familiarization trials, three maximal attempts were performed for each type of jump with 30 s of rest interval between trials. The average of the three scores for each type of jump was used for final data analysis. Jump height and athlete's body mass were used to estimate jump power according to Sayers equation: Peak Power (W) = 60.7 (jump height [cm]) + 45.3 (body mass [kg]) – 2055.

Aerobic Power

Maximum oxygen uptake (VO_2max) was estimated using multistage 20-m shuttle run test proposed by Leger & Lambert. [1988]. This test consisted of a shuttle running between two lines, spaced 20 m apart. The test started at a speed of 8.5 km/h and was increased by 0.5 km/h each one-minute period with the rhythm being controlled by a sound signal, emitted from a prerecorded tape. The VO_2max was estimated considering the athlete's race speed reached in the last period until fatigue, calculated by the equation $\text{VO}_2\text{max} = 5.857 \times \text{speed (km/h)} - 19.458$.

Anthropometric Measurements

Anthropometric measurements were performed during the morning, before any physical exercise. Procedures followed standardized procedures from the International Society for the Advancement of Kinanthropometry (ISAK). Body mass and height were assessed with a digital scale with 0.1 kg of resolution (Detecto, Webb City, MO, USA) and a stadiometer with 0.5 cm of resolution (Cescorf, Porto Alegre, RS, Brazil), respectively.

The same evaluator performed the skinfold thickness, bone diameter, and circumferences measurements of all athletes, utilizing a scientific caliper with 1 mm of resolution (Cescorf, Porto Alegre, RS, Brazil), a paquimeter (Cescorf, Porto Alegre, RS, Brazil) and a tape-measure (Cescorf, Porto Alegre, RS, Brazil) with 200 mm and 1 mm resolution, respectively. Two non-consecutive measurements were performed for each point, and if a variation higher than 5% for skinfold thickness measures and 2% for bone diameter or circumferences were observed, a third measure was performed. The skinfold points assessed were biceps, triceps, subscapular, abdominal, front thigh, medial calf, iliac crest, and supra-spinal. The bone diameter from the biepicondylar humerus and biepicondylar femur, and circumferences of the relaxed arm, flexed arm, wrist, waist, and leg were assessed.

Body fat percentage was then estimated using the equation of Withers *et al.* [1987], whereas lean skeletal muscle mass and somatotype followed the equation of Lee *et al.* [2000] and the Heat-Carter somatotype method procedures, respectively.

Statistical Analyses

Descriptive statistic was used to characterize the sample. Results are presented as mean \pm standard deviation (SD)

and range (minimum and maximum values). The coefficient of variation was also calculated (SD/mean). The Pearson's correlation product was performed to verify the correlation between the different body composition's and physical performance's variables, while the Hopkins' scale was used to classify them [Hopkins *et al.* 2009]. All statistical analyses were performed using the software SPSS 17.0 (SPSS Inc., Chicago, IL, USA).

Results

Descriptive data of the anthropometric and somatotype measurements from Colombian Judo elite athletes are presented in Table 1. The results obtained in the lower limbs muscle power (i.e. SJ and CMJ) and the aerobic power (i.e. $VO_{2\max}$) tests are presented in the Table 2.

Table 4 presents values of body mass and body fat from elite athletes of different origins.

The results from the correlation analysis between body composition's variables and physical performance's outcomes are presented in Table 3. A moderate negative correlation between the aerobic power with body fat percentage and the endomorph characteristic was found ($p < 0.05$). In addition, the skeletal muscle mass presented a very large correlation with power output from both SJ and CMJ ($p < 0.05$).

Discussion

The aim of the present study was to describe and analyze the physical performance, the body composition and somatotype from elite Colombian judokas and com-

Table 1. Mean and standard deviation values for morphological characteristics of Colombian Judo athletes.

	Women (n=8)	Range	Men (n=7)	Range
Age (years)	21 \pm 4.7	(17-31)	20.5 \pm 3.9	(16-27)
Height (cm)	157.7 \pm 6.4	(144-162)	171.6 \pm 8.6	(154-182)
Body mass (kg)	61 \pm 14.4	(48-93)	73.1 \pm 11	(58-88)
Body fat (%)	17.3 \pm 4.94	(11-28)	15.2 \pm 5.8	(9-23)
Smm (kg)	44.2 \pm 9.7	(34-66)	57.9 \pm 7	(48-68)
Endomorph	4.94 \pm 1.8	(3-9)	3.5 \pm 1.3	(2-6)
Mesomorph	5.6 \pm 1.4	(3-8)	6.24 \pm 0.83	(5-8)
Ectomorph	1.3 \pm 1.5	(1-5)	1.5 \pm 1.1	(0-3)

Smm: Skeletal muscle mass

Table 2. Mean and standard deviation values for physical performance parameters of Colombian Judo athletes.

	Women (n=8)	Range	Men (n=7)	Range
SJ _H (cm)	25.7 \pm 3.6	(20-30)	35.7 \pm 6.9	(28-43)
SJ _P (W)	2295 \pm 575	(1417-3374)	3428 \pm 487	(2497-4033)
CMJ _H (cm)	28.4 \pm 3.9	(22-32)	40.1 \pm 6.5	(31-47)
CMJ _P (W)	2481 \pm 622	(1592-3679)	3651 \pm 549	(2675-4167)
VO _{2max} (ml·kg·min ⁻¹)	43.6 \pm 4.3	(36-51)	51.2 \pm 5.6	(42-57)

SJ_H: Squat Jump height; SJ_P: Squat Jump power; CMJ_H: Counter Movement Jump height; CMJ_P: Counter Movement Jump power.

Table 3. Correlations between body composition and physical performance of Colombian judo athletes (n=15)

	SJ _H	SJ _P	CMJ _H	CMJ _P	VO2 _{max}
Body Fat	-0.40	0.33	-0.38	0.30	-0.67*
Body mass	0,26	0,82*	0,10	0,82*	-0,23*
Smm	0.22	0.88*	0.32	0.89*	0.02
Endomorph	-0.44	0.09	-0.49	0.04	-0.69*
Mesomorph	-0.08	0.45	-0.48	0.43	-0.31
Ectomorph	0.29	-0.30	0.30	-0.26	0.46

Smm: Skeletal muscle mass; SJ_H: Squat Jump height; SJ_P: Squat Jump power; CMJ_H: Counter Movement Jump height; CMJ_P: Counter Movement Jump power. * p<0.05.

Table 4. Body composition in elite judo athletes.

Reference	Country/Continent	BM (Kg)	BF (%)	TP	Equation BF
Male					
Degoutte <i>et al.</i> [2006]	France	74.7±6.7	14.9±3.0	CP	Durnin & Rahaman
Callister <i>et al.</i> [1991]	USA	83.1±3.8	8.3±1.0	CP	Jackson and Pollock
Thomas <i>et al.</i> [1989]	Canada	75.4±12.3	9.3±2.1	-	Lohman
Detanico <i>et al.</i> [2012b]	Brazil	77.3±13.4	13.4±3.3	NR	Siri
Drid <i>et al.</i> [2015]	Europe	100.7±0.8*	15.5±0.8*	CP	Bio impedance**
Ceylan <i>et al.</i> [2018]	Turkey	88.1±22.8	13.6 ± 4.4	NR	Bio impedance**
Casals <i>et al.</i> [2017]	Spain	85.9(24.5) [#]	7.8(3.5) [#]	CP	Carter
Female					
Ali <i>et al.</i> [2010]	Iran	66.01±6.4	23±4.4	CP	Latiffah - Hanachi
Callister <i>et al.</i> [1991]	USA	53.8±1.6	15.2±1.0	CP	Jackson and Pollock
Koury <i>et al.</i> [2007]	Brazil	66.0±8.0	22.0±5.0	CP	Jackson et al
Little <i>et al.</i> [1991]	Canada	62.3±5.2	15.2±2.1	-	Drinkwater - Ross
Ceylan <i>et al.</i> [2018]	Turkey	67.6±19.8	21.6±5.8	NR	Bio impedance**
Casals <i>et al.</i> [2017]	Spain	62.4(16.9) [#]	17.0(6.4) [#]	CP	Carter

BM, Body mass; BF, Body Fat; TP, Training period; CP, Competitive period; NR, Not reported. *Mean ± standard error of mean;

**Not an anthropometric measurement; [#] Median (Interquartile range).

pare it with elite athletes from countries with tradition in judo. The main results indicate that the male sample presented lower vertical jump height and aerobic power, although the latter was within the recommended values in literature. The mesomorphic component was predominant, albeit the body fat percentage was higher than described in elite judo athletes. The female Colombian athletes presented similar pattern than males, despite the diminished amount of studies to compare with. A lower physical performance was found, although the aerobic power was also within the recommended values for elite athletes. The somatotype of the female Colombian judokas was in agreement with the literature, with the endomorphism component as predominant.

Muscle power has great importance in the rapid execution of various judo techniques [Monteiro *et al.* 2014], and it has been evaluated by vertical jumps in athletes [Franchini *et al.* 2011; Kons *et al.* 2017b; Kons *et al.* 2018]. Despite some similarity concerning the male sample, Colombian elite athletes from the present study apparently presented decreased levels of lower-body power (i.e. SJ and CMJ height) compared to other athletes. Elite judokas from traditional countries (i.e. Portugal, Tunisia, Brazil, France and Spain), presented SJ and CMJ

height of 39.3 ± 5.6 cm and 41.2 ± 6.7 cm, respectively [Monteiro *et al.* 2011]. Similarly, Monteiro *et al.* [2014], found superior SJ height values in medalists (39.5 ± 4.9 cm) and non-medalists (39.8 ± 4.6 cm), whereas the CMJ results were similar to ours (Medalists: 41.1±5.7 cm and non-medalists: 41.7±1.1 cm). On the other hand, Detanico *et al.* [2016] evaluated Brazilian advanced athletes who achieved CMJ height of 49.5 ± 4.9 cm, significantly greater than Colombian male athletes. Lastly Koral and Dosseville [2009] assessed male French elite competitors and found superior jump height values for control group (SJ: 56.0 ± 6.3 cm; CMJ: 55.8 ± 7.9 cm) and intervention group (SJ: 58.6 ± 6.2 cm and CMJ: 61.6 ± 5.0 cm), about 40% and 35% higher than the Colombian male athletes for the SJ and the CMJ, respectively. In the same study, female athletes were assessed and the results of both control (SJ: 43.0 ± 8.9 cm and CMJ: 43.6 ± 8.6 cm) and intervention group (SJ: 45.6 ± 1.7 cm and CMJ 47.0 ± 3.9 cm) presented values nearly 43% higher for the SJ and 40% for CMJ than the Colombian female athletes from our sample Koral and Dosseville [2009]. A few studies were also carried out on female athletes. For instance, Spanish youth judokas obtained results of 27±13.5 cm in CMJ jump height, while another study

presented male and females' results together since there were only two women in the sample. Therefore, there is a significant lack of research evaluating jump height in female judokas, especially with elite athletes.

Nonetheless, it is important to consider that our study evaluated the jump height with a contact platform while others used a force platform [Monteiro *et al.* 2011, 2014] or kinematic analysis [Koral, Dosseville 2009]. In this sense, Ache-Dias *et al.* [2011] have verified that contact platform jump height values were about 24% (9 cm) less than force platform, and about 27% (10 cm) less than kinematic analysis. Therefore, the contact platform used in the present study may have underestimated the jump height, so the jump performance of the Colombian athletes would be similar than observed in aforementioned studies.

Aerobic power is an important physical capacity for performance maintenance, attenuating the fatigue process following successive intermittent efforts [Tomlin and Wenger 2001]. In the present study, the aerobic power was estimated using the multistage 20 metre shuttle run test. Although unspecific, this is a field test widely used in Judo [Thomas *et al.* 1989, Almansba *et al.* 2007], including French male elite athletes (60.5 ± 4.6 ml·kg·min⁻¹) [Almansba *et al.* 2007]. Considering studies that conducted cycle ergometer tests, the VO₂max of male Colombian judo athletes was similar to Tunisia 51.7 ± 7.6 ml·kg·min⁻¹ [Aloui *et al.* 2012] and Algeria athletes 50.6 ± 9.3 ml·kg·min⁻¹ [Almansba *et al.* 2010]. On the other hand, superior results were found when oxygen consumption was evaluated following an incremental test on a treadmill, which is renowned for demanding more muscle activity, therefore providing higher VO₂max values [Shephard 1984]. For instance, Cypriots achieved 57.2 ± 7.2 ml·kg·min⁻¹, [Papacosta *et al.* 2013], whereas competitive level Europeans presented 56 ± 2.2 ml·kg·min⁻¹. Regarding the female Colombian athletes, it was observed lower VO₂max values compared to judokas from Iran (47.8 ± 4.1 ml·kg·min⁻¹) [Ali *et al.* 2010], Italy (52.9 ± 4.4 ml·kg·min⁻¹), [Sbriccoli *et al.* 2007] and United States (52 ± 1.4 ml·kg·min⁻¹) [Callister *et al.* 1991], all assessed by spirometry following a treadmill incremental test. Although estimated by a cycle ergometer test, female athletes from Algeria also presented superior values (50.7 ± 6.0 ml·kg·min⁻¹) than participants from our sample [Almansba *et al.* 2010]. Despite the methodological issues and the fact that athletes from our study showed mean values between the recommendation limits (i.e. 50 to 60 and 40 to 60 ml·kg·min⁻¹ for men and women, respectively) [Franchini *et al.* 2011, Bonato *et al.* 2014], it seems that both male and female Colombian judo athletes should improve the aerobic power to achieve similar values to those presented by athletes from the traditional countries in the modality.

Optimal body composition is a relevant aspect in judo since competitors are divided by weight classes. The

body fat percentage of the Colombian athletes was 34.2% above the reference value of 10%, which is suggested to be related to better competitions results [Franchini *et al.* 2011]. Table 4 presents information regards body composition evaluation in several studies involving elite judo athletes. Studies presented a wide range of values, and several methods of measurements were reported. However, result from our male athletes was similar to French [Degoutte *et al.* 2006] and Brazilians [Detanico *et al.* 2012b]. On the other hand, Colombian athletes showed higher body fat percentage values than others, such as Canadians [Thomas *et al.* 1989], North Americans [Callister *et al.* 1991], Turkish [Ceylan *et al.* 2018], and Spanish athletes [Casals *et al.* 2017]. Thus, it seems that Colombian male athletes should reduce their body fat percentage, especially since a lower body fat content is associated with a higher anaerobic capacity and higher quantity of attacks during the combat [Franchini *et al.* 2005a]. Concerning females, the Colombian elite athletes showed lower body fat than Turkish athletes [Ceylan *et al.* 2018], Iranian [Ali *et al.* 2010] and Brazilian Olympic team [Koury *et al.* 2007]. Results from our female sample were higher than those reported by Canadian [Little 1991], North Americans [Callister *et al.* 1991], and Spanish athletes [Casals *et al.* 2017].

In terms of somatotype, male Colombian athletes showed accentuated mesomorphic properties, which was suggested to have importance on judo performance due to the high muscle proportion and lower body fat [Krstulovic 2012]. In addition, it seems that shorter athletes prefers to perform arm techniques (te-waza) than the taller athletes from the same weight category, which performs leg techniques (ashi-waza) with higher frequency Franchini *et al.* [2014a]. On the other hand, female athletes showed the endomorphic component predominant. Nonetheless, the mesomorphic values were near of endomorphic one, which could be expected due to the higher body fat percentage observed. In both cases, males and females Colombian judo athletes presented somatotype in accordance with the literature, since the mesomorphic and endomorphic predominance, respectively, have been the most reported [Franchini *et al.* 2011].

The relation between morphologic aspects and performance variables has been widely investigated in judo athletes [Detanico *et al.* 2012a, Franchini *et al.* 2005, Krstulovic 2012]. In our study, the endomorphic component and the body fat percentage were negatively correlated with the aerobic power, in accordance with the findings of Franchini *et al.* [2007] Therefore, it is reasonable to consider that by improving the aerobic power, the Colombian judo athletes could decrease the body fat component. In addition, a very large correlation was found between both total body mass and skeletal muscle mass with the peak power output achieved in the SJ and CMJ tests. The peak power output is recommended as the variable to be chosen for routine assessments of

muscle power from jumping performance [Markovic *et al.* 2014]. This result highlights the importance of the muscle mass development in combat sportsmen, due to the effort that athletes are subjected to when performing fast and explosive movements [Monteiro *et al.* 2011].

Some limitations regarding the sample and methods of evaluation can be mentioned in our study. Firstly, a small sample size was assessed, however, our sample was composed of elite athletes, which was the main goal of the study. In addition, athletes from our study were younger compared to the mean age of last Olympic games medalists in judo (male: -21.5%; females: -25%), which could represent our sample has the potential to develop skills and physical aspects in a near future. The Colombian athletes were in the preparatory period of training, another factor that could generate distinct results when compared with other elite samples. The evaluation of aerobic capacity was carried out in the athletic track, using an unspecific test, whereas the use of a renowned specific test as the Special Judo Fitness Test [Franchini *et al.* 2009] could have provided more useful data regarding the aerobic power.

Conclusion

The aim of the present study was to describe, analyze and compare the physical performance, the body composition and somatotype from elite Colombian judokas with elite athletes from successful countries in judo. We concluded that both male and female Colombian athletes presented lower physical performance and higher body fat percentage than others at the elite level. The somatotype was adequate and in accordance with the reported at elite level, albeit there is a need to decrease the body fat content due to its negative correlation with aerobic performance. Besides the obvious technical development, which is a critical determinant in judo success, our results emphasize that a physical improvement in lower limbs muscle power and aerobic power could help to achieve better results, maintaining the trend of growth of these less traditional countries in the modality, as seen in the last Olympics.

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Wydajność fizyczna, skład ciała i somatotyp kolumbijskich zawodników judo

Słowa kluczowe: tkanka tłuszczowa, masa mięśniowa, wydajność tlenowa, antropometria, skok w pionie, sztuki walki

Abstrakt

Tło. Judo jest sportem polegającym na mocowaniu się, który wymaga kombinacji potężnych działań (np. techniki rzucania) i wydolności tlenowej. Wydajność fizyczna, budowa ciała i somatotyp wpływają na wydajność sportowców.

Problem i cel. Celem badania była analiza fizycznej wydajności, składu ciała i somatotypu elitarnych judoków kolumbijskich i porównanie ich ze sportowcami z innych krajów. Ponadto, podjęto próbę zbadania korelacji między składem ciała a wydajnością fizyczną.

Metody. W badaniu wzięło udział piętnastu zawodników judo, osiem kobiet ($21 \pm 4,7$ lat) i siedmiu mężczyzn ($20,5 \pm 3,9$ lat). Zawodnicy posiadali czarny pas oraz mieli międzynarodowe i krajowe doświadczenia w rywalizacji, zdobywając medale na Igrzyskach Panamerykańskich, Mistrzostwach Ameryki Środkowej i Południowej. Wykonali oni skoki z przysiadem (SJ) i skoki z obrotem (CMJ) na platformie kontaktowej, w celu oceny siły kończyn dolnych. Maksymalny pobór tlenu (VO_{2max}) został oszacowany za pomocą wielostopniowego testu biegu wahadłowego na 20-m. Pomiar antropometryczne wykonano w celu oceny tkanki tłuszczowej i masy mięśni szkieletowych. Przeprowadzono korelację Pearsona między składem ciała a zmiennymi wydajności fizycznej.

Wyniki. Podsumowując, u kolumbijskich zawodników judo zaobserwowano niższą sprawność fizyczną i wyższy odsetek tkanki tłuszczowej w porównaniu z elitarnymi judokami. W innych krajach zaobserwowano umiarkowaną korelację ujemną między wydajnością tlenową a procentową zawartością tkanki tłuszczowej ($r = -0,67$) i cechą endomorficzną ($r = -0,69$). Ponadto masa mięśni szkieletowych wykazywała bardzo dużą korelację z wydajnością zarówno z SJ ($r = 0,88$), jak i CMJ ($r = 0,89$) ($p < 0,05$).

Wniosek. Elitarni kolumbijscy zawodnicy judo prezentowali niższe wyniki fizyczne i wyższy procent tkanki tłuszczowej niż najlepsi judocy z innych krajów. Somatotyp był odpowiedni i zgodny z obowiązującym na poziomie elitarnym.