

BODY COMPOSITION AND SOMATOTYPE OF THE TOP OF POLISH MALE KARATE CONTESTANTS

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ABSTRACT: The aim of this study was to determine body composition and somatotype of male karateists who were grouped by different level of competition and techniques used in effective attack. Analysis of body composition, with untrained men as a background, will update the data necessary for determination of somatic profiles of karateists. Thirty contestants were examined during the camp in Polish Olympic Training Center in Zakopane. The participants had level of competition at both international (I group, n=14) and national level (N group, n=16). Karateists were also grouped on the basis of the preferred techniques used in effective attack, i.e. hits with hand (H, n=12), hits with hand and legs (HL, n=11) or kicks (L group, n=7). An experienced evaluator performed 10 measurements necessary to designate somatotypes by means of Heath-Carter method and to estimate the percentage of body fat and composition. Group I were not significantly heavier than group N. Group I had higher mesomorphy and lower ectomorphy than group N (t-test). Group I were characterized by higher BMI and fat free mass index than karateists of the group N. Results from discriminant analysis were significant. Amongst the observations used to fit the model, (67%) were correctly classified. There were statistically significant differences between competitors grouped by techniques used in attack as endomorphy (H>HL, H>L) and ectomorphy (H<HL, H<L). Karateists' somatotypes differed from the somatotypes of the untrained. They were characterized by higher mesomorphy and lower ectomorphy, as well as greater fat free mass index and fat mass index.

KEY WORDS: karate, somatotype, sport level, techniques

INTRODUCTION

In theory of fighting sports, one can find, among others, the criteria determining the forms of direct opponent's contact which include: (a) weapon actions, (b) hits and (c) throws and grips limiting the opponent's movements [17]. Karate belongs to group 'b', in which the competitors use hits with upper and lower limbs. Karate fight is characterized by changeable effort intensity, i.e. periods of maximum exercise alternated with periods of lower intensity or with short intervals. Analysis of the course of karate matches during the European championships revealed that from among 1198 sequences of continuous exercise 11.4% lasted 1 to 7 seconds, 79.5% - 8 to 50 seconds and 9.1% of the total number of the recorded sequences of fight lasted 51 to 120 seconds [27]. Additionally, in a typical karate kumite match, contestants fight at 2:1 exercise-to-rest ratio (more specifically 18±6s of effort with 9±6s of interval) resulting in 16.3±5.1 high intensity actions during the whole match or 3.4±2.0 actions per minute lasting 1 to 3 s each [2].

Karate athletes move about in various directions on a square mat and attack their opponents with both upper and lower extremities in different moments of the match. Observations have shown that

straight blows with an upper extremity are the most effective punch technique, whereas round-house kicks are the most effective kicking technique. They can be used as a single attack, counter-attack, as well as combination [27]. Somatotype, which is complex information about body build, is associated with motor efficiency. It is a source of differences between the sports disciplines and events [5]. The somatic type – in Carter and Heath's [5] opinion – is an essential information pertaining to chances of success in the given sport discipline. Specialized training should develop the endomorphy, mesomorphy and ectomorphy components [6].

The somatotypes characterizing leading competitors usually occupy a certain area on the somatogram, determining optimal values for a given discipline. According to Claessens et al. [8] the connections between the body structure and its functions are very important and characteristic of the competitors of sport elite. Gualdi-Russo and Graziani [13] emphasized the relation between the somatotype (mesomorphy increase) and the sports achievements in fight sports, but not specified somatotype in karate. Giampietro et al. [11] research results pointed to a contrary conclusion. They did not notice

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statistically significant differences between the somatotypes of the high sport class competitors and amateurs. Giampietro et al. [11] noted greater length of lower limbs in the elite group in comparison to the intermediate competitors (which can be an effect of selection as the length features are not subject to training as it is in the case of muscles and body circumferences). Imamura et al. [16] noted statistically significant advantage of lean body mass (LBM) of advanced competitors (black belt level) over the beginners (white belt).

Some researchers looked for a relation between the sport result and the anthropometric variables [20, 30]. Kuleś et al. [20] awarded scores for participation and places won in the championships. The place in the ranking was correlated with body height and chest circumference, length of lower limbs and breadth factor. The results of another research indicated that selection of technical actions was related to body build proportions [30]. The correlation between shoulder-pelvis index and the frequency of hand technique use was moderate.

The aim of this research was to determine body composition and somatotype of contemporary top Polish karate fighters according those sports level and techniques preferred in fight.

MATERIALS AND METHODS

Subjects: Thirty representatives of Polish karate team participated in training camp in Polish Olympic Training Center in Zakopane during their preparation period. The subjects were interviewed in order to collect data on age, training experience (in years) and sports level, which was established on the basis of their previous sport achievements. The participants had level of competition at both international (I group, n=14) and national level (N group, n=16). Data from 165 randomly selected untrained men, students of the Warsaw University of Technology [24], were used to compare karateists' body build and body composition. In general, karateists were older and more diverse in terms of age than untrained students (Table 1).

The competitors were also interviewed about the preferred fight techniques used in effective attack. The participants were grouped on the basis of the declared techniques, i.e. hits with hand (group H, n = 12), hits with hand and leg (group HL, n = 11) or kicks mainly (group L, n = 7). The data was gathered according to

a broader project of PhD thesis [31] approved by the Council of the Faculty of Physical Education in the University School of Physical Education in Krakow. All interviewed participants were informed about aim of the study and than agreed to take part in anthropological research.

Anthropometric measurements: Body adiposity was measured by means of a Holtain caliper with a contact surface pressure of 10 g/mm². In order to determine somatotypes, 10 required measurements were used: body height and mass, four skinfold measurement (triceps, subscapular, supraspinale and medial calf), two girths (arm flexed and tensed, and calf), bi-epicondylar breadths of humerus and femur [5]. In addition - for the comparison with a group of untrained students (Piechaczek, 1998) – a thickness of abdominal skinfold was measured [24]. A qualified employee of the Department of Anthropology, with a 35-year experience, conducted anthropometric measurements, using the SiberHegner Machines SA (Zurich, Switzerland) instruments. To calculate the body density an equation [24]:

$D = 1.125180 - 0.000176 \text{LOGtriceps} - 0.000185 \text{LOGabdominal}$ was used, with a logarithmic value = $100 \cdot \log_{10}$ (compass measurement expressed in tenths of mm minus 18 as the correction for the thickness of the skin). To transform skinfolds measurements, the table presented by Edwards et al. [4] was used. The percentage of fat in body mass was calculated on the basis of the following equation [18]:

$$\%PF = 100 \left(\frac{4.201}{D} - 3.813 \right)$$

A Tanita scale (model: TBF 300, Tanita Co., Tokyo, Japan) was used for measuring body mass (Wt). Height-weight ratio HWR (height/mass^{-0.33}), body mass index BMI (Wt in kg/ height in m²), fat mass FM and fat free mass FFM (Wt-FM) were then calculated. Similarly to BMI, fat free mass index (FFMI) and fat mass index (FMI) were calculated [15].

Statistics: Average values (\bar{x}) and standard deviation (SD) of age, training experience, height and weight, somatotype (\bar{s}) and BMI, FFMI, FMI, and %PF indices were calculated. A special computer software "Somatotype calculations and analysis" was used to work out the results pertaining to the classification of somatotypes

TABLE 1. AGE, TRAINING EXPERIENCE, HEIGHT, WEIGHT, HWR AND SOMATOTYPE OF MALE POLISH NATIONAL KARATE TEAM PLAYERS ACCORDING TO THEIR SPORTS LEVEL (MEAN \pm SD)

Sports level	Age (years)	Training experience (years)	Height (m)	Weight (kg)	HWR	Somatotype		
						EN	ME	EC
International (n = 14)	26.7 \pm 6.58	13.9 \pm 4.78	1.79 \pm 0.05	86.1 \pm 8.25	40.63 \pm 0.97	3.7 \pm 1.1	5.8 \pm 0.8	1.3 \pm 0.6
National (n = 16)	23.5 \pm 4.67	10.7 \pm 3.72*	1.80 \pm 0.07	81.4 \pm 11.99	41.75 \pm 0.96*	3.5 \pm 1.1	5.0 \pm 0.9*	2.0 \pm 0.6*
Total (n = 30)	25.0 \pm 5.78	12.2 \pm 4.48	1.80 \pm 0.06	83.6 \pm 10.51	41.22 \pm 1.11	3.6 \pm 1.1	5.3 \pm 1.0	1.7 \pm 0.7
Untrained (n = 165)	20.6 \pm 0.97	.	1.79 \pm 0.06	72.1 \pm 8.96	43.21 \pm 1.66	3.7 \pm 1.5	4.3 \pm 1.2	3.1 \pm 1.2

Legend: HWR = height-weight ratio, or stature/weight^{0.3333}, EN – endomorphy, ME – mesomorphy, EC – ectomorphy,

* – indicates statistically significant difference from International, p < 0.05.



TABLE 2. BMI AND BODY COMPOSITION VARIABLES FOR MALE POLISH NATIONAL KARATE TEAM PLAYERS BY THEIR SPORTS LEVEL (MEAN ± SD)

Sports level	BMI (kg/m ²)	FFM (kg)	FFMI (kg/m ²)	FM (kg)	FMI (kg/m ²)	D (g/cm ³)	PF (%)
International (n=14)	26.8 ± 2.00	71.5 ± 5.88	22.3 ± 1.24	14.6 ± 3.28	4.5 ± 0.97	1.0537 ± 0.006	16.8 ± 2.51
National (n=16)	24.9 ± 1.74*	68.5 ± 9.76	20.9 ± 1.61*	11.7 ± 2.26	3.9 ± 0.72*	1.0604 ± 0.004	15.8 ± 1.93*
Total (n=30)	25.8 ± 2.20	69.9 ± 8.20	21.6 ± 1.58	13.7 ± 3.11	4.2 ± 0.88	1.0566 ± 0.006	16.25 ± 2.23
Untrained (n=165)	22.4 ± 2.46	60.6 ± 6.28	19.5 ± 2.02	11.5 ± 3.20	3.7 ± 1.03	1.0580 ± 0.007	15.7 ± 2.74

Legend: BMI – Body mass index, FFM – Fat free mass index, FMI – Fat mass index, PF (%) – Percent Fat (%), * – indicates statistically significant difference from International, p < 0.05.

defined by means of Heath-Carter method [12]. The group average values for international (I) and national (N) level of competition were compared by means of the t-test. Somatotype distributions of karateists by I and N groups were shown. Individual results in groups of karateists were illustrated on a body composition chart (BC), as a single graph allows for presentation of the BMI, FFMI, FMI, and %PF [15]. Discriminant analysis was used to develop a predictive model of group membership with competition level as a grouping factor. In addition, the ANOVA method was used, taking groups H, HL and L into account. Frequency for competition level (I, N) and techniques (H, HL, L) typically used in effective attack were compared by means of Chi-square function in logarithmic form (G-test) [32]. Somatotype of karateists, measurements and indices of weight and body composition were compared with a group of untrained men [24]. To assess the differences between the two averages a t-test for independent groups was performed. Data analyses were conducted the computer software STATGRAPHICS Centurion v. XV. The level of p<0.05 was considered significant.

RESULTS

Comparison of subjects according to the sports level. Descriptive statistics for age, height-weight indices, body composition and karate fighter somatotype are shown in Tables 1 and 2. The average values of age (t=1.56) and height (t=0.59) and weight (t=1.22) of the subjects in the two sports levels do not differ significantly (p>0.05). But they differed in their training period. Those who represented international level had significantly longer experience in karate (t=2.09, p<0.05). This group had lower values of HWR (t=3.17, p<0.01) and greater BMI (t=2.52, P<0.05), FFMI (t=2.34, p<0.05), FMI (t=5.76, p<0.05) and percent fat (t=2.09, p<0.05).

Figure 1 shows somatoplots for karate fighters competing on I and N levels.

Endomorphic mesomorph is typical for group I (11/14) as well as for group N (8/16). Endomorphic mesomorph somatotype (mesomorphy is dominant and endomorphy is greater than ectomorphy) is a somatotype characteristic of both levels of karateists and therefore it is dominant in those groups. Two out of fourteen of group I are characterized by a mesomorph-endomorph and one out of fourteen by a balanced mesomorph. For group N, there is also

high frequency of endomorphic mesomorph occurrence (8/16). Five out of sixteen of group N are characterized by balanced mesomorph (mesomorphy is dominant, endomorphy and ectomorphy are smaller or equal or do not differ by more than one-half unit) and mesomorph-endomorph (n=2) and the central type (one karateka) also occur. Somatotype Attitudinal Distance (SAD) between the $(\bar{s})_{\text{group I}} - (\bar{s})_{\text{group N}}$ average somatotype was 1.0 and exceeded the critical value by 0.5, which determined the minimum significant

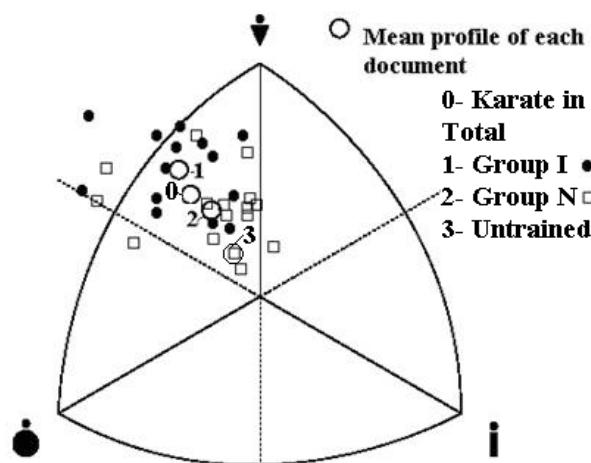


FIG. 1. SOMATOTYPES OF KARATE CONTESTANTS BY LEVEL OF COMPETITION (I – INTERNATIONAL, N – NATIONAL) AND UNTRAINED.

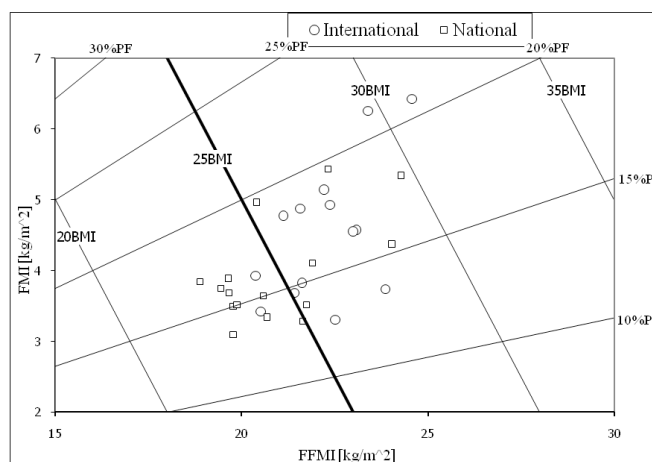


FIG. 2. BODY COMPOSITION CHART FOR KARATEISTS BY LEVEL OF COMPETITION. FFMI - FAT FREE MASS INDEX, FMI - FAT MASS INDEX. OBLIQUE LINES REPRESENT BMI – BODY MASS INDEX AND %PF – FAT PERCENTAGE IN BODY MASS.

TABLE 3. AGE, HEIGHT, WEIGHT AND HWR AND SOMATOTYPE OF MALE POLISH NATIONAL TEAM KARATE PLAYERS ACCORDING TO TECHNIQUES PREFERRED IN EFFECTIVE ATTACK (MEAN \pm SD)

Technique preferred in attack	Age (years)	Training experience (years)	Height (m)	Weight (kg)	HWR	Somatotype		
						EN	ME	EC
H (n=12)	24.9 \pm 5.49	12.0 \pm 3.55	1.81 \pm 0.06	87.4 \pm 9.32	40.78 \pm 1.25	4.3 \pm 1.1	5.8 \pm 0.8	1.4 \pm 0.8
HL (n=11)	25.1 \pm 6.57	13.55 \pm 5.05	1.79 \pm 0.07	81.1 \pm 11.07	41.53 \pm 0.90	3.2 \pm 0.4 ^a	5.2 \pm 1.0	1.9 \pm 0.6
L (n=7)	25.0 \pm 5.84	10.43 \pm 4.93	1.79 \pm 0.05	80.89 \pm 11.01	41.51 \pm 1.04	3.1 \pm 1.2 ^a	4.8 \pm 1.0	1.8 \pm 0.7

Legend: Legend: HWR = height-weight ratio, or stature/weight^{0.3333}, EN – endomorphy, ME – mesomorphy, EC – ectomorphy,
^a – indicates statistically significant difference from H, $p < 0.05$.

TABLE 4. BMI, BODY COMPOSITION VARIABLES FOR MALE POLISH NATIONAL KARATE TEAM PLAYERS ACCORDING TO THE TECHNIQUES PREFERRED IN EFFECTIVE ATTACK (MEAN \pm SD)

Sports level	BMI (kg/m ²)	FFM (kg)	FFMI (kg/m ²)	FM (kg)	FMI (kg/m ²)	D (g/cm ³)	PF (%)
H (n=12)	26.8 \pm 2.3	71.7 \pm 7.55	21.9 \pm 1.70	15.7 \pm 2.79	4.8 \pm 0.89	1.0522 \pm 0.006	17.9 \pm 2.14
HL (n=11)	25.1 \pm 1.74	68.5 \pm 9.13	21.2 \pm 1.43	12.6 \pm 2.31 ^a	3.9 \pm 0.51 ^a	1.0588 \pm 0.003 ^a	15.5 \pm 1.19 ^a
L (n=7)	25.2 \pm 2.23	68.9 \pm 8.42	21.4 \pm 1.68	11.9 \pm 3.06 ^a	3.7 \pm 0.76 ^a	1.0609 \pm 0.005	14.6 \pm 1.88 ^a

Legend: Legend: BMI – Body mass index, FFMI – Fat free mass index, FMI – Fat mass index, PF (%) – Percent Fat (%),
^a – indicates statistically significant difference from H, $p < 0.05$.

difference in this aspect. When SANOVA was used to compare the somatotypes comprehensively (three dimensions simultaneously), significant differences were observed between them ($F=3.99$, $p=0.05$). The differences between the particular components of the somatotype were confirmed with t-Student test for mesomorphy ($t=2.45$, $p<0.05$) and ectomorphy ($t=3.39$, $p<0.01$). The karateists competing at the international level were more mesomorphic (+0.8) and less ectomorphic as compared to those of national level (-0.7).

On the body composition chart (Fig. 2) the characteristic features of karateists are mainly marked on the surface between lines BMI 20 and 30 kg/m² (from 22.9 to 31.0 kg/m²), with the percentage of fat between 12.9 and 20.8%. The great majority (12/14) of the subjects competing on the international level (group I) were characterized by the BMI values greater than 25 kg/m², which indicates overweight. For the N group the situation was reverse: their profiles were located below the BMI criterion value. Although 12 from group I, and 6 group N karateists have a BMI value indicating overweight ($BMI \geq 25$ kg/m²), the percentage of fat cannot be unequivocally accepted as such an assessment because these subjects have a high FFMI. Among all karateists who fought at the international and national levels, the range of variation in FFMI and FMI ranged respectively from 18.9 to 24.6 kg/m², and from 3.1 to 6.4 kg/m².

The discriminant function analysis used the three somatotype components, endomorphy, mesomorphy and ectomorphy by karate groups I and N. Function 1 is significant ($p<0.01$) with a canonical correlation coefficient 0.601, and Wilks' $\lambda=0.637$. The coefficient of the function used to discriminate amongst the different karate groups is: $D1 = -0.661442 * Endo + 0.128844 * Meso - 1.1788 * Ecto$. This function group centroid discriminates between both groups. It separates them by 1.5 somatotype units. Five observations in international competing group are incorrectly classified into national

group. Amongst the 30 observations used to fit the model, 20 (67%) were correctly classified.

A comparison according to technique of attack preferred in competition. Tables 3 and 4 combine comparison data for karate contestants with consideration of the technique preferred in effective attack.

Comparison of groups according to the technique preferred in effective attack revealed that group H, HL and L contestants were homogenous in age ($F=0.00$, $p>0.05$), had similar period of training ($F=1.06$, $p>0.05$) and weight, height and HWR or BMI ($p>0.05$). All three groups characteristics were classified as endomorphic mesomorph somatotype, but the statistical important differences ($F=5.11$, $p<0.05$ and multiple comparisons Bonferroni test) were present between the endomorphy component. The group H were supreme of both HL (+1.1) and L (1.2 somatotype units) groups. In addition, there is observed tendencies toward ($F=2.49$, $p=0.102$) superiority of group H in mesomorphy over HL group (0.6) and L (1.0). An opposite configuration was in ectomorphy, where groups of HL and L had higher ectomorphy as compared to group H (ANOVA, $p>0.01$). Considering body composition, the significant differences (ANOVA, $p<0.01$) were revealed in FM, FMI, D and PF (%) between groups, when H was greater than HL and H was greater than L. Groups HL and L were homogenous (multiple comparisons Bonferroni test).

Table 5 shows how often the two levels of competition occur together with each of group of technique used in effective attack.

TABLE 5. FREQUENCY FOR COMPETITION LEVEL AND TECHNIQUES USED IN EFFECTIVE ATTACK

Groups	H	HL	L	Total
International	7	6	1	14
National	5	5	6	16
Total	12	11	7	30

Legend: H – hits with hand, HL – hits with hand and leg, L – kicks mainly

There were 7 times when competitors at the international level declared using mostly hand techniques in effective attack. In that group (n=14) only one karateka was found to prefer kicks, whereas there were 6 subjects specialized in kicks in group N (n=16). Distributions of the counts between both groups I and N were not statistically significant (Chi-squared=4.26 < 5.99, p>0.05).

Comparison of karateist to untrained men. Karate athletes (in total) were more diverse in age and older by 4.4 years than untrained adult men. They did not differ in body height (t=0.59). Karateists were significantly heavier (t=6.287, p<0.001), and were characterized by a more robust muscular body build, as shown by the indices of HWR and BMI (t=8.28, p<0.001 and t=10.71, p<0.001, respectively). They had more FFM and FM (t=7.07, p<0.01 and t=3.45, p<0.001) as compared to untrained men. As a consequence of similarity in height, they had higher indices of FFMI and FMI (t=5.26, p<0.001 and (t=2.60, p<0.05). Fat percentage was higher than in untrained men, but the difference between the means was not statistically significant (t=1.03, p=0.301).

Figure 1 illustrates location of the karateists mean somatotype (0) in relation to untrained students of the Warsaw University of Technology (3). Both compared somatotypes (no. 0 and 3) are classified as endomorphic mesomorph, but the karate contestants had more mesomorphy (t=4.30, p<0.001) and less ectomorphy (t=6.19, p<0.001). There were no significant differences in endomorphy (t=0.35, p>0.05).

DISCUSSION

Level of competition. In the present study of karate players, international sports level depends on the length of training period. Therefore, group I have to be younger than group N when they start practicing karate. Development of coordination motor abilities is crucial for tactical and technical schooling in martial arts. Younger age is better for development of the coordination of body movements [13]. There is also dependence between the rank of sports level criterion and results of the fitness test battery [29].

International-level fighters were more muscular and were also higher in mesomorphy and lower in ectomorphy than those who competed on national level. In the present study, there were no relative adipose tissue and sports level of performance of karate athlete. Comparing body composition, national level competitors had FFMI lower than in group I, and, as a consequence, they showed lower BMI. It was observed that Polish representatives were prepared to open tournament (without weight division). In that kind of tournament, the heavier competitors typically advanced to next rounds [27].

It is remarkable that PF% values estimated in present research on the basis of the measurement of skinfolds were higher than those obtained in BIA. A reverse relation was documented by the German researchers who, however, used different measurement methods [26]. Adiposity of karate fighters increased in the heavier weight categories [26]. This relation was not so prominent in the earlier tests among

Polish team members [30]. In comparison to current results, the competitors examined during direct preparation for the European championships in weight categories [30], similar to research done by Krawczyk et al. [19], were characterized by a lower fat percentage in body mass. For outstanding Italian competitors observed for three years, no significant fluctuations in body mass and PF% were noted [3]. The Japanese karate fighters, described by higher advanced level in this sport discipline, were characterized by lower relative fat (PF%), which is symptomatic because they had greater body mass than the beginner karateists [15].

A comparison according to technique of attack preferred in competition. The group H had greater body mass and, in consequence, FFM and FM were greater than in group HL and group L. Furthermore, group H had higher endomorphy (p < 0.05) and mesomorphy (p=0.10) than in group HL and group L. As mentioned before, karate fighters with wider shoulders showed tendency to use hand techniques more frequently in fight. The sportsmen who specialize in leg techniques in karate are characterized by longer lower limbs in relation to torso [30]. Body mass in Polish karateists substantially correlated with both fat free mass index (r=0.84) and fat mass index (r=0.64, p<0.001). *International findings review and development trend for Polish team somatotype.* In the somatoplot for 14 group profiles (Fig. 3) the balanced mesomorph (6 profiles) and endomorphic mesomorph (4) is dominant. The occurrence of the ectomorphic mesomorph is less frequent (2), similarly to mesomorphic ectomorph and mesomorph-ectomorph (1 each).

In order to compare the results from the present research and data available in the subject literature a somatoplots method [5] and the analysis of means (ANOM) were used. Their main advantage is that it allows for determination of grand mean for the whole set (CL) of data as well as lower (LDL) and upper decision limits (UDL), which

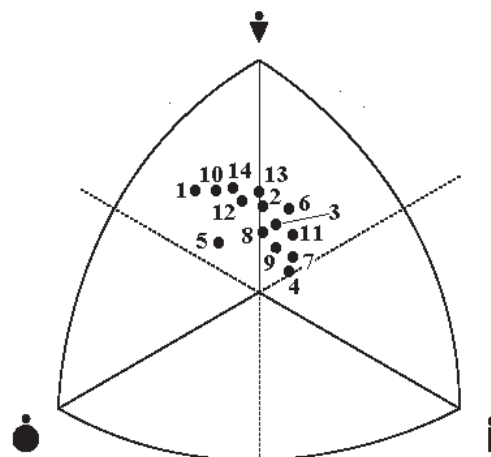


FIG. 3. SOMATOTYPE OF POLISH TEAM KARATE FIGHTERS AGAINST A BACKGROUND OF OTHER RESEARCH: 1- Poland Karate Athletes (Present Research) Endomorphic Mesomorph; 2- Phillippines Team 2008 [25] Balanced Mesomorph; 3- Germany Kumite 2006 [10] Balanced Mesomorph; 4- Germany Kata 2006 [10] Mesomorph-Ectomorph; 5- Germany Amateurs 2006 [10] Endomorphic Mesomorph; 6- Tunisia 2004 [26] Ectomorphic Mesomorph; 7- Italy Elite 2003 [11] Mesomorphic Ectomorph; 8- Italy Amateurs 2003 [11] Balanced Mesomorph; 9- Botswana 1999 [1] Balanced Mesomorph; 10- Poland 1993-95 [19] Endomorphic Mesomorph; 11- Slovakia 1999 [9] Ectomorphic Mesomorph; 12- Poland 1987 [30] Balanced Mesomorph; 13- Belgium 1986 [7] Balanced Mesomorph; 14- Korea 1985 [5] Endomorphic Mesomorph.

helps interpret the statistical significance and thus the direction of differences in averages [22]. In Figure 4 (panels A-C) the average values of somatotype components from the present research and that of the other authors were compared. In the ANOM method, two teams were excluded because in the publication the standard deviation was not given for the somatotype components. Karate fighters' somatotype components in twelve groups of competitors are shown in Figure 4. This plot shows the mean of each of the 12 samples. The grand mean and the 95% decision limits are also presented in the figure. The sample which falls outside the decision limits is significantly different from the grand mean.

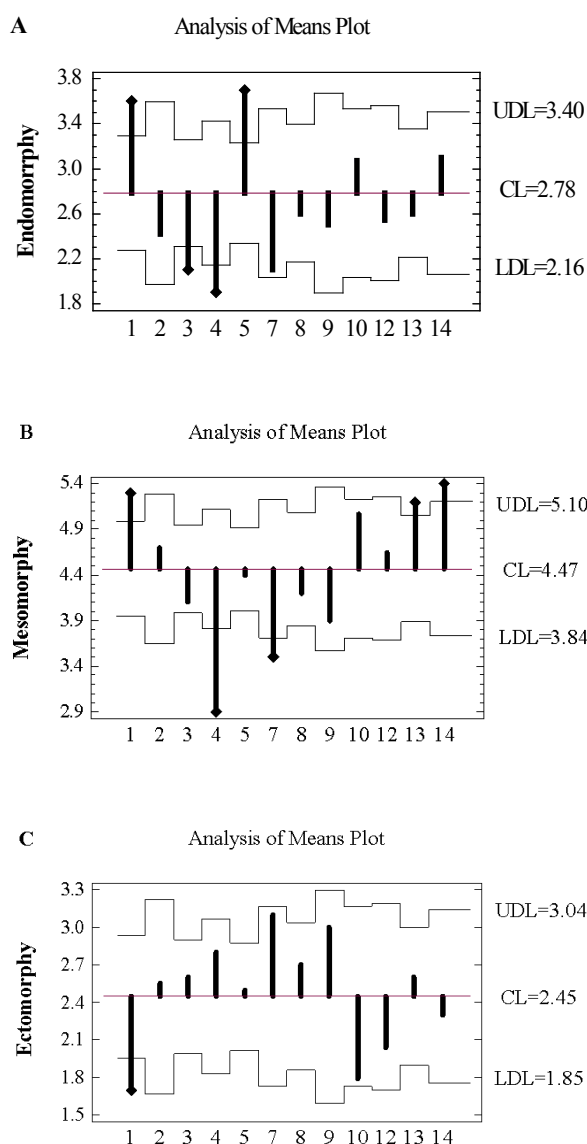


FIG. 4. (PANELS A-C). ANALYSIS OF MEAN SOMATOTYPE COMPONENTS OF POLISH TEAM KARATE ATHLETES (A- ENDOMORPHY, B- MESOMORPHY, C- ECTOMORPHY): 1- POLAND (PRESENT RESEARCH); 2 - PHILLIPPINES TEAM 2008 [25]; 3-GERMANY KUMITE TEAM 2006 [10]; 4- GERMANY KATA TEAM 2006 [10]; 5- GERMANY AMATEURS 2006 [10]; 7- ITALY ELITE 2003 [11]; 8- ITALY AMATEURS 2003 [11]; 9- BOTSWANA 1999 [1]; 10- POLAND 1993-95 [19]; 12-POLAND 1987 [30]; 13-BELGIUM 1986 [8]; 14-KOREA 1985 [5]. AVERAGE KARATE ATHLETES SOMATOTYPE 2.78-4.47-2.45.

With the background of grand mean (CL – central line) value of endomorphy (Fig. 4, panel A), the profile of the national team taken from present research (#1) and from German amateurs (5) is dominating (above UDL – upper decision limit). Exceptionally low endomorphy characterizes the German representatives (3 and 4). In comparison to the grand mean of mesomorphy (Fig. 4, panel B) its higher share in Polish (1), Belgian (13) and Korean (14) draws particular attention, whereas lower values of this component (below LDL – lower decision limit) can be observed in German karateists specializing in formal exercise kata event (4) and outstanding Italian elite fighters (7). The ANOM graph pertaining to karate fighter's ectomorphy (Fig. 4, panel C) shows its significantly lower value for Polish competitors (this study) in comparison to grand mean from all tests.

ANOM graphs (panels A-C) clearly shows development trend for Polish team somatotype (trials 12,10,1). This is due to the observed increase in endomorphy and mesomorphy components together with a decrease in ectomorphy. Based on the performed analysis one can say that the average somatotype of karate competitors is 2.8-4.5-2.5, which indicates the balanced mesomorph type. An upward trend towards increase in mesomorphy component for leading Polish competitors was revealed. The somatotype of contemporary karate fighters in Poland identified as endomorphic mesomorph (3.6-5.3-1.7) is significantly different from the average somatotype of the world competitors (grand mean) for development of endomorphy (+0.8), mesomorphy (+0.8), as well as ectomorphy (-0.8).

Karate players versus untrained men. The superiority of the Japanese representatives in open tournament over average values of body weight and height in the population of those men was particularly evident [27].

We observed the combined effect of long-lasting training period, as well as selection in this sports discipline. In comparison with Polish non-training students (n=165) [24], the karate players had similar adiposity (16.3 vs. 15.7%). According to McArdle et al., [21] percent fat in men's body mass should not be lower than 4 and higher than 25%PF. In general, adiposity in leading Polish competitors was within the abovementioned range of PF%. The supremacy of contemporary Polish karate fighters in preparation for open weight category tournament is visible in a body weight, deeper development of mesomorphy (+1.0) and a decrease in ectomorphy (-1.4). Average somatotype for non-training 165 men is located in the endomorphic mesomorph category [24]. On the basis of measurement morphological features, karate fighters were distinguished from non-training students by Sterkowicz and Żarów [30] by: bigger circumferences of arms, forearms, thighs and shins. The breadths of ankles were smaller, and the fighters had longer lower limbs and longer heads with necks, as well as wider feet, chest, elbow, and wrist and hand width. Additional research shows that there is an adaptation of metacarpus and wrist bones, caused by axial impact on II and III bone of metacarpus and os capitatum during hits with fists [28].

CONCLUSIONS

In conclusions, somatotypes are key determinants of choice and coping with the challenge of long-lasting training. In comparison with karate participants on national sports performance level, the competitors taking part in international tournaments differed in training period, body composition and somatotype. The karate participants who preferred hand techniques were characterized by higher development of mesomorphy component than those who are specialists in punches and kicks and mostly kicks. The body build of top Polish karate competitors (present research), as compared to the data from the subject literature, is characterized by an increased value of endomorphy and mesomorphy component and a lower value of ectomorphy. Comparison to non-practicing Polish

students revealed a supremacy of competitors in mesomorphy with a low level of ectomorphy somatotype component. The search for specific features of sportsmen body build should take place with consideration of research results from other countries as well as with a relation to non-practicing people in the given country.

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