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COACHING

Beata Wolska[1(ABCDEF)], Marek Adam[1(ABCDEF)], Amel Mekic[2(DEF)]
[1]University of Physical Education and Sport, Department of Combat Sports – Gdansk (Poland)
[2]Faculty of Sport and Psychical Education, University of Sarajevo – Sarajevo (Bosnia and Herzegovina)
Correspondence: Beata Wolska, AWFiS, University of Physical Education and Sport,
80-336 Gdansk, ul. Kazimierza Gorskiego 1, e-mail: beata.wolska@wp.pl
Co-author: Adam Marek, Prof. AWF, University of Physical Education and Sport,
80-336 Gdansk, ul. Kazimierza Gorskiego 1,
e-mail: awfadammarek@wp.pl

The correlation of general and special physical fitness indices with somatic indicators in 16-18-year-old female judokas

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Key words: stage of training, physical preparation, body composition, women's judo

Abstract
Background.The purpose of this work was to determine the correlation between the indexes of general and special physical preparedness with the age-somatic parameters of 16-18-year-old female judo competitors (stage of directed training) during preparation to the competitive period.
Material/Methods. Fifteen female judo competitors participated in the study- all of them were representatives of Poland in the category of juniors and regional team of Pomerania. Their average age was 16.8±0.7 years, and their athletic experience was 7.2±42.5 years. To determine somatic features - body mass and body components: FAT (kg), FAT (%), FFM (kg), FFM (%), TBW (kg), TBW(%) the Body Composition Analyser was used. To assess general physical preparedness the standard IPFT test was used. The level of athletes' special physical preparedness was assessed by Sterkowicz test (SJFT) and Igumienow test.
Results. The female judo competitors who had lower body weight, smaller absolute and percentage values of the fatty component perform better in all running tests of IPFT. Of the power performance test, the IPFT index showed a statistically significant correlation with their somatic characteristics. In this case female athletes who had a smaller body height and a lower BMI showed the best results. It should also be noted that in this group of competitors 8 correlation coefficients between SJFT indexes and somatic characteristics were revealed, whose values ranged from 0.53 to 0.58 ($p>0.05$). Also 7 cases of correlations between somatic indicators and the Igumienow test indicators, whose values were in the range of-0.52 to 0.64 ($p>0.05$), have been observed.

Introduction

A training process has many components. They interact in a variety of ways creating a certain structure. We understand it as an internal organization of the entire process, a system of basic elements and the links between them, as well as the principles and ways of a hierarchical structure [Platonov, Sozanski 1991:5]. Due to the complexity, the multilayered structure and the temporal scale, Platonov and Sozanski [1991] view the training processstructure in two aspects: the material one (fitness, technical, tactical, mental and theoretical preparation) and the temporal one (stages, periods, macro-, meso-, and microcycles, training units) [Platonov, Sozanski 1991].

In the process of training athletes with a high level of preparation, a prominent place is given to general and special physical preparation. In sports theory and practice, it is believed that the general and special physical preparation is an inherent condition of the development of motor skills being one of the most important factors that determine the effectiveness of athletes' training and competitive activity [Matwiejew 1999; Kalina 2000]. General physical preparation is focused on increasing the functional capacity of an organism, its comprehensive development and mastering a variety of movement habits. Beside health, physical conditions and mental traits, it is the basis of any special performance. On the other hand, special physical preparation is targeted at the development of motor skills which are closely connected with the requirements of a particular sport discipline.

Somatic composition is one of the components of physical fitness and plays an important role in shaping

the motoric structure. According to Szopa [1985], body tissue composition, as a significant element of morphological composition, determines the current and potential motor skills.

In the available literature extensive information on determiningjudo athletes' body composition has been collected [Jagiello 2008; Orkwiszewska, Smaruj, Adam 2006]. Defining judokas' general body composition and tissue composition, determining the degree of dimorphic differentiation of somatic traits in top-class judokas [Orkwiszewska, Smaruj, Laskowski 2006; Franchini *et al.* 2011] and searching for the relation between body composition and the applied techniques [Marachocka 1988] have also been subject to research.

Unfortunately, the available literature does not provide enough information on the relationship between general and special physical fitness indices and somatic indicators of female judokas who are at the directed stage of training.

Therefore, the problems related to determining the properties of body composition and the level of general and special fitness as well as the search for correlations between them are of particular importance in both the cognitive and the applicatory aspect. The hitherto collected information does not satisfy the needs related to knowing the essence of the analyzed phenomena, particularly in the group of female judokas at the directed stage of training.

Hence the purpose of the study was to determine the relationship between general and special physical fitness indices and somatic indicators in 16–18-year-old female judokas.

Bearing in mind the objective of the study, it was considered necessary to obtain answers to the following research questions:

1. What level of general and special effort capabilities is presented by 16–18-year-old female judokas?
2. What are the relationships between the selected somatic composition indicators and the general and special physical fitness indices?

Material, methods

Fifteen female judokas aged 16–18 years (the directed stage of training), Polish representatives in the juniors category and representatives of the provincial team were subject to research. The subjects'mean age was 16.8 years (SD±0.7), and the average training experience was 7.2 years (SD±2.5). The research was conducted at the Combat Sports Department and at the Laboratory of Functional Diagnostics at Gdansk University of Physical Education and Sport (AWFiS) during the preparatory period, in which the athletes did not regulate their body weight. All athletes had current sports medical certificates. Written consent was obtained from the athletes and parents of underage athletes to participate in the tests.

The somatic characteristics were based on body height and on indicators characterizing its mass and composition. Body weight and body composition of the adipose tissue (FAT), fat-free body mass (FFM) were measured with a Tanita Body Composition Analyzer TYPe TBF-410 MA III. The Quaetelet II index (BMI) [$kg \cdot m^{-2}$] was also calculated (Table 1).

To assess the general physical preparedness a standard test (IPFT) was used: running at 50 m (s), standing long jump (cm), running at 800 m (s), carpal dynamometry of the dominant hand (kg), time of flexed-arm hang(s), shuttle run 4x10 m (s), sit up from the supine position for 30 (s), sit and reach (cm).The test was conducted within two days. Performance assessment in trials from first to third was conducted on the first day. Trials from the fourth to the eighth one were made on the second day. The conversion of results obtained in particular trials were made on the basis of tables for groups of the calendar age [Pilicz *et al.*, 1999].

To assess special exercise capabilities, the Special Judo Fitness Test (SJFT) [Sterkowicz 1995] was used. It consists of three periods or work: 15 s (series A), 30 s (series B), 30 s (series C), separated by 10 s intervals. During each effort the subject's task was to execute as many *seoinage* throws on two partners from the same weight category and with a similar body height, standing 6 meters apart, while the examined athlete was in the middle between them. Directly after on completion of series C and 1 minute after the end of the test, the heart rate (HR) was measured, for which a sport-tester POLAR 810 i™ (Finland) was used. In addition, the number of throws in each series and the sum of throws were registered. On the basis of the results the index was calculated:

To assess the subjects' special exercise capabilities also another test was used [Igumienow *et al.*, 1987].

Table 1. The somatic indexes of female judo competitors (n = 15)

	Indices								
Statistics	Height (cm)	Weight (kg)	BMI	FAT (kg)	FAT (%)	FFM (kg)	FFM (%)	TBW (kg)	TBW (%)
M	165.3	64.8	23.6	15.4	23.3	49.4	76.7	36.1	56.1
SD	±7.8	±11.2	±2.9	±5.4	±5.5	±7.4	±5.5	±5.4	±4.0
BMI – body mass index, FAT – body fat, FFM - fat-free body mass, TBW – total body water									

The test consisted of three periods of work, separated by 1-minute breaks. During each test series the subject's task was to execute 15 *seoinage* throws in the shortest possible time. The throws were performed with three partners from the same weight category, positioned one after another. Before the first throw of each series the athletes were lined up against each other shoulder length apart, in a preparatory position to perform *seoinage*. Each test series started with a command *hajime* (forward) and completed on command *mate* (a command interrupting the fight, exercise). During the test, the time of executing 15 throws of each series, the sum of times of all series, the heart rate (HR) directly after the effort, and after 1 minute from the end of the effort were registered. To determine the test results, the sum of times from the three series of throws was included.

The "STATISTICA 7.0 PL" computer program was used for the mathematic-statistical data processing: average mean (M), standard deviation (SD), correlation coefficient (r).

Results

As it is evident from the presented data, the sum of all points in the IPFT test amounted to 490.6 pts, which according to valuation regulation of the specified test is regarded as an index of high total preparedness (in accordance with the grading scale of this test, the values of 481 pts and above are considered as high) (Table 2). An analysis of tests results showed that the examined female competitors achieved the mean value of the index (SJFT) – confirming achievements in SJFT – at the level 14.4±1.26 (Table 3). The number of throws in the shortest series (A) was 5.8±0.38, whereas in the 30-second series B the number of throws was 8.9 ±0.83. A decrease in the number of throws in 30-second series C in comparison to the previous series (8.03±1.03) was observed. Altogether female competitors of the examined group performed 22.1±1.92 throws in the analyzed test. The heart rate directly after finishing the test as well as after 1 minute break was 181±10.6 and 137±10.8, respectively (Table 3).

Table 2. The indexes of general physical preparedness of female judo competitors in the IPFT test (n=15)

Statistics	Indexes																
	Running at 50 m [s]		Standing long jump(cm)		Running at 800 m (s)		Carpal dynamometry of dominant hand (kg)		Time of flexed-arm hang (s)		Shuttle run 4x10 m (s)		Sit upfrom the supine position-for30 (s)		Sit and reach (cm)		Σ pts IPFT
	s	pts	cm	pts	s	pts	kg	pts	s	pts	s	pts	amount.	pts	cm	pts	
M	8.13	59.5	192	61.1	210.9	57.9	32.7	61.8	15.3	55.1	10.9	6.,1	30.9	71.0	15.7	59.1	490.6
SD	±0.55	±7.8	±17.3	±8.2	±27.8	±8.2	±6.4	±12.6	±11.9	±9.7	±0.51	±4.5	±4.3	±11.3	±6.1	±10.9	
The integral index of IPFT general physical fitness, Σ pts IPFT (sum of points).																	

Table 3. The indexes of special physical preparedness of female judo competitors in the SJFT test (n=15)

Statistics	Indexes						
	Amount of throws in series A	Amount of throws in series B	Amount of throws in series C	Sum of throws in three series	HR immediately after series C [bt·min^{-1}]	HR after 1 min rest after series C [bt·min^{-1}]	Index $_{SJFT}$
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
Throws - number of throws completed during the test, HR - heart rate registered immediately after the test; and heart rate obtained 1 minute after the test.							

Table 4. Igumienow test indicators (n = 15)

	Indicators					
	Time of 15 throws in series A [s]	Time of 15 throws in series B [s]	Time of 15 throws in series C [s]	Sum of times A,B,C [s]	HR immediately after series C [bt·min^{-1}]	HR after 1 min rest after series C [bt·min^{-1}]
M	25.0	24.3	23.4	72.8	178	132
SD	±4.1	±3.6	±3.4	±10.4	±10.6	±11.7
Time – the time of executing the given number of throws, HR the heart rate registered immediately after the test; and the heart rate obtained 1 minute after the test.						

Table 5. The correlation matrix (coefficients *r*), reflecting the relationship of general and special physical preparedness indexes of female judo competitors with their age-somatic characteristics (by dense type marked the correlation coefficients, the level of significance which $p < 0,05$) (n=15)

Indexes		Age-somatic characteristics								
		Age	Height	Weight (kg)	BMI	FAT (kg)	FAT (%)	FFM (kg)	FFM (%)	TBW (kg)
Test IPFT	Running at 50 m	0.33	**0.62**	0.39	**0.53**	0.48	0.28	**0.58**	-0.28	**0.58**
	Long jump	-0.22	**-0.63**	-0.12	**-0.73**	-0.49	-0.26	**-0.60**	0.26	**-0.60**
	Running at800m	0.26	**0.68**	0.28	**0.71**	**0.67**	0.48	**0.55**	-0.48	**0.55**
	Hand dynamometry	-0.05	0.48	0.11	**0.57**	0.41	0.28	0.43	-0.28	0.43
	Holding time of hang	0.17	**-0.54**	-0.06	**-0.68**	**-0.69**	**-0.64**	-0.31	**0.64**	-0.31
	Shuttle run 4x10m	0.17	**0.78**	0.40	**0.73**	**0.73**	0.50	**0.66**	-0.50	**0.66**
	Sit up 30 s	-0.00	**-0.72**	**-0.60**	**-0.56**	**-0.68**	**-0.52**	**-0.59**	**0.52**	**-0.59**
	Sit and reach	-0.33	-0.20	0.08	-0.31	-0.18	-0.07	-0.18	0.07	-0.18
Test SJFT	Series A	0.28	-0.51	-0.29	-0.43	-0.42	-0.21	-0.47	0.21	-0.47
	Series B	-0.43	-0.50	-0.47	-0.29	-0.30	-0.03	**-0.55**	0.02	**-0.54**
	Series C	-0.12	-0.49	-0.47	-0.29	-0.51	-0.36	-0.37	0.36	-0.37
	Sum of three series	-0.20	**-0.58**	-0.51	-0.37	-0.48	-0.25	**-0.53**	0.25	**-0.53**
	HRimm after series C	-0.25	-0.33	-0.25	-0.27	-0.31	-0.21	-0.28	0.21	-0.28
	HR after 1 min rest	-0.08	**-0.54**	-0.29	**-0.54**	**-0.56**	-0.42	-0.41	0.42	-0.41
	I_{SJFT}	0.08	0.34	0.39	0.11	0.21	0.02	0.36	-0.02	0.36
Igumienow Test	Time of throws in ser.A	-0.23	0.35	0.41	0.14	0.38	0.27	0.26	-0.27	0.25
	Time of throws in serB	-0.27	0.49	0.41	0.33	**0.56**	0.45	0.33	-0.45	0.33
	Time of throws in ser.C	-0.17	**0.56**	0.43	0.41	**0.64**	**0.52**	0.38	**-0.52**	0.38
	Sum of times A, B,C	-0.23	0.47	0.44	0.29	**0.53**	0.41	0.32	-0.41	0.32
	HR after effort	0.24	-0.20	-0.24	-0.06	-0.27	-0.28	-0.10	0.28	-0.10
	HR after 1 min rest	0.15	-0.18	-0.41	0.11	-0.13	-0.02	-0.18	0.01	-0.18

BMI – body mass index, FAT – body fat, FFM - fat-free body mass, TBW – total body water,
HR - heart rate registered immediately after the test; and the heart rate obtained 1 minute after the test.

It follows from the data presented in Table 4 that the time of executing15 throws in each successive series of test was shorter: from 25±4.1 (s) in series A to 23.4±3.4 (s) in series C.

From analysis of the collected data it follows that only 6 of the correlation coefficients revealed the existence of very high relationships ($r \geq 0.7$) between the studied indicators. The above correlations were observed mainly between the International Physical Fitness Test indicators and somatic indicators (Table 5).

Results of the *50 m run* test highly correlated ($0.5 \leq r < 0.7$) with body height (r = 0.62) as well as with fat-free body mass (FFM) and total body water (TBW) expressed in (kg) respectively (r = 0.58); (r = 0.58); at $p < 0.05$ (Table 5).

Results of *800 m run* test the most strongly correlated with: body height (r = 0.68), BMI (r = 0.71), FAT (kg) (r = 0.67); all at $p < 0.05$ (Table 5).

An interesting and the strongest correlation is between the results of the *4x10 m run*trial and the body height (r = 0.78); BMI (r = 0.73), FAT (kg) (r = 0.73); at $p < 0.05$. A high correlation was also found between results of the *4x10 m run* trial with the level of FFM (kg) (r = 0.66) and TBW (kg) (r = 0.66); at $p < 0.05$ (Table 5).

Also significant correlations were observed between IPFT strength trials and certain somaticindicators. The results of the *standing long jump* trial negatively correlated with: body height (r = -0.63), BMI (r = -0.73), FFM (kg) (r = -0.60), TBW (kg) (r = -0.60); at $p < 0.05$ (Table 5).

A similarly negative correlation was observed between the results of *lying sit-ups* trials and: body height (r = -v0.7), body weight (r = -0.60), FAT (kg) (r = -0.68), FFM (kg) (r = 0.59), TBW (kg) (r = -0.59); at $p < 0.05$.

Correlations of the results of relative strength measurement (*flexed arm hang*) also proved significant with: BMI (r = -0.68), FAT (kg) (r = -0.69), FAT (%) (r = 0.64); at $p < 0.05$. A different, positive correlation was observed between the results of the *flexed arm hang* trial and: FFM (%) (r = 0.64), TBW (%) (r = 0.64); at $p < 0.05$.

Analysis of relationships between indices of special physical fitness trialsand somatic indicators revealed definitely fewer statistically significant correlations and of a smaller magnitude of relationship than in the case of IPFT. The strongest correlations regarded the sum of throws of the three series of SJFT with body height (r = -0.58) and the time of executing 15 throws in series C of the Igumienow test with the level of the adipose tissue (FAT (kg)) (r = 0.64) and body height (r = 0.56); at $p < 0.05$ (Table 5).

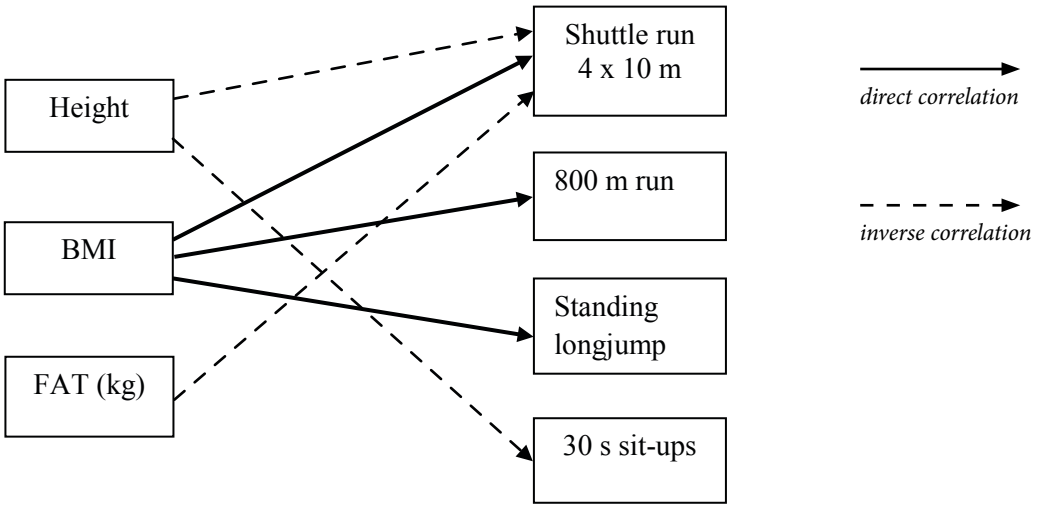

Figure 1. Interrelations indicating a high degree of correlation (r≥0.7) between individual somatic indexes and indexes in tests of general and special preparedness of the female judo competitors (n=15).

The features of interactions indicate a high degree of correlation (r≥0.7) between individual somatic indexes and the indexes in tests of general and special physical preparedness in this group of subjects are shown in Fig. 1.

Discussion

One of the major factors determining the efficiency of sporting activity is fitness preparationwhose nature and level result from the development, shaping and improvement of motor skills [Raczek 1988; Platonov 1997]. Sikorski *et al.* [1987] and Thomas *et al.* [1989] suggested that some physical fitness and anthropometric variables are considered requisites for high performance in judo competition.

Solving the research problem of this study involved not only determining somatic characteristics, the level of general and special physical fitness but mainly examining the relationships between them. The results of the IPFT showed that, in accordance with the point brackets, the sum of points obtained by the studied judo athletes (490.6 points) can be assessed as an indicator of high general physical fitness. The results of a correlative analysis between somatic indicators and achievements in IPFT validate a statement that 16–18-year-old female judokas, characterized by a taller body and a higher content of fat and fat-free tissue achieved worse results in running trials. The results of the above study also showed that in contrast to running trials, the studied female athletes with a shorter body height and a lower level of fat-free body mass and total body water obtained better results in IPFT strength trials.

The level of achievements in the SJFT is proved by the value of the index. According to the test author, lower values of the index indicate greater achievements [Sterkowicz 1997]. The ability to execute a large number of throws in a short period mainly depends on the efficiency of anaerobic metabolism, while the value of HR at rest is associated with aerobic metabolism [Sterkowicz, Franchini 2006]. HR reduction at the end of the test with a given number of throws testifies to the cardiovascular efficiency, and reduction of the same indicator after 1 minute since the end of the test proves better restitution and improvement in aerobic capacity [Franchini *et al.* 1999]. The examined athletes obtained the index value at 14.4±1.26. In Sogabe's *et al.* Study [2015] on Japanese athletes (age 17.2±2.3 years), the index value was 12.50±1.30; in studies of Serbian athletes [Drid *et al.* 2009] the index value amounted to 11.30±1.00, and among representatives of Poland in the group of seniors it was 12.6±0.69 [Smulskij *et al.* 2011].

The results of the special fitness test (SJFT) obtained by Drid *et al.* [2009] concerning the mean group indices of the heart rate immediately after completion of the test showed similar values than in the presented study and were 184±5.0 Also a similar value of the heart rate immediately after completion of the test was also observed in the case of Japanese athletes and it amounted to 182.3±7.2[bt·min^{-1}], while HR after 1 minute since the end of the test was 152.1±12 [bt·min^{-1}] [Sogabe *et al.* 2015].

Escobar-Molina *et al.* [2012] showed that the examined competitors in the junior group in SJFT received the index value at the level 13.32±1.44 and the heart rate directly after completion of the test and after a minute of rest was 187±5.0 and 162±15, respectively. In accordance with the classification by Sterkowicz-Przybycien and Fukuda [2014], the investigated by us athletes received level – poor in relation to the sum of throws and the values of the SJFT index, while in relation to the heart rate immediately after completion of the test and after a

minute of rest, respectively: regular and good. A reference to the classification by Sterkowicz-Przybycen and Fukuda [2014] is valid mainly due to the level of sports proficiency and the numbers of subjects in the test groups and the age category.

The results obtained in the study referring to SJFT can also be compared to achievements of female ju jitsu athletes,as a large part of the combat elements are elements of judo [Kano 1986; http://www.jjeu.eu/). Research of Sterkowicz-Przybycien *et al*. [2014) showed that the examined ju jitsu athletes achieved the index value of 13.84±2.60 in the SJFT, while the heart rate immediately after completion of the test was 191±27 [bt·min^{-1}] and after one minute since the end of throws it was 153.3±25.4 [bt·min^{-1}]. Analysis of the relationship between special physical fitness test indices and somatic indicators revealed the existence of a much fewer statistically significant correlations and of a smaller magnitude than in the case of IPFT. It was found that 16–18-year-old judo athletes with shorter body height executed in total a greater number of throws in the SJFT test, and athletes with a higher content of the adipose tissue needed more time to execute the given number of throws in the Igumienow test.

Analyzing the relationship between general and special physical fitness indices and somatic indicators pointing to a very high level of correlation ($0.5 \leq r < 0.7$), it was observed that in a group of athletes of the highest level of sports mastery the number of analyzed correlations is much higher (28 cases) [Smulskij *et al*. 2011], and in the case of this study on 16–18-year-old female judokas there were only six cases.

Summary / Conclusions

The examined athletes aged 16-18 years were characterised by high indexes of general physical fitness, which proves that judo is an appropriate measure to stimulate the comprehensive physical development of youth. Definitely lower values of indexes defining the special fitness level in comparison to athletes from the seniors group can demonstrate that long-term judo training develops specific motor properties at a high level.

Presumably, the results of this study may be useful in two respects. On the one hand, they may be considered from the perspective of their importance in the selection process, carried out both as part of selection and sports orientation and as part of particular weight categories at a later stage of long-term sports training. On the other hand, they may be considered from the perspective of corrections in the individual level of somatic indicators, such as, for example body weight, BMI, FAT%, FFM% in order to increase the level of general and special physical fitness in judo athletes.

This kind of approach to the studied issues will allow for a more detailed exploration of the mechanisms shaping and increasing the level of general and special fitness, and it can also be used as a basis for further theoretical justification of optimization of the training process of judo athletes at various stages of their long-term preparation.

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Współzależność wskaźników sprawności fizycznej ogólnej i specjalnej ze wskaźnikami somatycznymi 16-18 letnich zawodniczek judo

Słowa kluczowe: etap szkolenia, przygotowanie fizyczne, struktura masy ciała, judo kobiet

Abstrakt

Wprowadzenie. Celem niniejszej pracy było określenie zależności między wskaźnikami sprawności fizycznej ogólnej i specjalnej a wiekiem i wskaźnikami somatycznymi 16-18 letnich zawodniczek judo (etap szkolenia ukierunkowanego) w okresie przygotowawczym do zawodów sportowych.

Materiał i metody. W badaniach uczestniczyło piętnaście zawodniczek judo – reprezentantki Polski juniorek oraz kadry wojewódzkiej Pomorza. Średnia wieku badanych wyniosła 16.8 ±0.7 lat, a średnia stażu treningowego – 7.2±42.5 lata. Masę ciała oraz skład ciała w postaci tkanki tłuszczowej: FAT_{kg}, $FAT_{\%}$, FFM_{kg}, $FFM_{\%,}$ TBW_{kg}, $TBW_{\%}$ zmierzono przy użyciu analizatora Tanita Body Composition Analyzer. Do oceny sprawności fizycznej ogólnej wykorzystano standardowy test MTSF. Poziom przygotowania specjalnego badanych zawodniczek oceniono za pomocą Special Judo Fitness Test (SJFT) i testu Igumienowa.

Wyniki i wnioski. Zawodniczki, charakteryzujące się większą wysokością ciała, a także wyższą zawartością tkanki tłuszczowej i beztłuszczowej, osiągały gorsze wyniki testów biegowych. Wyniki badań wykazały również, że w odróżnieniu od prób biegowych, badane zawodniczki, charakteryzujące się mniejszą wysokością ciała oraz niższym poziomem beztłuszczowej masy ciała i zawartością wody w organizmie, uzyskiwały lepsze wyniki w próbach siłowych MTSF. Stwierdzono, że 16-18 letnie zawodniczki charakteryzujące się mniejszą wysokością ciała, wykonywały w sumie większą liczbę rzutów w teście SJFTa zawodniczki o wyższym poziomie tkanki tłuszczowej potrzebowały więcej czasu na wykonanie zadanej ilości rzutów w Teście Igumienowa**.** Zaobserwowano również 8 współczynników korelacji między wskaźnikami SJFT a wskaźnikami somatycznymi, których wartości znajdowały się w przedziale 0.53 to 0.58 ($p>0.05$) oraz 7 przypadków współzależności między wskaźnikami somatycznymi a wskaźnikami testu Igumienowa, których wartości znajdowały się w przedziale -0.52 do 0.64 ($p>0.05$).