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Estimation of body composition in adolescent judo athletes

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Summary

Introduction. Adolescent judo athletes are often involved in weight reduction practices. Knowledge and adequate follow-up of the body compostion of adolescent judo athletes is of uttermost importance to guarantee an optimal growth and development in combination with optimal performance in an acceptable weight category. Regular follow-up of body composition requires reliable field methods.

Material and methods. In total 30 adolescent judo athletes (13 girls; 17 boys) of regional, national or international level participated in the study (mean age: 16.3±1.3 years of age). Body composition was assessed using 4 different technics and methods. It was the aim of the present study to estimate body fat percentage with different field methods in comparison with the under water weighing technique as criterium value.

Results. Body fat percentage differed as a function of the used technique for the girls while values for boy where more homogenous. Strong correlations were obtained when comparing the different methods for the girls only. In adolescent athletes, follow-up of body composition should be carried out on regular time intervals.

Conclusions. Field methods may be used but comparison against a criterion methods is required. Due to the specific morphology of judo athletes a further standardization of methods to estimate the body compostion is required.

Introduction

Body composition is an important component in weight sensitive sports. Several reports indicate high muscularity and low body fat percentage in combat sports organized in weight categories [1,2]. The number of studies estimating body composition in adolescent wrestling or judo athletes is limited. The reported percentage of body fat is ranging from 9.9±4.4% to 16.0±7.9% in boys and from 16.1±3.5 % to 23.8±8.3% in girls [2,3,4,5,6,7,8]. Traditionally, prior to competition most athletes undergo rapid weight loss in an attempt to qualify in a lighter weight class in order to gain an advantage over smaller and weaker opponents [9]. The possible negative effects of weight cycling are well documented. Several official organs published policy statement and guidelines in the promotion of healthy weight control practices [10,11]. Especially the weight cycling in young athletes is of concern [11]. Weight reduction practices in adolescents should be strongly discouraged since growth and development require additional energy and nutrient input. It has been shown that even in adolescent athletes inappropriate weight loss methods are used resulting in caloric deficit, nutrient deficit and dehydration. This may result in incomplete recovery after training, additional injury risk and eventually disturbed growth and development. In order to prevent extreme weight loss regimens immediately before the competition the Wrestling Federation developed the system of minimal wrestling weight. Briefly, wrestling athletes need a pre competition body composition analysis under euhydrated conditions (as indicated by urine density analysis). For boys the lower limit of body fat percentage is 7% whilst girls need at least 12% body fat. Athletes beneath these limits need medical clearance before they start competition. If the body composition is above the body fat percentage limits, maximal weekly changes are given (1.5%/week). In the wrestling guidelines body fat percentage is estimated by means of skinfold measurements. Reliable skinfold measurements can only be obtained when measurements are carried out by a trained anthropometrist.

In the most recent position stand on Nutrition and Athletic Performance, the ACSM points to the errors associated with all body composition assessment techniques [12]. It is believed that the accuracy of Bio Electrical Impedance Analyses (BIA) is similar to skinfold assessment. BIA may be preferable because it does not require the technical skill associated with skinfold measurement. Several BIA instruments became commercially available. The ACSM asks for evaluation of these recent impedance devices in specific athletic populations, especially in youngsters [12].

It was the aim of the present study to estimate the percentage of body fat in adolescent judo athletes. Several field techniques (skin folds; total body BIA; upper body BIA; lower body BIA; and near infra red interactance) were compared with the under water weighing method.

Material and methods

In total 30 adolescent judo athletes (13 girls; 17 boys) of regional, national or international level participated in the study (mean age: 16.3±1.3 years of age). All participants and their parents were informed about the study and signed informed consent.

Prior to the measurement the subjects were asked to avoid any type of exercise up to 12 hours before the measurements and to restrain from eating and drinking up to 4 hours before the measurements. Athletes were in normal training period and not involved in a weight reduction procedure.

Body composition was assessed using the following techniques and/or methods:

(1) *Anthropometric techniques for the determination of percentage of body fat and muscular mass.* Body height was measured using a wall mounted stadiometer (precise up to 1 mm). Skinfolds were measured at the biceps, triceps, subscapular, suprailiac, thigh, and calf. Upper arm, thigh and calf circumferences were measured as well as bicondular femur and humerus width. All measurements were carried out by one and the same investigator following ISAK guidelines [13].

Using the Durnin and Womersly equations [14] body density was calculated using the sum of 4 skinfolds (biceps, triceps, subscapular and suprailiac). Body density obtained with these formulas was used in the Siri formula [15] to calculate the percentage of body fat.

Using the corrected arm, thigh and calf circumferences in the formula proposed by Poortmans et al. [16], total skeletal muscle mass was calculated.

(2) *BIA techniques.* The Tanita Body Composition Analyzer TBF 410® was used as the BIA foot-foot method. This instrument uses a current at 50 kHz with an intensity of 500 µA. After introducing gender, age and height of the subject and after selection of the athletic or non-athletic mode (based on the weekly hours of physical activity), the subject stands on the instrument with the feet on the electrodes. The instrument displays the body weight and an estimate of the percentage of body fat, using the introduced parameters, the measured body weight and the impedance value (formula not available). The impedance value is also displayed (for possible use in another biometrical formula).

The Omron Body Fat Analyzer ® was used as the BIA hand-hand method. This single frequency instrument uses a current of 50 kHz with an intensity of 500 µA. After introducing gender, age, weight and height of the subject the instrument is held in both hands in front of the body with straight arms. The instrument displays an estimate of body fat using the introduced parameters in combination with the measured impedance value (formula not available).

The Nutriguard® is a multiple frequency (5, 50 and 100 kHz) hand-foot method operating at 0.8 mA. Self-adhesive electrodes are applied at the ankle and de wrist with the subject in supine position. After introducing body weight, height, age and gender the instrument is ready to measure. When the measurement is finished the instrument displays the resistance and the capacitance. Based on these values body composition is calculated.

(3) *Near infra red reactance.* The Futrex® analyzes the amount of reflected near infrared light emitted into the biceps (anterior midline of the biceps brachii midway between the antecubital fossa and acromion process of the right arm). The near infrared light is absorbed by fat and reflected by lean tissue. The local amount of subcutaneous and intramuscular fat at the biceps was found to be proportional to the percent fat of the total body. Percentage of body fat is estimated using a pre-programmed regression equation that includes age, gender height and optical density values (intensity of re-emitted light), (equation not available).

(4) *Under water weighing.* As criterion value for body fat, percentage of body fat was estimated by the under water weighing (UWW) technique using the Siri equation [15].

Briefly, the weight of the subject is measured before and during submerging under water. Using Archimedes law, body density is calculated. Body density is introduced in the formula of Siri for the estimation of the percentage of body fat:

Percentage of Body Fat = (495/UWD) – 450 with UWD= under water body density. Underwater body density was calculated using the following formula:

$$\text{Underwater body density} = W/(W - Ww)/dw) - (RV + GI)).$$

Where W is body weight in air, Ww is body weight in water accurate to 1 g (highest value of 5 measurements, after maximal expiration), dw is the density of the water (determined after measuring the water temperature), RV is residual lung volume (based on gender, height, and weight), and GI is the gas in the gastrointestinal tract (fixed to 100 g).

The athletes underwent the measurements in a randomized order, except for the UWW which was the last technique applied.

Body fat and muscle mass estimation methods were compared for both genders. In case of a normal distribution, methods were compared using the repeated measures ANOVA or the Friedman (in case of non normal distribution) procedure with Post Hoc analyses. Correlations between methods were calculated using the Pearson or the Spearman procedure. The significance level was set at 0.05.

Results

Mean body height and weight for the girls were respectively 163.3±7.6 cm and 56.2±9.7 kg. Body weight ranged from 41.2 to 71.3 kg representing weight categories from -40 kg to -70kg. Most of the girls were U17 (n=10) while the other girls were U20 (n=3). Boys' mean body height was 169.4±8.1

cm whilst mean body weight was 62.5±11.4 kg. Body weight ranged from 43.9 to 91.7 kg representing weight categories from -50 to -90 kg. Again, 10 subjects were U17 while 7 male subjects were U20.

Muscle mass was analysed for both genders taking into account the age categories. U17 girls had an absolute and relative muscle mass of respectively 22.4±3.7 kg or 36.7±4.6%. For U20 girls these values were respectively 29.9±1.8 kg and 35.9± 1.3%. For U17 boys absolute muscle mass was 27.2± 3.5 kg resulting in a relative muscle mass of 45.4±1.8%. For U20 boys these values were respectively 34.9±5.5 kg and 44.6±0.2%.

The Nutriguard® instrument could not calculate values for 3 out of the 13 female athletes. For the males no values were obtained with the Nutriguard® in 5 out of 17 athletes whilst the Omron instrument failed to calculate a value for 3 out of the 17 athletes (Table 1).

For the girls, the ANOVA procedure indicated significant differences between the used techniques/methods (F=36.4; p=0.001). Post hoc analyses revealed significant lower body fat percentage values for the UWW compared to estimates by skinfolds (p<0.001), Tanita® (p=0.006), Nutriguard® (p=0.011) and Futrex® (p <0.001). The estimate with the Omron® instrument was significantly lower compared to the skinfolds (p< 0.001), the Tanita® (p=0.016) the Nutriguard® (p=0.023) and the Futrex® (p=0.028). The results for the boys showed less variability. Due to the not normal distribution of the results obtained with the Nutriguard® and the Futrex® (both Kolmogorov Goodness of Fit test, p=0.0200) non-parametric statistics were applied. The Friedman procedure did not detect statistical difference between the used measurement methods.

Analysis of the correlation coefficients between the different methods for the girls, indicate that all correlations, except between the UWW technique and the Tanita® were significant. However, only between UWW and skinfold measurements a very strong correlation was obtained (r=0.924). Strong correlations were obtained between respectively the Futrex® instrument and skinfold measurements (r=0.843), Omron® and skinfold measurements (r=0.850) and between Nutriguard® and skinfold measurements (r=0.805).

The correlation between the different methods in the boys was only significant between the Nutriguard® and the UWW (p=0.007) and between the Omron® instrument and the Tanita® instrument (p=0.004). The obtained correlations were strong (respectively r=0.727 and r =0.714).

Discussion

The aim of this study was to evaluate body composition in adolescent judo athletes using different methods to estimate body fat (under water weighing, calculation from skin folds, bio electrical impedance methods (hand-hand, foot-foot, and hand-foot)) and an anthropometrical technique to estimate muscle mass. Females' body fat ranged between 16.4± 5.6% en 23.7±4.6% as a function of the used technique or instrument. The values obtained in our study corroborate the reported values in the literature on female judo and wrestling athletes. The mean value obtained with skinfold measurements

Table 1. Pearsons ‘ correlation (and p values) between body fat % in girls according the different methods/instruments

	Females		Males	
	n	% body fat	n	% body fat
Skinfolds	13	23.7 ±4.6	17	10.2±2.6
Tanita	13	22.1±4.5	17	9.7±3.7
Omron	13	17.7±3.3	14	9.3±5.1
Nutriguard	10	21.6±4.6	12	10.4±6.2
Futrex	13	23.4±5.7	17	8.9±2.6
UWW	13	16.4±5.6	17	7.2±4.5

Table 2: Pearsons ‘ correlation (and p values) between body fat % in girls according the different methods/instruments

	SKF (n=13)	Futrex (n=13)	Tanita (n=13)	Omron (n=13)	Nutriguard (n=10)
UWW	r=0.924 p<0.001	r=0.758 p=0.003	r=0.486 p=0.092	r=0.770 p=0.002	r=0.723 p=0.018
SKF		r= 0.843 p<0.001	r=0.616 p=0.025	r= 0.850 p<0.001	r=0.805 p=0.005
Futrex			r= 0.598 p=0.031	r=0.646 p=0.017	r=0.774 p=0.009
Tanita				r=0.572 p=0.041	r=0.752 p=0.018
Omron					r= 0.790 p=0.007

Table 3: Spearmans' correlation (and p values) between body fat % in boys according the different methods/instruments

	SKF (n=17)	Futrex (n=17)	Tanita (n=17)	Omron (n=14)	Nutriguard (n=12)
UWW	r=0.364 p=0.151	r=-0.204 p=0.433	r=0.222 p=0.391	r=0.467 p=0.092	r=0.727 p=0.007
SKF		r= 0.414 p=0.098	r=0.449 p=0.071	r=0.445 p=0.111	r=0.552 p=0.063
Futrex			r= 0.502 p=0.040	r=0.166 p=0.572	r=0.140 p=0.665
Tanita				r=0.741 p=0.004	r=0.382 p=0.220
Omron					r=0.274 p=0.440

in our study (23.7±4.6%) is in line with the 22.9±4.6% obtained on female adolescent wrestlers in the study of Hetzler et al. [6]. In the latter study body fat was estimated using 4 skinfolds (triceps, suprailium, abdominal, and thigh) and the Jackson & Pollock [17] equation while in the present study, skinfolds at biceps, triceps, subscapular and suprailiac were used in combination with the Durnin and Wommersly equation to estimate body density and the Siri equation to estimate percentage of body fat. In the study of Boisseau et al. [4] the same skinfolds were used for studying young (16.1± 0.3 years) French national female judo athletes. Body fat percentage was 23.3±1.5% whilst estimated muscle mass (using equally the formula proposed by Poortmans et al., [16]) was 22.2±1.2 kg (compared to 22.4±3.7 kg in our study). Also, in the U18 judokas studied by Little [2] using triceps, subscapular, suprailiac, abdominal, front thigh and medial calf skinfolds measurements a mean body fat percentage of 16.1±3.5% was obtained.

The present results for the boys corroborate very well the body fat percentage reported by Little [2] for the U17 Canadian judoka's (10.2±2.6% versus 10.2±1.6% respectively).

The criterion UWW technique revealed for both girls and boys lowest absolute values. For girls the UWW estimate was significantly different from all other techniques except with the Omron. In boys only a trend towards different values was detected and hence no post hoc analysis was performed. The low values for the UWW may be caused by specific bone density values in judo athletes. Indeed, as demonstrated by Proteau et al. [18] the specific biomechanical environment of intensive judo training results in high bone mineral density. The latter is known to result in lower estimates of body fat percentage with the UWW technique. The low values obtained for the girls with the Omron instrument is in line with earlier obtained results on a student population (n=128), [19] and may be explained by the uneven body fat distribution in females since the hand-hand BIA techniques estimate of body fat is mainly based on the upper body with a minor contribution of the lower body. The failure of the instruments (Omron, Nutriguard) to calculate an estimate of the percentage of body fat may be due to the out of range resistance measurements caused by the abovementioned specific body composition.

Only in girls acceptable correlations were obtained between the different methods. The latter may be an indication that the user-friendly skinfold, BIA and infra red techniques can be used as a follow up method in order to detect changes in body composition. The combination of yearly measurement of the body composition using more specialized techniques (UWW, Dexa) in combination with a more frequently follow-up with field methods may result in a better weight management throughout the year. However, it should be born in mind that even the most specialized techniques deliver only an indirect estimate of the percentage of body fat [20]. Additionally, the follow up of the SMM in combination with body fat can deliver information on the weight management procedures since a loss of SMM may point to an inadequate weight reduction program. The morphology of a judo athlete requires a high mesomorphic component [1]. Our results indicate equally a substantial difference in muscle mass when comparing U17 judo athletes with U20 athletes. Again, an optimal growth and muscle development is only possible when training intensity; nutritional intake and recuperation are well balanced.

Conclusions

In conclusion, adolescents' changing body composition needs sufficient follow up as most of the athletes go often through weight reduction periods in the preparation for competition. It may be important not only to estimate the percentage of body fat but equally the muscle mass since absolute and relative power are important determinants of judo success.

Relying on a single method/technique without control with a more standardized method may lead to considerable over or underestimation of the percentage of body fat. The specific morphology of judo athletes with a high muscular component and a high bone density calls for the development of a specific validated body composition assessment methodology. Further standardization is required with selection of an adequate reference method if measures are optioned to protect athletes for extensive weight loss procedures as proposed by Artioli et al. [21].

References

1. Claessens A, Beunen G, Wellens R, Geldhof G. Somatotype and body structure of world top judoists. J. Sports Med Phys Fitness 1987; 27: 105-13.
2. Little NG. Physical performance attributes of junior and senior women, juvenile, junior and senior men judokas. J. Sports Med Phys Fitness 1991; 31 (4): 510-520.
3. Vidalin H, Dubreuil C, Coudert J. Judokas ceinture noire. Suivi physiologique: etudes biometrique et bio-energetique. Suivi de l'entrainement. Medecine du sport 1988; 62 (4): 184-189.
4. Boisseau N, Vera-Perez S, Poortmans J. Food and fluid intake in adolescent female judo athletes before competition. Pediatric exercise Science 2005; 17 (1): 62-71.
5. Brown D, Mackenzie J, Dennis K, Cullen R. Comparison of body composition techniques to determine body fat in high school wrestlers. Journal of Exercise Physoplogyonline 2006; 9 (3): 24-32.
6. Hetzler RH, Kimura IF, Haines KH, Labotz M, Smith J. A comparison of Bioelectrical Impedance and skinfold measurements in determining minimum wrestling weights in high school wrestlers. Journal of Athletic training 2006; 41(1): 46-51.
7. Zuniga J, Housh TJ, Mielke M et al. Validity of fat-free weight equations for estimating mean and peak power in high school wrestlers. Pediatric Exercise Science 2009; 21: 100-112.
8. Wolska-Paczoska. Aerobic and anaerobic capacity and a special mobility Fitness in young female judo competitor. Baltic journal of health and physical activity 2010; 2 (2): 124-131.
9. Artioli GG, Franchini E, Nicastro H, Sterkowicz S, Solis MY, Lancha AH. The need of a weight management control program in judo: a proposal based on the successful case of wrestling. Journal of the International Society of Sports Nutrition 2010; b7: 15.
10. ACSM Position Stand on Weight loss in Wrestlers Med. Sci Sports Exerc. 1996; 28 (2): 9-12.
11. American Academy of Pediatrics, Policy Statement. Promotion of Healthy Weight Control Practices in Young athletes. Pediatrics 2005; 116 (6): 1557-1564.
12. Rodriguez NR, DiMarco NM, Langley S. Nutrition and Athletic Performance American College of Sports Medicine – American Dietetic Association – Dietitians of Canada Position statement. Med Sci Sports Exerc. 2009; 41: 709 -731.
13. Marfell-Jones M, Olds T, Stewart A, Carter L. International standards for anthropometric assessment. Potchefstroom. South Africa: ISAK; 2006.
14. Durnin JVGA, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutrition 1974; 32: 77-97.
15. Siri WE. The gross composition of the body. pages 239-280. IN: Lawrence JH, Tobias CA (editors). Advances in Biological and Medical Physics. Academic Press, Inc. Advances in Biological and Medical Physics. 1956; 4: 239-280.
16. Poortmans JR, Boisseau N, Moraine JJ, Moreno-Reyes R,. Goldman S. Estimation of total-body skeletal muscle mass in children and adolescents Med Sci Sports Exerc. 2005; 37 (2): 316-322.
17. Jackson AS, Pollack ML. Practical assessment of body composition. Phys Sport Med. 1985; 13: 76-90.
18. Proteau S, Pelle A, Collomp K, Benhamou L, Courteix D. Bone density in eltie judoists and effects of weight cycling on bone metabolic balance. Med. Sci. Sports Exerc. 2006; 38 (4): 694-700.
19. Clarys P, Deiremaeker P, Clijsen R, Taeymans J, Aerenhouts D, Barel AO. The influence of stratum corneum hydration on body fat determination by bio-electrical impedance. Skin Res. & Technol. 2012; 18: 55-60.
20. Eston R, Hawes M, Martin A, Reilly T. Human body composition. In: Eston R, Reilly T (editors). Kinanthropometry and exercise physiology laboratory manual. Tests, procedures and data. Volume 1: Anthropometry 3rd edn. London and New York: Routledge; 2009: 3-53.
21. Artioli GG, Gualano B, Franchini E et al. Prevalence, magnitude, and methods of rapid weight loss among judo competitors. Med Sci Sports Exerc. 2010; a42 (3): 436-442.

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