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The interdependence of indices of efficiency, special fitness and body composition in judo athletes during the period of comprehensive training

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Abstract

Background & study aim: Anaerobic and aerobic capacity belong to the most commonly used indices of performance not only in judo athletes. The study aim is the interdependence of indices of capacity (aerobic and anaerobic), special fitness and body composition in female judo athletes during the period of comprehensive training.

Material & Methods: The study involved 14 judo contestants aged 13-15 years and representing the female junior and younger junior team of Pomeranian Voivodeship in Poland. The height and body weight as well as indices characterizing the body composition were determined. To assess their aerobic capacity, the test of incremental workload until exhaustion was used, while anaerobic capacity was evaluated by means of the 30-second Wingate Test with a load on the lower limbs. The assessment of special fitness was based on the results of the Special Judo Fitness Test (SJFT). A correlation analysis between somatic indices and SJFT indices and a correlation analysis between aerobic and anaerobic capacity indices and SJFT results were also carried out.

Results: SJFT indices correlated with relative values of critical work power and with the maximum oxygen uptake. No statistically significant relationships between SJFT indices and WAnT indices were observed. A lower level of aerobic and anaerobic capacity indices as well as achievements in SJFT were noted in comparison with the results of other authors.

Conclusion: The stage of judo training significantly differentiates certain adaptive effects. Judo athletes who are in comprehensive training (initial) are inferior in special fitness and in the level of aerobic and anaerobic capacity to athletes who continue judo training at the directed and special stage.

Key words: combat sports • technical preparation • Special Judo Fitness Test • long-standing sports training

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Technical preparation – basic technical actions applied in competitions or being training means as well as improvement in the selected forms of sports technique.

Long-standing athletic training – periodization of sports training illustrating its phase nature and indicating the need to achieve specific training objectives at each of the stages through solutions appropriate to the given development phase, subordinated to the strategic aims.

INTRODUCTION

In combat sports, as in other disciplines, achieving high sports performance is a result of many years of training work. The issue of long-standing training in combat sports has been the most extensively presented in the work of, among other [1-3].

Many experts stress that the main objective of the initial stage of training is a comprehensive development of a young athlete's personality, increasing his/her motor and adaptation capabilities, and proper preparation to subsequent stages. Czajkowski [1] believes that this is a typical teaching for the future. The pursuit of this phase is to design an optimal basis for achieving maximum results at the age of the highest natural abilities of the body, with particular regard to the laws of biological development. Analysis of the structure of long-standing sports training of judo athletes showed that over 70% of outstanding athletes began systematic training at the age of 10-15 years [5]. The duration of the comprehensive (initial) stage in judo is usually 1 to 3 years and mainly depends upon the age at the start of regular sports activities [5,6], the development level of basic motor skills [7], and the child's adaptive properties [8].

Judo belongs to acyclic disciplines, which are characterized by a variable intensity of effort and frequent changes of the conditions of fight. Wołkow and Szijan [9] emphasise that judo training requires comprehensive physical preparation based on metabolic changes, both aerobic and anaerobic ones, defining the level of the athlete's special capacity. The share of the above functional capacity in the potential of special capacity is subject to, among others, such factors as the sports level, age, and body weight.

In the available literature, publications related to determining aerobic and anaerobic effort capacities mainly concern judo athletes pursuing the special training stage in seniors groups [10, 11]. Quite a different state of research is in the case of female judo athletes at the initial and the directed training stage [12].

So far collected experimental data and theoretical considerations confirm that judo requires that athletes have a comprehensive physical and technical preparation. In sports theory and practice it is believed that physical preparation is an essential condition of the development of motor skills as one of the most important factors determining athletes' efficiency in training and competitive activity [13]. Therefore, problems associated with defining characteristics of body composition and physical fitness as well as their structure and search for the links between them are gaining particular importance both in terms of the cognitive and the application aspect. The collected so far data are insufficient to know the substance of the analysed phenomena, especially concerning female judo athletes at the stage of comprehensive training.

The study aim is the interdependence of indices of capacity (aerobic and anaerobic), special fitness and body composition in female judo athletes during the period of comprehensive training.

MATERIAL AND METHODS

Participants

The study involved 14 judo contestants aged 13-15 years (the stage of comprehensive training) in the category of female juniors and younger juniors, representatives of the voivodeship team of Pomeranian (Poland). The research was conducted at the Combat Sports Department and the Functional Diagnostics Laboratory at AWFiS Gdańsk, during the preparatory period, in July 2007.

Somatic characteristics were based on the body height and indices of its mass and composition. The body weight and level of adipose tissue (FAT) and fat-free mass (FFM) were measured using a Tanita Body Composition Analyzer, TYPE TBF-410 MA III. The Quetelet II index (BMI) [kg·m^{-2}] was also calculated (Table 1).

To evaluate special effort potential, the Special Judo Fitness Test (SJFT) was used [14]. It consists of three work periods: 15 s (series A), 30 s (series B), 30 s (series C) separated by 10-sec intervals. During each effort the subject's task was to perform as many *seoi*

Table 1. Somatic characteristics of female judo competitors (n=14)

Mean values / standard deviation	Training experience (years)	Age (years)	Body height (cm)	Body mass (kg)	BMI (kg·m-1)	FAT (kg)	FAT (%)	FFM (kg)	FFM (%)
M	5.5	13.9	164.1	54.4	20.2	12.2	22.0	42.1	78.0
SD	1.9	1.1	7.4	6.9	2.1	4.6	5.9	3.9	5.9

nage throws with two partners of the same weight category and with similar body height, who were standing 6 meters away from each other while the subject was in the middle between them. Directly after the end of series C and after 1 minute since completion of the test, the heart rate (HR) was measured, for which a POLAR 810 i™ sport tester (Finland) was used. Figure 1 illustrates the initial arrangement of the athletes prior to the start of series A, B, and C.

On the basis of the obtained results, the SJFT index was calculated:

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

To assess aerobic capacity under laboratory conditions, the test of incremental workload until exhaustion was applied [15]. The study made use of a computerized exhaled gas analyser K4b2 of Cosmed company and of a cycling ergometer „Monark 828 E Ergometric". The test was carried out in a sitting position. The test started with a 5-minute physical exercise with a constant load of 1.5 Watt per kilogram of body mass ($W \cdot kg^{-1}$), at a frequency of 50 revolutions per minute ($50 \cdot min^{-1}$). In the main phase of the test the load was increased by 25 W every minute until exhaustion. The heart rate (HR) was recorded by a POLAR 810 i™ sport tester (Finland). To assess anaerobic capacity under laboratory conditions, the Wingate Anaerobic Test (WAnT), in the 30-second version, was applied [16]. The subjects performed a test on the lower limbs on a bicycle ergometer «Monark 824 Ergometric» with the load related to body weight: 75 $g \cdot kg^{-1}$. To calculate mechanical indices in the above test, a computer program MCE v2.0 was used [17].

Statistical analyses were conducted using STATISTICA 6.0 PL software by StatSoft. Arithmetic means, standard deviation and correlation coefficients were calculated.

RESULTS

Analysis of the study results showed that the tested athletes achieved the average value of the index (I_{SJFT}) – proving their achievements in SJFT – at the level of 15.2±1.51 (Table 2). The number of throws in the shortest series (A) amounted to 4.7±0.61, while in the 30-second series B the number of throws was 9.3±0.93. A decline was noted in the number of throws in 30-second series C in comparison to the previous series (8.8±0.8). In total, the athletes of the studied group performed 22.9±2.01 throws in the analysed test. The heart rate immediately after completion of the test as well as after 1-minute break was 191±4.8 and 153±10.2, respectively.

The correlation analysis between somatic indices and SJFT indices showed that only one of the indices of the special fitness test (SJFT), namely the heart rate (HR) after 1 minute since the end of the test, significantly correlates with somatic indices. The strongest correlations regarded the HR after 1 minute since the end of the test with: BMI (r = –0.70), FAT level (kg) (r = –0.65), FAT (%) (r = –0.67), FFM (%) (r=0.67) and body height (r = –0.57); at $p<0.05$ (Table 3).

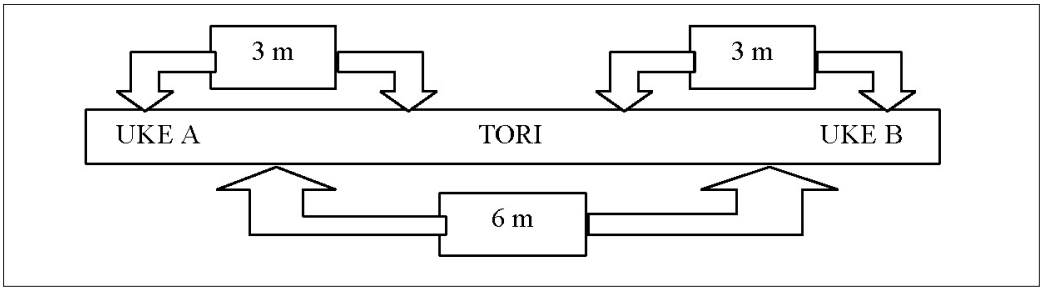

Figure. 1. Initial arrangement of the athletes prior to the start of series A, B, and C of the SJFT test

Table 2. Mean values of SJFT indices (n=14)

Mean values / standard deviation	Number of throws in series A	Number of throws in series B	Number of throws in series C	Number of throws (total)	HR after SJFT [bt·min-1]	HR 1 min after SJFT [bt·min-1]	Index SJFT
M	4.7	9.3	8.8	22.9	191	153	15.2
SD	0.61	0.93	0.8	2.01	4.8	10.2	1.51

Table 3. Correlations between SJFT indices and age and somatic indices (n=14)

SJFT indices	Age (years)	Body height (cm)	Body mass (kg)	BMI (kg·m-2)	FAT (kg)	FAT (%)	FFM (kg)	FFM (%)
Number of throws in series A	–0.24	–0.19	–0.35	0.,04	–0.18	–0.15	–0.13	0.15
Number of throws in series B	–0.08	–0.15	–0.26	0.02	0.02	0.09	–0.30	–0.09
Number of throws in series C	0.28	–0.34	–0.14	–0.31	–0.22	–0.13	–0.36	0.13
Number of throws in series (total)	0.00	–0.26	–0.27	–0.10	–0.13	–0.05	–0.31	0.05
HR after SJFT [bt·min-1]	–0.02	–0.04	0.04	–0.09	–0.15	–0.22	0.10	0.22
HR 1 min after SJFT [bt·min-1]	0.23	–0.57	–0.05	–0.70	–0.65	–0.67	–0.24	0.67
Index SJFT	0.04	0.06	0.26	–0.15	–0.08	–0.16	0.21	0.16

If follows from the obtained data that the absolute value of critical power (W_{cr}) developed at the level of 179±30.8 W, which constituted 3.3±0.49 W·kg^{-1} per kilo of body weight. The maximum absolute value of oxygen consumption reached the level of 2034±260 mL·min^{-1}, which relatively amounted to 37.8±3.1 mL·kg^{-1}·min^{-1}. The average value of the maximal heart rate (HR_{max}) in the stress test "until exhaustion" developed at the level of 192.0±5.6 bt·min^{-1} (Table 4).

Absolute value of mean power ($P_{WAnTmid}$) developed at the level of the 354±55 W, while the relative values (expressed per kilogram of body weight) at 6.50±0.70 W·kg^{-1}. The maximum power (MP_{WAnT}) recorded during WAnT, expressed in absolute terms, reached the value of 431±66 W and in relative terms – 7.98±0.92 W·kg^{-1}. The subjects implemented work (W_{tot}) at 10.61±1.64 kJ, which was 196±21 J·kg^{-1} per kilogram of body weight. Other indices determining the anaerobic capacity, such as the time to obtain the maximum power (TOMP) and time of maintaining the maximum power (TMMP) was also analysed, and their value amounted to 5.66±1.15 s and 3.82±1.13 s, respectively. The value of the index characterising the speed of the decline in power (DP) during the 30-second effort reached 0.161±0.041 W·kg^{-1}·s (Table 5).

The strongest correlations regarded critical power (W_{cr}), expressed in relative values, with the heart rate immediately after completion of the test (r = –0.59) and the relative values of the maximum oxygen uptake ($VO_{2\,max}$) with the sum of throws and

Table 4. Aerobic capacity indices of female judo competitors (n=14)

Aerobic capacity indices	M±SD
VE_{max} (L·min^{-1})	74.9±14.3
$VO_{2\,max}$ (mL·min^{-1})	2034±260
$VCO_{2\,max}$ (mL·min^{-1})	2161±325
$VO_{2\,max}$ (mL·kg^{-1}·min^{-1})	37.8±3.1
$VE{\cdot}VO_2^{-1}$	38.6±7.9
$VE{\cdot}VCO_2^{-1}$	36.9±3.8
RQ	1.11±0.14
HR_{max}	192.0±5.6
$O_2{\cdot}HR^{-1}$ (mL)	10.7±1.4
W_{cr} (W)	179±30,8
W_{cr} (W·kg^{-1})	3.3±0.49

Table 5. Anaerobic capacity indices of female judo competitors (n=14)

Anaerobic capacity indices	M±SD
$P_{WAnTmid}$ (W)	354±55
$P_{WAnTmid}$ (W·kg^{-1})	6.50±0.70
W_{tot} (kJ)	10.61±1.64
W_{tot} (J·kg^{-1})	196±21
MP_{WAnT} (W)	431±66
MP_{WAnT} (W·kg^{-1})	7.98±0.92
DP (W·kg^{-1}·s)	0.161±0.041
TOMP (s)	5.66±1.15
TMMP (s)	3.82±1.13

Table 6. Correlation coefficients of efficiency test and SJFT among female judo competitors (n=14)

Wskaźniki SJFT	$VO_{2\,max}$ (mL·kg^{-1}·min^{-1})	W_{cr} (W)	W_{cr} (W·kg^{-1})	$P_{WAnTmid}$ (W·kg^{-1})	W_{tot} (J·kg^{-1})	MP_{WAnT} (W·kg^{-1})	TOMP (S)
Number of throws in series A	0.50	0.08	0.19	0.35	0.35	0.36	–0.06
Number of throws in series B	0,51	0.09	0.21	0.39	0.40	0.37	–0.06
Number of throws in series C	0.51	–0.04	0.22	0.48	0.48	0.47	–0.28
Number of throws in series (total)	0.54	–0.02	0.16	0.43	0.43	0.47	–0.09
HR after SJFT [bt· min^{-1}]	–0.35	–0.52	–0.59	0.21	0.21	0.28	–0.41
HR 1 min after SJFT [bt·min^{-1}]	0.21	–0.20	0.16	0.33	0.33	0.20	–0.08
I_{SJFT} (Index)	–0.53	–0.20	–0.26	–0.39	–0.39	–0.44	0.03

with the value of the SJFT index: (r = 0.54) and (r =-0.53), respectively at $p<0.05$. No statistically significant correlations between WAnT indices and indices diagnosing the level of special physical fitness were found

DISCUSSION

A solution to the research problem of this study demanded not only determining the level of special exercise potential, the level of aerobic and anaerobic capacity but also examining correlations between them and between the somatic indices and the SJFT indices.

The results of correlation analysis between somatic indices and achievements in SJFT permit declaring that in the studied group of judo athletes lower values of body height, FAT [kg], FAT [%], and higher values of FFM [%] correspond to lower values of the heart rate (HR) after 1 minute since completion of the test, which suggests slower recovery after a specific workload connected with performing the test. Similarly, in a group of 16-18-year-old athletes, who were at the stage of directed training, the strongest correlations regarded the heart rate (HR) after 1 minute since the end of the test with body height (r = -0.54), BMI (r = -0.54), FAT [kg] (r = –0.56), and the sum of throws in three series of the test with the body height (r = –0.58) [18]. The correlation aspect of morphological determinants with sports activity of Polish national judo representatives was the subject of research by Jagiello et al. [19].

The index value indicates the level of achievements in SJFT. Greater achievements in the test correspond to a lower value of the index. Female athletes of the studied group obtained the index value of 15.2±1.51 and thus much higher than Brazilian athletes preparing to the Pan-American Games 12.62±1.48 [20], while the Polish athletes 12.6±0.69 [21] and 13.23±1.54 [22].

The ability to perform a large number of throws in a short time mainly depends on the efficiency of anaerobic metabolism, while the recovery value of the HR is associated with aerobic metabolism [23].

In the analysis of values of selected aerobic capacity indices, it was found that the tested female athletes obtained definitely lower values of $VO_{2\,max}$ (37.8±3.1 mL·kg^{-1}·min^{-1}) compared with the research results by Borkowski et al. [24] – 48.6±8.6 mL·kg^{-1}·min^{-1} (the subjects' age 22.1±3.2) and compared with athletes of the Olympic team – 51.8 mL·kg^{-1}·min^{-1} [11]. The results of own research were also lower compared to the results of studies on athletes of another sport discipline (15-16-year-old female foil fencers), who in terms of the maximum oxygen uptake achieved 40.10 mL·kg^{-1}·min^{-1} [25].

The observed difference can be explained by the fact that although the studied athletes, being at the stage of comprehensive training, are indeed predisposed to aerobic work, it is only later with age that an ability appears to withstand work requiring a demonstration of maximum strength and endurance during efforts of an aerobic character [6].

The values of anaerobic capacity indices proved lower in comparison to the results of tests carried out in groups of older athletes, especially in the case of maximum anaerobic power, being a measure of human ability to perform work of supramaximal intensity whose values in the test group were at the level of 7.98±0.92 $W \cdot kg^{-1}$. The mean value of the maximal anaerobic power in Borowski's et al. research [24] was established at the level of 10.3±1.2 $W \cdot kg^{-1}$ (the athletes' age of 22.1±3.2), while in Laskowski's research [11] at 10.9 $W \cdot kg^{-1}$ (the athletes' age being 24.3±2.3). The obtained values of maximal power were lower compared to the values obtained for 15-16-year-old foil fencers (8.2±1.0) [25], 16-18-year-old sprinters 9.72±0.66 [26] and higher than the results obtained by the 14-15-year-old swimmers 7.75±0.94 [26].

Clearly lower mean values of total work (W_{tot}), often considered to be a measure of overall anaerobic capacity (or colloquially called "speed endurance") have also been observed. Laskowski's research [11] showed that during the 30-second test judo athletes of the female Olympic team performed work at the level of 238.8-255.0 $J \cdot kg^{-1}$, compared to the present results of 196±21 $J \cdot kg^{-1}$. The obtain study results were similar to the results achieved by the 14-15-year-old swimmers 194.08±20.47 [26] and lower than the results of tests in a group of 16-18-year-old sprinters 243.3±13.2 [26] and 15-16-year-old foil fencers 207.2±23.1 [25].

Significantly lower values of indices characterizing anaerobic capacity in the studied group of female athletes can be explained by the fact that the adaptation to efforts based on anaerobic metabolism increases with age [26]. Szczęsna-Kaczmarek's et al. [27] research showed that the maximum anaerobic power is lower in children than in adults. This is confirmed by Ziemann and Garsztka's research [28], who recorded lower values of parameters characterizing anaerobic capacity in younger groups of athletes.

The study also searched for correlations between results obtained in SJFT and results of laboratory tests. Test results revealed a moderate correlation of SJFT indices with indices characterising aerobic capacity and the lack of statistically significant correlations with WAnT indices. The study of relationships between the results of laboratory tests and indices diagnosing the level of special physical fitness in the group of athletes at the stage of directed [18] and special [21] training demonstrated an increase in the number and strength of these correlations together with the increase in the level of sports mastery. In the seniors group, the above correlations mainly regarded the relative values of indices characterizing aerobic and anaerobic capacity (9 strong and 9 moderate correlations).

CONCLUSIONS

The stage of judo training significantly differentiates certain adaptive effects. Judo athletes who are in comprehensive (initial) training are inferior in special fitness and in the level of aerobic and anaerobic capacity to athletes who continue training judo at the directed and the special stage. Also the correlation of indices of special fitness and aerobic capacity is lower in judo beginners, and there are no significant correlations with anaerobic capacity indices. Therefore, although the statement that a female judokas reveal relatively high aerobic and anaerobic capacity and are distinguished by special fitness tests results already at the stage of comprehensive (initial) training seems a bit far-fetched, these indices on the whole can be a useful criterion to predict success in a long-term sports career.

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