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Physical Fitness and Anthropometrical Profile of the Brazilian Male Judo Team

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Abstract The present study had as objectives (1) to compare the morphological and functional characteristics of the male judo players of the Brazilian Team A (n=7) with the judo players of Teams B and C (reserves; n=15), and (2) to verify the association between the variables measured. Thus, 22 athletes from the seven Olympic weight categories were submitted to: a body composition evaluation (body mass, height, ten skinfolds, eight circumferences, three bone diameters and percent body fat estimation); the *Special Judo Fitness Test* (SJFT); maximal strength tests (one repetition-maximum, 1 RM, in bench press, row, and squat); and the Cooper test. One-way analysis of covariance was used to compare the groups. The relationships between variables were determined by the Pearson coefficient correlation. The significance level was fixed at 5%. No significant difference was found in any variable between them. The main significant correlations observed were between the following variables: $\dot{V}O_2max$ and number of throws in the SJFT ($r=0.79$); percent body fat and estimated $\dot{V}O_2max$ ($r=-0.83$) and number of throws in the SJFT ($r=-0.70$); chest circumference and bench press 1 RM ($r=0.90$) and in the row ($r=0.80$); and thigh circumference and squat 1 RM ($r=0.86$). However, there was no significant correlation between circumferences and 1 RM/kg of body mass. According to these results the main conclusions are: (1) the physical variables measured do not discriminate performance when analysis is directed to the best athletes; (2) a higher percent body fat is negatively correlated with performance in activities with body mass locomotion (Cooper test and the SJFT); (3) judo players with higher aerobic power performed better in high-intensity intermittent exercise; (4) judo players with bigger circumferences present bigger absolute maximal strength. *J Physiol Anthropol 26(2): 59–67, 2007* http://www.jstage.jst.go.jp/browse/jpa2
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Introduction

Competitive judo can be described as a combative, high-intensity sport in which the athlete attempts to throw the opponent onto his/her back or to control him/her during groundwork combat. Both attempts depend on specific techniques and tactical skills with the support of good physical fitness (Franchini et al., 2005a; Thomas et al., 1989). Since 2003 the format of international judo competition has been one continuous 5-min period, which can be complemented by extra time until one athlete scores or to the end of the new 5-min period (IJF website, 2004). However, during the time allowed, there are many interruptions during combat. The typical time structure is 30 s of activity with a 10 s interval (Castarlenas and Planas, 1997; Sikorski et al., 1987). The physiological demands of this format tax both the aerobic and the anaerobic systems. The anaerobic system provides the short, quick, all-out bursts of maximal power during the match, while the aerobic system contributes to the athlete's ability to sustain effort for the duration of the combat and to recover during the brief periods of rest or reduced effort (Franchini et al., 2003; Muramatsu et al., 1994).

Physiological testing is commonly used to assess the overall fitness level of the athletes and to set guidelines for individualized training (Little, 1991; McArdle et al., 2003). Some physical fitness and anthropometrical variables are considered requisites for high performance in judo competition (Sikorski et al., 1987; Thomas et al., 1989). As judo is a weight-classified sport, it has been suggested that high level judo players should have low body fat (Kubo et al., 2006). Callister et al. (1991) reported that high level judo players presented lower percent body fat compared with judo players worse qualified in USA ranking. A high arm circumference has also been pointed out as an important characteristic for judo athletes (Claessens et al., 1987). Franchini et al. (2005a) compared national-level judo players to others presenting a lower competitive level and remarked, using weight as a co-variable, that high-level judo players presented larger circumferences (flexed arm, forearm, wrist and leg) and bone diameters (femur and humerus epicondyles). A recent study (Kubo et al., 2006) 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. In fact, the muscle thickness normalized to the height of the individual was larger in judo players at the international level than in those at the university level.

From the physiological viewpoint, anaerobic power and capacity, strength, and aerobic power have been considered the main characteristics to be developed by judo players (Thomas et al., 1989). Although these aspects are thought to be important to judo performance, few studies (Borkowsky et al., 2001; Fagerlund and Häkkinen, 1991; Franchini et al., 2003; Franchini et al., 2005a) compared high level with lower level judo players concerning physical fitness. Borkowsky et al. (2001) did not find any difference in lower-body Wingate and $\dot{V}O_2max$ values among Polish Championship winners and second and third placers. Nevertheless, these authors did not adjust variables to weight differences. Performance in high-intensity intermittent exercise (four repetitions of upper-body Wingate test with 3-min interval between them) was better in judo athletes at the national (Brazil) and state (São Paulo) level than at the city (São Paulo) level (Franchini et al., 2003). Franchini et al. (2005a) found larger mean and peak power during an upper-body Wingate test and larger number of throws during the Special Judo Fitness Test (SJFT) in elite compared to non-elite judo players. Fagerlund and Häkkinen (1991) have found differences in a one maximal repetition (1 RM) and strength-speed curve during squat, but not during bench-press, among international, national (Finnish), and recreational judo players.

Besides this, there are few reports in the literature (Franchini et al., 2005b) about the relationship between several variables mentioned above for high-level competitive judo players, especially concerning the association between morphological and functional variables and the relationship between aerobic power and high-intensity intermittent performance.

Thus, the purposes of this study were: (1) to describe and compare morphological and functional features of the male judo players of the Brazilian A Team to the judo players of Teams B and C (reserves); (2) to check the association between morphological and functional variables and between aerobic power and performance on a high-intensity intermittent task.

Methods

Subjects

Twenty-two judo players, with more than 10 years of judo practice, participated in this study. The three best in Brazilian *ranking* in the 60 kg, 60–66 kg, 66–73 kg, 73–81 kg, 81–90 kg and +100 kg categories and the four best in the 90–100 kg category were analyzed. Seven were team members and 15 were reserves. All participants took part voluntarily in the study, after being informed about the procedures involved, and signed a consent agreement, previously approved by the local Ethics Committee. Athletes were assessed twenty days before the definition of teams that would participate in European Circuit competitions in 2002.

Anthropometrics

The following anthropometric measures were carried out: body weight, height, skinfold thickness (triceps, biceps, subscapular, pectoral, medium axillar, iliac crest, supra-spinal, abdominal, front thigh, and medial calf), circumferences (thorax, relaxed arm, flexed arm, forearm, wrist, waist, gluteus, and leg) and bone diameters (humeral and femoral epicondyle and wrist styloid process). Three of the authors were responsible for measuring skinfolds, circumferences, and bone diameters. An assistant carried out height and body weight measurements. Skinfold thickness measures (Harpenden caliper) were carried out three times on each point in a rotation system. The person responsible for assessment had 7 years' experience in this type of procedure and a variation of less than 2% between measurements, with reproducibility determined by an intra-class correlation coefficient of 0.98, within the assessment performance period. Researchers with more than 10 years of experience in this measurement procedure carried out circumference and bone diameter measurements once on each point, with a variation of less than 1% for the measurements taken. Fat percentage was estimated based on a Jackson and Pollock (1978) protocol, a procedure used in two other studies that, among other variables, estimated fat percentage in judo players (Callister et al., 1990; Callister et al., 2001).

Aerobic Power

A 12-min test proposed by Cooper was used to estimate $\dot{V}O_2max$. This test was performed on a 400-m official athletic track, with tartan floor, marked each 10 m. It was carried out according to aspects described by McArdle et al. (2003); all athletes had already been submitted to this test, at least once, during the two years preceding assessment.

Judo-specific test

Athletes were submitted to the specific test proposed by Sterkowicz (1995), according to the following protocol: two judo players (*ukes*) with similar height and body mass (same category) of the executor are positioned at 6 m distance from one another, while the test executor (*tori*) is 3 m from the judo players that will be thrown. The procedure is divided into three periods: 15 s (A), 30 s (B), and 30 s (C) with 10-s intervals among them. During each period, the executor throws partners using the *ippon-seoi-nage* technique, as many times as possible. Immediately after and 1 minute after test completion, the athlete's heart rate is checked. Throws are added and the index below is calculated (Equation 1):

$$\text{Index} = \frac{\text{HR (bpm)} + \text{HR 1 min after test completion (bpm)}}{\text{Throws (total number)}} \quad (1)$$

Thus, the higher the test performance, the lower is the index value. To increase heart rate measurement objectivity, a *Polar Vantage Night Vision* (*Polar Electro Oy*, Finland) monitor was used.

Maximal strength test

Quantifications of one maximal repetition (1 RM) for straight bench-press, rowing at 45°, and squatting with knee flexion at 90° were carried out. Bench-press and rowing exercises were performed on a bench and wooden board, respectively, and a 10-kg bar with 20, 10, 5, and 1-kg rings were used for both exercises. The squat test was performed on a *hack-machine* type device from Portico®. All athletes were familiar with the performance of these exercises. Each athlete carried out at least three and at most five trials, with 3- to 5-minute intervals between them. The interval between exercises was of at least 30 min. A previous warm-up was carried out on each piece of equipment, comprised of two series of 12–15 repetitions at 50% of the value attributed by the athletes as 1 RM value. Besides the absolute value, 1 RM values relative to the athlete's weight were also calculated.

Statistical treatment

Statistical analysis involved variables description, through mean and standard deviation. Comparison between A Teams and reserves (B and C Teams) was performed through one-way analysis of co-variance (weight as co-variable). Calculation of correlation between variables was made through the Pearson coefficient correlation. For all analyses, 5% was adopted as the significance level (Zar, 1999).

Results

Table 1 shows the main anthropometrical results from Team A compared to the other teams and shows that no significant difference ($p>0.05$) was found for these variables.

The aerobic power ($\dot{V}O_2max$) estimated by the Cooper test showed no difference ($p>0.05$) between team members (48.3±8.1 ml/kg/min) and reserves (49.6±5.5 ml/kg/min) athletes.

Table 2 presents the athletes' results for the SJFT. It should be remarked that the lower the value is for this component, the higher is the athlete's performance. Groups studied here did not present differences ($p>0.05$) in number of throws, heart rate, or SJFT index.

Table 3 shows judo players' results for maximal strength tests.

No significant difference ($p>0.05$) was remarked for absolute or relative strength between groups.

Figure 1 presents the relationship between body weight or body fat percentage and performance variables.

Positive correlations were found between weight and bench press, row, and squat 1 RM and negative correlations were found between weight and SJFT throws, body fat, and $\dot{V}O_2max$.

Figure 2 presents the positive relationship between circumferences and maximal strength. No significant

Table 1 Characteristics of male judo players on the Brazilian Team (n=22)

Variable	A Team	B and C Teams
Age (years)	25.6±4.0	25.5±4.6
Weight (kg)	90.6±23.8	86.5±16.3
Height (cm)	176.2±8.9	176.0±8.0
Sum of 10 skinfold thicknesses (mm)	98±68	89±44
Fat percentage	11.4±8.4	10.1±5.7
Femur epicondyle diameter (cm)	10.1±0.8	10.1±0.5
Humerus epicondyle diameter (cm)	7.4±0.8	7.4±0.3
Wrist diameter (cm)	5.7±0.5	5.7±0.2
Relaxed arm circumference (cm)	35.5±4.7	36.0±2.9
Contracted arm circumference (cm)	38.1±4.2	38.3±2.7
Forearm circumference (cm)	31.1±3.6	31.6±1.8
Wrist circumference (cm)	18.1±1.6	17.6±2.3
Thorax circumference (cm)	106.4±11.0	107.0±6.7
Waist circumference (cm)	88.6±13.1	91.7±7.3
Gluteus circumference (cm)	102.5±9.0	103.1±6.3
Medial calf circumference (cm)	40.9±5.8	40.8±2.4

Table 2 Performance and heart rate of male judo players on the Brazilian Team in the Special Judo Fitness Test (n=20)

Variable	A Team	B and C Teams
Throws total	28±3	27±2
HR after (bpm)	178±9	175±9
HR 1 min (bpm)	151±7	157±11
Index	11.83±1.16	12.21±1.26

HR=heart rate; two athletes could not take the test owing to knee pain.

Table 3 One maximal repetition (1 RM) with male judo players on the 2002 Brazilian Team

Variable	A Team	B and C Teams
1 RM Bench-press (kg)	110±25	110±23
1 RM Row (kg)	116±21	115±24
1 RM Squat (kg)	104±27	104±18
1 RM Bench-press (kg/kg of body mass)	1.24±0.11	1.28±0.16
1 RM Row (kg/kg of body mass)	1.16±0.14	1.21±0.10
1 RM Squat (kg/kg of body mass)	1.44±0.14	1.39±0.11

Four judo players did not perform the squat exercise owing to knee pain. Two of them did not perform the bench-press exercise and one did not perform the rowing exercise, owing to lack of time.

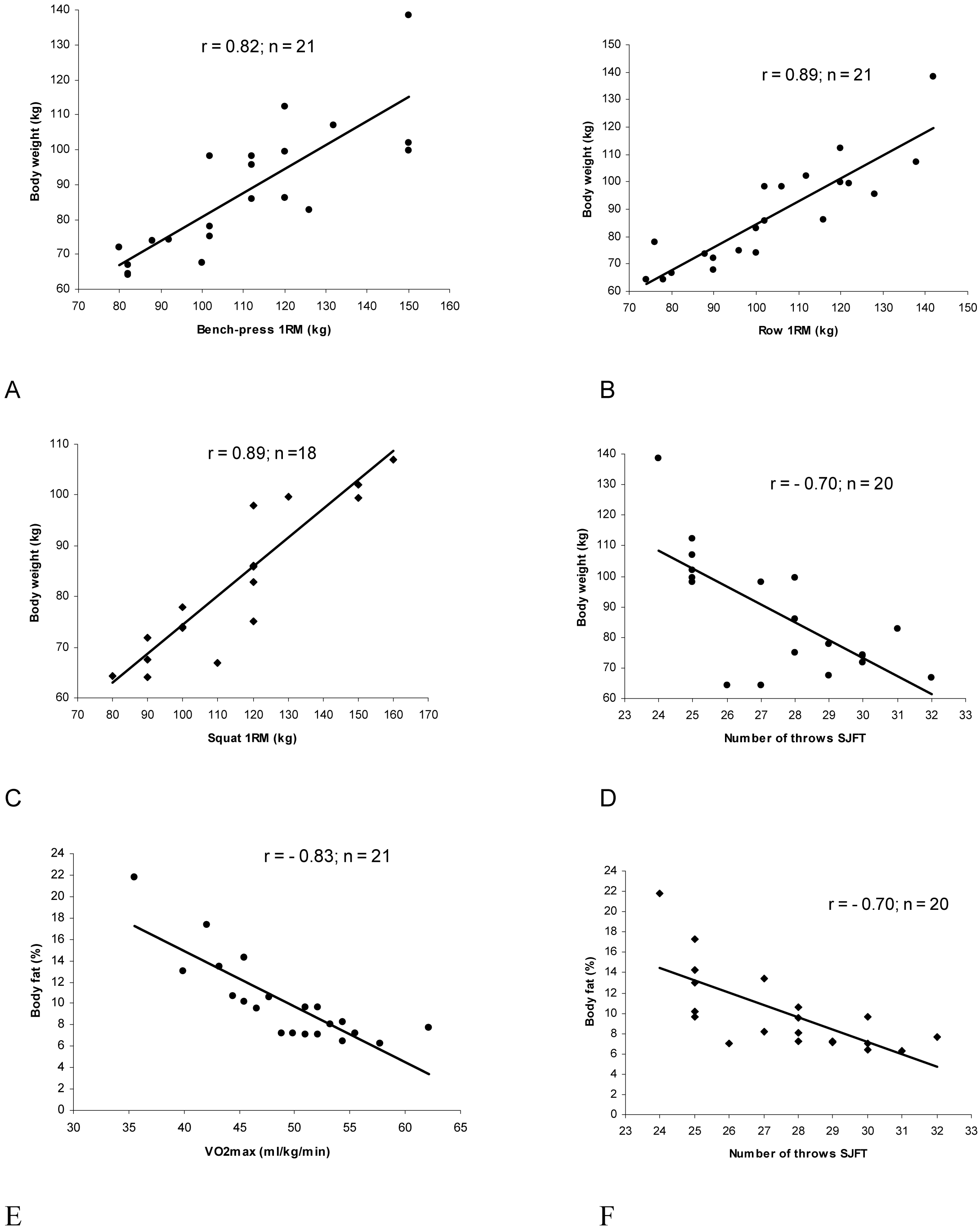

Fig. 1 Relationship between body weight and performance variables (panels A–D) and between body fat percentage and performance variables (panels E and F) in high-level judo players. Pearson correlations (r) and number of subjects (n) are presented in each panel. All correlations presented are significant at $p<0.001$.

correlations were found between circumferences and 1 RM/kg of body mass.

Figure 3 presents the relationship between $\dot{V}O_2max$ estimated and number of throws in the Special Judo Fitness Test.

Other significant correlations found were between: index in the SJFT and body weight ($r=0.52$; $p<0.05$; $n=20$), estimated $\dot{V}O_2max$ ($r=-0.52$; $p<0.05$; $n=20$) and body fat percentage ($r=0,57$; $p<0,01$; $n=20$); body fat percentage and relative bench-press 1 RM ($r=-0.49$; $p<0.05$; $n=21$) and relative rowing 1 RM ($r=-0.47$; $p<0.05$; $n=21$).

Discussion

Despite there being no difference between the groups in anthropometrical characteristics, it is important to note that the

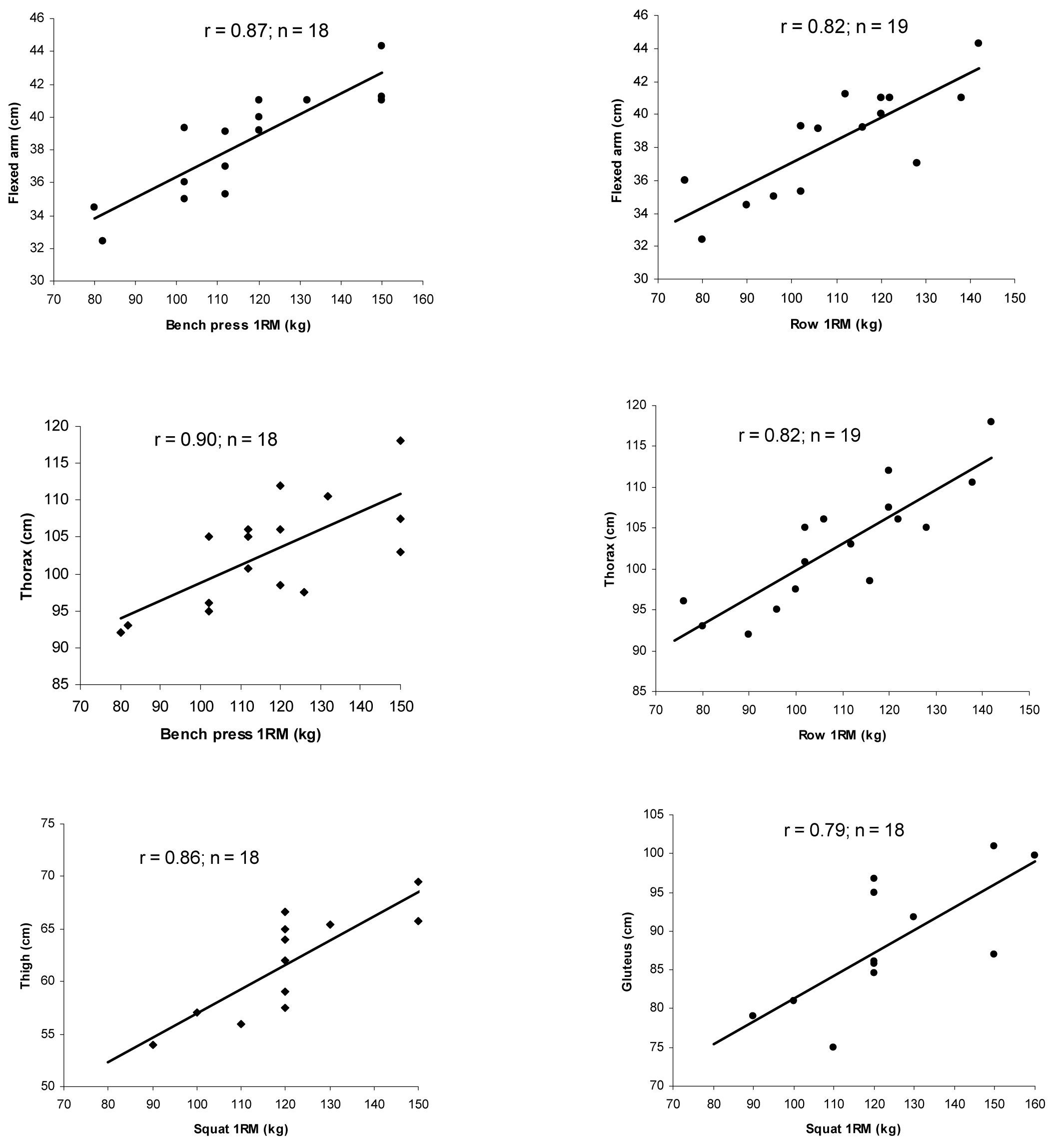

Fig. 2 Relationship between circumferences and maximal strength in high-level judo players. Pearson correlations (r) and number of subjects (n) are presented in each panel. All correlations presented are significant at $p<0.001$.

skinfold thickness and percent body fat percentage were low and the circumferences values were large for both groups. It indicates that those judo players were very lean. This result supports the assumption that judo players try to maximize lean body mass and minimize fat mass for a given weight category (Callister et al., 1991; Claessens et al., 1987; Kubo et al., 2006; Thomas et al., 1989). In fact, the body fat percentage values found for both groups in the present study are similar to those found in other studies with national teams or high-level judo players (Table 4), despite the fact that only two of these studies (Callister et al., 1990; Callister et al., 1991) have used the same procedures as those used here.

A comparison among weight categories was not conducted in the present study because it would reveal the individual values of Team A members, which would be against ethical principles (Walford, 2005). However, in order to control the influence of weight on the variables analysed we used weight as a covariate. Some other studies (Claessens et al., 1987; Iida et al., 1998) compared weight categories concerning the percentage of body fat and they found a linear increase from the under-60 kg to the 81–90 kg category and a big increase in the half-heavy-weight (100 kg) and heavy-weight (more than 100 kg) categories.

One study (Franchini et al., 2005a) reported that elite judo athletes had higher circumferences (flexed arm, forearm, wrist, and medial calf) and higher femur and humerus epicondyle diameters than non-elite judo players. In the present study both groups had similar values in all these measures. However, for our groups, flexed arm, forearm, wrist, and medial calf circumferences were sligthly superior compared to those reported for the elite group studied before (Franchini et al., 2005a). This is interesting, because Kubo et al. (2006) found

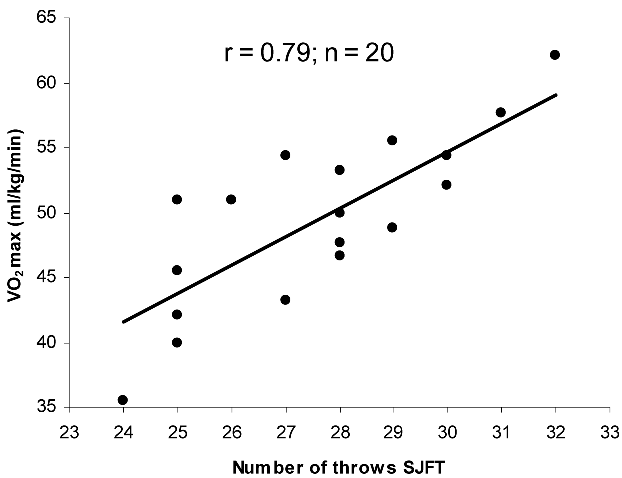

Fig. 3 Relationship between $\dot{V}O_2max$ estimated and number of throws in the Special Judo Fitness Test in high-level judo players. Pearson correlations (r) and number of subjects (n) are presented in the panel. The correlation presented is significant at $p<0.001$.

Table 4 High-level judo players' fat percentage

Nationality	Fat percentage (mean±standard deviation)	Author(s)
Hungarian team 1979	8.9±0.8	Farmosi (1980)
Canadian team 1979	12.3±3.9	Taylor and Brassard (1981)
Canadian team 1987	9.3±2.1	Thomas et al. (1989)
North American	8.3±1.0	Callister et al. (1991)
Japanese—university level	16.2±5.7	Iida et al. (1998)
Brazilian university team	13.7±5.2	Franchini et al. (2005b)

that the normalized thickness of the elbow flexor and extensor were larger at international level compared to university level judo athletes who did not take part in competitions, and a larger elbow flexor than in a group of university judo players who participated in competitions. No difference was found between the university athletes who take part in competitions and those who do not. Altogether, the data from different articles (Franchini et al., 2005a; Kubo et al., 2006; Ichinose et al., 1998) and those from our study seem to point out that when the athletes' competitive level is similar no significant differences are observed in anthropometrical variables. However, it is important to emphasize that a superior anthropometrical (high free-fat mass and big circumferences, especially in upper-body segments) is considered important to judo performance (Franchini et al., 2005a; Kubo et al., 2006; Ichinose et al., 1998). According to Kubo et al. (2006), during the period of combat both athletes try to throw and restrain the opponent by holding the collar and sleeve of the judo jacket of the adversary. When a judo player is holding the opponent's judo jacket and wants to increase his/her distance from the adversary it is necessary to extend the elbow joint. Conversely, to reduce the distance from the opponent it is necessary to flex the elbow joint. Differences in the strengths of these movements might influence judo performance. As muscular strength is proportional to muscle size (McArdle et al., 2003), a bigger arm circumference can be advantageous. Thus, a big circumference, specifically in arm segments, can be indicative of a higher muscle mass cross-sectional area and consequently of higher power and force output for these segments. Actually, some of the correlations observed in our study (flexed arm circumference and bench-press and rowing 1 RM; thorax circumference and bench-press and rowing 1 RM; gluteus circumference and squat 1 RM; thigh circumference and squat 1 RM) confirm this idea.

The humerus and femur epicondyle diameter values were quite similar to those reported before in elite judo players (Franchini et al., 2005a). The big breadth of femur and humerus epicondyles found in both the A Team and the B and C Teams may be a result of many years of engagement in judo training, which involves many movements such as carrying and pulling or pushing the opponent. This adaptation allows the judo players to withstand the training stress. Using a more sophisticated method (x-ray absorptiometry), Andreoli et al. (2001) found a higher arm bone mineral density in judo athletes compared to control subjects, and water polo and karate athletes.

Recently (Franchini et al., 2006), a normatory table was proposed to classify performance in the SJFT. The athletes of the present study are classified as good in all variables in this test (number of throws, heart rate after, heart rate 1 min after, and index).

Two studies (Franchini et al., 2005a; Sterkowicz, 1996) reported a higher number of throws and a lower index in judo players (Brazilian and Polish) at the national level compared to athletes at a lower level. These results were interpreted by the authors as a higher specific anaerobic capacity (inferred from number of throws) and a better balance between anaerobic and aerobic process (inferred from the index) in the elite group compared to the non-elite group. In the present study, no difference was found between Team A and the reserves (B and C Teams), which indicates the same level of development for both groups. However, when comparing judo players of the present study to other groups concerning the SJFT performance (Table 5) we remark that: (1) the total throws number is similar to high-level Polish and Brazilian judo players, but higher compared to non-elite judo players, indicating that a higher anaerobic capacity (inferred by the number of throws during intermittent exercise) may be an important requirement for high-level judo performance; (2) heart rate after the test is similar to Polish and Brazilian judo players, independent of level, suggesting that cardiovascular stress was quite similar; (3) heart rate one minute after the test was higher than that found in Polish judo players, but similar to that evidenced in Brazilian ones. This result can be interpreted as resulting from the better recovery ability of Polish judo players compared to the Brazilian judo players studied here; (4) the index was slightly higher (worse) than the one remarked for high-level Polish judo players, similar to high-level Brazilian judo players and lower (better) than that for non-elite

Table 5 SJFT Performance of high-level and non-high-level judo players

Variable	Nationality and level	Average±standard deviation	Author(s)
Number of throws	Elite Polish (n=10)	27±5	Sterkowicz (1996)
	Non-elite Polish (n=10)	24±2	
	Elite Brazilian (n=23)	28±2	Franchini et al. (2005a)
	Non-elite Brazilian (n=53)	25±2	
HR after (bpm)	Elite Polish (n=10)	177±10	Sterkowicz (1996)
	Non-elite Polish (n=10)	182±6	
	Elite Brazilian (n=23)	181±10	Franchini et al. (2005a)
	Non-elite Brazilian (n=53)	186±11	
HR 1 min (bpm)	Elite Polish (n=10)	130±10	Sterkowicz (1996)
	Non-elite Polish (n=10)	136±6	
	Elite Brazilian (n=23)	162±10	Franchini et al. (2005a)
	Non-elite Brazilian (n=53)	165±11	
Index	Elite Polish (n=10)	11.57±2.52	Sterkowicz (1996)
	Non-elite Polish (n=10)	13.28±1.34	
	Elite Brazilian (n=23)	12.53±1.11	Franchini et al. (2005a)
	Non-elite Brazilian (n=53)	14.16±1.52	

HR=heart rate

Table 6 $\dot{V}O_2max$ (ml/kg/min), according to different methodologies, in judo players of different nationalities

Author(s)	Ergometer	Subjects	$\dot{V}O_2max$ (ml/kg/min)
Callister et al. (1990)	treadmill	8 American (high-level)	53.2±1.4
Callister et al. (1991)	treadmill	18 American (high-level)	55.6±1.8
Ebine et al. (1991)	treadmill	13–Japanese team	45.9±4.8
Little (1991)	treadmill	17 Canadian juveniles,	57.62±3.42
		9 juniors and	59.26±3.95
		17 seniors	53.75±5.57
Majean and Gaillat (1986)	not defined	9 French	59.8±8.5
Mickiewitz et al. (1991)	not defined	54 Polish juniors and	60.23±6.75
		157 seniors	60.22±8.67
Taylor and Brassard (1981)	not defined	19–Canadian team	57.50±9.47
Thomas et al. (1989)	treadmill	22–Canadian team	59.2±5.18
Tumilty et al. (1986)	bicycle	17 Australian (high-level)	53.2±5.1
Vidalin et al. (1988)	bicycle	8 French	53.8±5.2

Polish and Brazilian judo players. These results show the ability of the SJFT to discriminate, especially the index proposed by Sterkowicz (1995), when used to compare groups with a wider difference in competitive levels.

$\dot{V}O_2max$ estimated for the groups studied is near the lower limits remarked for high-level judo players (Table 6). Together with the lower heart rate recovery after the SJFT, this result can be interpreted as indicating a need to improve the aerobic fitness of the groups studied in the present investigation.

Table 6 shows that most judo players presented $\dot{V}O_2max$ values between 50 and 60 ml/kg/min, even using different protocols and equipment. However, the importance of aerobic power to judo performance is controversial. While some authors (Borkowsky et al., 2001; Franchini et al., 2005a) did not find significant differences in $\dot{V}O_2max$ between elite and non-elite judo players, some results (Gariod et al., 1995; Muramatsu et al., 1994) indicate that aerobic power has a positive influence in high-intensity intermittent exercise. In fact, the values of aerobic power ($\dot{V}O_2max$) presented in one study (Franchini et al., 2005a) where it was similar for both elite and non-elite groups was well developed (elite−58.13±10.83 ml/kg/min; non-elite−63.28±10.55 ml/kg/min). Thus, although it is not a competitive performance discriminatory variable, it is a valuable one. This hypothesis seems plausible because Muramatsu et al. (1994) found high correlations between aerobic power ($\dot{V}O_2max$) and total work on five 10 s supramaximum efforts with 55 s interval at 80%$\dot{V}O_2max$ ($r=0.86$; $p<0.01$) and total work on ten 10 s supramaximum efforts with 20 s interval at 80% $\dot{V}O_2max$. Gariod et al. (1995) found that judo players with a higher $\dot{V}O_2max$ presented a faster CP resynthesis (^{31}P-NMS) compared with judo players with a lower $\dot{V}O_2max$. It can be important in intermittent tasks as in the case of judo, where the athlete must perform many high intensity tasks with little time to recover. It has been suggested (Castarlenas and Planas, 1997; Muramatsu et al., 1994) that judo players with a higher $\dot{V}O_2max$ would have an advantage in a period of combat with maximal duration (5-min) because the same absolute supramaximum effort would represent a lower relative intensity compared to an athlete with a lower $\dot{V}O_2max$. Together with the faster CP resynthesis, a faster lactate removal and pH recovery in individuals with higher aerobic power could benefit the recovery process. An increase in aerobic contribution is believed to be another factor in improved performance in subjects with higher aerobic fitness (Tomlin and Wenger, 2001). The positive influence of a higher $\dot{V}O_2max$ on intermittent exercise performance is partially confirmed by the positive correlation between this variable and the number of throws and the index in the SJFT for the groups studied.

Maximal strength data in regular exercises, such as bench-press, rowing, and squat are not largely described in the literature concerning judo athletes. The present study results for the bench-press exercise are similar to those remarked by Thomas et al. (1989), when analyzing judo players from the 1987 Canadian Team (100±21 kg). When bench-press and squat 1 RM values are compared to non-athlete individuals, results presented by both the A Team and the reserves (B-C) are lower than what was reported as excellent (Heyward, 1997). As found in other groups, athletes with higher muscle development—inferred in our study by circumference—present higher absolute strength (Heyward, 1997). However, these correlations are no longer significant when strength values are expressed relative to body weight. Fagerlund and Häkkinen (1991) found differences during 1 RM and in the strength-speed curve during squat, but not during bench-press, among international-, national-, and recreational-level Finnish judo players. Thus, considering this study and the present investigation, it seems that strength is a discriminatory component between groups with larger differences concerning competitive level (International versus National versus Recreational), but not among athletes with similar competitive level (National).

The main correlations presented indicate that athletes from heavier categories are stronger in absolute terms, similar to what was reported by Thomas et al. (1989). However, there was a negative correlation between weight and performance in the SJFT, indicating that heavier athletes present a lower anaerobic power in activity that involves throwing opponents from the same category. Heavier judo players' lower performance in the Cooper test can also be inferred by the correlation between weight and estimated $\dot{V}O_2max$. Thomas et al. (1989) have also remarked a negative correlation between relative $\dot{V}O_2max$ and judo players' weight. Nevertheless, in our study it seems clear that a large part of this relation can be explained by the high fat percentage and low performance. The negative influence of body fat on motor performance observed in the present study was similar to that found in other studies (Franchini et al., 2005b; Nakajima et al., 1998). Nakajima et al. (1998) found a negative influence of body fat on isometric strength, flexibility, balance, and aerobic power in female judo players. A previous study also presented a negative correlation between body fat percentage and number of throws in the SJFT ($r=-0.70$) and between body fat percentage and number of attacks conducted in a combat simulation ($r=-0.76$) in high-level college judo players (Franchini et al., 2005b).

Conclusions

Based on results, we can conclude that: (1) physical and morphological components are not discriminatory to the performance of judo athletes rated among the three best at national level; (2) the higher the fat percentage, the lower is the performance in activities involving body displacement (Cooper and SJFT tests); (3) judo players presenting higher aerobic power present a better performance in high-intensity intermittent activities; (4) judo players with larger circumferences present higher absolute maximal strength, but this relation is not significant when strength is expressed relative to body weight. While these variables do not necessarily predict performance in a sport where techinique and tactics are essential elements for success, they may provide some goals for developing judo players. The data provide the judo player with information on where training might be directed to compensate for areas where the athlete is below average for successful judo players. A judo player who does not match the ideal profile can still succeed through improved or superior techniques and tactics. Other variables (psychological factors, for example) should be studied to verify which factors can discriminate properly first placers and reserves at the national level.

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