Anthropometrical and physiological profiles of the Algerian Olympic judoists

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Abstract

Background and Study Aim: To establish the anthropometrical and physiological characteristics of male and female of the Algerian Olympic judoists team.

Material/Methods: Thirteen members of the Algerian judo team, seven males aged 27.14±3.02 years and six females aged of 24±4.14 years. The anthropometrical dimensions were carried out: body weight, 6 height point, 6 breadths, 5 circumferences and 4 skinfold thickness, Body fat was estimated using Durnin and Womersley method. The body composition (BC) Hattori chart was used for the representation of individual percentage fat (PF%), (FFMI), (FMI) (BMI). For physiological tests, were used: Ruffier-Dickson test Power output (PWC_{170} cycle test). Results in jumping Sargeant test (VJ) was also used for counting power (P) according to Lewis formula.

Results: A sexual dimorphism observed on the morphological variables. Males are higher in two lengths (anterior iliac spine and Acromion-dactylion III points), three breadths (thorax transverse, knee and elbow), and 3 circumferences (thorax, relaxed arm and waist) than females. A significant differences ($p<0.05$) exists between males and females in body composition (BM, PF%, FFM, FFMI) and RDI. However we didn't observe a sexual dimorphism in: height and BMI, PWC_{170} and $\dot{V}O_2max$, VJ and Power.

Conclusions: We must have consider the both components FFMI and FMI to interpret the BMI.The new rules of IJF requires 5 minutes duration in female combat and the golden score proposal in case of combat tie. Thus, it is imperative to increase their $\dot{V}O_2max$ for a better performance optimization.

Key words: anthropometry • $\dot{V}O_2max$ • heart rate • muscular power • judo • body composition

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Background

Physiological tests are necessary to assess the physical condition of the athletes and should be used as guidelines to determinate the intensity of training [1,2]. Some physiological and anthropometrical variables are considered requisites in high level judo [3]. Judo is a weight-category sport; it has been supposed that high level, judoists should have low adipose tissue [4]. Previous researches have shown that morphological and physiological characteristics of judo athletes correlate with technical factors performed during a judo fight [3,5–9] For this reason, it seems that the improvement in some of the mentioned variables may have a positive effect

Anthropometry – the measurement of the size and proportions of the human body and its different parts [43].

$\dot{V}O_2$max – is the maximum power of person body's to transport and utilize the oxygen during maximal exercise, which reflects the physical fitness of the individual. $\dot{V}O_2$max is expressed either as an absolute rate in liters of oxygen per minute (l/min) or as a relative rate in milliliters of oxygen per kilogram of bodyweight per minute (ml/kg/min) [43].

on performing the techniques during the fight [10]. It has been demonstrated that high level judoist shave a lower body fat percent (PF%) than a judo athlete less qualified in USA ranking [7].

A comparison between national-level judoists and lower competitive level [11] found that high-level judoists had large circumferences (contracted arm, forearm, wrist and leg) and bone diameters (femur and humerus epicondyles). Judo athletes who participated in the Olympic Games or Asian Games had significantly higher fat-free mass (FFM) than university judo athletes who didn't participate in intercollegiate competitions [4]. In fact, the muscle thickness normalized to the height of the individual was larger for international judoists than for university level judoists.

Other researchers showed [12,13] that judo competitors with a higher maximal oxygen uptake ($\dot{V}O_2$max) would have an advantage in a period of combat with total duration (5-min), because the same absolute supra-maximum effort would represent a lower relative intensity compared to an athlete with a lower $\dot{V}O_2$max. Together with the faster creatine phosphate (CP) resynthesis, a faster lactate metabolized and PH recovery in individuals with higher aerobic power could improve the recovery process. A rising in the aerobic involvement can be considered as another factor for leveraging the performance of the judoist [14]. The $\dot{V}O_2$max of elite judo competitor has been reported to be varying from 50 to 60 $ml \cdot kg^{-1} min^{-1}$ [1,7,15,16].

From video analysis of judoist in competition [17], two strategies have been observed: (a) an aerobic profile judoist, who wins the fight in the end; (b) an anaerobic profile judoist, who wins at the very beginning of the fight. Therefore, endurance performance became extremely important in judo fight, above all with the introduction of the golden score. According to this scoring process, judo fights in high level can last 8 minutes [18]. A judo competitor can take part in several combats on the same day [13].These factors demonstrate the importance of the aerobic pathway for ATP resynthesis.

Analysis of blood lactate concentration ([La]) in specific condition of judo has been studied in order to provide information on the metabolic requirements for the monitoring and the prescription of work intensity [19]. It should be noted that since the Osaka World championship of 2003 [20], the fighting time is extend of 5 additional minutes [1]. From Beijing Olympic Games [18], the golden score was reduced at 3 minutes.

The scientific studies didn't show a model characterizing the anthropometrical and physiological indices of African champion judoists. Thus, the purposes of this study were to establish a body composition and physiological profile of both male and female Algerian elite judoists to be considered as representatives of the African judo.

Material and Methods

Thirteen chosen members of the Algerian judo team, whose seven males aged 27.1±3 years, winners of three golden medals (73, 90, 100 kg), silver one (66 kg) and a bronze one (81 kg), and six females aged of 24±4.1 years who won three golden medals (52, 57, 70kg) and a silver medal (63 kg) in the Africa Championship of May 2008. Males and females are African champions of the teams for competitions held in the same year. The measurements assessed in recovery microcyle of competitive period. All subject participated at Beijing Olympic Games 2008.

This study was approved by the Ethics and Research Committee of the Faculty of Health Sciences of the University of Algiers.

Anthropometry measurements

The anthropometrical measures were carried out: body mass (BM), height points (vertex, sitting height, anterior spine iliac, shinbone point, acromio-dactylionIII, malleolus point) skinfold thickness (triceps, biceps, subscapular and abdominal), circumferences (chest, relaxed arm, waist, medial calf and thigh) and bone diameters (thorax transverse, thorax antero-posterior, knee, biacromial, elbow and iliac-crest). Skinfold thickness measures (Harpenden caliper) were carried out three trials on each point in a rotation system. Researchers with more than 10 years experience in this field carried out circumference and bone diameter measurements once on each point, with a variation of less than 1% for the measurements taken. Body fat was estimated using Durnin and Womersley [21] (1974) method. The body composition (BC) chart [22] was exploited for the individual PF% representation, FFMI, FMI and BMI.

Ruffier-Dickson test

The test consists of 30 flexions-extensions of the legs, in which buttocks must touch heels. Arms reaching forward or half-bent for 45 seconds. The measurement of the heart rate (HR) must be done before the event (P0), at the end of the test (P1) and one minute after the completion of the test (P2). Pulsometer (Polar RS800, made in Finland) was used for recording of the heart rate during the test.

P0: must be measured at rest, the subject is lying.

P1: measured at the end of the test, the subject remains standing.
P2: measured one minute after the test (at the end, on the subject minute rest).

The Ruffier-Dickson index will use the following formula: [(P1-70) +2 (P2-P0)] / 10 [23].

Power output (PWC_{170} cycle test)

Each subject was examined by doctor prior to participating at the study to exclude eventual cardiac pathology. The aim of the study was explained before starting the test.

The heart rate at rest (RHR) was estimated with electro cardiogram (ECG) in Algerian National Center of Sport Medicine by a doctor specialized in sport medicine who has 10 years experience. The maximal oxygen uptake was estimated by the PWC_{170} test.

The athlete pedal two consecutive six minute bicycle ergometer rides in which the workloads are selected to reach a heart rate between 120 and 140 bpm on the first session and 150 and 170 bpm on the following session. The heart rate was recorded with an ECG for each session. The average HR and the Power Output ($kgm \cdot min^{-1} \cdot kg^{-1}$) have also been measured [6].

Vertical Jump Test (Sargeant Test)

The athlete stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. This is called the standing reach height. The athlete then stands away from the wall, and leaps vertically as high as possible using both arms and legs to assist in projecting the body upwards. The jumping technique uses squat jump, starting from the position of knees being bent a 45 degree. Attempt to touch the wall at the highest point of the jump. The difference in distance between the standing reach height and the jump height is the score. The best of three attempts is recorded. This test presents an advantage very accessible and didn't generate fatigue. Additionally, it is very familiar in judo testing [24]. The power extrapolated was calculated by the Lewis equation as following [25].

P = (√4.9 (Weight) √D"); where weight in kg, D" – Jump reach score in meter.

Statistical analysis

We use Student test to compare all physiological and anthropometrical variables between males and females. All the results are expressed by means ±SD. The Cohen's d will be used to verify the effect size when a significant difference is found.

Results

The anthropometrical characteristics of male and female judo players are summarized in Table 1. Results of the present research demonstrate the sexual dimorphism in judoists of both composition and functional character of the body. A comparison between male and female judo players was prove an expected advantage of male in length variables, breadths and circumferences over female. However there were not significantly differences in fat mass – FM and BMI. If we take in consideration the body size i.e. indices per kg or per m^2, specific and statistically significant differences appear. Male had a higher FFMI (large effect) than female. Female characterized higher PF%, than in male group (large effect).

BMI is composed of two indices: fat free mass index (FFMI) and fat mass index (FMI). These complementary characteristics of the body composition of both male and female elite judoists are illustrated in Figure1.The BMI is suitable for group-diagnosis, but in individual cases it can be unreliable. Most subjects are classified as overweighted (BMI ≥25 $kg \cdot m^{-2}$), but we also found some subjects over-weighted according to the adiposity criterion.

The physiological variables were represented in Table 2 which didn't demonstrated differences between male and female judoists for RHR measurements, PWC_{170} and $\dot{V}O_2max$ ($p>0.05$). Nevertheless we observed a significant difference on the RDI ($p<0.05$, large effect).

Table 3 presents the results of the vertical jump (VJ) and estimated the power reached by males and females. Power expressed by Watts differs between males and females. A large effect of gender was observed because of a bigger body mass for males than females. When we used relative units this difference disappears.

Discussion

Anthropometry

The PF% for females is higher than for males. This result is functional physiologically because muscle mass in male is under strong hormonal influence, (i.e. testosterone), which is not the case for females, who might actually easier FFM mass with decreased training loads (i.e., menstrual cycle). We cannot exclude either, that male judoists might simply be more active than the females and thus maintaining their muscle mass from one season to another.

Heart rate (HR) – is the number of heart beats per unit time, usually expressed as beats per minute (bpm). The heart rate is based on the number of contractions of the ventricles [43].

Judo – meaning "gentle way" is a modern Japanese martial art and combat sport, that was created in Japan in 1882 by Dr Kano Jigoro [44].

Body composition – the proportion of fat, muscle, and bone of an individual's body, usually expressed as percentage of body fat and percentage of fat free mass [43].

Muscular power – The product of force generated and speed of movement [43].

Table 1. Anthropometrical characteristics of male (n=7) and fema le (n=6) elite judo players

Anthropometrics variables	Male	Female	Relative size of Cohen's d
Ages (years)	27.14±3.02	24±4.14	
Body mass (kg)	91.85±25.06	65.5±10.59*	1.36 large
Body height (cm)	176.28±9.12	163.5±12.16	.
BMI (kg·m^{-2})	29.32±6.30	24.42±1.75	.
PF (%)	12.28±4.16	19.52±3.88**	–1.80 large
FM (kg)	12.10±7.97	12.98±4.38	.
FMI(kg·m^{-2})	3.81±2.32	4.80±1.20	.
FFM (kg)	79.75±17.50	52.51±7.18**	2.03 large
FFMI (kg·m^{-2})	25.51±4.01	19.62±1.11**	2.00 large
Sitting posture (cm)	92.14±5.52	86.83±3.87	.
Anterior iliac spine (cm)	101±4.16	93.83±7.36*	1.20 large
Shinbone point (cm)	48.42±2.99	45±3.03	.
Acromio-dactylionIII point (cm)	80.14±5.08	71±5.02**	1.81 large
Malleolus point (cm)	8.71±0.95	7.83±0.41	.
Thorax circumference (cm)	104.71±11.12	84.33±3.67**	2.46 large
Relaxed arm circumference (cm)	35.43±4.58	25.5±3.62**	2.41 large
Waist circumference (cm)	87.57±12.50	71.16±5*	1.72 large
Medial calf circumference (cm)	40.29±4.89	35±2.83	.
Tight circumference (cm)	60.14±7.73	55.33±3.20	.
Thorax transverse diameter (cm)	30.57±3.15	28.83±3.31*	0.53 medium
Thorax antero-posterior diameter (cm)	21.14±2.19	18.33±1.03	.
Knee diameter (cm)	10.71±0.69	9±0.63**	2.59 large
Biacromial diameter (cm)	37.57±6.55	34.5±4.32	.
Elbow diameter (cm)	7.43±1.27	5.6±0.52*	1.88 large
Iliac crest diameter (cm)	31.71±3.73	28±3.27	.

* p<0.05; ** p<0.01.

In the present study, the body fat value of male elite judo players was more comparable to that reported in the literature [26] in French male judo players (22 elites). Thomas et al. [3] reported that Canadian male judo player's values are ranged from 6.7% to 15.8%, with a mean of 9.3%. These findings were similar to those of Callister et al. [7] who shown that the mean of the body fat values for elite North American male players to vary from 8.9±0.8%. In the three cases, the body fat percentage was determined via skin-fold thickness. It has been suggested that the body PF% may be a determining factor for sport achievement. Callister et al. [7] found that the more successful male players (those with more international success or competition points) maintain lower body PF% during competitive periods. Even true, it may just be a reflection of physiological adaptations to long-term judo training; in addition successful players seem to be older with greater experience. However, judo athletes must maintain an optimal body mass, in the competitions morning days according to IJF rules weight. In fact, weight management and corresponding weight loss are important factors to predict the success of the judoist.

Several authors stated that the value of the fat body mass is higher in sub-elite judoists than in elite ones. For example, Almansba et al. [27] obtained values of 12.2±0.8% for sub-elite judo players and 11.1±1.9% for elite ones. The higher value of PF% was observed

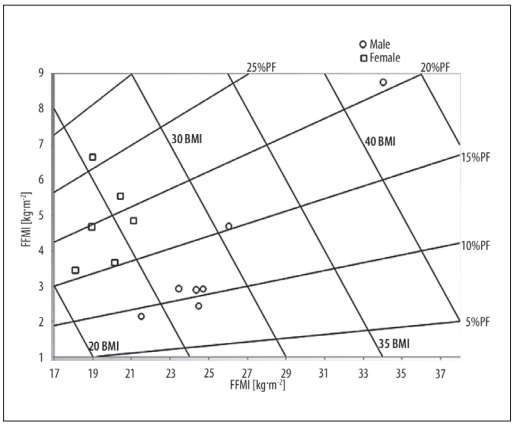

Figure 1. Relations between the indices of BMI, FFMI, and FMI as well as percentage of fat of both male and female judo competitors (BMI – body mass index, FFMI – fat free mass index, FMI – fat mass index, %PF – percentage of fat in body mass).

These results corroborated the findings of Callister et al. [7], who found a correlation between the body mass and PF% (r=0.64). In judo, it is very important to keep a compromise between an optimal body weight and both physiological and motor efficiency.

The present study shows that the values of males are higher than those of the females in thorax circumferences (104.7±11.1 *vs.* 84.3±3.7 cm), relaxed arm (35.4±4.6 *vs.* 25.5±3.6 cm) and waist circumferences (87.6±12.5 *vs.* female 71.1±5 cm). But we registered the same values in medial calf and tight circumferences between the two groups. The male's group in this study presents similar values in thorax circumferences than the group of Brazilian elite judoists described by Franchini et al. [11], but medial calf circumferences slightly superior compared than those of the same group of com-

Table 2. Performance of male (n=7) and female (n=6) elite judo players R&D Index and PWC_{170}.

Subjects	HRR (b·min^{-1})	R&D index	PWC_{170} (kgm·min^{-1}·kg^{-1})	$\dot{V}O_2$max (ml·kg^{-1}·min^{-1})
Males Min-Max values	53±8	7.5±3.2	21.36±3.7	50.6±9.3 34.6–58.3
Females Min-Max values	61±11	10.70±1.4*	18.46±2.5	50.7±6.0 40.5–58.6
Cohen's d	.	–1.30 large	.	.

* p<0.05.

Table 3. Results of male (n=7) and female (n=6) elite judo players in the Vertical Jump test.

Subjects	Vertical jump (cm)	Power (Watts)	Power[a] (W·kg^{-1})	Power[b] (W·kg^{-1})
Males	57.3±8	1488.1±292.4*	16.2±1	18.5±0.5
Females	51.8±12.2	1020.9±239.6	15.5±2	19.3±2.7
Cohen's d	.	1.35, large	.	.

*p<0.05; [a] Power normalized to body mass; [b] Power normalized to fat free mass.

in low level judo players as demonstrated in the table IV with male Caucasian American University judoists reported by Iida et al. [28] for Japan University male judo players.

The PF% in female judo players in this study is high but lower than a sedentary subject reported by Prouteau et al. (2006). This difference between the two groups gives evidence that the muscular character of judo activity and the permanent morphological adaptations. Nevertheless, our result are inferior than the value quoted by some authors [29,31] for the Polish and French female judo players respectively.

Table 4 summarizes observed the results of PF% from various researches using different methodologies. Some researches results done by some authors [28,32] (observed a rise of adiposity in heavy category judoists.

parison. This is interesting, because Kubo et al. [4]. found that the normalized thickness of the elbow flexor and extensor were larger at international level compared to university level judoists who don't take part in competitions, and a larger elbow flexor than those who participate in competitions. They also noted that during the combat, each fighter tries to throw and restrain the opponent by holding the collar and sleeve of the judo jacket. When a judo player is holding the opponent's judo jacket and wants to increase the distance from the adversary, it is important to extend the elbow joint. However, to reduce the distance from the opponent, it is necessary to flex the elbow joint. The differences in the strength in these movements might influence the judo performance. A larger arm circumference maybe an advantageous measure because the strength is correlated to the muscle size [2].

Table 4. Elite judo players' fat percentage (PF%) with different methodology used on the different National teams quoted in the literature.

Teams and reference	Number and level of subjects	PF (%)
Males		
North American [7]	18 elites	8.9±0.8
Brazilian 10	7 elites	13.7±5.2
Japanese 28	University	16.2±5.7
Polish [15]	14 sub-elites	13.7±3.4
French [27]	11 elites	11.1±0.8
French [27]	12 sub-elites	12.2±1.9
French [31]	22 elites	11.6±3.6
Polish [32]	22 elites	14.3±4.3
Slovakian [33]	11 elites	11.6±3.9
Slovenian [33]	11 elites	13.0±3.8
Females		
Polish [29]	13 elites	24.67±1.43
French [31]	26 elites	23±4.1

Heart rate at rest

The RHR of the Algerian male judo players is similar statistically to the female judo player's one. Our finding corroborated with a recent study [35], who compared the responses of HR during the judo fights and in the subsequent recovery times and didn't revealed a difference between male and female elite judoists. These outcomes suggest that the high level training seems to regulate this difference.

The value of RHR is lower for the Algerian male elite players than both the RHR of the French sub elite judo players (53±8 *vs.* 54.7±3.8 b·min^{-1}) reported by Degoute et al. [36] and the RHR of Cameroonian elite judoist examined by Kingue et al. [37]. McArdle et al. [2] demonstrated that in high level training, the responses of the HR is lower for a well trained athlete than a less trained one. In fact, our study demonstrated that both males and females have a good cardiovascular adaptation to effort. In the same view, Borresen et al. [38] observed that regular physical activity leads to a reduction of the RHR. Our results supported the researches of Lamberts et al. [39] who concluded that RHR is a sensitive marker which tracks the changes in the training condition of well-trained athletes and can have an important role in controlling and prescribing the workload.

Ruffier Dickson test

The literature didn't show data related to the RDI for judo athletes and we cannot provide more information about the usefulness of this index. In the present study the RDI is significantly higher in female judo players than in male ones. The values for males and females are respectively 7.5±3.2 and 10.7±1.4. A high value of RDI is an indicator of a worse adaptation to efforts. When taking in consideration the $\dot{V}O_2$max our findings are controversial and then more investigations are recommended for the RDI validity and interpretability. Our outcomes converge with the study of Jousselin et al. [23] who concluded that the RDI should be reconsidered in its context and that it is not significant.

Maximal Oxygen Consumption ($\dot{V}O_2$max)

The aim of aerobic processes in judo is to prepare the functional capacity of the heart and ability of blood circulation to transport the oxygen to muscles, which will have an effect on the improvements in bringing the oxygen through continuous training.

The table V shows that high level judoist presented $\dot{V}O_2$max values vary from 50 to 62 ml·kg^{-1}·min^{-1} for males and 42 to 52 ml·kg^{-1}·min^{-1} for females, even using different protocols and apparatus. Males and females Algerian judo players evaluated in this study were not statistically differed in $\dot{V}O_2$max. Before 2003, several authors 5 [1,6–9]demonstrated a significant difference of $\dot{V}O_2$max between male and female judo players. Nevertheless, our findings comfort one current study [40] that compared the physiological responses of the special judo fitness test between Australian male and female elite judoist and didn't found a significant difference in the parameters measured (HR and [La]).

The $\dot{V}O_2$max was equal to that reported by Sterkowicz et al. [15] for Polish male elite judoists (50.1±6.5 ml·kg^{-1}·min^{-1}), but lower than the value reported by Borkowski et al. [6] for the best Polish Judoists (males, n=58, 57.6±4.6 ml·kg^{-1}·min^{-1}, *vs.* females n=49, 50.7±5.5 ml·kg^{-1}·min^{-1}, p<0.001). Surprisingly, our value is significantly lower than the one reported by Brikci [41] for the male Algerian elite judoists (59.6 ml·kg^{-1}·min^{-1}). Our data in the present research suggest a lack of aerobic training but seems to be a rational falling off, because the physiological adaptation effects coincide with anaerobic training planned by elite judoists to response a maximal workload (i.e. competitive period) of competition for the Beijing Olympic Games 2008.

In contrast, the result obtained in our study is higher than the values cited by Ebine et al. [8] in judoists who

Table 5. Maximal oxygen uptake ($\dot{V}O_2max$) of male and female judo players' elite and sub-elites level of different nationalities using different apparatus and methodologies (treadmill and ergocycle).

Nationalities	Number and level of subjects	Apparatus and methodology used	$\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$)
Males			
Italia [16]	6 Olympics	Treadmill	47.3±10.9
French [36]	16 sub-elites	Ergocyle	55±2.9
Polish [6]	17 elites	Ergocycle (PWC_{170})	55.6±3.2
Polish [6]	58 elites	Ergocycle (PWC_{170})	57.6±4.6
Polish [15]	14 elites	Treadmill	50.1±6.48
Korean [9]	10 elites	NC	62.8±5.9
Japanese [8]	13 elites	Treadmill	45.9±4.8
American [7]	18 elites	Treadmill	55.6±1.8
Canadian [1]	17 elites	Treadmill	53.8±5.6
Canadian [3]	22 elites	Ergocycle (PWC_{170})	59.20±5.20
Females			
Italia (Sbriccoli et al., 2007)	5 Olympics	Treadmill	52±4.4
Polish [6])	18 elites	Ergocycle (PWC_{170})	49.9±4.8
Polish [6]	49 elites	Ergocycle (PWC_{170})	50.7±5.5
Korean [9]	10 elites	Not defined	50.5±6.9
American [7]	9 elites	Treadmill	52.0±1.4
Japanese [8]	16 elites	Treadmill	42.1±4.4
Canadian [1]	8 elites	Treadmill	43.7±3.5

NC – Not communicated.

participated in Olympic Games. The highest values of $\dot{V}O_2max$ were described for the Korean representatives investigated by Kim et al. [9] and the elite Canadian judoists quoted by Thomas et al. [3] (cf. Table 5).

The $\dot{V}O_2max$ of the female judoists in the present study is near to that of the American female elite ones cited by Callister et al. [7] and similar to the Korean elite ones described by Kim et al. [9] and the Polish elite reported by Borkowski et al. [6]. However, our values are higher than those reported by some studies [1,8].

Although, differences in peak values may be due to the methodology and apparatus used for the assessment (i.e. treadmill tests vs. arm and leg ergometry). It was reported that $\dot{V}O_2max$ relatively to body size was inversely related to the weight division for both males and females. This was similar to the findings of Thomas et al. [3], who concluded that aerobic power relative to body size seems to decline when the weight increases. This may be a consequence of a big percentage of the body fat in heavy categories.

Some authors [6,11] didn't show significant differences in $\dot{V}O_2max$ between elite and sub-elite judo players, even that some results [12,17] highlight that the aerobic power has a positive impact in a short high-intensity exercise.

Previous studies [6,11] found that the values of $\dot{V}O_2max$ were well developed and similar for both elite and sub-elite groups. Thus, although it is not a distinguishing factor between elite and sub elite players, it is a valuable one. This assumption seems to be credible because Muramatsu et al. [12] found a strong correlation between $\dot{V}O_2max$ and peak power during intermittent anaerobic exercise of judo players ($r=0.86$, $p<0.01$).

One study [17] shows that judo players with a high $\dot{V}O_2max$ have a better resynthesis of CP compared with judo players with a lower $\dot{V}O_2max$. It can be important in intermittent exercises with high intensity like judo, where the athlete must do many high intensity efforts with short breaks. It has been suggested [7,12] that judo players with a high $\dot{V}O_2max$ would have an advantage in

the maximal duration combats (5-min or longer in case of equality (golden score)). The same absolute high intensity effort would represent a lower relative intensity compared to an athlete who has a lower $\dot{V}O_2$max and the best CP resynthesis. A faster lactate removal and pH recovery in individuals with higher aerobic power could benefit the recovery process. This ability to recover quickly is crucial in judo fights, because the judo competitor may participate during a tournament in several combats a day.

Surprisingly, in the present research we reported a wide scatter in $\dot{V}O_2$max which varies from 34.6 to 58.3 ml·kg^{-1}·min^{-1} for males and 40.5–58.6 ml·kg^{-1}·min^{-1} for females. The same result approximately was reported in one recent Italia study [16] who recorded $\dot{V}O_2$max ranged from 37.4–61.8 ml·kg^{-1}·min^{-1} and 49.9–56.8 ml·kg^{-1}·min^{-1} in males and females elite judoist respectively with similar sport level, confirming that $\dot{V}O_2$max alone cannot be a physiological accurate indicator of judo performance. Consequently, the $\dot{V}O_2$max results need to be interpreted with carefulness in well- trained judo athletes.

Vertical Jump Test

The muscular power normalized to BM didn't show a significant difference between Algerian male and female judo players. The same power relativized to FFM doesn't provide more information. According to a research of Almansba et al. [27] the BM of high level judo player is strongly correlated with the FFM ($r=0.98$, $p<0.01$). Our results are higher than those reported by Prouteau et al. [31] who recorded jumping height performance respectively for French male and female elite judoist.

Kim et al. [9] tested the Korean male elite judoists and registered 58.1±5.6 cm. Some authors quoted lower values [3]. Our results are similar to those reported by Almansba et al. [27] about French elite judoists but higher than the sub-elite ones. These findings suggested that the explosive strength is higher in elite judoists than in sub-elite. Furthermore, we observe the best results in world and Olympic Games medal holder for both males and females

Conclusions

To interpreter the BMI minimizing the risk of diagnostic error, we must have interest principally to the both components FFMI and FMI. The new rules of IJF requires 5 minutes duration in female combat. Thus, it is more advantageous to increase their $\dot{V}O_2$max particularly in golden score case.

The $\dot{V}O_2$max cannot be used as a physiological indicator determining the judo level. Nevertheless, a good aerobic performance presents a big advantage in recovery processes, since judo is an intermittent activity of short duration and high intensity. The explosive strength can be used as a physiological variable predicting the successful in judo competition

In this study, the anthropometrical composition state of male and female judoists was characterized. We would like to recommend measuring both FFMI and FMI before use planning of the workload and during each period of preparation.

Professional coaches and sport scientists must remember that the aerobic performance is not significant indices in the physical development of world class judo athletes. Judo performance requires a moderate aerobic power, and this can be developed through judo exercises. Applications to judo performance involve a greater recovery from anaerobic work (via lactate metabolism) and a faster re-synthesis of phosphate creatine. Training exercises should be reproducing the temporal structure of judo fights. In training methods, the coaches should use rather intermittent aerobic exercises than continue aerobic exercises. The explosive strength and anaerobic training should be updated according to the new requirements on the physical condition in judo fights and the recent rules of International Judo Federation.

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