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BODY BUILD AND BODY COMPOSITION VS. PHYSICAL CAPACITY IN YOUNG JUDO CONTESTANTS COMPARED TO UNTRAINED SUBJECTS

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AUTHORS: Sterkowicz S.[1], Lech G.[1], Pałka T.[2], Tyka A.[2], Sterkowicz-Przybycień K.L.[3], Szyguła Z.[2], Kłys A.[1]

[1]Department of Theory and Methodology of Combat Sports, University School of Physical Education, Krakow, Poland
[2]Institute of Human Physiology, University School of Physical Education, Krakow, Poland
[3]Department of Theory and Methodology of Gymnastics, University School of Physical Education, Krakow, Poland

Reprint request to:
Stanisław Sterkowicz
University School of Physical Education, Department of Theory and Methodology of Combat Sports,
Al. Jana Pawła II 78,
31-571 Kraków – Poland
Tel/fax +48 12 6831133
Email: wtsterko@cyf-kr.edu.pl or stanislaw.sterkowicz@awf.krakow.pl

ABSTRACT: The aim of the present study was to (1) find differences in body build and aerobic and anaerobic capacity between young judoists and untrained peers; (2) compare correlations for indicators of body build with indicators of aerobic and anaerobic capacity among the group of trained and untrained subjects. The study group comprised 18 subjects selected during a competitive period, who had taken at least fifth place in national judo tournaments. Their training experience ranged from 6 to 11 years, 8 to 10 hours a week. The control group was composed of 18 untrained students from one of the schools included in the study. Their body height and mass (BM) did not differ compared to judoists. A body composition chart was employed for analysis of body build and body composition. Physiological investigations encompassed measurements of anaerobic (Wingate test) and aerobic (graded exercise test on cycle ergometer) capacity. Judo contestants are typically characterized by higher BMI, fat-free mass and fat-free mass index compared to the untrained. Compared to the group of untrained peers, young athletes in this sport are distinguished by the time needed to generate peak power. This difference is not observed in the indices characterising aerobic capacity. The level of the indices of body build and composition in young judo contestants shows a moderate and strong correlation with indices of anaerobic and aerobic capacity. The amount of total work in the Wingate test was positively correlated with BMI ($r=0.65$, $p<0.01$), fat-free mass index ($r=0.63$, $p<0.01$), body mass ($r=0.49$, $p<0.05$), fat mass index ($r=0.49$, $p<0.05$) and percentage of fat ($r=0.48$, $p<0.05$). Maximal peak anaerobic power was positively correlated with fat-free mass index ($r=0.48$, $p<0.05$) and percentage of fat ($r=0.50$, $p<0.05$). A strong negative correlation between $\dot{V}O_{2max}$ with body mass ($r=-0.75$, $p<0.001$), BMI ($r=-0.72$, $p<0.001$), moderate correlation with PF% ($r=-0.64$, $p<0.01$), fat-free mass index ($r=-0.52$, $p<0.05$), and fat mass index (-0.67, $p<0.01$) were observed. Heart rate at the anaerobic threshold (%HRmax) showed positive relationships with fat-free mass index ($r=0.52$, $p<0.05$). In the untrained subjects, only a negative relationship between BM and TOPP was observed ($r=-0.48$, $p<0.05$). These findings confirm interrelations between structural and functional parameters, developed through many years of training. Although physical capacity might affect the course of a fight, it should be considered in coaching practice only in conjunction with the level of technical and tactical preparation, which determines the result of the fight.

KEY WORDS: judo athletes, body composition, aerobic capacity, anaerobic capacity

INTRODUCTION

The concept of physical capacity has existed in the domains of occupational and sport medicine, physical therapy or clinical diagnostics. Its most popular indicator is the level of maximal oxygen uptake ($\dot{V}O_2max$) expressed in millilitres per kilogram of body mass and the level of work load at the anaerobic threshold (WL_{AT}) [28]. With respect to some sports, including judo, with domination of short bouts of exercise at maximal or submaximal power, this definition of physical capacity is imprecise.

Finding sports with specific components of physical capacity having an essential impact on achievement of a high level of performance by an athlete is not problematic to sport theorists. In practice, depending on a particular metabolic pathway for energy acquisition, a division into speed-strength and endurance disciplines/events has been typically used. Increasing the number of motor abilities relating to sport results causes more and more problems with their unequivocal categorization. However, this operation seems to be necessary since it allows for determination of e.g. morphofunctional predictors which determine performance. Knowledge about these predictors should be utilized by coaches during recruitment and selection of athletes for professional sport and development of training programmes.

It is generally accepted that performance of judo contestants (apart from a specific psychological predisposition profile) is a resultant of

TABLE 1. TRAINING EXPERIENCE, BODY HEIGHT AND MASS IN JUDO CONTESTANTS AND THE UNTRAINED BOYS

Age category	Age (years)	Training experience (years)	BH (cm)	BM (kg)
Juniors (n=10)	17.5 ± 0.71 16 - 18	8.4 ± 1.17 7 - 11	180.4 ± 3.62 173 - 186	85.8 ± 10.5 72.0 - 101.2
Cadets (n=8)	15.5 ± 0.53 [a] 15 - 16	6.1 ± 0.83 [a] 5 - 7	177.4 ± 6.23 170 - 185	71.7 ± 7.48 [a] 56.5 - 82.4
Total (n=18)	16.6 ± 1.20 15 - 18	7.4 ± 1.54 5 - 11	179.1 ± 5.03 170 - 186	79.5 ± 11.54 56.5 - 101.2
Untrained boys (n=18)	16.3 ± 1.04 14.8 - 17.8		180.9 ± 7.66 170 - 195	73.5 ± 14.0 51.5 - 99.1

Note: The values are: mean ± SD, min-max, BH – body height, BM – body mass

technical skills and motor abilities (strength, speed and endurance), determined by functional abilities of the body, which in most cases perform (in relation to these components) an overriding function of tactical skills [16]. Coaching practice has shown that achievement of considerable results in judo is possible when all the above-mentioned elements are at an optimal level or when leading components considerably dominate the others [12].

These statements, however, do not provide the answer to the question of which abilities are dominant in judo contestants and what is their optimal level in individual age groups. Predominantly, the level of the indices measured among the best athletes (seniors), medallists in the Olympic games and world championships is adopted as a model. However, this information can be used only in relation to national team athletes. It is difficult to compare the results of these studies to the results obtained for young contestants. Yet, the quality of selection, recruitment and training in clubs determines, particularly in the case of young athletes, their success at the age of senior competitors. Comparison of judo players to unrelated controls are rather scarce [4]. Comparison of indicators of physical capacity and morphological body build in judo contestants to the untrained should allow for identification of the directions of development and the effect of training on the predictors. Based on this comparison, it will be possible to draw indirect conclusions about the rate of transformations and the level of these indices in particular study age groups.

The aim of the present study was to (1) find differences in body build and aerobic and anaerobic capacity between young judoists and their untrained peers; (2) compare correlations obtained for body build with the indices of anaerobic and aerobic capacity measured among trained and untrained subjects.

MATERIALS AND METHODS

The study group was selected during the competitive season and covered 18 contestants who had taken at least fifth place in national judo tournaments. Juniors (n=10) competed in weight categories under 73 kg (n=3), 81 kg (n= 2), 90 kg (n=3), and 100 kg (n=2). Cadets (n=8) competed in weight categories under 55 kg (n=1), 73 (n=5), and 81 (n=2). Judoists in total trained for 6-11 years, 4-5 times a week, which means 8 to 10 hours a week. The control group was composed of 18 untrained students from one of the schools included in the study. The subjects were randomly selected, with the consent of the headmaster. Before the tests, candidates underwent a medical check-up and ECG tests were carried out. Based on the medical check-up, exercise testing was contraindicated in one of the participants. All the subjects included in the study gave their consent for participation in the study and, in the case of the young people, consent was also obtained from their legal guardians. The project was approved by the Bioethical Commission at the Regional Medical Chamber in Krakow No. 47/KBL/OIL/2010.

General characteristics of the 36 subjects (males) are presented in Table 1.

Anthropometrical studies included measurements of body height using a Martin anthropometer (USA). Body mass (BM) was measured by means of a Sartourius digital scale, type F1505 – DZA (Germany), with readability of 1g. Measurements of both skinfolds (triceps and subscapular skinfolds) were repeated three times by means of Harpenden calliper and intra-observer error was calculated. Typical errors of skinfolds measurement [9] were 1.8% for triceps, and 2.0% for subscapular. Both measurements were within proper anthropometric tolerance (5%) which is recommended for skinfold measurements [21]. Intra class correlation coefficients (ICC >0.95) show high reliability of repeated skinfold measurements [30]. Body fat percentage in body mass was evaluated according to a regression equation [22].

Body mass index BMI (BM in kg/ height in m^2), fat mass (FM) and fat-free mass (FFM) were then calculated. Similarly to BMI, FFMI and FMI were calculated, with BMI=FFMI+FMI [8]. A body composition chart [8] (not presented in this article) was used for analysis and diagnosis of individual body build and composition as it allows for simultaneous presentation of BMI, fat-free mass index (FFMI), fat mass index (FMI) and percentage of fat (PF%). Analysis of body build was based on BMI classification, with normal values ranging from 18.50 to 24.99 $kg \cdot m^{-2}$, whereas the critical value for assessment of excessive percent of body fat in males is PF >20% [20].

Physiological examinations covered measurements of indices of anaerobic capacity (Wingate test) and aerobic capacity (graded exercise test on cycle ergometer). Choosing this test was entirely deliberate as it is highly specific for assessment of anaerobic endurance. This is because the share of anaerobic energy processes in overall effort reaches nearly 90% [6]. The main exercise was preceded with a 5-minute warm-up using a bicycle ergometer with individually selected intensity of 50% $\dot{V}O_{2max}$ with pedalling rate of 60 rpm, three 5-second maximal accelerations at 2nd, 4th and 5th minute. Two minutes after the warm-up, participants performed 30-second maximal physical exercise. The objective for a studied person was that they would achieve, as soon as possible, maximal rhythm of pedalling and maintain it as long as possible. External resistance of pedalling was selected individually and amounted to 7.5% of body weight. Computer testing (MCE v-2.4 JBA, Staniak) was employed during the test to evaluate total work (TW), peak anaerobic power (RPP), fatigue index (FI) and time to peak power (TOPP), and time of maintaining peak power (TUPP) were evaluated [11]. The mechanical cycle ergometer Monark 834 E (Sweden) was used for the Wingate test. In order to assess aerobic capacity, reflected by maximal oxygen uptake per minute ($\dot{V}O_{2max}$), a graded exercise test on an ER 900 Jaeger (Germany) cycle ergometer was carried out. It was preceded with three-minute warm-up with the intensity of 110 W and pedalling cadence (RPM) of 60 revolutions per minute. After the warm-up, power was gradually increased by 20 W, every 2 minutes.

The exercise was continued until the examined person was unable to manage the pedalling cadence indicated by the metronome. Oxygen uptake ($\dot{V}O_2$) and heart rate (HR) were measured during the test. Respiratory changes were analysed by means of Medikro ergospirometer M202E (Finland). Heart rate (HR) was measured telemetrically by means of a Polar Electro S610iTM S cardiomonitor (Finland).

$\dot{V}O_{2max}$ was assumed as an indicator of current and potential endurance abilities. Based on the analysis of kinetics of changes in selected parameters of the respiratory system, the ventilatory threshold, which reflects the onset of the threshold of decompensated metabolic acidosis (TDMA), was determined [31,32]. Immediately before the exercise, blood lactate concentration (LA) reached 1.4 to 1.75 $mmol \cdot l^{-1}$. Three minutes after completion of this effort, blood samples were also taken from earlobes for enzymatic-colorimetric determination of LA using a Dr. Lange Plus LP– 20 mini-photometer (Germany).

Statistics

Quantitative data were statistically analysed, which allowed for determination of basic characteristics (arithmetic mean, standard deviation) as well as minimal and maximal values. Mean values for each variable were compared between juniors and cadets and between the group of judoists and the untrained subjects. Student's t-test for independent samples was employed for comparative analysis of the results of the study and, if necessary, the unequal variance version of the test was also used. Significance level for differences between the means was determined at $p<0.05$. Moreover, Pearson product correlation coefficients between the indicators of body build and composition and indicators of physical capacity were calculated in both judoists and the untrained groups. Statistical analysis of the quantitative data was based on Statgraphics Centurion v. XVI.I software.

RESULTS

a) Comparison of body build and composition in judoists and the untrained subjects

The judo contestants in the study were different in their calendar age ($p<0.001$) and training experience ($p<0.001$). Juniors had mass by 14 kg higher than cadets ($p<0.01$). Body height and mass in judo contestants (n=18) did not differ markedly compared to their untrained peers (n=18) (Table 1).

Levels of all the analysed indices of body build and composition (Table 2) considerably differed in juniors compared to cadets ($p<0.05$). Considerably higher BMI, FFMI, FMI and PF% were observed in the group of juniors. Results for BMI revealed that seven in ten juniors had BMI ≥25 $kg \cdot m^{-2}$. They also showed higher FFMI.

TABLE 2. BODY BUILD AND BODY COMPOSITION IN JUNIOR AND CADET JUDOISTS AND THE UNTRAINED BOYS

Age category	BMI ($kg \cdot m^{-2}$)	FFM (kg)	FFMI ($kg \cdot m^{-2}$)	FM (kg)	FMI ($kg \cdot m^{-2}$)	PF (%)
Juniors (n = 10)	26.3 ± 2.61 22.5 - 30.6	72.09 ± 5.51 64.42 - 79.04	22.13 ± 1.29 19.88 - 24.04	13.61 ± 7.06 4.51 - 26.22	4.17 ± 2.08 1.42 - 8.09	15.4 ± 6.28 5.6 - 26.5
Cadets (n=8)	22.8 ± 1.91 [a] 19.1 - 24.8	65.18 ± 6.31 [a] 52.44 - 72.81	20.69 ± 1.38 [a] 17.73 - 2.07	6.52 ± 3.09 [a] 3.31 - 11.10	2.08 ± 0.97 [a] 0.98 - 3.47	9.0 ± 3.69 [a] 4.5 - 14.0
Total (n=18)	24.7 ± 2.89 19.1 - 30.57	69.02 ± 6.70 52.44 - 79.04	21.49 ± 1.49 17.73 - 24.04	10.49 ± 6.61 3.37 - 26.21	3.24 ± 1.96 0.98 - 8.09	12.5 ± 6.10 4.5 - 26.5
Untrained boys (n=18)	22.2 ± 3.11 [b] 17.0 - 29.9	62.38 ± 8.07 [b] 49.23 - 77.55	18.99 ± 1.48 [b] 16.26 - 21.47	10.56 ± 7.20 2.22 - 31.1	3.17 ± 2.11 0.73 - 9.39	13.5 ± 6.87 4.3 - 31.4

Note: The values are: mean ± SD, min-max, BMI – body mass index, FM – fat mass, FFMI – fat-free mass index, FFM – fat-free mass, FMI – fat mass index, PF (%) – percent fat (%), a – indicates statistically significant difference from juniors, $p < 0.05$, b – indicates statistically significant difference from judoists in total, $p < 0.05$

TABLE 3. RESULTS FROM WINGATE TEST FOR JUDOISTS AND THE UNTRAINED BOYS

Age category	TW (kJ)	RPP ($W \cdot kg^{-1}$)	FI (%)	TOPP (s)	TUPP (s)	La ($mmol \cdot l^{-1}$)
Juniors(n=10)	268.3 ± 3.0	11.3 ± 0.7	43.4 ± 6.5	3.5 ± 0.8	3.6 ± 0.8	13.5 ± 1.2
	265 - 283	10.2 - 12.3	32.6 - 52.4	2.2 - 4.5	2.5 - 4.9	11.3 - 15.1
Cadets(n=8)	260.5 ± 10.2 [a]	11.2 ± 0.5	45.0 ± 5.6	4.6 ± 0.7 [a]	3.3 ± 0.9	13.1 ± 1.4
	248 - 286	10.4 - 11.6	35.6 - 51.9	3.6 - 5.4	2.4 - 4.8	10.9 - 15.0
Total(n=18)	264.8 ± 8.0	11.2 ± 0.6	44.1 ± 6.0	4.0 ± 1.0	3.5 ± 0.8	13.3 ± 1.2
	248 - 286	10.2 - 12.3	32.6 - 52.4	2.2 - 5.4	2.4 - 5.0	10.9 - 15.1
Untrained boys(n=18)	276.3 ± 28.53	11.9 ± 1.34	46.7 ± 8.0	5.3 ± 1.4 [b]	4.0 ± 1.2	13.8 ± 2.1
	204 - 312	6.3 - 13.4	32.6 - 61.2	3.0 - 8.0	1.0 - 6.5	10.0 - 18.1

Note: The values are: mean ± SD, min-max, TW – total work, RPP – relative peak power, FI – fatigue index, TOPP – time needed to generate peak power, TUPP – time needed to keep peak power, a – indicates statistically significant difference from juniors, $p < 0.05$, b – indicates statistically significant difference from judoists in total, $p < 0.05$

TABLE 4. INDICES WHICH CHARACTERIZE AEROBIC CAPACITY IN YOUNG JUDOISTS AND UNTRAINED BOYS

Age category	$\dot{V}O_2max$ ($ml \cdot kg^{-1} \cdot min^{-1}$)	HRmax (bpm)	HR_{TDMA} (bpm)	%HRmax (%)	% $\dot{V}O_2max$ (%)	La ($mmol \cdot l^{-1}$)
Juniors(n=10)	40.6 ± 4.91	189.6 ± 7.01	164.7 ± 6.89	86.9 ± 2.5	71.0 ± 6.3	11.9 ± 1.2
	32.2 - 46.8	181 - 204	151 - 173	83.4 - 90.5	59.5 - 82.6	10.0 - 13.3
Cadets(n=8)	43.5 ± 3.91	189.1 ± 6.6	160.3 ± 4.59	84.8 ± 1.7	71.0 ± 2.5	9.8 ± 1.3 [a]
	36.6 - 49.5	177 - 197	152 - 167	82.1 - 86.8	68.2 - 76.4	8.4 - 11.4
Total(n=18)	41.9 ± 4.62	189.4 ± 6.6	162.7 ± 6.25	85.9 ± 2.4	71.0 ± 4.9	10.9 ± 1.6
	32.2 - 49.5	177 - 204	151 - 173	82.1 - 90.5	59.5 - 82.6	8.4 - 13.3
Untrained boys(n=18)	39.8 ± 7.80	190.2 ± 10.7	166.6 ± 9.87	87.3 ± 4.6	72.7 ± 9.5	10.4 ± 2.1
	27.4 - 51.8	162 - 208	153 - 183	76.9 - 93.2	49.4 - 87.6	6.9 - 14.3

Note: The values are: mean ± SD, min-max, Values at anaerobic threshold: HRTDMA (bpm), %HRmax(%), %, $\dot{V}O_2max$(%), a – indicates statistically significant difference from juniors, $p < 0.05$

In the group of cadets, BMI was at the level of the norm for the people in this age category and percentage fat (PF) was below 15%. In individual cases in this category of athletes, the body fat level was very low (FMI<1, PF<5%). In the light of body composition classification for all the judoists (n=18), 11 subjects demonstrated proper BMI, whereas seven were overweight. Excessive percentage fat (PF>20%) was found in three subjects. In the group of untrained controls, this ratio (normal to overweight) was 16 to 2. Considerable differences in BMI ($p<0.05$) and FFM ($p<0.05$) and large differences in FFMI ($p<0.001$) were observed between the group of judoists and the untrained subjects. Judoists (n=18), with body height similar to the untrained subjects, were characterized by higher FFM compared to the untrained peers. Body fat indices (FMI, PF%), either in the absolute or relative approach, did not show intergroup differences. High positive correlations between BMI and PF% were observed in both trained athletes ($r=0.84$, $p<0.001$) and untrained subjects ($r=0.89$, $p<0.001$).

b) Comparison of indices which determine physical capacity in judoists and the untrained subjects

Numerical data contained in Table 3 show that the results for total work (TW, $p<0.05$) and time to peak power (TOPP, $p<0.01$) recorded during the Wingate test differed significantly. Older athletes with longer competitive experience exhibited considerably higher anaerobic capacity (TW) compared to their younger peers, whereas no differences were found between both groups of athletes in RPP, FI, TUPP and LA after the Wingate test. In judoists, a shorter time is needed to generate peak power (TOPP). The indices which characterize aerobic capacity are compared in Table 4. The results for $\dot{V}O_2max$, which characterizes aerobic capacity, did not differ considerably in the studied groups of athletes and the untrained subjects. A significant difference in post-exercise LA levels ($p<0.01$) was found between juniors and cadets. Other analysed indices did not differ significantly. There were no differences between judoists and the untrained controls in aerobic capacity indices.

c) Selected correlations between body build characteristics and indices which characterize physical capacity in judoists and the untrained subjects

In the group of judoists, the amount of total work (TW) in the Wingate test was positively correlated with BMI ($r=0.65$, $p<0.01$), FFMI ($r=0.63$, $p<0.01$), body mass ($r=0.49$, $p<0.05$), FMI ($r=0.49$, $p<0.05$) and PF% ($r=0.48$, $p<0.05$). Peak anaerobic power (RPP) positively correlated with FMI ($r=0.48$, $p<0.05$) and PF% ($r=0.50$,

$p<0.05$). A strong negative correlation between $\dot{V}O_{2max}$ with body mass and body composition ($r=-0.75$, $p<0.001$) and BMI ($r=-0.72$, $p<0.001$) and a moderate correlation with FFMI ($r=-0.52$, $p<0.05$) and FMI (-0.67, $p<0.01$), and PF (-0.64, $p<0.01$) were observed. Heart rate at the anaerobic threshold (%HRmax) exhibited a positive relationship with FFMI ($r=0.52$, $p<0.05$). In the untrained subjects, only a negative relationship between BM and TOPP was observed ($r=-0.48$, $p<0.05$). Conversely, no significant correlation ($r=-0.26$) between BM and TOPP was observed in judoists.

DISCUSSION

Judo is a sport in which the duration of a fight is adjusted to the athlete's age: 4 minutes in juniors and 5 minutes in seniors with extra time of 3 minutes in the case of a draw. The present study demonstrated that BMI levels are greater in athletes, which results from higher fat-free mass. Hence, in the case of contestants, BMI has a limited diagnostic value. In sports with weight classes, nearly 76% of competitors are subjected to body mass reduction before major competitions [26]. Usually it is not only body water which is reduced but also adipose tissue. Karateists who represented international level had significantly longer experience in karate, greater BMI, FFMI, FMI, and percent fat than those of national sports level [24].

At the time of the study, 9 among 18 judoists exceeded the upper limit for their weight categories. Therefore, they were forced to undergo body mass reduction regimes before competitions. A previous study [29] found that body mass reduction in judoists occurred at the expense of fat-free mass and percent body fat. In competitive senior judoists and wrestlers from the National Polish Team, percentage fat was 11.3% and 9.8%, respectively [27]. This study demonstrated that juniors had significantly higher body fat (15.4%) than cadets (9%). By contrast, all the judoists including seniors in the study by Pałka et al. [19] were characterized by lower percent fat in body mass than the untrained controls. Lastly, Kim et al. [13] reported that for international level Korean judo seniors ($n=10$), the correlations were moderate among FM (in kg), peak power (0.52), and mean power ($r=0.57$). In national level juniors ($n=28$, aged 14-17 years) the correlations among FM, peak power, and mean power were low (0.17 and 0.24). According to the authors of this study, the positive correlation of TW and RPP with PF and FMI in judo contestants results from different morphological build and body composition in athletes with speed-strength and endurance predispositions. These correlations between TW and PF can be explained by the relationship between TW and FFMI. After exclusion of the effect of FFMI, the partial correlation coefficient between TW and PF amounts to barely 0.16 and it is even negative in RPP (-0.30). It was demonstrated in the studies on professional athletes (unpublished data) that athletes who took part in sprinting competitions exhibited higher body fat than endurance runners.

An adverse effect of body mass reduction in judoists was documented by Umeda et al. [29]. Competitors who reduced body mass by 5.5% on average exhibited a significant decline in anaerobic power [29]. An original method of controlling these procedures was proposed in judo [2].

In judoists, anaerobic capacity is a leading predictor which determines effective performance in both rapid several-minute bouts of technical and tactical actions and extended sequences of effort, separated by short rests which do not allow for full restitution of high-energy substrates (ATP and PCr). The present study demonstrated that older athletes (juniors) with longer competitive experience were characterized by significantly higher TW and TOPP compared to their younger peers (cadets). This might show that physical stimuli used in judo training predominantly stimulate anaerobic capacity in the muscles. This is connected with sport experience and increase in FFM. The authors' own results for young judoists did not differ from the results (TW and TOPP) in seniors [19], which might point to stabilization of anaerobic capacity determined by the amount of total work (TW) in the Wingate test. It should be emphasized that considerably higher peak power (RPP – 12.2 $W \cdot kg^{-1}$) and higher post-exercise lactic acid concentration (LA) were observed in seniors tested by our research team compared to juniors [19]. This might suggest that physical exercise typical of judo training perfectly stimulates the glycolytic anaerobic component of physical capacity. In Japanese judoists aged 19.3 ± 1.30 years, peak power (RPP) was even greater than in Polish athletes and amounted to 14.4 ± 0.9 $W \cdot kg^{-1}$ [18]. This might indicate that athletes with high anaerobic muscle potential had been selected for national judo teams in Japan.

It is difficult to unequivocally explain the lack of significant differences in post-exercise concentrations of blood lactate (LA) after the Wingate test and after the graded exercise test between the group of judoists and untrained controls.

As can be concluded from comparison of the results obtained for TOPP in the study groups, starting speed (ability to generate peak power in a short time) is developed in line with sport experience. The demands of judo training and competitions are conducive to formation of high levels of this index of anaerobic capacity (TOPP). No significant correlations were found in judoists ($r=-0.26$) between BM and TOPP, whereas the untrained subjects with greater body mass reached peak power much faster ($r=-0.48$, $p<0.05$). The untrained subjects were characterized by considerably longer time for TOPP ($p<0.05$). Senior judoists reported by Pałka et al. [19] demonstrated the shortest time to obtaining peak power.

Analysis of the results for $\dot{V}O_{2max}$ in the groups of judoists gives the impression that this indicator is not a leading predictor which would determine sport performance level since the mean value of $\dot{V}O_{2max}$ in judoists (41.9 $ml \cdot kg^{-1} \cdot min^{-1}$), did not differ from the results obtained for the untrained controls (39.8 $ml \cdot kg^{-1} \cdot min^{-1}$) or seniors (40.8 $ml \cdot kg^{-1} \cdot min^{-1}$) [19]. However, some coaches seem to forget that the level of this indicator determines the rate of high energy substrates resynthesis during competition, especially between the matches. Japanese Olympic judo team members were characterized by greater $\dot{V}O_{2max}$ (45.9 $ml \cdot kg^{-1} \cdot min^{-1}$) compared to Polish judoists [5]. In other Japanese judoists of international class, the level of $\dot{V}O_{2max}$ of 44.5 ± 7.1 ml · kg^{-1} · min^{-1} was observed [18]. The maximal oxygen consumption in male elite wrestlers was higher reaching 59.8 ml · kg^{-1} · min^{-1} [10]. There were no statistically significant findings between judoists and the untrained controls in $\dot{V}O_{2max}$ [5,19]. Some researchers, in their longitudinal studies which covered representatives of other sports (alpine skiing and snowboarding) with similar energy requirements, found that $\dot{V}O_{2max}$ decreases with competitive experience, which is accompanied by a constant rise in anaerobic capacity [28]. Observation of the level of $\dot{V}O_{2max}$ in judoists in a training macrocycle which encompassed the subperiod of general preparation, subperiod of special preparation and competitive season did not reveal significant changes in this index [1].

Due to the complexity of judo fighting, laboratory methods of monitoring physical capacity are not sufficient. They usually focus on continuous exercise rather than on actual intervals of different intensity. In this light, attempts to assess the response of the athlete's body to exercise on a cycle ergometer with varied intensity and different duration can prove useful. Peak power during 30 second anaerobic exercise was almost the same after (a) constant exercise (80% $\dot{V}O_{2max}$) without any power exercise and (b) significantly decreased after constant exercise (80% $\dot{V}O_{2max}$) with 10-second power exercise every 30 seconds during five minutes. The correlation coefficients between PP and $\dot{V}O_{2max}$ were all negative in each trial during 10 seconds of power exercise every 30 seconds during 5 minutes, but positive correlation coefficient was found between TW and $\dot{V}O_{2max}$ [18]. The Special Judo Fitness Test (SJFT) [23,25] was used; the test uses periodically interrupted effort to simulate fighting bouts. The number of throws and SJFT Index correlated with parameters of anaerobic capacity (relative total work, peak power, fatigue index) and with those of aerobic fitness (relative $\dot{V}O_{2max}$, threshold running speed at TDMA, and the time the judoist took to achieve it). The correlation between the SJFT Index and the aerobic variables results from the fact that the component from the one-minute rest period is taken into account. The drop in heart rate after effort is a variable that is used quite frequently in estimates of the degree of training. SJFT, which was verified in terms of reliability and validity and which is based on standards [7], has been used not only in monitoring of training adaptations used by coaches but also in scientific experiments.

The present study emphasizes a number of correlations which occur between the indices of body build and body composition and the results of laboratory exercise tests. Body mass reduction causes changes in body composition and might affect the level of physiological indices [29] which are connected with the characteristics of the course of the fight. As previous studies have shown, the relationship between physical capacity and indices of the course of the fight can be observed [14,16,17]. Anaerobic capacity is of dominant importance in the group of cadets. Total work (TW) and relative peak power output (RPP) seem to be particularly essential. The level of TW was positively correlated with activeness and effectiveness of actions in the first part of a fight, whereas RPP was connected with activeness in the first part of a fight and high effectiveness during the whole match [14]. Time to peak power seems to be particularly important to juniors [16]; its level correlated with effectiveness of actions in the second part of a fight and with sport level. The results of the study carried out on a group of seniors [17] point to a key role of cardiorespiratory fitness in effective fighting. It was demonstrated, among other things, that the activity of contestants in the second part of a fight and extra time rose with an increase in $\dot{V}O_{2max}$ (ml · kg^{-1} · min^{-1}) [17]. Although physical capacity might affect the course of a fight, it should be considered in coaching practice only as a predisposition which occurs in conjunction with the level of technical and tactical preparation, which determines the specific fitness level and result of a fight.

CONCLUSIONS

It can be concluded from the results observed in this study that judo contestants in general are characterized by typical stocky build and demonstrate higher levels of BMI, FFM and FFMI compared to untrained subjects. During assessment of body build, one should take into consideration not only body mass and BMI but also their components. Compared to untrained controls, young athletes in this sport are distinguished by time needed to generate peak power (TOPP). This difference is not observed in the indices characteristic of aerobic capacity. The level of the indices of body build and composition in young judo contestants demonstrates a moderate and strong correlation with indices of anaerobic (7) and aerobic capacity (6). This fact might point to the relationships between the body structure and the functions developed throughout many years of judo training, since moderate (negative) correlations were observed in the group of untrained controls only in body mass and TOPP index.

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