Special Judo Fitness Test Level and Anthropometric Profile of Elite Spanish Judo Athletes

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Abstract

Casals, C, Huertas, JR, Franchini, E, Sterkowicz-Przybycień, K, Sterkowicz, S, Gutiérrez-García, C, and Escobar-Molina, R. Special judo fitness test level and anthropometric profile of elite spanish judo athletes. *J Strength Cond Res* 31(5): 1229–1235, 2017—The aim of this study was to determine the anthropometric variables that best predict Special Judo Fitness Test (SJFT) performance. In addition, anthropometric profiles of elite Spanish judo athletes were compared by sex and age category (seniors and juniors). In this cross-sectional study, a total of 51 (29 females) athletes from the Spanish National Judo Team were evaluated during a competitive period. All athletes performed the SJFT and underwent an anthropometric assessment through skinfold thickness measurements. Mann-Whitney comparisons by sex and age category showed that males had significantly higher muscle mass and lower fat mass than females ($p < 0.001$), whereas juniors and seniors exhibited few differences in body composition. Linear regression analyses (stepwise method) were performed to explore the relationships between anthropometric characteristics and SJFT variables. Model 1 included sex, age category, and body mass as predictors. Body mass and sex significantly predicted the SJFT index ($R^2 = 0.27$, $p < 0.001$); thus, both criteria should be considered before interpreting the test. The predictors of model 2 were quick-assessment variables, including skinfolds, breadths, girths, and height. This regression model showed that the biceps skinfold significantly predicted the SJFT index in elite athletes ($R^2 = 0.31$, $p < 0.001$). Model 3 included body compositions and somatotypes as predictors. Higher muscle and bone masses and lower ectomorphy were associated with better SJFT performance ($R^2 = 0.44$, $p < 0.001$). Hence, training programs should attempt to increase the muscle mass percentage and reduce the upper arm fat, whereas the bone percentage could be considered in the selection of talented athletes in conjunction with other factors.

Key Words anthropometry, somatotypes, body composition, skinfold thickness, martial arts, sports performance

Introduction

As judo is a weight-categorized sport, one of the most difficult challenges for elite judo athletes is to achieve excellent physical fitness while maintaining an optimal body mass. Low body fat and a high arm muscle mass have been related to better judo competition performance (8,9,18,22). Moreover, the body composition and somatotypes of judo athletes seem to influence other performance indicators, such as anaerobic power, muscle torque, power output, and maximal oxygen uptake (14,21,23). Therefore, the anthropometric profile of an elite athlete could be a relevant factor for success in competition and for performance in specific judo tests.

The assessment of physical fitness in elite judo athletes requires specific tests because the anaerobic system is responsible for the scoring actions in combat, whereas the aerobic component is required for recovery during and between matches in tournaments (10). On this basis, Sterkowicz (34) developed the Special Judo Fitness Test (SJFT), a specific judo test aimed at evaluating anaerobic and aerobic fitness (33), and it is currently one of the most used tests in judo research (15). Compared with the Wingate Anaerobic Test, the SJFT has proven to be more appropriate for evaluating the anaerobic capacity of judo athletes because of its specificity (38). However, although some studies have considered the correlations between some body composition

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Table 1. Regression analyses and partial correlations of physical fitness and body composition in elite Spanish judo athletes ($n = 51$).*†‡

	Regression analyses				Partial correlation	
	B	*SE β*	*β*	*p*	*r*	*p*
Model 1						
Body mass (kg)	0.03	0.01	0.54	<0.001	0.489	<0.001
Sex (0 = female, 1 = male)	−0.93	0.35	−0.35	0.010	−0.225	0.116
Model 2						
Biceps skinfold (mm)	0.17	0.04	0.56	<0.001		
Model 3						
Bone mass (%)	−0.53	0.13	−0.82	<0.001	−0.519	<0.001
Ectomorphy	0.78	0.24	0.67	0.002	0.435	0.002
Muscle mass (%)	−0.06	0.02	−0.36	0.010	−0.363	0.010

*Model 1—Dependent variable: Special Judo Fitness Test (SJFT) index, $R^2 = 0.27$, $\Delta R^2 = 0.24$, $p < 0.001$. Excluded variables: age category.
†Model 2—Dependent variable: SJFT index, $R^2 = 0.31$, $\Delta R^2 = 0.30$, $p < 0.001$. Excluded variables: triceps, subscapular, supraspinal, abdominal, thigh and calf skinfolds, arm, thigh, and leg girths, femur, humerus, and wrist breadths, and height.
‡Model 3—Dependent variable: SJFT index, $R^2 = 0.44$, $\Delta R^2 = 0.40$, $p < 0.001$. Excluded variables: Body fat mass, arm, and leg muscle areas, endomorphy, and mesomorphy.

parameters and SJFT performance (17,20,32), the best anthropometric predictors in elite judo athletes have not been established.

In addition, the physical fitness of judo athletes differs by judo-classification criteria (11,24), including sex (30), age (29,28), and weight category (4,35). Hence, the SJFT results could differ according to these criteria, resulting in the possibility of erroneous interpretations of the test. In light of these considerations, this study aimed to determine the anthropometric variables that best predict SJFT performance and to determine whether body mass, sex, and age category affect the test results. Furthermore, in our study, we aimed to compare the body composition and somatotypes of elite Spanish judo athletes by age (junior vs. senior categories) and sex (males vs. females). This information can play a role in the identification of talented athletes, in establishing desirable anthropometric characteristics in elite judo athletes and in making training plan adjustments.

Methods

Experimental Approach to the Problem

In this descriptive cross-sectional study, the anthropometric profiles and specific physical fitness of elite Spanish judo athletes were compared regarding sex and age (seniors and juniors). The most significant associations between anthropometric variables and the SJFT index were also established. The study was performed in the sport facilities of the High Performance Centre "Joaquín Blume" (Madrid, Spain) during the competitive period of one training meeting before an international tournament of each of the Spanish national judo teams (juniors and seniors). Anthropometric assessments were performed in the morning (on an empty stomach) and before the daily training sessions. Two hours after the anthropometric evaluation, judo athletes performed the SJFT in an athletic training room after receiving thorough information about the test protocol.

Subjects

The sample consisted of 51 elite athletes from the Spanish National Judo Team (22 males and 29 females) from all weight categories; 9 males and 17 females competed in senior division (above 20 years of age), whereas 13 males and 12 females competed in junior division (from 17 to 19 years of age). None of the subjects were under medical or psychiatric treatment when participating in the study. This study obtained ethical approval from the Research Ethics Committee of the University of Granada and was in accordance with the Helsinki declaration. After the participants were informed about the procedure and possible risks involved, written informed consent was obtained from all participants or from both parents in cases where the athlete was under 18 years of age.

Procedures

Anthropometric Variables and Body Composition. Anthropometric measurements were performed following the protocol developed by the International Society for Advanced of Kinanthropometry (ISAK) (25). Anthropometric variables included body mass, height, 7 skinfolds (biceps, triceps, subscapular, supraspinal, abdominal, front thigh, and medial calf), 3 girths (upper arm flexed, thigh, and medial calf), and 3 breadths (humeral and femoral epicondyles and wrist). Height was measured to the nearest 0.1 cm using

Table 2. Anthropometric characteristics of elite Spanish judo athletes.

	Median (interquartile range)				*p*			
	Males		Females		Males vs. females		Seniors vs. juniors	
	Senior ($n = 9$)	Junior ($n = 13$)	Senior ($n = 17$)	Junior ($n = 12$)	Seniors	Juniors	Males	Females
Body mass (kg)	85.9 (24.50)	73.5 (35.35)	62.4 (16.90)	69.8 (23.10)	0.005*	0.270	0.471	0.152
Height (cm)	180 (15.50)	173 (15.50)	164 (10.80)	167 (10.50)	<0.001*	0.002*	0.393	0.370
Body fat (%)	7.81 (3.53)	7.19 (7.29)	16.98 (6.39)	24.97 (13.69)	<0.001*	<0.001*	0.896	0.097
Body muscle (%)	52.59 (3.64)	52.11 (4.19)	47.71 (6.88)	40.31 (13.73)	<0.001*	<0.001*	0.235	0.140
Body bone (%)	15.09 (2.04)	15.62 (3.46)	14.69 (2.69)	13.63 (2.88)	0.916	0.060	0.324	0.166
Endomorphy	1.91 (1.47)	1.77 (3.25)	2.81 (1.56)	4.63 (2.70)	0.016*	0.014*	0.896	0.021†
Mesomorphy	5.56 (1.36)	4.86 (1.63)	4.39 (2.00)	4.59 (1.15)	0.200	0.225	0.556	0.679
Ectomorphy	1.60 (1.99)	2.31 (2.02)	1.74 (1.28)	0.93 (2.16)	0.597	0.270	0.512	0.152
Arm muscle area (cm^2)	95.7 (24.37)	77.2 (27.36)	70.4 (16.17)	61.3 (9.31)	<0.001*	<0.001*	0.021†	0.080
Leg muscle area (cm^2)	202.5 (35.48)	197.6 (49.94)	143.0 (29.69)	135.4 (20.13)	0.001*	<0.001*	0.209	0.263
Biceps skinfold (mm)	3.5 (1.25)	4.0 (3.75)	4.5 (2.00)	6.7 (6.88)	0.021*	0.019*	0.357	0.012†
Triceps skinfold (mm)	6.0 (4.25)	7.5 (7.00)	11.0 (8.50)	16.5 (9.63)	0.002*	<0.001*	0.556	0.152
Subscapular skinfold (mm)	10.0 (3.25)	8.5 (15.50)	10.0 (4.25)	17.7 (13.38)	0.396	0.110	0.471	0.117
Supraspinal skinfold (mm)	5.0 (6.25)	5.5 (15.50)	5.0 (4.00)	12.2 (11.13)	0.958	0.030*	0.948	0.002†
Abdominal skinfold (mm)	7.5 (7.00)	6.0 (12.25)	13.0 (6.25)	18.5 (14.63)	0.045*	0.026*	0.556	0.195
Thigh skinfold (mm)	9.5 (5.75)	10.0 (17.25)	23.0 (13.00)	37.5 (30.25)	<0.001*	0.004*	0.556	0.227
Calf skinfold (mm)	12.0 (6.75)	11.0 (10.75)	14.5 (8.00)	27.5 (22.13)	0.013*	0.007*	0.896	0.195
Arm girth (cm)	36.2 (5.35)	33.0 (6.45)	32.0 (5.05)	32.0 (4.20)	0.006*	0.205	0.082	0.811
Thigh girth (cm)	52.8 (7.40)	52.6 (14.50)	51.4 (8.35)	53.5 (8.85)	0.200	0.769	0.512	0.879
Leg girth (cm)	37.6 (5.50)	37.3 (6.70)	35.5 (5.05)	37.2 (5.00)	0.066	0.852	0.647	0.303
Femur breadth (cm)	10.1 (1.25)	9.8 (0.80)	8.8 (0.90)	9.1 (1.00)	0.004*	0.005*	0.794	0.370
Humerus breadth (cm)	6.8 (0.45)	7.0 (0.70)	5.8 (0.70)	6.1 (0.60)	<0.001*	<0.001*	0.896	0.394
Wrist breadth (cm)	5.9 (0.60)	5.6 (0.50)	5.1 (0.50)	5.0 (0.30)	<0.001*	<0.001*	0.082	0.811

*Significant differences by sex.
†Significant differences by age category, both established through the Mann-Whitney *U*-test.

Table 3. Special Judo Fitness Test (SJFT) performance of elite Spanish judo athletes.*†

	Median (interquartile range)				SJFT classifications according to			
	SJFT index	Number of throws	HR after (ppm)	HR 1 min after (ppm)	SJFT index	Number of throws	HR after (ppm)	HR 1 min after (ppm)
Male seniors (n = 9)	13.22 (1.94)	27 (2)	185 (14.0)	160 (24.5)	Regular	Good	Regular	Good
Male juniors (n = 13)	12.44 (1.43)	27 (3)	183 (8.5)	153 (11.0)‡	Good	Good	Good	Good
Total males (n = 22)	12.80 (1.55)	27 (3)	184 (9.5)	155 (18.3)				
Female seniors (n = 17)	12.56 (1.98)	25 (3)	178 (10.0)§	154 (15.0)	Regular	Poor	Regular	Regular
Female juniors (n = 12)	12.89 (0.96)	27 (2)	187 (11.5)	162 (17.8)	Good	Excellent	Regular	Poor
Total females (n = 29)	12.70 (1.29)	26 (2)	181 (14.0)	157 (19.0)				

*HR = heart rate.
†Classificatory norms were obtained from Franchini et al. (11) and Sterkowicz-Przybycien et al. (37) for males and females, respectively.
‡Significant differences by sex, p = 0.035.
§Significant differences by age category, p = 0.014; both using a Mann-Whitney U-test.

a stadiometer (GPM, Seritex, Inc., Carlstadt, NJ, USA). Body mass was measured to the nearest 0.1 kg using a portable scale (model 707; Seca Corporation, Columbia, MD, USA). Skinfold thickness was recorded to the nearest 0.2 mm at a constant pressure of 10 $g \cdot mm^{-1}$ using a Holtain skinfold caliper (Holtain Ltd., Crymych, United Kingdom). Girths were determined to the nearest 0.1 cm using a flexible anthropometric steel tape measure (Holtain Ltd.). Skinfolds were measured three times at each site in a rotation system, as described by Heyward (19), and the mean of the 3 measurements was used in the analyses. The procedure was performed by a researcher with more than 15 years of experience with this technique. The researcher presented a variation of less than 2.29% between measurements, with reproducibility determined by an intraclass correlation coefficient of 0.987 within the assessment performance period. Breadths and girths were measured only once at each site by the same experienced evaluator who previously presented less than 0.89% of variation between measurements. Somatotypes were determined according to the Carter and Heath method (6). Body composition was estimated following the four-component model and in accordance with the ISAK recommendations (25). Body fat was assessed by applying the following formula for males (5): Fat%= ($\sum$6 skinfolds × 0.1051) + 2.58; and for females, the following formula was used (5): Fat%= ($\sum$6 skinfolds × 0.1548) + 3.58, where the 6 skinfolds were triceps, subscapular, supraspinal, abdomen, thigh, and medial calf expressed in millimeters. Body muscle mass corresponded to the following equation (40): Muscle (kg) = Total Body Mass − (Fat + Bone + [Total Body Mass × C/100]), where C was 24.1 in males and was 20.9 in females. All variables are expressed in kilograms. Finally, body bone mass was calculated with the following formula for both males and females (31): Bone (kg) = 3.02 $(Height^2 \times WristB \times FemurB \times 400)^{0.712}$, where B means breadth and the 3 variables were expressed in meters.

Special Judo Fitness Test. This specific judo test was developed by Sterkowicz (34). Three athletes of similar body mass are needed to perform the SJFT: 1 participant (tori) is evaluated and the other 2 (ukes) receive throws. The tori begins the test between the 2 ukes (3 m away from each uke). On a signal, the tori runs to one of the ukes and applies a throwing technique called ippon-seoi-nage (1 shoulder throw). The tori then immediately runs to the other uke and completes another throw. The athlete must complete as many throws as possible within the test time. The SJFT is composed of three parts (15, 30, and 30 seconds) separated by 10-second recovery periods. The total number of throws completed by the tori during each of the three periods was recorded; the tori's heart rate (HR) was measured immediately after and 1 minute after the test (Polar Team 2, Polar, Finland). The SJFT index was calculated according to the following equation: Index = (HR after + HR 1 minute after)/total number of throws. The index value

decreases with better test performance. Reliability values for this test were reported as 0.97 (34).

Statistical Analyses

Data are presented as the median and the interquartile range. The Kolmogorov-Smirnov statistic was used to test the normality of distributions. Differences by age category and sex were compared using a Mann-Whitney *U*-test. To explore the relationships between anthropometric characteristics and the SJFT index, linear regression analyses (stepwise method) were performed. A total of 3 models were fitted with the SJFT index as the outcome variable; b values (B) and standardized b values (β) were estimated, and R^2 and adjusted R^2 (ΔR^2) were used to provide a goodness-of-fit of the models. Model 1 included sex, age category, and body mass as predictors. This model aimed to establish whether these judo-classification variables affect the SJFT index. Model 2 included the anthropometric variables that can be quickly measured and easily used by coaches and researchers as predictors. The predictors of model 2 were skinfolds, girths, breadths, and height. Finally, model 3 included body composition (fat, muscle, and bone masses) and somatotypes as predictors to establish possible desirable characteristics in elite judo athletes. Partial correlations were performed for each regression model to better isolate variable relationships without the effect of the other variables included in the predictor model. All analyses were conducted using the SPSS statistical package for Windows (version 17.0; SPSS, Inc., Chicago, IL, USA); the level of significance was set at $p \leq 0.05$.

Results

Some classification parameters in judo, such as body mass and sex, significantly affected the SJFT performance of elite Spanish athletes. Moreover, the biceps skinfold had a significant association with the SJFT index, with a prediction of up to 31%, whereas the ectomorphy component, bone, and muscle masses were able to jointly predict 44% of the test results (Table 1).

Descriptive statistics of the athletes' anthropometric profiles are presented in Table 2, comparing data by sex and age category. Sexual dimorphism in judo athletes was apparent for body fat and muscle percentages, whereas juniors and seniors exhibited few differences in body composition.

Performance indicators achieved in the SJFT are shown in Table 3; their corresponding classifications were estimated according to previous classification norms (12,37). Few significant differences of the specific fitness were found between the four groups of elite athletes, although their SJFT classifications showed relevant differences with better performance grades in juniors than in seniors.

Discussion

As has been previously mentioned, the SJFT is widely used by researchers and coaches to test the physical fitness of judo athletes (15). For this reason, the SJFT classification norms have been published for males (12) and females (37), but only the SJFT norms for females differ between senior and junior categories. This study highlights that body mass and sex are significantly associated with the SJFT index. This information should be taken into consideration when evaluating athletes of different weight categories because heavier judo athletes achieve worse SJFT results than lighter athletes, although there is not a classificatory adjustment by weight (14,32). In addition, it has been reported that lighter judo athletes have higher throwing speed (seoi-nage technique), more power, and better oxygen uptake than heavyweight athletes (1,4,12). Hence, the judo athlete's body mass should be considered before applying the SJFT results at an elite level.

In our study, the body composition of elite judo athletes was significantly related to the SJFT index. Thus, higher relative bone and muscle masses were associated with better SJFT performance (lower index). Accordingly, previous studies showed that high fat-free mass might be an advantage for judo performance (21,22). In addition, the ectomorphic component showed to be an undesirable body composition in our athletes; this result is expected because the mean somatotype of international judo athletes is endomorphic mesomorph (36). Therefore, the training program should attempt to increase muscle mass and slightly reduce or maintain body fat, thus increasing the percentage of muscle mass. Moreover, this study provides information about the quickly assessable anthropometric variables that best predict judo-specific performance. This analysis revealed that the biceps skinfold has a strong association with SJFT performance and is able to explain 31% of the index, which is a high prediction value for a single anthropometric measure. Thus, although the fat mass percentage does not seem to be relevant for judo performance (8,14,20), decreased upper arm fat at the biceps may be a discriminating variable in the elite context (3). As the relative body bone mass cannot be modified by training or diet, this information has an application only in the selection of talented athletes; however, other factors must also be taken into consideration in this process.

The anthropometric characteristics of the elite Spanish judo athletes differed by sex but demonstrated few differences by age. Thus, male judo athletes had higher muscle mass, lower body fat, and a lower endomorphic component than female judo athletes for both age categories (junior and senior). Age differences in somatotype components were found only for females with a lower endomorphy component in seniors than in juniors, whereas male seniors showed a higher arm muscle area than male juniors, without other relevant differences. The few studies that examined anthropometric differences by sex or age category in judo athletes (2,13,36) reported similar results. A common limitation when analyzing judo athletes is the fact that they are classified according to their body mass, which results in

differences concerning anthropometric variables between weight categories (16). For this reason, body mass can be a confusing variable in judo research and training, as we have previously mentioned regarding the SJFT index.

Previous research showed correlations between the SJFT and aerobic capacity and power in both males (7,33) and females (32,39). Our SJFT results indicated that female seniors should improve their anaerobic capacity inferred from the total number of throws, whereas female juniors must increase their aerobic component because their recovery capacities were classified as poor. Male seniors also should improve their aerobic capacity, whereas male juniors had similar classifications (good) for all the SJFT variables. Both classificatory norms have 5 levels (very poor, poor, regular, good, excellent), but only the female classification (37) differed between seniors and juniors; thus, the male classification (12) can overestimate our senior values. To the best of our knowledge, this is the first study to compare SJFT results between males and females. Sex-related differences were found when analyzing groups by their SJFT classifications; however, these differences were not statistically significant, except for the HR 1 minute after the test in the junior category. Although sex and age should be considered in testing the athlete and planning the training program (26–28), our sample was not of sufficient magnitude for detecting relevant SJFT differences unless classificatory norms are used.

Practical Applications

This study analyzed the anthropometric profiles of elite judo athletes and their judo-specific physical fitness assessed through the SJFT. This study has three main applications: (a) body mass should be considered in the SJFT interpretation because heavier athletes achieve worse results than lighter athletes, but they can have similar competitive success in their respective weight divisions; (b) the biceps' skinfold is able to predict up to 31% of the SJFT index and can be quickly assessed, making it a useful tool in testing elite judo athletes; and (c) higher muscle and bone mass percentages and lower ectomorphy are associated with better judo-specific fitness and can jointly predict 44% of the SJFT index. These predictions are high for a model exclusively based on anthropometric characteristics at an elite level. The anthropometric profile of elite judo athletes seems relevant for their physical fitness and can be partially modified by training. Thus, the training program of these elite athletes should aim to increase their muscle mass. Further research is needed to confirm whether changes in these anthropometric variables translate into SJFT performance and to judo competition performance. The body fat percentage was not relevant for the judo-specific physical fitness of elite athletes, although it must be at least maintained because an increase supposes a decrease of the body muscle and bone percentages. However, upper arm fat at the biceps may discriminate judo performance at an elite level. Other parameters, such as bone mass, can be used only in the selection process of talented judo athletes in conjunction with other sport-specific abilities.

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