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The effects of kyokushin karate training on the anthropometry and body composition of advanced female and male practitioners

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Summary

Introduction. The aim of the study was to assess the effects of 4 months of karate training on the body composition of advanced males and females and its comparison from the preparatory and start period with the results of a control group.

Material and methods. The study covered 18 kyokushin karate contestants (9 females, 9 males) from a Polish karate kyokushin club (R – research group), mean age of 22,8±4,9 years (18-33), mean BMI of 23,3±2,20 [kg/m^2] (19,6-27,5), mean number of years of experience of 8,3±3,36 years (5-16) and 20 individuals (10 males, 10 females; C - control group) - performing up to 1 hour of physical activity per week, mean age of 24,5±3,39 years (22-33), mean BMI of 24,1±2,71 [kg/m^2] (20,4-29,8). Two measurements of the body composition of athletes were made with the use of: OMRON BF 306 and BODYSTAT 1500 devices.

Results. The study results show no statistically significant change in body composition in women who participate in kyokushin karate training between the first and second measurement ($p>0,05$), in turn, such changes were demonstrated in men when analyzed by BODYSTAT 1500: the percentage of fat mass was lower and fat free mass was higher after preparation period ($p<0,01$) and the percentage of total body water was higher ($p<0,05$). Anthropometric characteristics of athletes surveyed in both preparation and start periods show no significant differences ($p>0,05$).

Conclusions. Anthropometric factors, type of body building, body mass index and body composition are all of great importance in a highly qualified sport like the karate. However, the large number of measurement tools, questionable repeatability of tests conditions and differences found between the sexes or ethnic discrepancies makes the evaluation and comparison analyzes of selected anthropometric indices and body composition rather difficult.

Introduction

The physical requirements put before contemporary athletes are rigorous and strictly defined and only an elite few possess the physical capacity and preparation to succeed. These requirements are mostly related to the construction of the physical body, the athletes motor, tactical and psychological skills; all of which determine the level of sports achievement obtained or the desired sport result [1,2]. Significant impact on the athlete's potential capacity has his physique, whereas the body composition (for example fat free mass FFM, adipose tissue – fat mass FM, total amount of body water TBW) determines the level of achievements in many sports. Training regimes used in sport, including martial arts like kyokushin karate, affect the parameters of individuals' cardio-respiratory and musculoskeletal system, body weight and especially body composition. Body composition assessments are widely used in sports and recreation centers as well as in fitness facilities, gyms, clinics, hospitals, medical and dietary research centers and help to determine the level of body fat and lean tissue in the body. There are many methods of determining body composition, including: bioelectrical impedance analysis (BIA), X-ray absorptiometry (DEXA), computed tomography (CT), magnetic resonance imaging (MRI), ultrasounds and isotopic methods [3,4,5]. The usefulness of these methods in sport diagnosis is unquestionable, however, for economic reasons using them on daily basis is severely limited. Due to this limitation, methods of body composition examination such as bioelectrical impedance (BIA), which is fast, noninvasive, reproducible and reliable while requiring little financial commitment, have become very popular [4]. Analysis of the body composition allows to control changes in body weight while preparing for competitions and also defines the content of fat, lean tissue and water in the body thus allowing to control changes in the training process. It gives the opportunity to monitor the resting metabolism, which in turn helps to specify daily energy expenditure.

It was hypothesized that kyokushin karate training and additional physical activity practiced by advanced athletes will result in alternation of their body composition.

Taking into account the characteristics of the preparatory and start period, it was assumed that the results of the second measurement of the body composition will significantly differ from the fist measurement made 4 months earlier, showing a significant reduction of body fat and increase in lean tissue. It was also assumed that changes in body composition will be accompanied by differences in body water content (increase in the value of total body water) and lower values of tissue resistance.

It was assumed as well that the research group will be significantly different from the control group in the analyzed parameters, both during the preparatory and start period.

The aim of the study was to assess the impact of 4 months of karate training on athletes' body composition and to compare the body composition of kyokushin karate athletes with those from the control group. This research attempts to answer following questions:

1. Does kyokushin karate training significantly alter the athletes body composition?
2. What are the differences in body composition of karate athletes and individuals from the control group?
3. Is there a relationship between the body composition and age, training experience, the overall level of physical activity of kyokushin karate athletes in the research group?

Material and methods

The research group (R) consisted of 18 individuals (9 women, 9 men) - athletes (age range 18-34) training in Kyokushin Karate Club section from Gliwice. The control group (C), consisted of 20 people (10 women, 10 men), whose physical activity in leisure time was limited to maximum of 1 hour per week (walking).

All subjects' anthropometric parameters and body composition were measured by the bioelectrical impedance method. Two devices were used – BOSYSTAT 1500 and OMRON BF 306. The first method included the measurement with the use of tetrapolar electrode placement in supine position, immediately after the 10-minute rest period. During the second one the subject stood with his arms flexed at 90 degrees and held the measuring device in both hands.

Anthropometric parameters and body composition of R group were compared with non -training women and men from the C group. The comparison for the R group was done between the results of the preparatory and start period.

We also analyzed the correlation of changes in body fat [%] with age [year], training experience [year] and general physical activity [h/week].

Basic statistical methods, the *t*-Student *test* of significance of differences between groups and Pearson's correlation analysis were used. For all statistical analysis the *Statistica 9.0* software was used, assuming a level of $p<0,05$ as statistically significant. The results were presented in tables.

Results

Basic anthropometric data characterizing the research and control groups were shown in tables 1. and 2.

Table 3. presents a comparative analysis of the mean values of anthropometric parameters analyzed in the R group of females during the preparatory and start period. In this group, after 4 months of training there was some increase in body mass index, but the waist circumference mean value was reduced. These differences proved not to be statistically significant.

Table 4. presents the results of comparative analysis during the preparatory period between the female R and C groups. There were no significant statistical differences between these groups.

Similar results were obtained when performing the same comparison between female of R and C groups during the start period. In this case values of female athletes were slightly higher when compared to the control group, but the observed differences did not reach the level of statistical significance (table 5).

Among the men from the R group there were no statistically significant differences between anthropometric values measured during the preparatory and start period. The BMI and waist circumference remained at the same level (table 6).

Table 7. presents a comparative analysis of the mean values of anthropometric parameters of males in both R and C groups during the preparatory period. Statistically significant difference was found for waist circumference value ($p<0,05$),

Table 1. Anthropometric characteristics (x±SD) of the kyokushin karate female (n=9) and male (n=9) groups during the preparatory and start period

	The period of preparation	
	The preparatory period	The start period
Age [years]	♀ 22,5 ±3,24 (19-29) ♂ 23,1 ±6,37 (18-33)	
Body height [cm]	♀ 166,6 ±5,29 (158-173) ♂ 175,8 ±5,88 (166-184)	
Body mass [kg]	♀ 64,4±7,88 (50,5-79,4) ♂ 72,7 ±8,9 (63,3-88,5)	♀ 65,2 ±7,44 (52,4-80,1) ♂ 72,5 ±8,43 (63,4-87,5)
Waist circumference [cm]	♀ 72,6 ±5,5 (64-81) ♂ 81,2 ±7,62 (74-94)	♀ 71,6 ±4,35 (63-76) ♂ 81,1 ±7,62 (72-94)
BMI [kg/m^2]	♀ 23,1 ±2,11 (20-27,5) ♂ 23,5 ±2,41 (19,6-27,3)	♀ 23,4 ±1,98 (20,7-27,7) ♂ 23,4 ±2,38 (19,5-27)

$\bar{x}$- mean; SD - standard deviation; n - number of respondents; BMI - body mass index; ♀- females; ♂ - males

while the difference in BMI did not reach the level of statistical significance (p>0,05).

The characteristics of the observed differences were similar during the start period (table 8.). A statistically significant change in waist circumference was found (p<0,05), whereas the BMI value was similar in both groups.

Table 9. presents a comparative analysis of women from R group, and the average values of components of body composition, during the period of preparation. The analysis shows some tendency in the observed parameters: the percentage of body fat measured by BODYSTAT 1500 and OMRON BF 360 decreased, while the values of parameters measured with BODYSTAT 1500 such as lean tissue [%] and total body water [%, lt] increased, while tissue resistance [Ω] – decreased. However, none of the observed changes reached the level of statistical significance (p>0,05).

Table 10. presents a comparison of body composition in women from C group during the preparatory period with females from the R group. Statistically significant differences occurred in the percentage of body fat measured by OMRON BF 360, also in total body water [%] and the value of the resistance [Ω] (all p<0,05). For other parameters such as body fat, lean [%] and the total body water [lt] no statistically significant differences between the two groups were found

Table 2. Anthropometric characteristics (x±SD) of the non- training control groups both female (n=10) and male (n=10) during the preparatory period

	The period of preparation	
	The preparatory period	
	♀	♂
Age [years]	24,6 ±3,47 (22-33)	24,5 ±3,5 (22-32)
Body height [cm]	166,5 ±6,27 (155-175)	181,4 ±9,03 (163-194)
Body mass [kg]	63,2 ±7,6 (55,6-80)	83,6 ±12,06 (72-112)
Waist circumference [cm]	72,4 ±4,59 (65-80)	88,6 ±7,53 (81-103)
BMI [kg/m^2]	22,7 ±2,04 (20,4-27)	25,4 ±2,75 (22,2-29,8)

$\bar{x}$- mean; SD - standard deviation; n - number of respondents; BMI - body mass index; ♀- females; ♂- males

Table 3. Comparison of anthropometric characteristics of the female from the research group (R) during the preparatory (P) and start (S) period (n=9).

Characteristics		**Mean -SD**	***p***
BMI [kg/m²]	P	23,14 ±2,11	SI
	S	23,42 ±1,98	
Waist circumference [cm]	P	72,66 ±5,5	SI
	S	71,66 ±4,35	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; P – preparatory period; S – start period; BMI – body mass index

Table 4. Comparison of anthropometric characteristics of the female from the research group (R) (n=9) and female from the control group (C) (n=10) during the preparatory period

Characteristics		**Mean -SD**	***p***
BMI [kg/m²]	R	23,14 ±2,11	SI
	C	22,76 ±2,04	
Waist circumference [cm]	R	72,66 ±5,5	SI
	C	72,4 ±4,59	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; C – control group; BMI – body mass index

Table 5. Comparison of anthropometric characteristics of the female from the research group (R) (n=9) and female from the control group (C) (n=10) during the start period

Characteristics		**Mean -SD**	***p***
BMI [kg/m²]	R	23,42 ±1,98	SI
	C	22,76 ±2,04	
Waist circumference [cm]	R	72,84 ±4,35	SI
	C	72,4 ±4,59	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; C – control group; BMI – body mass index

(p>0,05). The female athletes were characterized by a lower percentage of body fat and lower resistance, as well as higher content of lean tissue and higher levels of total body water in the body, compared to women from control group.

Significant differences in body composition between women from the R and C groups were also found during the starting period (table 11). In this case, statistically significant differences between groups were observed except for the value of total body water [lt] (p>0,05). Other analyzed variables: the percentage of fat mass and of fat free mass, the total body water [%] and tissue resistance [Ω] differed statistically (p<0,05). The female athletes during researched period were characterized by lower body fat percentage and resistance [Ω] and higher contents of lean tissue [%] and total body water [%, lt] in their body, when compared to the control group.

Table 12. presents a comparative analysis between the mean values of body composition elements during the preparatory and start period of men from the R group. The percentage of the body fat measured by OMRON BF 360 did not show statistically significant differences between the first and second measurement, in contrast to the value of the tissue resistance [Ω] and total body water [lt] measured by BODYS-

Table 6. Comparison of anthropometric characteristics of the male from the research group (R) during the preparatory (P) and start (S) period (n=9)

Characteristics		Mean -SD	*p*
BMI [kg/m²]	P	23,48 ±2,41	SI
	S	23,42 ±2,38	
Waist circumference [cm]	P	81,22 ±7,62	SI
	S	81,11 ±7,88	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; P – preparatory period; S – start period; BMI – body mass index

Table 7. Comparison of anthropometric characteristics of the male from the research group (R) (n=9) and male from the control group (C) (n=10) during the preparatory period

Characteristics		Mean -SD	*p*
BMI [kg/m²]	R	23,48 ±2,41	SI
	C	25,39 ±2,75	
Waist circumference [cm]	R	81,22 ±7,62	**0,05**
	C	88,6 ±7,53	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; C – control group; BMI – body mass index

Table 8. Comparison of anthropometric characteristics of the male from the research group (R) (n=9) and male from the control group (C) (n=10) during the start period

Characteristics		Mean -SD	*p*
BMI [kg/m²]	R	23,42 ±2,38	SI
	C	25,39 ±2,75	
Waist circumference [cm]	R	81,11 ±7,88	**0,05**
	C	88,6± 7,53	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; C – control group; BMI – body mass index

Table 9. Comparison of body composition for the females from the research group (R) during the preparatory (P) and start (S) period (n=9)

Characteristics		Device	Mean -SD	*p*
Fat mass [%]	P	OMRON	28,71 ±3,74	SI
	S	OMRON	28,61 ±3,69	
Fat mass [%]	P	BODYSTAT	22,87 ±4,42	SI
	S	BOSYSTAT	22,77 ±4,04	
Fat free mass [%]	P	BODYSTAT	77,12 ±4,42	SI
	S	BODYSTAT	77,22 ±4,04	
Total body water [%]	P	BODYSTAT	53,66 ±3,21	SI
	S	BODYSTAT	53,86 ±2,65	
Total body water [lt]	P	BODYSTAT	34,46 ±3,44	SI
	S	BODYSTAT	35,05 ±3,70	
Resistance [Ω]	P	BODYSTAT	554,66 ±55,06	SI
	S	BODYSTAT	542,11 ±55,35	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; P – preparatory period; S – start period; OMRON – OMRON BF 360;
BODYSTAT – BODYSTAT 1500

Table 10. Comparison of body composition for the females from the research group (R) (n=9) and females from the control group (C) (n=10) during the preparatory period

Characteristics		Device	Mean -SD	*p*
Fat mass [%]	R	OMRON	28,71 ±3,74	**0,05**
	C	OMRON	32,44 ±3,39	
Fat mass [%]	R	BODYSTAT	22,87 ±4,42	SI
	C	BOSYSTAT	26,4 ±3,08	
Fat free mass [%]	R	BODYSTAT	77,12 ±4,42	SI
	C	BODYSTAT	73,6 ±3,08	
Total body water [%]	R	BODYSTAT	53,66 ±3,21	**0,05**
	C	BODYSTAT	50,95 ±1,96	
Total body water [lt]	R	BODYSTAT	34,46 ±3,44	SI
	C	BODYSTAT	32,11 ±3,26	
Resistance [Ω]	R	BODYSTAT	554,66 ±55,06	**0,05**
	C	BODYSTAT	625,4 ±67,71	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; P – preparatory period; S – start period; OMRON – OMRON BF 360;
BODYSTAT – BODYSTAT 1500

Table 11. Comparison of body composition for the females from the research group (R) (n=9) and females from the control group (C) (n=10) during the start period

Characteristics		Device	Mean -SD	*p*
Fat mass [%]	R	OMRON	28,55 ±3,94	**0,05**
	C	OMRON	32,44 ±3,39	
Fat mass [%]	R	BODYSTAT	22,77 ±4,04	**0,05**
	C	BOSYSTAT	26,4 ±3,08	
Fat free mass [%]	R	BODYSTAT	77,22 ±4,02	**0,05**
	C	BODYSTAT	73,6 ±3,08	
Total body water [%]	R	BODYSTAT	53,86 ±2,65	**0,05**
	C	BODYSTAT	50,95 ±1,96	
Total body water [lt]	R	BODYSTAT	35,05 ±3,70	SI
	C	BODYSTAT	32,11 ±3,26	
Resistance [Ω]	R	BODYSTAT	542,11 ±55,35	**0,05**
	C	BODYSTAT	625,4 ±67,71	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; P – preparatory period; S – start period; OMRON – OMRON BF 360;
BODYSTAT – BODYSTAT 1500

Table 12. Comparison of body composition for the males from the research group (R) (n=9) during the preparatory (P) and start (S) period

Characteristics		Device	Mean -SD	*p*
Fat mass [%]	P	OMRON	16,05 ±4,56	SI
	S	OMRON	15,48 ±4,06	
Fat mass [%]	P	BODYSTAT	11,7 ±4,15	**0,01**
	S	BOSYSTAT	10,71 ±3,66	
Fat free mass [%]	P	BODYSTAT	88,3 ±4,15	**0,01**
	S	BODYSTAT	89,28 ±3,66	
Total body water [%]	P	BODYSTAT	62,24 ±3,36	**0,05**
	S	BODYSTAT	63,2 ±3,03	
Total body water [lt]	P	BODYSTAT	45,02 ±3,52	SI
	S	BODYSTAT	45,63 ±3,46	
Resistance [Ω]	P	BODYSTAT	470,33 ±44,36	SI
	S	BODYSTAT	459,11 ±43,80	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; P – preparatory period; S – start period; OMRON – OMRON BF 360;
BODYSTAT – BODYSTAT 1500

TAT 1500 in this group of subjects which showed a significant increase ($p<0,05$) after 4 months of training. In the case of the differences in the percentage of fat mass and fat free mass in men from the R group after the completion of the preparation period the level of statistical significance was also reached ($p<0,01$) – the content of adipose tissue [%] significantly decreased and the percentage of lean tissue increased.

Men training karate differed statistically from untrained men during the preparatory period in: fat content measured by OMRON BF 360 and BODYSTAT 1500 (both $p<0,05$) as

Table 13. Comparison of body composition for the males from the research group (R) (n=9) and males from the control group (C) (n=10) during the preparatory period

Characteristics		Device	Mean -SD	*p*
Fat mass [%]	R	OMRON	16,05 ±4,56	**0,05**
	C	OMRON	21,15 ±4,67	
Fat mass [%]	R	BODYSTAT	11,7 ±4,15	**0,05**
	C	BOSYSTAT	15,72 ±3,81	
Fat free mass [%]	R	BODYSTAT	88,3 ±4,15	**0,05**
	C	BODYSTAT	84,28 ±3,81	
Total body water [%]	R	BODYSTAT	62,24 ±3,36	**0,05**
	C	BODYSTAT	57,82 ±3,56	
Total body water [lt]	R	BODYSTAT	45,02 ±3,52	SI
	C	BODYSTAT	48,36 ±5,49	
Resistance [Ω]	R	BODYSTAT	470,33 ±44,36	SI
	C	BODYSTAT	472,2 ±62,31	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; P – preparatory period; S – start period; OMRON – OMRON BF 360;
BODYSTAT – BODYSTAT 1500

Table 14. Comparison of body composition for the males from the research group (R) (n=9) and males from the control group (C) (n=10) during the start period

Characteristics		Device	Mean -SD	*p*
Fat mass [%]	R	OMRON	15,48 ±4,06	**0,05**
	C	OMRON	21,15 ±4,67	
Fat mass [%]	R	BODYSTAT	10,71 ±3,66	**0,01**
	C	BOSYSTAT	15,72 ±3,81	
Fat free mass [%]	R	BODYSTAT	89,28 ±3,66	**0,01**
	C	BODYSTAT	84,28 ±3,81	
Total body water [%]	R	BODYSTAT	63,2 ±3,03	**0,01**
	C	BODYSTAT	57,82 ±3,56	
Total body water [lt]	R	BODYSTAT	45,63 ±3,46	SI
	C	BODYSTAT	48,36 ±5,49	
Resistance [Ω]	R	BODYSTAT	459,11 ±43,80	SI
	C	BODYSTAT	472,2 ±62,31	

SD – standard deviation; n – number of respondents; p – level of significance; SI – statistically insignificant;
R – research group; P – preparatory period; S – start period; OMRON – OMRON BF 360;
BODYSTAT – BODYSTAT 1500

well as in the percentage of fat free mass and total body water ($p<0,05$). During the preparatory period the two studied groups did not differ significantly from each other in the total body water in the body [lt] and in the value of tissue resistance [Ω] (table 13).

Changes between the values of men from the R and C groups were also present at the time of the start period, as is shown in table 14. Significant differences occurred in: percentages of body fat, fat free mass and total body water measured by BODYSTAT 1500 (all $p<0,01$). The difference between the percentage of body fat measured by OMRON BF 360 in this case also reached the level of statistical significance ($p<0,05$). The values of tissue resistance [Ω] and the total body water [lt] showed no significant differences in the two groups of men, as in the case of preparatory period.

In the research groups participating in the karate kyokushin training the analysis of Pearson correlation was also made and it concerned the relationship between the values of body composition of advanced practitioners and their age, experience and training level of physical activity. None of the correlation reached the level of statistical significance ($p>0,05$).

Discussion

It is well known that karate training improves the overall condition of the organism and the circulatory and respiratory capacity as well. At the same time there are only few publications concerning the evaluation of the minimum oxygen consumption (VO_2max) as well as assessment of body composition among karate training athletes [6]. Available publications about evaluation of the construction and body composition in athletes of martial arts focus mainly on male population, but there are also some concerning only female athletes. Due to gender differences body composition is usually discussed separately in these two sex groups.

According to Sterkowicz study [7], foreign studies that had been conducted on athletes practicing karate showed their harmonious construction and low fatness. In the study: "Characteristics of selected indicators of the preparedness of the karate players" Sterkowicz presented data of 13 kyokushin players from Polish national team. Those athletes were of mean age of 25,69±2,46 years, their mean time of karate experience was 8,7±2,8 years, the content of fat in their bodies was equal to 12,16±2,31% and lean tissue 87,84±2,22 %.

The percentages results of body fat and lean tissue obtained by the quoted author were very similar to the ones from the present study (measurement by BODYSTAT 1500). Moreover, Sterkowicz cited Piechaczek's results of the somatic parameters of 198 male students from the Warsaw University of Technology. They were of mean age of 20,61±1,28 years, the amount of fat content was 14,38±2,36 % and fat free mass was 85,64±2,37 %. The cited author concluded that the 13 members of national kyokushin team players had lower fatness and lower absolute mass when compared to the control group of 198 students and he also noted that athletes' content of lean tissue was higher when compared with the men from the control group [7], which is in agreement with characteristics of body composition of the athletes of kyokushin karate from Gliwice.

Similar anthropometric characteristics and the body composition analysis (Tanita TBF 300 weight measurement and Keys and Brożek equations applied) was performed by Sterkowicz-Przybycień [8], who examined 30 karate men, divided into subgroups according to the criteria of the possessed level of sport preparation and 165 untrained men. The 14 men studied represented the international level and 16 of them – the national level of sport preparation. The mean age of 14 men was 26,7±6,58 years and their training experience was 13,9±4,78 years. Their BMI was 26,8±2,00 [kg/m^2], the content of fat in their bodies was equal to 14,6±3,28 kg, 16,8±2,51 % and lean tissue 71,5±5,88 kg. The mean age of 16 men who were on the national level was 23,5±4,67 years and their time of experience was 10,7±3,72 years. The mean BMI in this group of men was 24,9±1,74 [kg/m^2], fat tissue content in that group amounted to 11,7±2,26 kg, 15,8±1,93%, while the lean tissue was 68,5±9,78 kg. Despite of fewer years of training experience in case of Gliwice athletes, in comparison with the men practicing karate from the Sterkowicz-Przybycień study it could be concluded that the athletes from Gliwice had much lower fat content (measured by BODYSTAT 1500) and lower body mass index which could be explained by the potential differences in physique (somatotype) of the surveyed subjects. The quoted author also analyzed the body composition of untrained 165 male students from the University of Warsaw and compared their results with those practicing karate. Noteworthy was a lower body mass index in untrained group of men, which amounted to 22,4±2,46 [kg/m^2] and their lower fat content – 11,5±3,20 kg, 15,7±2,74 when compared with those practicing karate. However, if we compared amount of fat free mass of training karate men with untrained one, it appeared that the students had less amount of lean tissue (60,6±6,28 kg) compared with athletes (international athletes had 71,5±5,88 kg and national ones had 68,5±9,76 kg). Results of the fat content and BMI value differed from the ones obtained in the group of kyokushin athletes from Gliwice and from our control group. These values in athletes were lower in comparison with those observed in untrained group in our study. On the other hand the group of students researched by Sterkowicz-Przybycień was much more homogeneous which may explain these differences.

Sterkowicz-Przybycień and Żarów [9] made a comprehensive analysis of the somatic structure and body composition (fat content measurement with the use of Tanita TBF 300 and equations of Slaughter et al equation and Keys and Brożek) in 142 men, contestants of combat sports such as: karate, judo, wrestling, boxing, fencing and ju-jutsu. Those athletes were members of the national team and were of mean age of 23,65±4,61 years and mean BMI of 25,26±3,2 [kg/m^2]. Estimated percentage of fat in their body was various, and ranged from 9,97 to 14,66 [%], while the level of their lean tissue amounted to 85-90 [%]. Analysis of the results of the cited authors showed that the athletes had lower amount of body fat, compared with individuals who did not do any sports, which we also observed in the results of athletes from Gliwice when we compared them with the body composition data from the control group.

Immamura et al [6] in turn, performed the analysis of body composition, strength and maximal oxygen uptake in 16 men practicing karate. Those men were divided according to the criteria of duration of training experience: 7 of them had black stripes and 9 of them – the white ones. Authors measured the fat fold of the triceps muscle, assessed the percentage of their body fat (with the use of Keys and Brożek equation) and estimated maximal oxygen uptake during the exercise treadmill test according to a modified Bruce protocol. Their strength was assessed with the maximal half squat test and bench press test with the barbell. Men with black belts were of average of 21,3±0,8 years, their training experience was 12,6 ±3,4 years, while men with white stripes were of average age of 19,9±0,8 years and 1,2±0,5 years of experience. The authors of that analysis showed that the studied men did not differ significantly from one another in percentage of body fat content, which in more experienced group amounted to 10,7±2,0 [%] and in less advanced to 12,6±4,5 [%]. The percentage values of body fat obtained by the quoted authors are consistent with the results of our study (measured by BODYSTAT 1500). The cited authors also found no statistically significant differences between the values of VO_2max, blood lactate and maximum heart rate values assessed on the exercise treadmill test between both groups of karate athletes. Significant differences between more experienced athletes and those with less experience were seen in the parameters of strength, maximum minute ventilation and the value of lean body mass in favor of athletes possessing more training experience. As in the present study, the quoted authors pointed out that the percentage of fat content in studied athletes was lower when compared with the age-matched untrained individuals what was also confirmed by the results of the comparison of body composition (body fat) of athletes training kyokushin in Gliwice with the non – training group of men.

Pieter et al [10] have evaluated content of body fat (weight-growth rate of the reciprocal ponderal index RPI) and skinfolds of the Philippine national team members' style of karate and pencak silat style of martial arts. The 12 men and 5 women practicing karate and 17 men, 5 women training pencak silat participated in the study. The average age of men from karate group was 24,0±4,8 years and 20,3±1,3 years in case

of women. The authors of the quoted study showed that karate athletes, both males and females, possessed similar content of fat as the ones training pencak silat. The results showed however that women and men training karate have thinner fatty folds than both men and women training pencak silat. The breakdown by sex of the karate athletes showed differences in the thick folds (much larger fat skin folds in women 63,3±24,7 mm, than in men – 48,1±15,7 mm), but on the other hand it did not show significant differences in the RPI index (females 42,3±1,4, males 42,5±1,5 cm/kg^{0,333}). Apart from the observed differences between men and women training karate in Pieter's et al study it is worth noting, that in their analysis they focused on characteristics of karate athletes according to sex criteria. Pieter et al study suggested that karate athletes have low body fatness which was also confirmed in the present work, though the measuring devices used by Pieter et al were different than in our study.

Amusa and Onyewadume [11] studied selected anthropometric parameters, body composition and somatic types of body construction in 17 individuals – 10 males and 7 females in Botswana karate athletes. The mean age of men was 26,4± 3,0 years and their body mass index amounted to 22,0±2,5 [kg/m^2]. The percentage of body fat mass in male athletes was 12,2±4,6 [%]. Women in turn, were 22,4±3,7 years of age, their BMI amounted to 23,8±2,5 [kg/m^2] and the mean level of their body fat was 18,6±3,2 %. Noteworthy is the fact that those athletes had a much lower content of fat and higher level of lean tissue when compared with athletes from Gliwice Kyokushin Karate Club, which can be explained by the fact that the studied karate individuals examined by the cited authors were highly qualified – they were participating in international contests. However, as in the case of athletes from Gliwice, men were characterized by lower content of adipose tissue, lower body weight and lower body mass index when compared with female athletes.

Koropanovski et al [12] made the analysis of anthropometrics and physical performance in 31 male karate competitors of the Serbian national karate team. Athletes who participated in this study were divided according to the major specialties in karate – 19 of them were kumite athletes and 12 of them specialized in kata. The mean age of male kumite athletes was 21,0 ±2,8 years and their BMI amounted to 23,5± 2,1 [kg/m^2]. Kata group in turn, was 20,7±4,4 years of age and their BMI amounted to 23,2±1,8 [kg/m^2]. The data obtained by the quoted authors did not show any statistically significant differences in body composition assessed by body mass index in surveyed athletes. The BMI values calculated by the cited authors were similar to our BMI results in male group of karate participants. Koropanovski et al noticed that kumite athletes had larger body size when compared to kata athletes. The cited authors focused mainly on testing athletes' physical performance rather than on estimation of body composition. Evaluation of physical performance included total number of 5 skills-specific tests of flexibility, speed, agility, power and endurance. Kumite athletes presented with statistically higher acceleration tested by maximum acceleration sprint and higher explosive power tested by standing triple jump in comparison to kata athletes.

Burdukiewicz et al [13] presented diversification of the selected elements of somatic structure and body composition (content of fat and muscle mass measured by the 101S Akern analyzer) in 28 female judokas and 28 female weightlifters, participants of Polish Championships. The mean age of female judokas was 20,3±2,88 years of age and female weightlifters were 20,4 ±3,98 years of age. The minimal training experience was 5 years for all the athletes. The results showed that female judokas had lower amount of fat – 24,99±6,36% and body mass index – 22,69±3,91 [kg/m^2] compared with values observed in female weightlifters, respectively – 26,45 ±7,04% and 24,33±4,69 [kg/m^2]. However weightlifters had higher mean values of skinfold thickness and greater content of muscle mass - 55,46±9,05% than judokas whose muscle mass amounted to 52,19±9,08%. Results obtained by the quoted authors are different in comparison with the results of karate athletes from Gliwice. Karate male athletes had lower BMI value and lower amount of fat mass (measured by BODYSTAT 1500) compared with female judokas and weightlifters measured by Burdukiewicz et al which may be due to the fact that karate is a more dynamic sport discipline compared with the mentioned disciplines. Burdukiewicz et al pointed out that professional athletes differed from one another in body composition. They also noted that athletes' body composition differs from people who normally do not engage in any kind of sport, what is in agreement with the results of our study.

Sterkowicz-Przybycień [14] have evaluated the age, training experience, age of onset of training and the level of anthropological features in 30 Polish ju-jitsu male athletes – 6 of them were Duo System contestants while 24 were Fighting System athletes. The author compared the morphological traits of top ju-jitsu contestants with results of 165 male students from the Warsaw University of Technology. The mean age of 6 Duo System athletes was 22,00±3,06 years, their mean practice experience was 8,00±3,41 years and the mean age of taking up ju-jitsu training was 14,00±2,75 years. Their BMI was 25,06±1,85 [kg/m^2], fat tissue content in their bodies was 11,06±2,63 kg, 14,06±3,31 % and fat free mass amounted to 67,68±6,99 kg, 85,94±3,38%. The values for 24 Fighting System athletes were respectively: 23,20±4,58 years, 11,00± 4,64 years, 12,20±3,94 years, 24,35±3,24 [kg/m^2], 10,11±3,03 kg, 13,12±2,12% and 65,92±10,54 kg, 86,86±2,12%. Analysis of the results of the quoted author showed that the athletes did not differ from one another in age, training experience and the age of taking up training. Moreover morphological features of surveyed athletes measured by Sterkowicz-Przybycień were congruent. The analysis however showed significant differences between the height and body mass of both ju-jitsu athletes compared with the control group of men from University – surveyed athletes were shorter and heavier than untrained men. Ju-jitsu athletes were characterized by the lower amount of fat tissue and higher value of fat free mass compared with untrained male from control group what is also presented in the comparison of our karate athletes with untrained group of

men. Ju-jitsu athletes did not differ from our karate male athletes in age but the differences were noted in body mass index, content of fat and fat free mass. Karate kyokushin participants had lower body mass index and lower amount of fat mass compared with both group of ju-jitsu athletes. Karate male from our study also had higher value of fat free mass compared with ju-jitsu individuals measured by Sterkowicz-Przybycień. The observed differences may result from more dynamic character of this full contact form of karate in contrast to ju-jitsu art.

Conclusions

1. Anthropometric factors, type of body building, body mass index and body composition are all of great importance in a highly qualified sport like the karate. However, the large number of measurement tools, questionable repeatability of tests conditions and differences found between the sexes or ethnic discrepancies makes the evaluation and comparison analyzes of selected anthropometric indices and body composition rather difficult.
2. As in the case of all martial arts, karate kyokushin includes activities in which the prognosis concerning the athletes' direction (specialization) is difficult to determine, therefore is important to individualize the training process. This approach may results in athletes' better preparation for competitions.

Glossary

FFM – fat free mass, lean body mass – mass equal to the mass of muscle and internal organs.

FM – body fat mass – fat mass in the body.

TBW – total amount of water in the body which primarily reflects lean body mass.

Karate kyokushin – full-touched Japanese style of martial art, combat sport created by Masutatsu Oyama. Kyokushin is translated as ""supreme truth".

BIA – bioelectrical impedance analysis – the resultant electrical impedance of the body, its essence is the measurement of the resistance to the flow of an electric current through body tissues.

RPI – the reciprocal ponderal index – is used as an index of relative fatness.

Pencak silat – collective term for all various traditional martial art styles originating from the present-day area of Indonesia.

Judo – modern martial art, combat sport created in Japan by Jigorō Kanō. The meaning of judo is "gentle way".

Weightlifting – athletic discipline in which participants attempt a maximum-weight single lift of a barbell loaded with weight plates.

Ju-jitsu – traditional Japanese martial art or method of combat without weapons or with the use of small arms used in attack and defense in a confrontation with one or more armed/unarmed opponents. Ju-jitsu means "gentle art".

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