Anthropometrical profile of elite Spanish Judoka: Comparative analysis among ages

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Abstract

Background and Study Aim: Judo athletes usually try to maximize muscle mass and to minimize adiposity in each weight category, but few studies focused on comparisons of different age categories and little is known about sexual dimorphism among judo athletes. The aim of the study was to compare anthropometrical variables in male and female judoka from Spanish National Teams.

Material/Methods: Eighty-seven national level Spanish judoka from all seven weight categories took part in this study: females (n=46) – cadet (n=16), junior (n=12) and senior (n=18); males (n=44) – cadet (n=18), junior (n=15) and senior (n=8). Body mass, height, skinfold thickness, circumferences and breadth anthropometric measurements were carried out. Somatotype components, body mass index, body fat and muscle mass were also estimated. A two way (gender and age groups) analysis of variance and Tukey test were used to compare groups.

Results: (1) males were heavier, taller, had lower body fat and higher muscle mass absolute and relative values, circumferences and bone diameters, lower endomorphic and higher mesomorphic components than females; (2) for skinfold thickness males presented lower values in limbs' sites than females, but no difference was found in trunk skinfold thicknesses; (3) few differences were found among age categories, with cadets presenting smaller flexed arm circumference and humerus epicondyle bone breadth compared to junior and seniors, and lower absolute muscle mass compared to seniors; (4) tendency for reducing sexual dimorphism in some anthropological dimensions and in endomorphic and mesomorphic components was observed across age categories.

Conclusions: Morphologically high level cadet judo athletes are quite similar to older athletes and coaches can select them from these ages. These data can be used as reference to coaches and physical conditioning professionals.

Key words: Judo • martial arts • skinfold thickness • bone diameters • circumferences • combat sports

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Background

Judo is a weight-classified, high-intensity combat sport where the athlete attempts to throw the opponent onto his/her back or to control him/her during groundwork combat [1]. Additionally, judo athletes are classified according to their ages and compete in international level tournaments (e.g., World Championships) in the following age divisions: cadets – under 17 years-old; juniors – under 20 years-old; and seniors – above 20 years-old. It

Judo – an educational system created by Jigoro Kano, literally meaning the "gentle way". In this article we refer to the competitive aspect of judo.

Martial arts – systems of codified practices and traditions of combat, initially created for warrior purposes, and nowadays practiced for a variety of reasons, including self-defense, competition, physical conditioning etc.

Skinfold thickness – a measure of the amount of subcutaneous fat, obtained by inserting a fold of skin into the jaws of a caliper.

Bone diameters – a distance measurement through bone's extremities.

Circumferences – in this study, the distance around a body segment.

Combat sports – are competitive contact sports where two combatants fight against each other using certain rules of engagement". *Cited from The influence of the wrestling technique on contact efficiency of young male team handball players. Nikola Foretić, Hrvoje Karninčić, Ognjen Uljević. Arch Budo, 2011; 7(2): OA87–91.*

is known that judo players usually try to maximize muscle mass and to minimize adiposity in each weight category, and that this process starts at the early adolescence in an attempt to increase power-body mass ratio [2].

Furthermore, the body structure can play a determining role in the achievement of top judo performance [3,4], and it seems to influence the type of techniques applied [5]. Moreover, body fat has been reported to be negatively associated with judo athletes' performance in both aerobic and anaerobic tests [5,6]. Therefore, several studies have aimed to obtain anthropometrical parameters, such as body composition, bone diameter and circumferences, due to their utmost importance for performance [3,5–9]. Callister et al. [10] eported smaller body fat percentage in higher-ranked judo athletes, compared with non-high level athletes (5.1±0.6% *vs.* 8.2±0.8%). Additionally, Kubo et al. [9] demonstrated that judo athletes who participated in the Olympic Games or Asian Games had significantly larger fat-free mass than university judo athletes who did not participate in intercollegiate competitions. Kim et al. [7] found that for international level Korean judo athletes muscle mass was positively related to anaerobic performance, while for lower level judo athletes (junior and university level competitors) this was not observed. However, Franchini et al. [11] did not find any significant difference in skinfold thickness between elite and nonelite judo players, but identified higher circumference values (flexed arm, forearm, wrist and medial calf) and breadths (humerus and femur epicondyles) in elite when compared to nonelite athletes.

Despite the fact that judo athletes start to compete early in their careers [12], the re-edition of the Cadet World Championship in 2009 and the inclusion of judo in the Youth Olympic Games, few studies focused on comparisons of different age categories [13]. Additionally, little is known about sexual dimorphism among judo athletes [14]. In fact, recently Franchini et al. [1] suggested that little is known regarding the differences among weight classes, age groups and sexes. The knowledge of the anthropometrical characteristics of different age groups and genders can help in the process of talent identification and promotion, as well as better nutrition suport to these athletes. Thus, the purpose of this study was to compare anthropometrical variables in male and female judo athletes from cadet, junior and senior Spanish National Teams.

Material and Methods

Participants

The sample was composed by 87 national level Spanish judo athletes from all seven weight categories (Spanish National Teams). These athletes competed in cadet, junior and senior divisions: females (n=46) – cadet (n=16; age = 16.5±0.4 years-old), junior (n=12; age =18.6±0.5 years-old) and senior (n=18; age =24.1±0.4 years-old); males (n=44) – cadet (n=18; age =16.7±0.4 years-old), junior (n=15; age =18.9±0.5 years-old) and senior (n=8; age =22.1±0.6 years-old). All participants took part voluntarily in the study after being informed about the procedures involved (risks and benefits), and signed an informed consent agreement form, previously approved by the local Ethics' Committee. All the athletes were at the competitive period and were not engaged in any weight loss procedure at the week of the measurements, as all subjects were evaluated one week after the national championship. Their competitive level was national and international.

Anthropometrical measurements

The following anthropometric measurements were carried out: body mass, height, skinfold thickness (biceps, triceps, subscapular, supraspinale, abdominal, front thigh, and medial calf), circumferences (flexed arm, thigh and medial calf) and breadth (humerus and femur epicondyles and wrist). Skinfold thickness measurements (Harpenden plicometer; John Bull British Indicators®, England; constant pressure of 10 g/mm and precision of 0.2 mm) were carried out three times on each point in a rotation system, as described by Heyward [15]. A researcher with more than 15 years of experience in this measurement procedure carried it out, presenting a variation of less than 2.29% between measurements, with reproducibility determined by an intra-class correlation coefficient of 0.987, within the assessment performance period. The breadths and circumferences were measured only once at each point by the same experienced evaluator, who presented less than 0.89% of variation between measurements.

Body mass index (BMI) was calculated. Somatotype was determined using the procedures described by Carter and Heath [16]. Body fat [17] and muscle mass [18] were calculated according to the International Society for the Advancement of Kinanthropometry [19]. These values were expressed in both absolute and relative (%) terms.

Statistical analysis

Data are presented as mean ±standard error. Levene's test was used to test the null hypothesis that the error variance of the dependent variable is equal across groups, which was the case. A two way (gender and age groups) analysis of variance and Tukey test were used to compare groups. Effect size was calculated by means of eta-squared which describes the proportion of total variability attributable to the factor. The level of significance

Table 1. Body mass (kg), height (cm), body mass index (kg/m^2) and skinfold thickness (mm) of male and female judo athletes from cadet, junior and senior categories.

	Females			Males		
	Cadet	Junior	Senior	Cadet	Junior	Senior
Body mass (kg)*	58.2±4.8	70.7±5.0	64.7±4.1	78.5±4.1	82.5±4.5	82.5±6.2
Height (cm)*	162.3±1.9	165.6±2.2	163.3±1.8	173.7±1.8	176.7±2.0	179.8±2.7
Body mass index (kg/m^2)	21.8±1.2	25.6±1.4	24.2±1.2	25.8±1.2	26.1±1.3	25.4±1.7
Skinfold thickness (mm)						
Biceps*	7.0±1.0	8.7±1.2	6.3±1.0	7.2±1.0	5.5±1.1	3.7±1.4
Triceps	12.2±1.6	16.4±1.9	14.6±1.5	11.7±1.5	8.5±1.7	6.9±2.3
Subscapular	13.5±2.5	17.7±2.9	15.0±2.4	15.0±2.4	14.5±2.6	9.5±3.5
Supraspinale	10.0±2.6	15.5±3.0	9.6±2.4	12.9±2.4	12.6±2.7	6.5±3.7
Abdomen	14.9±3.0	19.7±3.4	15.8±2.8	16.8±2.8	15.0±3.1	9.3±4.2
Thigh	28.9±3.0	34.5±3.5	27.5±2.9	19.2±2.9	17.0±3.1	9.5±1.0
Medial calf	20.3±2.2	26.1±2.6	19.0±2.1	17.4±2.1	12.8±2.3	13.6±3.2

* Gender effect (P<0.05). Data are mean ± standard error.

Table 2. Bone breadths (cm) and circumferences (cm) of male and female judo athletes from cadet, junior and senior categories.

	Females			Males		
	Cadet	Junior	Senior	Cadet	Junior	Senior
Bone breadth (cm)						
Wrist*	4.9±0.1	5.0±0.1	5.0±0.1	5.5±0.1	5.6±0.1	5.8±0.1
Humerus*,**	5.5±0.1	6.0±0.1	5.9±0.1	6.7±0.1	6.8±0.1	6.9±0.2
Femur*	8.8±0.2	9.0±0.2	8.9±0.2	9.9±0.2	9.9±0.2	9.8±0.3
Circumferences (cm)						
Flexed arm*,**	27.8±0.9	31.3±1.1	32.5±0.9	32.0±0.9	33.7±1.0	35.6±1.3
Thigh*	47.3±1.6	51.9±1.9	52.0±1.5	52.9±1.5	54.1±1.7	53.5±2.3
Medial calf*	34.7±1.1	37.3±1.2	35.6±1.0	39.1±1.0	38.4±1.1	38.0±1.5

* Gender effect (P<0.05); ** age group effect (P<0.05). Data are mean ± standard error.

was set at 5%. All analyses were conducted using SPSS 13.0. Looking for a size of sexual dimorphism in anthropometric dimensions within the three age group the two steps ratio (SDI) was used [20]: (1) if M ≥F, SDI = M/F; (2) if F ≥M, SDI =2 – F/M, where M and F are respective male and female means.

Results

Table 1 presents judo athletes' body mass, height, BMI and skinfold thickness.

Body mass ($F_{1.81}$ =18.2; P<0.001; eta squared =0.18) and height ($F_{1.81}$ =58.0; P<0.001; eta squared =0.42) differed between genders, with males being heavier and taller (P<0.001 for both variables) than females. However, BMI did not differ between genders (P>0.05).

For skinfold thickness, some differences were found. Males presented lower values of biceps skinfold thickness ($F_{1.81}$ =4.3.;P=0.042; eta squared =0.05) compared to females (P=0.04). For triceps skinfold thickness an interaction effect was found ($F_{2.81}$ =3.2; P=0.046; eta squared =0.07). The post hoc test indicated that cadet (P=0.046) and junior males (P=0.042) had lower values compared to junior females. For subscapular, supraspinale and abdomen skinfold thicknesses no effect of gender or age group were found (P>0.05). Thigh ($F_{1.81}$ =30.7; P<0.001; eta squared =0.28) and medial calf ($F_{1.81}$ =13.0; P<0.001; eta squared =0.14) skinfold thickness differed between genders, with lower values in males (P<0.001 for both comparisons) compared to females.

Table 2 presents judo athletes' bone breadths and circumferences.

Table 3. Body fat and muscle mass in absolute (kg) and relative (%) values of male and female judo athletes from cadet, junior and senior categories.

	Females			Males		
	Cadet	Junior	Senior	Cadet	Junior	Senior
Body fat (kg)*	12.1±2.3	18.0±2.7	14.3±2.2	10.6±2.2	9.8±2.4	7.1±3.3
Body fat (%)*	19.5±1.8	24.0±2.1	19.9±1.7	12.1±1.7	10.6±1.9	8.0±2.6
Muscle mass (kg)*,**	25.0±1.6	28.5±1.8	27.8±1.5	37.4±1.5	40.8±1.6	45.8±2.2
Muscle mass (%)*	44.0±1.5	41.5±1.7	44.7±1.4	48.5±1.4	50.3±1.5	53.2±2.1

* Gender effect (P<0.05); ** age group effect (P<0.05). Data are mean ± standard error.

Table 4. Endomorphy, mesomorphy and ectomorphy components of male and female judo athletes from cadet, junior and senior categories.

	Females			Males		
	Cadet	Junior	Senior	Cadet	Junior	Senior
Endomorphy	3.6±0.5	4.9±0.6	3.8±0.5	3.6±0.5	3.2±0.5	2.1±0.7
Mesomorphy	3.5±0.3	4.6±0.4	4.8±0.3	5.2±0.3	5.3±0.4	5.2±0.5
Ectomorphy	2.4±0.3	1.2±0.3	1.7±0.3	1.9±0.3	1.7±0.3	1.6±0.4

Data are mean ± standard error.

Bone breadths also differed among groups. Wrist ($F_{1.81}$ =61.4; P<0.001; eta squared =0.43), humerus epicondyle ($F_{1.81}$ =99.2; P<0.001; eta squared =0.55) and femur epicondyle breadths ($F_{1.81}$ =32.7; P<0.001; eta squared =0.29) were bigger in males compared to females (P<0.001 for all variables). For humerus epicondyle there was also an effect of age group ($F_{2.81}$ =5.6; P=0.005; eta squared =0.12), with cadets presenting smaller breadths compared to juniors (P=0.015) and seniors (P=0.032).

For medial calf ($F_{1.81}$ =32.7; P<0.001; eta squared =0.29), thigh ($F_{1.81}$ =32.7; P<0.001; eta squared =0.29) and flexed arm circumferences ($F_{1.81}$ =32.7; P<0.001; eta squared =0.29) men presented higher values compared to females (P=0.01; P=0.032 and P<0.001 for medial calf, thigh and flexed arm, respectively). There was an effect of age group on flexed arm circumference ($F_{2.81}$ =8.6; P<0.001; eta squared =0.18), with cadets presenting lower values compared to juniors (P=0.039) and seniors (P<0.001).

Table 3 presents body fat and muscle mass in absolute and relative terms in judo athletes from different genders and age groups.

Significant differences between genders were detected for both absolute ($F_{1.81}$ =7.2; P=0.009; eta squared =0.08) and relative body fat ($F_{1.81}$ =44.9; P<0.001; eta squared =0.36), with lower values for males compared to females (P=0.008 for absolute and P<0.001 for relative body fat). Muscle mass absolute ($F_{1.81}$ =106.0; P<0.001; eta squared =0.57) and relative values ($F_{1.81}$ =29.7; P<0.001; eta squared =0.27) differed between genders, with higher values for males compared to females (P<0.001 for both variables). Absolute muscle mass also differed between age groups ($F_{2.81}$ =5.8; P=0.005; eta squared =0.27), with lower values in cadets compared to seniors (P=0.005).

Table 4 presents the somatotypes of judo athletes from different genders and age categories.

There was a significant difference between gender in the endomorphic component ($F_{1.81}$ =6.6; P=0.012; eta squared =0.08), with males presenting a lower value compared to females (P=0.011). A significant difference also existed between genders concerning the mesomorphic component ($F_{1.81}$ =10.1; P=0.002; eta squared =0.11), with higher values in males compared to females (P=0.002). No difference was found between groups in the ectomorphic component (P>0.05).

Analysis of data presented in Tables 1–4 shows a trend of decrease sexual dimorphism (SDI) in anthropometric dimensions, which is revealed across age. Cadets had higher SDI than juniors, which have higher SDI than seniors, as documented in skinfolds thickness: triceps (1.81>0.07>–0.12), subscapular (1.11>0.78>0.42), supraspinale (1.29>0.77>0.52), abdomen 1.13>0.69>0.30), and in consequence in body fat percentage (0.39>–0.26>–0.49. The same pattern was revealed in thigh circumference (1.10>1.04>1.03). Similar trends across age categories

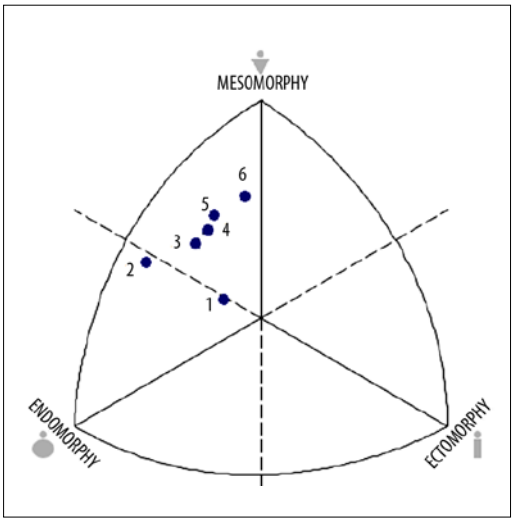

Figure 1. Somatochart of Spanish National Team member judo athletes according to gender and age groups. 1 – cadet females; 2 – junior females; 3 – senior females; 4 – cadet males; 5 – junior males; 6 – senior males.

were observed in endomorphy (1.00>0.47>0.19) and mesomorphy (1.49>1.15>1.08), but not in ectomorphy (0.74<1.42>0.94).

Furthermore, judo athletes' somatotype analysis presented in Figure 1 shows mostly endomorphic-mesomorph body type (senior females; cadet and junior males). Two groups were classified as meso-endomorphic (cadet and junior females). Senior males presented balanced mesomorphic somatotype.

Discussion

The objective of the present study was to characterize and compare anthropometrical variables in male and female judo athletes from cadet, junior and senior categories. The main results were the following: (1) males were heavier, taller, had lower body fat and higher muscle mass percentage and absolute values, higher circumferences and bone diameters, lower endomorphic and higher mesomorphic components than females; (2) for skinfold thickness males presented lower values in limbs' sites than females, but no difference was found in trunk skinfold thicknesses; (3) few differences were found among age categories, with cadets presenting smaller flexed arm circumference and humerus epicondyle bone breadth compared to junior and seniors, and lower absolute muscle mass compared to seniors; (4) tendency for reducing sexual dimorphism in some anthropological dimensions and in endomorphy and mesomorphy somatotype components was observed across the age categories.

The mean value of body mass index for junior females and for all groups of males was above the normal weight status World Health Organization classification (i.e., 25.0 $kg \cdot m^{-2}$). Values presented by our sample were above that reported by Úbeda et al. [21] with the Spanish National Team (24.3 $kg \cdot m^{-2}$), although the range (21.9–38.2 $kg \cdot m^{-2}$) reported by them is also wide, which can be a consequence of the different weight categories. Despite the higher than normal BMI, our sample presented lower values of body fat percentage when compared to non-athletes [15].

Previous sample of national level Spanish judo players (n=72; 42 females and 30 males, aged between 16–30 years old) presented lower body fat percentage (10.99±2.67% for females and 7.34±1.37% for males) [22].

When the results of body fat percentage of our sample are compared to other studies with World and Olympic level judo athletes, values slightly lower are found in the literature, i.e., values below 10% for males [5,6,10,13,23–25] and near 16% for females [10,13,24,25]. This seems to confirm the assumption that high level judo athletes must have a very small percentage of body fat compared with an average male of the same height and age [1], although only one study reported a significant difference in body fat among best ranked judo athletes and lower ranked ones [10].

When the mesomorphic somatotype component is considered, the athletes from our sample presented values slightly lower than those reported in both male [3,23] and female international level judo athletes [1]. However, when the values in different components are considered, our sample confirmed that judo athletes generally have a profile that accentuates the mesomorphic properties (very high muscularity, low linearity and low fat), while among females, the endomorphic component has values near to the mesomorphic one [1].

Few studies have analyzed the anthropometric profile of high level female judo athletes [26,27]. Measuring skinfold thickness of female Filipino judo athletes, Pieter et al. [27] reported similar results in triceps, subscapular and suprailiac, higher values in abdominal and lower values in thigh and medial calf sites compared to our female sample.

On the other hand, the senior male group of our sample presented lower values of triceps, subscapular, suprailiac, abdominal, front thigh and medial calf skinfold thicknesses and higher values of flexed arm than elite and non-elite judo athletes. For bone diameters, similar results were found in our sample and both elite and non-elite judo athletes [11].

Few studies about anthropometric profile were also conducted with cadet judo athletes [4,28]. Pérez and

Sanagua [28] reported lower values of body fat percentage and both male and female judo athletes participating of the Cadet Judo World Championship compared to the values estimated in our sample.

When the cadet subsample is considered, the values from our group are also slightly higher for the endomorphic component and slightly lower for the mesomorphic component when compared to athletes taking part in the Cadet World Judo Championship [28]. Comparing our cadet subsample to 70 sedentary boys [29], they presented identical endomorphy (3.6), but higher mesomorphy (5.2 *vs.* 2.1), and lower ectomorphy (1.9 *vs.* 2.9). The mesomorphy of cadets is also substantially higher than in boys who trained soccer (4.4) and fitness (3.2).

The bigger skinfold thickness in the segments in females compared to males observed in our study was also reported previously in sample of cadet judo athletes, i.e., female judo athletes presented bigger thigh and medial calf skinfold thicknesses than male judo athletes taking part in the World Cadet Judo Championship [28].

The differences observed in our study between male and female judo athletes are similar to those reported by Sterkowicz-Przybycień and Almansba [14]. These authors reported that male judo athletes presented higher values than female in the following variables: body height, humerus breadth, arm girth and body density and the values of absolute and relative fat-free mass, fat-free mass index and mesomorphic component. Conversely, male presented lower values than female for triceps skinfold thickness, body fat percentage and fat-free mass index. In general, the differences between males and females are the same as classically reported in the literature about sexual dimorphism [16], i.e., differences in male and female somatotypes, for both trained and untrained subjects, manifest in lower endomorphy and higher mesomorphy. Sterkowicz-Przybycień and Almansba [14] stated in Polish National Judo Teams that 16 out 21 anthropological dimensions and indexes showed a tendency to a reduced sexual dimorphism as compared to that observed in untrained people. When the somatotype components of untrained male and female judo athletes were compared no difference was found concerning endomorphy and mesomorphy. Additionally, the somatotype of senior female judo athletes was the same as in younger male judo athletes (i.e., endomorphic-mesomorphic). Conversely, in younger female judo athletes the body type was characterized as being mesomorph-endomorphic, whereas senior male judo athletes were balanced mesomorphs. Male senior judo athlete's somatotype is similar with previous Spanish study results [22], although a lower mesomorphy (5.2 *vs.* 6.16) component was observed in our study. Similar mesomorphy component was found in senior female judo athletes (4.8 *vs.* 4.7). In Polish Senior Teams the typical body type was the endomorphic-mesomorphic in both genders [14]. Possible causes of these differences can be the sport selection process and the heavy resistance training to which judo athletes are submitted to.

Thus, it seems that the engagement in judo results in an anthropometrical profile specifically adapted to the demands of the sport, even in early ages. Investigation with wrestlers reported that after 16 years-old no difference in anthropometrical profile was observed [30]. Specifically with judo athletes, we found only one research that compared male and female judo athletes across different age groups (junior and senior for females; cadet, junior and senior for males), but this research was directed more to physical fitness, reporting only body fat and body mass comparisons across age groups, with similar findings to our study [13].

Conclusions

Our study indicated that male judo athletes were heavier, taller, had lower body fat and higher muscle mass percentage and absolute values, higher circumferences and bone diameters, lower endomorphic and higher mesomorphic components than females. Most of the difference between male and females concerning body fat were related to a lower skinfold thickness in the limbs' sites by males compared to females. Additionally, few differences were found among age categories, with cadets presenting smaller flexed arm circumference and humerus epicondyle bone breadth compared to junior and seniors, and lower absolute muscle mass compared to seniors.

It is recommended that future studies be conducted to compare different categories and the relationship between anthropometrical, championship performance and functional variables such as muscle power, muscle endurance and anaerobic capacity.

Practical applications

Morphologically, high level cadet judo athletes are quite similar to older athletes and coaches can select them from these ages, although other aspects (e.g., technical, psychological, physiological) should be taken into account. Additionally, as this sample is large and was constituted by high level judo athletes these data can be used as reference to coaches and physical conditioning professionals. These professionals can direct their training considering the desirable morphological profile athletes must have. Nutrition professionals can also benefit from these information results to organize proper diet to athletes who have to achieve a specific morphological profile.

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