

## The Level of Aerobic and Anaerobic Capacity and the Results of a Special Mobility Fitness Test of Female Judo Competitors Aged 16–18 Years

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**Key words:** judo, female contestants, special fitness, aerobic and anaerobic function.

### Abstract

**Background:** *The purpose of this work is to determine the correlation between the indexes of the special fitness test and the parameters of aerobic and anaerobic capacities of women judo competitors, during the preparation period to competitions.*

**Material/Methods:** *The research material comprised of 15 female judo contestants either members of the Polish representatives in the junior team and the competitors the Pomeranian Province Team aged 16-18. In order to define the somatic characteristics, the height of the body and indices that characterize its mass and composition of body components were determined. In order to assess the aerobic capacity a test with increasing charge until the refusal of continuation of the test was applied, while the anaerobic capacity was assessed thanks to the application of 30 seconds Wingate Test (WAnT) with charge of lower limbs. Within the framework of the assessment of special mobility fitness, the Special Judo Fitness Test (SJFT) was applied. An analysis of correlation between the anthropometric indices and SJFT indices was carried out; besides that a correlation between the indices of aerobic and anaerobic capacity and the results of the special mobility fitness test were analyzed.*

**Results:** *The indicators of special fitness test moderately correlated both with the indicators of aerobic and anaerobic capacity; however, the most clear dependencies concerned relative values of the maximum power. The tested female competitors at the beginning of the preparatory period achieved definitely lower values of indicators characterizing aerobic and anaerobic capacity in comparison to the results of other tests.*

**Conclusions:** *The presented dependencies give background to presume that at the level of directed training of female judo competitors in order to further raise their sport effectiveness, it seems adequate to pay more attention to preparation of special character whereby general physical preparation should also be directed to specialization.*

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## **Introduction**

Contemporary judo is characterized by growing competition both nationally and internationally, which forces to search for more and more effective methods of technical-tactical training as well as improving functional abilities of the organism.

From the research by Mickiewicz et al. [1] it is known that due to the specificity of starting effort of competitors, judo should be characterized by an ability to perform short term efforts of big power, conditioned by high fitness anaerobic-non lactate energy processes as well as intensive efforts lasting for a longer period in which the decisive role is played by the capacity of glycolic processes (anaerobic-lactate). Belotti et al. [2] qualified judo to individual disciplines, in which anaerobic-non lactate processes play a special role, while anaerobic-lactate and aerobic ones play a considerably lesser role. In the analysis of the physiological aspect of preparation of judo competitors, at the same time attention is paid to the essential meaning of aerobic efficiency. In the case of fights lasting 5 minutes as well as possibility of a 3-minute extra-time fight, current absorption of oxygen is a vital factor. Therefore, considering the time of fight and their number during the tournament, aerobic efficiency favouring economizing work of judoka's organism and the proper and fast course of the regeneration process [3,4,5] is also significant.

In the available literature, publications connected with defining aerobic and anaerobic exercise possibilities concern mainly female judo competitors of senior groups who are at the stage of special training [4,5]. Entirely another state of research takes place in the case of female judo competitors at the initial and directed stage of training [6].

For an assessment of training effects of judo competitors laboratory tests [7,8] as well as specific tests are applied [9,10,11]. Sikorski points out [12] that a specific test for judo is just a fight. That is why, from the practical point of view, in the assessment of the functional capacity, applying tests, which to the greatest extent characterize the kind of effort typical of a given sport discipline, is the most advantageous.

Hitherto collected experimental data and theoretical considerations confirm that judo demands from competitors versatile physical and technical preparation. In the theory and practice of sport it is regarded that physical preparation constitutes an inseparable condition of the development of motor abilities as one of the most important factors determining the effectiveness of training and starting activity of sportsmen [13]. Therefore, problems connected with determining properties of the body build and physical efficiency as well as defining their structure and searching for relationships between them achieve a special meaning both in the cognitive and in applicatory aspect. Information collected so far does not satisfy needs connected with the cognition of essence of the analyzed phenomena, particularly in the group of female judo competitors at the initial and directed stage of training.

In respect to this, the aim of the research is to assess the state of training of 16–18-year-old female judo competitors at the preparatory stage for sport competitions on the basis of a special motor efficiency test and laboratory tests.

Having in mind the aim of the work, obtaining answers to the following research questions was assumed necessary:

1. What is the level of special functional capacity of female judo competitors?
2. What relations occur between the chosen indicators of somatic build and indicators of special efficiency?
3. What is the level of aerobic and anaerobic capacity of female judo competitors?
4. To what extent are chosen indicators of aerobic and anaerobic capacity connected with the results of the special test of motor fitness?

## Material and method

Fifteen judo competitors aged 16–18 years (stage of directed training) were tested in the research, all of them were representatives of Poland in the category of juniors and regional team of Pomerania. The examinations were carried out in July 2007 at the Combat Sport Department and the Functional Diagnosis Laboratory at AWFIS Gdańsk.

In order to determine the somatic features, body heights and body mass indexes and components were measured. Body mass, fat mass content (FAT) and fat-free mass content (FFM), were measured by the TBF-410 TANITA MA III Body Composition Analyzer TYPE TBF-410 MA III, with making use a bioimpedance electric method. The body mass index (BMI) [ $\text{kg}\cdot\text{m}^{-2}$ ] was also calculated [14,15]. The mean values of somatic features of the examined competitors are presented in Table 1.

Tab. 1. Anthropometric features of women judo competitors (n=15)

Statistics	Experience (years)	Age (years)	Height (cm)	Weight (kg)	BMI ( $\text{kg}\cdot\text{m}^{-2}$ )	FAT (kg)	FFM (kg)
M	7.2	16.8	165.3	64.8	23.6	15.4	49.4
SD	2.5	0.7	7.8	11.2	2.9	5.4	7.4

Special Judo Fitness Test (SJFT) was used to assess special effort capacities [9]. The test is composed of three periods of work: 15 s (series A), 30 s (series B), 30 s (series C), separated by 10 s breaks. During each effort the tested athlete's task was to perform the greatest number of *seoi-nage* throws, with two partners of a similar height and the same weight category; they stood 6 m apart each other, and the thrower was between them. Immediately on completion of series C and after 1 min since the test completion HR measurement was taken [ $\text{bt}\cdot\text{min}^{-1}$ ]. To measure the frequency of the heart rate, a sport tester "Polar Sport Tester" was used (POLAR 810 I™ Finland). On the basis of the obtained results, the index was calculated:

$$\text{Index} = \frac{\text{HR after effort} [\text{bt}\cdot\text{min}^{-1}] + \text{HR after 1 min. since effort comp.} [\text{bt}\cdot\text{min}^{-1}]}{\text{Sum of throws (series A + series B + series C)}}$$

To assess aerobic capacity in laboratory conditions, the test of increasing load up to exhaustion was used [16]. The computerised analyzer of exhalation gases the Cosmed brand K4b<sup>2</sup> and the "Monark 828 E Ergometric" ergometer were used. The trial was performed in a sitting position. The test started with five-minute physical effort with load of 1.5 watt per one kilogram of body mass ( $\text{W}\cdot\text{kg}^{-1}$ ), at the frequency of rotation of 50 per minute ( $50\cdot\text{min}^{-1}$ ). At the main stage of the test the load was increased by 25 W every minute up to the exhaustion phase. The heart rate was measured by the POLAR 810 i™ (Finland). To assess anaerobic capacity in laboratory conditions, the Wingate Anaerobic Test (WAnT) of 30-seconds version was used [17]. The examined competitors performed the test for lower limbs, using the "Monark 824 Ergometric", with the loads related to their body mass:  $75\text{ g}\cdot\text{kg}^{-1}$ . The MCE v 2.0 computer program was used for calculating the mechanic indexes WAnT [18].

Statistic analyses were conducted by means of the programme "STATISTICA 6.0 PL" of StatSoft company. Arithmetic means, standard deviation and correlation coefficients were calculated.

## Results

The values of indicators diagnosing the level of special physical efficiency achieved on the basis of Special Judo Fitness are presented in Table 2.

An analysis of tests results showed that the examined female competitors achieved mean value of the index ( $I_{SJFT}$ ) – confirming achievements in SJFT – at the level  $14.4 \pm 1.26$ . The number of throws in the shortest series (A) was  $5.8 \pm 0.38$ , whereas in 30-second series B the number of throws was  $8.9 \pm 0.83$ . A decrease in the number of throws in 30-second series C in comparison to the previous series ( $8.03 \pm 1.03$ ) was observed. Altogether the female competitors of the examined group in the analyzed test performed  $22.1 \pm 1.92$  throws. The frequency of heart beats directly after finishing the test as well as after 1 minute break was  $181 \pm 10.6$  and  $137 \pm 10.8$ , respectively.

A correlation analysis between somatic indicators and SJFT indicators showed a negative correlation between body height and the sum of throws ( $r = -0.58$ ); at  $p < 0.05$  (Table 3). A negative correlation between the level of FAT (kg) and heart beats after 1 minute from finishing the test ( $r = -0.56$ ) was observed as well as one between FFM (kg) and the number of throws in B series ( $r = -0.55$ ), at  $p < 0.05$ .

Mean values of the chosen indicators characterizing action of circulatory and respiratory systems as well as corresponding to them values of standard deviation are presented in Table 4.

The obtained data show that the absolute value of critical power ( $W_{cr}$ ) was formed at the level  $216 \pm 25.2$  W, which calculated per kilogram of the body mass was  $3.8 \pm 0.60$   $W \cdot kg^{-1}$ . The maximum absolute value of oxygen absorption achieved the level of  $2603 \pm 405$   $mL \cdot kg^{-1}$ , which relatively constituted  $35.4 \pm 7.8$   $mL \cdot kg^{-1} \cdot min^{-1}$ . The mean value of maximum frequency of heart beats ( $HR_{max}$ ) in the test of physical effort “to refusal” was formed at the level of  $182.6 \pm 8.4$   $sk \cdot min^{-1}$ .

Mean values of basic parameters of power dynamics achieved during WAnT and corresponding to them values of standard deviation are presented in Table 5.

Absolute values of mean power ( $P_{WAnTmid}$ ) were formed at the level  $408 \pm 66$  W, whereas relative values (calculated per body mass)  $6.32 \pm 0.50$   $W \cdot kg^{-1}$ . The maximal power ( $MP_{WAnT}$ ) registered during WAnT, expressed in the absolute values, achieved the value of  $498 \pm 85$  W whereas in relative values  $7.69 \pm 0.54$   $W \cdot kg^{-1}$ . The examined competitors performed work ( $W_{tot}$ ) at the level  $12.25 \pm 1.97$  kJ, which calculated per kilogram of body mass constituted  $189 \pm 15$   $J \cdot kg^{-1}$ . Also other indicators determining anaerobic possibilities such as time of achieving maximum power (TUZ) and time of maintaining maximum power (TUT) were analyzed, the values of which were:  $5.20 \pm 1.43$  s and  $3.46 \pm 1.43$  s, respectively. The value of the indicator characterizing the speed of power decrease (WSM) during 30 second effort gained  $0.166 \pm 0.058$   $W \cdot kg^{-1} \cdot s$ .

In Table 6 coefficients of correlation of physiological parameters which were significantly connected with achievements in special fitness test are presented.

The strongest relations concerned the ventilator equivalent of oxygen consumption ( $VE \cdot VO_2^{-1}$ ) with the frequency of heart beats directly after finishing the test ( $r = 0.59$ ), and relative values of critical power ( $W_{cr}$ ) with the number of throws in series A SJFT ( $r = 0.58$ ); at  $p < 0,05$ . The analysis of dependence between WAnT indicators and SJFT indicators showed a negative correlation of absolute values  $MP_{WAnT}$  with: the number of throws in series A ( $r = -0.62$ ), the sum of throws ( $r = -0.63$ ), the number of throws in series B ( $r = -0.56$ ). Attention is drawn to negative relations between WSM and the number of throws in series A ( $r = -0.56$ ), the number of throws in series C ( $r = -0.59$ ) and a positive correlation with SFJT index ( $r = 0.58$ );  $p < 0.05$ . A moderate correlation between relative values  $MP_{WAnT}$  and the frequency of heart beats directly after finishing SJFT ( $r = 0.60$ ),  $p < 0.005$ , were also observed.

**Tab. 2. Mean values of the SJFT indexes of women judo competitors (n=15)**

Statistics	The number of throws in series A	The number of throws in series B	The number of throws in series C	Sum of throws in three series	HR immediately after series C (bt·min <sup>-1</sup> )	HR after 1 min rest since series C (bt·min <sup>-1</sup> )	IsJFT (index)
M	5.8	8.9	8.03	22.1	181	137	14.4
SD	0.38	0.83	1.03	1.92	10.6	10.8	1.26

**Tab. 3. Correlation analysis between somatic indicators and indicators of SJFT (n=15)**

Indicators of SJFT	Age (years)	Height (cm)	Weight (kg)	BMI (kg·m <sup>-2</sup> )	FAT (kg)	FFM (kg)
Series A SJFT	0.28	-0.51	-0.29	-0.43	-0.42	-0.47
Series B SJFT	-0.43	-0.50	-0.47	-0.29	-0.30	<b>-0.55</b>
Series C SJFT	-0.12	-0.49	-0.47	-0.29	-0.51	-0.37
Sum of throws in three series	-0.20	<b>-0.58</b>	-0.51	-0.37	-0.48	<b>-0.53</b>
HR after series C (bt·min <sup>-1</sup> )	-0.25	-0.33	-0.25	-0.27	-0.31	-0.28
HR after 1 min rest. (bt·min <sup>-1</sup> )	-0.08	<b>-0.54</b>	-0.29	<b>-0.54</b>	<b>-0.56</b>	-0.41
IsJFT (index)	0.08	0.34	0.39	0.11	0.21	0.36

**Tab. 4. Aerobic capacity indexes of women judo competitors (n=15)**

Indicators of aerobic capacity	M±SD
VE <sub>max</sub> (L·min <sup>-1</sup> )	94.7±19.4
VO <sub>2max</sub> (mL·min <sup>-1</sup> )	2312±294
VCO <sub>2max</sub> (mL·min <sup>-1</sup> )	2603±405
VO <sub>2max</sub> (mL·kg <sup>-1</sup> ·min <sup>-1</sup> )	35.4±7.8
VE·VO <sub>2</sub> <sup>-1</sup>	48.3±12.3
VE·VCO <sub>2</sub> <sup>-1</sup>	41.3±6.1
RQ	1.23±0.14
HR <sub>max</sub>	182.6±8.4
O <sub>2</sub> ·HR <sup>-1</sup> (mL)	13.1±1.6
W <sub>cr</sub> (W)	216±25.2
W <sub>cr</sub> (W·kg <sup>-1</sup> )	3.8±0.60

**Tab. 5. Anaerobic capacity indexes of women judo competitors (n=15)**

Indicators of anaerobic capacity	M±SD
P <sub>WAN<sub>T</sub>mid</sub> (W)	408±66
P <sub>WAN<sub>T</sub>mid</sub> (W·kg <sup>-1</sup> )	6.32±0.50
W <sub>tot</sub> (kJ)	12.25±1.97
W <sub>tot</sub> (J·kg <sup>-1</sup> )	189±15
MP <sub>WAN<sub>T</sub></sub> (W)	498±85
MP <sub>WAN<sub>T</sub></sub> (W·kg <sup>-1</sup> )	7.69±0.54
WSM (W·kg <sup>-1</sup> ·s)	0.166±0.06
TUZ (s)	5.20±1.43
TUT (s)	3.46±1.43

**Tab. 6. The correlation indexes of the capacity tests and the SJFT of women judo competitors (n=15)**

Indicators of SJFT	VO <sub>2max</sub> (mL·kg <sup>-1</sup> ·min <sup>-1</sup> )	VE·VO <sub>2</sub> <sup>-1</sup>	RQ	W <sub>cr</sub> (W·kg <sup>-1</sup> )	P <sub>WAN<sub>T</sub>mid</sub> (W·kg <sup>-1</sup> )	MP <sub>WAN<sub>T</sub></sub> (W)	MP <sub>WAN<sub>T</sub></sub> (W·kg <sup>-1</sup> )	WSM (W·kg <sup>-1</sup> ·s)
Series A SJFT	0.14	0.16	0.11	<b>0.58</b>	0.21	<b>-0.62</b>	-0.12	<b>-0.56</b>
Series B SJFT	<b>0.54</b>	0.45	<b>0.54</b>	0.36	0.38	<b>-0.56</b>	0.30	-0.24
Series C SJFT	0.24	0.12	0.07	0.20	0.30	-0.48	0.21	<b>-0.59</b>
Sum of throws in three series	0.39	0.29	0.30	0.38	0.37	<b>-0.63</b>	0.22	-0.54
HR after series C (bt·min <sup>-1</sup> )	0.09	<b>0.59</b>	0.37	0.44	<b>0.56</b>	-0.14	<b>0.60</b>	0.03
HR after 1 min rest.(bt·min <sup>-1</sup> )	0.35	0.01	0.12	0.42	0.39	-0.49	0.16	-0.30
IsJFT (index)	-0.25	-0.08	-0.13	-0.14	-0.13	0.55	0.01	<b>0.58</b>

## Discussion

In achieving sport championship, the physiological aspect of conducting training is essential demanding proper forming of the general physical efficiency level as well as special, including specific of a given sport discipline. The basis in accomplishment of the above demands should be the structure of a long-term training process [19]. Among many factors determining structure of the long-term training process in judo, Jagiełło [20] distinguishes among others the structure of preparation of competitors and their starting activity, the regularity of forming various ingredients of sport championship and adaptation processes as well as leading for a given discipline functional systems of organism.

Solving the research problem of the present tests anticipated not only the determination of the aerobic and anaerobic efficiency level, the level of special effort possibilities but also testing dependence both between them and between the somatic indicators and SJFT indicators.

The results of a correlation analysis between somatic indicators and SFJT indicators entitle us to claim that female competitors characterized by lesser body height performed altogether a bigger number of throws, whereas the competitors of a lower FFM level performed a bigger number of throws in B series of test. A similar situation was observed in the case of older competitors [21], but the results of tests in a female seniors group give convincing evidence of a bigger and more meaningful amount of dependencies between the tested indicators.

The value of the index shows the level of achievements in SJFT test. It results from the formula that the lesser value of the index corresponds to bigger achievements in the test. The competitors of the tested group achieved the index value of  $14.4 \pm 1.26$ , so significantly higher than representatives of Poland in the group of female seniors  $12.6 \pm 0.69$  [21] and Brazilian female competitors getting prepared to Panamerican Competitions  $12.62 \pm 1.48$  [22]. An ability to perform a large number of throws in a short time depends mainly on anaerobic metabolism fitness; however, restitutive HR value is connected with anaerobic metabolism [23].

By analyzing values of the chosen indicators of aerobic capacity it was revealed that the tested female competitors achieved significantly lower values within  $VO_{2max}$  ( $35.4 \pm 7.8 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ ) in comparison with the results of Mickiewicz et al. tests [1]  $49.9 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ , Callister et al. [24]  $52.0 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ , Borkowski et al. [4]  $49.88$  and  $50.66 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  and Laskowski [5]  $48.6$ – $51.8 \text{ mL} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ . The values of indicators of anaerobic capacity also occurred to be clearly lower compared to tests of other authors. Particularly in the case of the maximal anaerobic power, which is the measurement of human capacity for performing work of supramaximum intensity, the values of which in the examined group proved to be at the level of  $7.69 \pm 0.54 \text{ W} \cdot \text{kg}^{-1}$ . According to Belotti et al. [2] the maximal anaerobic power decides about the effectiveness of starting effort of judo competitors. The mean value of maximum anaerobic power in research of Zdanowicz and Wojczuk [25] was determined at the level of  $9.63 \text{ W} \cdot \text{kg}^{-1}$ , in Borkowski et al. tests [4]  $10.57 \text{ W} \cdot \text{kg}^{-1}$  whereas in Laskowski's tests [5]  $10.9 \text{ W} \cdot \text{kg}^{-1}$ . Clearly lower mean values of total work ( $W_{tot}$ ) was observed, which was often considered as a measurement of general anaerobic capacity (or commonly called "speed efficiency"). Laskowski's tests [5] indicated that during 30 seconds female judo competitors performed work at the level of  $238.8$ – $255.0 \text{ J} \cdot \text{kg}^{-1}$ , whereas in Zdanowicz and Wojczuk's tests [25] the mean value of performed work equaled  $220.8 \pm 16.9 \text{ J} \cdot \text{kg}^{-1}$ .

In the work also dependencies between the results achieved during SFJT and results of laboratory tests were also pursued. As a result of the analysis, a moderately negative correlation of results of series A and B was revealed, with absolute values of the maximal power achieved in the Wingate test ( $r = -0.62$ ;  $r = -0.56$  respectively) and the number of throws of series C with the indicator of power decrease ( $r = -0.59$ ). The total number of throws SFJT depended on absolute values of the maximal power ( $r = -0.63$ ). A different situation was observed in the group of senior female competitors, in which the strongest dependencies were observed between the number of series B throws and indicators characterizing aerobic capacity and number of series C throws and sums of throws with relative values of both aerobic capacity indicators and anaerobic [21]. A synthetic SFJT

index in the group of 16–18-year-old female competitors moderately correlated only with the indicator of power fall ( $r=0.58$ ) while in the group of female seniors [21] a strong negative correlation of the index with relative indicators  $VO_{2max}$  ( $r=-0.89$ ),  $W_{cr}$  ( $r=-0.84$ ),  $P_{WAN_{Tmid}}$  ( $r=-0.76$ ),  $W_{tot}$  ( $r=-0.76$ ) and a moderate one with  $MP_{WAN_{T}}$  ( $r=-0.68$ ) was observed. In tests by Franchini et al. [26] relative mean power in the Wingate test correlated with the number of throws in series A ( $r=0.87$ ), in series C ( $r=0.75$ ), the sum of throws ( $r=0.79$ ) and SFJT index ( $r=-0.83$ ). However, the index of power decrease correlated with the number of throws in series B ( $r=-0.75$ ), in series C ( $r=-0.72$ ) and the sum of throws in SJFT ( $r=-0.71$ ).

## Conclusions

As a result of the analysis of the collected empirical material, it was decided that the indicators of special fitness test moderately correlated both with the indicators of aerobic and anaerobic capacity; however, the most clear dependencies concerned relative values of the maximal power. It should be observed that the results of tests of other authors in the group of older female competitors revealed a greater variety and power of relations between the tested indicators in comparison to 16–18-year-old female competitors. It was also stated that the tested female competitors at the beginning of the preparatory period achieved definitely lower values of indicators characterizing aerobic and anaerobic capacity in comparison to the results of other tests.

The presented dependencies give background to presume that at the level of directed training of female judo competitors in order to further raise their sport effectiveness, it seems adequate to pay more attention to preparation of special character whereby general physical preparation should also be directed to specialization.

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