ORIGINAL ARTICLE

Differentiation of the body composition in taekwondo-ITF competitors of the men's Polish national team and direct based athletes

Władysław Jagiełło

Department of Combat Sports, Faculty of Physical Education, Gdańsk University of Physical Education and Sports, Gdańsk, Poland

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Abstract

Background & Study Aim: Body build of competitors of those combat sports where there is a breakdown into weight categories still provides substantial information on the effects of long-term training of people who have gone through stages of selection for the given sport. Yet, in fact, there is still a lack of scientific knowledge about the morphofunctional potential of persons (mainly children and adolescents) who became interested in particular combat sports. The purpose of the study is knowledge of the properties of body composition of taekwondo-ITF competitors of the men's Polish national team and direct based athletes competitors from the national team in comparison to members of the same population not professionally engaged in sport.

Material & Methods: The study involved 21 taekwondo-ITF athletes. The subjects' age was 18.5-32.2 years (x̄24.5 ±4.1), body weight 62.7-100 kg (x̄75.3 ±10.3), body height 167.0-195 cm (x̄179.64 ±8.33). Their training experience was 8.42-22.42 years (x̄13.62 ±3.37) and was significantly diversified (V% = 24.76). The examined persons represented four weight categories: light-weight, middle-weight, heavy-weight, and hyper-weight one. The reference group was made of students of Warsaw University of Technology (Poland). Twenty basic somatic features were measured. The following indices were calculated: slenderness, BMI, Rohrer's, Manouvrier's, shoulder-pelvis. Body density, total body fat, active tissue, the general profile of body composition, and internal proportions of body composition were determined.

Results: Weight categories are an important factor in determining the morphological diversity of taekwondo-ITF competitors. A characteristic feature of their body composition is extremely low contribution of fat in all weight classes with a simultaneous significance of the length factor in the heavy-weight and the hyper-weight category and the stoutness one in the light-weight and the middle-weight category.

Conclusions: The choice of an appropriate combat technique (hits with extremities and a combination of these elements of combat) for the body composition and other components of a taekwondo-ITF athlete's personality will remain a constantly open problem. These problems must be solved by coaches with reference to specific athletes on an individual basis.

Key words: combat sports · internal proportions · Perkal's method · indices: BMI, Manouvrier, Rohrer

Corresponding author: Władysław Jagiełło, Department of Combat Sports, Faculty of Physical Education, Academy of Physical Education and Sport, Kazimierza Górskiego 1, 80-336 Gdańsk, Poland; e-mail: wjagiello1@wp.pl

Body composition – athlete's predisposition in terms of the proportion of active mass and inactive mass in the body

Introduction

The sports result is determined by many factors. As confirmed even by everyday observations of the sport practice, most sports theoreticians usually distinguish three groups of an athlete's properties which prejudge his/her sports success: fitness preparation, psychomotor properties (associated with the superior functions of the nervous system), and the characteristics of the somatic composition. Barczyński et al. [1] are right that scholars from Russia, Poland, and Ukraine are precursors of research on this issue, and many important works have been published in the national languages these scholars [2-5].

Most of the well-founded scientific data concerns athletes' fitness preparation [6-13]. This scientific knowledge (verified by practice) allows specifying the desired level of athletes' preparation for most sports disciplines at different stages of many-year sports training. It is beyond doubt that physical preparation has the decisive influence on success in a fight in a given sport discipline.

Results of research in sport on the superior properties of the central nervous system are fairly well justified. We have information in most sports disciplines on the tribological properties of athletes' psychomotor features [5, 8].

Contemporary anthropologists' research indicates the presence of specific correlations between the body composition and a sports discipline. In athletics, swimming, rowing and most team games such indicators are one of the basic criteria for selection of candidates to these sports. They allow, in fact, judging the level of sports championships and predict the competitive effectiveness [14-16]. A more complex problem concerns acyclic sports and, in particular, combat sports [17-20]. The problem is complicated by the complexity of the structure of sports preparation and a division into weight categories.

Starting from these general premises and assumptions, the main objective of the study was knowledge of the properties of body composition of taekwondo-ITF competitors of the men's Polish national team and direct based athletes competitors from the national team in comparison to members of the same population not professionally engaged in sport.

The specific objectives regard settling the following issues:

Are there any somatic features which substantially determine the specific body composition of taekwondo-ITF athletes?

Are there in the population of taekwondo-ITF athletes of a high level of sports championships any internal body proportions, characteristic of this particular combat sport?

Material and methods

The study involved 21 taekwondo-ITF athletes. Fourteen competitors belonged to the Polish national team; the remaining examined athletes (direct based athletes) represent a high sports level. The subjects' age was 18.5-32.2 years ($\bar{x}$24.5 ±4.1), body weight 62.7-100 kg ($\bar{x}$75.3 ±10.3), and body height 167.0-195 cm ($\bar{x}$179.64 ±8.33). Their training experience was 8.42-22.42 years ($\bar{x}$13.62 ±3.37) and was significantly diversified (V% = 24.76). The examined persons represented four weight categories: light-weight, middle-weight, heavy-weight, and hyper-weight one. The reference group was made of students of Warsaw University of Technology (Poland). Twenty basic somatic features were measured. The following indices were calculated: slenderness, BMI, Rohrer's, Manouvrier's, shoulder-pelvis. Body density, total body fat, active tissue, the general profile of body composition, and internal proportions of body composition were determined.

Subjects represented four weight categories (in accordance with the binding rules in this sport): light-weight <63 kg, middle-weight <7l kg, heavy-weight <80 kg and hyper-weight >80 kg. The research was conducted during the Polish national team camp (Spała – the Central Sports Centre from 29 February to 5 March 2012 and during the Seniors' Polish Cup-Kłobuck, 2-4 February 2012).

Anthropometric measurements: (a total of 20 basic features) were conducted in accordance with the adopted rules [21] using standard instruments. In addition, five indicators were calculated: slenderness, Rohrer's, BMI, Manouvrier's, and the shoulder-pelvis one.

Tissue components were estimated on the basis of the determined body density: to calculate it, an indirect method was applied – an anthropometric estimation of body density based on the measurement of subcutaneous fat, using the predicting equation [22]:

$$D = 1.125180\ \ 0.000176 \bullet \log x_1\ \ 0.000185 \bullet \log x_2$$

where: D the body density; x_1 thickness of the fold on the shoulder [log]; x_2 thickness of the fold on the abdomen [log]).

Total body fat: in percentage of the body weight (F%) was calculated according to the formula: F% = 100 (4.201/D 3.813).

Active tissue: in percentage of the body weight: T.A.% = 100 F%

The general profile of body composition was defined by the method of standardization of features: $Z = x_j \; x_s / SD_s$

(where: Z – standardized value; x_j – mean value of the feature for the group of taekwondo-ITF athletes; x_s mean value of the feature for the reference group; SD_s – standard deviation of the reference group).

An assessment of internal proportions of the body composition was based on the method of Perkal's natural indicators [23] with Milicerowa's modifications [24]. In order to do so, the following have been defined:

- Composition factors m – by summing up the standardized values within each factor and dividing the sum by the number of features identifying the given factor. The obesity factor is an exception, as it is the standardized value of skin and fat folds: Z = m.
- Index of total body size of the group (M): $M = m_1 + m_2 + m_3 / 3$
- Assessment of internal proportions of body composition was made through calculating Perkal's natural indicators for each composition factor: m_1 M; m_2 M; m_3 M
- Evenness of the composition was determined by means of the intrapersonal variability index – the difference between the natural indicator with the highest numerical value and the natural indicator with the lowest value.
- The code of internal proportions of the group on the basis of the point scale of Perkal's natural indicators (Table 1).
- Assessment of internal proportions of the body composition within each of the factors has been made by taking away the value of factor m from the standardized feature.

Table 1. Point scales of Perkal's natural indicators

Points	Values of Perkal's natural indicators			
1	X	to	–1.07	values less than average
2	–1.06	to	–0.57	
3	–0.56	to	–0.18	
4	–0.19	to	0.18	average value
5	0.19	to	0.57	values greater than average
6	0.58	to	1.06	
7	1.07	to	X	

The reference group for the present study was made of students of Warsaw University of Technology [25].

Results

Body composition of Polish representatives in taekwondo-ITF varies depending on the represented weight category (Table 2).

Specific profiles of body composition of taekwondo ITF competitors were defined on the basis of standardizing features with a breakdown into four weight categories (Figure 1).

The distance from the zero line (the means of features for the reference group – students of Warsaw University of Technology) – tells the difference in composition between the athletes and men from the reference group. Direct measurements of taekwondo-ITF competitors' bodies reveal a progressive trend along with the weight category (from the light-weight one), which is a natural phenomenon. The athletes' body composition profiles show differences, although not in all cases with the same intensity.

Of all the subjects, athletes of the light-weight category are characterized by the smallest body-build, both in comparison to other competitors and the reference group. They are much inferior to the reference group in the knee width (2.89 Z), the sitting body height (1.42 Z), the body area (1.39 Z) and the body height (1.37 Z). These athletes represent an average (slenderness index) and athletic (Rohrer's index) build with a normal body weight (BMI). They qualify as long-legged (Manouvrier's index) with a more masculine physique (shoulder-pelvis index). Compared to the group of students of Warsaw University of Technology, they also have a higher density of the body (1.43 Z) and the lowest fat content (1.37 Z fat content in percentage of the body weight was 11.94%).

Table 2. Features of the body build of Polish men's taekwondo-ITF representatives and students of Warsaw Technical University

Somatic features	Students n = 165		Weight categories											
			light (<63kg, n = 5)			middle (<71kg, n = 6)			heavy (<80kg, n = 6)			super-heavy (>80kg, n =4)		
	X	SD	X	SD	V	X	SD	V	X	SD	V	X	SD	V
Body mass [kg]	72.11	8.96	62.82	0.13	0.21	70.98	0.04	0.06	79.87	0.20	0.25	90.35	8.24	9.12
Standing body height [cm]	179.36	6.19	170.90	3.13	1.83	175.17	3.49	1.99	183.33	4.27	2.33	191.75	2.99	1.56
Sitting body height [cm]	93.86	3.06	89.52	1.85	2.07	92.65	3.66	3.95	95.45	2.74	2.87	100.63	1.90	1.89
Length of upper extremity [cm]	78.30	3.51	76.14	2.64	3.47	76.93	2.44	3.17	82.05	1.96	2.39	84.75	2.47	2.91
Length of lower extremity [cm]	85.50	4.10	81.38	2.65	2.97	82.52	2.83	3.20	87.18	2.17	2.26	91.13	4.09	4.12
Shoulder width [cm]	40.67	1.59	39.06	1.75	4.48	39.28	2.13	5.42	41.03	1.26	3.07	42.25	1.45	3.43
Pelvic width [cm]	28.44	1.46	27.76	1.03	3.71	27.85	1.09	3.91	28.72	0.93	3.24	31.20	1.12	3.59
Elbow width [cm]	6.98	0.34	6.78	0.46	6.78	7.18	0.21	2.92	7.22	0.17	2.35	7.63	0.25	3.28
Knee width [cm]	9.82	0.45	8.52	0.48	5.63	8.77	0.48	5.47	8.92	0.26	2.91	9.60	0.32	3.33
Forearm perimeter [cm]	26.02	1.80	26.70	0.62	2.32	27.80	0.69	2.48	29.30	0.63	2.15	29.58	1.16	3.92
Shank perimeter [cm]	36.86	2.30	35.66	0.74	2.08	37.82	0.88	2.33	38.92	1.89	4.86	40.13	3.00	7.48
Body density [g/cm^3]	1.06	0.01	1.07	0.00	0.37	1.07	0.01	0.93	1.06	0.01	0.66	1.06	0.01	0.94
Fatty tissue [%]	15.66	2.72	11.94	0.60	5.03	12.69	2.41	18.99	14.27	0.55	3.85	16.05	2.24	13.96
Active tissue [%]	84.34	2.74	88.06	0.60	0.68	87.31	2.41	2.76	85.74	0.55	0.64	83.95	2.24	2.67
Body surface [m^2]	1.90	0.13	1.73	0.02	1.16	1.86	0.02	1.08	2.02	0.03	1.49	2.19	0.10	4.57
Slenderness index	43.21	1.66	42.98	0.81	1.88	42.31	0.84	1.99	42.57	0.97	2.28	42.79	1.35	3.15
Rohrer's index	1.25	0.15	1.26	0.07	5.56	1.32	0.08	6.06	1.30	0.09	6.92	1.28	0.12	9.38
BMI index	22.40	2.46	21.55	0.82	3.81	23.16	0.92	3.97	23.79	1.10	4.62	24.58	2.23	9.07
Manouvrier's index	91.01	2.82	90.94	3.44	3.78	89.19	4.10	4.60	92.15	5.01	5.44	90.57	1.17	1.29
Shoulder-pelvis indicator	69.93	2.40	71.18	3.96	5.56	70.96	1.91	2.69	70.01	2.30	3.29	73.85	1.20	1.62

Features that significantly distinguish representatives of the middle-weight category are the knee width (2.33 Z), the forearm perimeter (0.99 Z), the shoulder width (0.87 Z), the length of the lower extremity (0.74 Z) and the elbow width (0.59 Z). Athletes in this category represent an average (slenderness index), athletic (Rohrer's index) build with a normal body weight (BMI). These athletes also qualify as long-legged (Manouvrier's index) with a more masculine physique (shoulder-pelvis index). The density of the body compared to the non-training group amounted to 1.71 Z and the fat content to 1.09 Z.

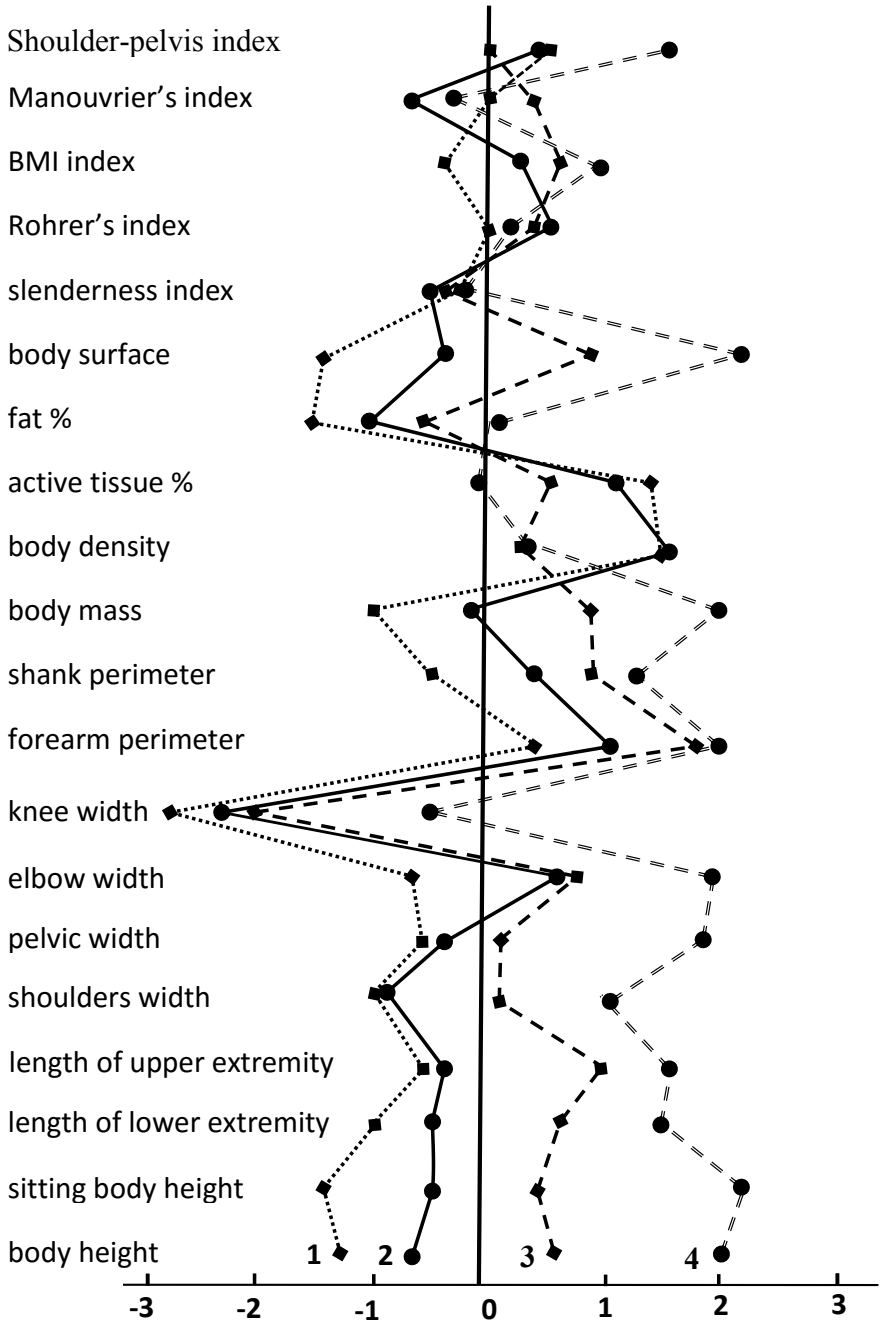

Figure 1. Profiles of the body build of Polish men's taekwondo-ITF (n=21). Numbers of weight categories: 1 light, 2 medium, 3 heavy, 4 super-heavy – against a reference group

Athletes of the heavy-weight category in comparison to the reference group are distinguished the most by the knee width (2.01 Z), the forearm perimeter (1.82 Z) and the length of the upper extremity (1.07 Z). These athletes represent an average (slenderness index), athletic (Rohrer's index) build with a normal body weight (BMI). These athletes are qualified as long-legged (Manouvrier's index) and also with a more masculine physique (shoulder-pelvis index). The density of the body and the fat content compared to the non-training group amount to 0.23 Z and 0.51 Z, respectively.

In comparison to the reference group, taekwondo-ITF athletes from the hyper-weight are the most distinguished by the body area (2.23 Z), the sitting body height (2.21 Z), the body height (2.00 Z), the forearm perimeter (1.98 Z), the elbow width (1.91 Z), the pelvis width (1.90 Z), the upper extremity length (1.84 Z), the shank perimeter (1.42 Z), the lower extremity length (1.37 Z). Competitors of the hyper-weight category represent an average (slenderness index), athletic (Rohrer's index) build with a normal body weight (BMI). They are qualified as long-legged (Manouvrier's index) and with averagely masculine physique (shoulder-pelvis index). This is the group in which the lowest density of the body was noted (0.10 Z) and the highest fat content (0.14 Z).

The defined values of body composition factors confirm in a more generalized way the standardized values of particular features (Table 3).

Table 3. Factors of body build of Polish men's taekwondo-ITF representatives (n=21)

Factor	Competitors from the adopted weight categories			
	light (n=5)	medium (n=6)	heavy (n=6)	super-heavy (n=4)
Length (m_1)	–1.10	–0.55	0.70	1.86
Stoutness (m_2)	–0.85	0.27	0.32	1.28
Fatty tissue (m_3)	–2.38	–1.89	–1.04	0.53
Overall size index M	–1.44	–0.90	–0.02	1.22

Athletes of the light-weight category are characterised by generally smaller dimensions compared to the reference group (M = 1.44). The biggest difference is notable in the fat content factor (m_3 = 2.38). Slightly lower values are revealed in length and stoutness factors (respectively: m_2 = 1.10 and m_1 = 0.85).

Taekwondo-ITF athletes of the middle-weight category are also characterised by a smaller overall size of the body in comparison to the reference group (M = 0.90). In this weight category the fat content factor (m_3 = 1.89) deviates the most from the reference group.

Athletes representing the heavy-weight category are distinguished by body composition which is the closest to the reference group (M = 0.02). The most characteristic factor of these athletes' composition is fat content (m_3 = 1.06) and the length factor (m_1 = 0.7). The stoutness factor is the closest in value to the reference group (m_2 = 0.31)

The hyper-weight category athletes mainly differ from the comparative group in generally larger body dimensions (M = 1.22), the length (m_1 = 1.86) and the stoutness factor (m_2 = 1.28). The value nearest to the reference group is the fat content factor (m_3 = 0.53).

Analysing mutual proportions between factors of body composition (natural indicators of composition factors) in taekwondo-ITF athletes from different weight categories, major differences in particular sets of somatic composition features become apparent (Figure 2).

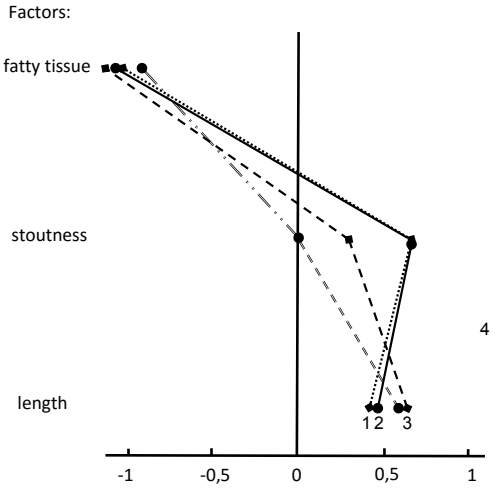

Figure 2. Natural indicators of the body build features of Polish men's taekwondo-ITF representatives (n=21). Numbers of weight categories: 1 light, 2 medium, 3 heavy, 4 super-heavy

Taekwondo-ITF competitors of the four examined weight categories are characterized by a significant intragroup variability (big differences of the natural indicator for the factor with the highest and the lowest numerical values). The evenness of the composition index in the light-weight and the middle-weight category is 1.53 and 1.62, in the heavy-weight one 1.76 and in the hyper-weight category 1.33.

Using the point scale of natural indicators, codes of internal proportion of athletes in the four weight categories were obtained. The code of internal proportions of body composition for light-weight category athletes has the value of 5-6-2. This means that the

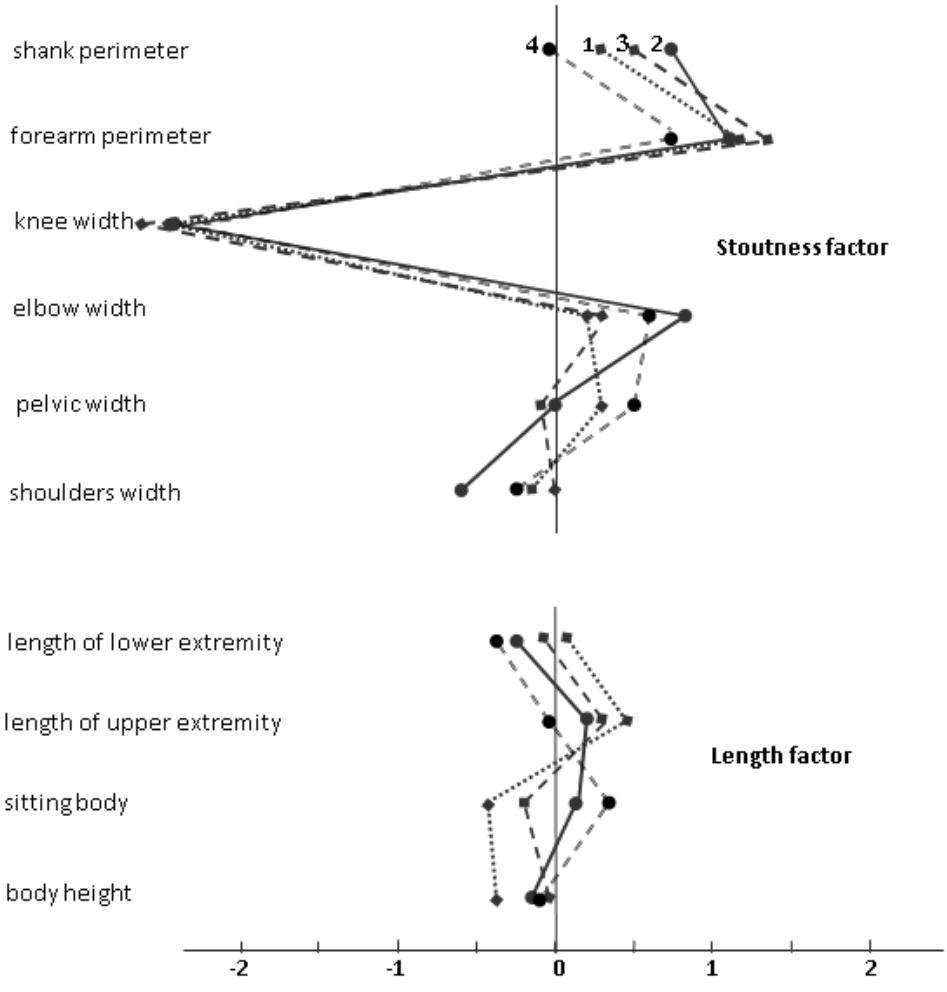

Figure 3. Natural indicators of the somatic features within factors, of Polish men's taekwondo-ITF (n=21). Numbers of weight categories: 1 light, 2 medium, 3 heavy, 4 super-heavy

overall body size (M) is due to average body lengths, big values of stoutness and very small ones of the fat content. The code of internal proportions for athletes of the middle-weight category is expressed by the following values: 5-6-2; the heavy-weight one: 6-5-1, and the hyper-weight category: 6-4-2.

Defining internal proportions of composition features within each of the factors provides very important information on the body composition of taekwondo-ITF athletes. In all weight categories the forearm is especially heavily and the shank quite weakly muscled (Figure 3).

In the features expressing skeletal stoutness, apparent is an advantage of the elbow width over the pelvis width (except for the light-weight category) and very clearly over the shoulders width, with an extremely small value of the knee width.

The length factor in all weight categories is the least diverse. Apparent is an advantage of the upper extremity length over the lower one and a slight one over the sitting body height (except for the hyper-weight category).

Discussion

Thus conducted analysis shows the general profile of body composition of taekwondo-ITF athletes from the four weight categories in comparison to the reference group, but it brings little information about internal proportions of these groups. To define these proportions, the method of Perkal's [23] natural

indicators modified by Milicerowa [24] was applied. The values of composition factors confirm in a more generalized way the observations made on the standardised values of individual features (Table 3).

The most commonly used method of assessing athletes' body composition is the so-called somatotypes (patterns of specific types of body composition, characterized by means of several significantly different factors). Among the many typologies used in anthropology, the most widely used is Sheldon's somatotypology [26], which had a number of modifications, e.g. Heath, Carter [27], improving the objectivity of its evaluation. Sheldon's method is also of great interest for scientists dealing with combat sports [28-33].

In our study, the method of Perkal's natural indicators [23] modified by Milicerowa [24] was used. It gives many opportunities to use and is particularly important in sports training –for example, due to the possibility of assessing internal proportions of body composition (selection for a discipline, individual technique, etc.). It also allows comparative studies with other somatotypological methods. Because research on the Polish population using this method has been conducted since 1956, it is possible to compare body composition of athletes from nearly sixty years [24, 34].

Morphological differentiation of taekwondo-ITF athletes revealed in this research is a resultant of two processes: on the one hand, the process of sports selection; on the other hand, the effect of adaptation of an organism to external factors affecting it. Athletes of the light-weight, middle-weight, and heavy-weight categories are characterized by generally smaller body size in comparison to the reference group (students of Warsaw University of Technology). Only hyper-weight category athletes greatly outweigh the reference group in this respect. However, students of Warsaw University of Technology are counted among the best (in terms of physical development) academic youth – the mean body height is 179.4 cm.

Polish representatives in wrestling [35] only in the light-weight category were inferior to the reference group in terms of overall body size (M) (M = 1.19 and M = 1.32, respectively). Representatives of Poland in baseball [36] (M = 0), in pentathlon [37, 38] (M = 0.02) and in tennis [39] (M = 0.22) are the closest in the overall size of the body.

Representatives of Poland in taekwondo-ITF represent the correct body weight with an athletic physique. They are long-legged, with the exception of the middle-weight category (average-legged). They represent better expressed masculine proportions of body composition (except for the hyper-weight category – averagely expressed). However, the factor distinguishing the athletes the most from students of Warsaw University of Technology [40] is the extremely low level of fat content in all categories except the hyper-weight one. This factor also distinguishes taekwondo-ITF competitors from other representatives of combat sports (judo and wrestling). The length factor is dominant only in the heavy-weight and the hyper-weight category.

Numerous scientific studies, based on the example of combat sports, confirm the disclosed in our study general direction of the development of body composition indicating well-muscled athletes with an athletic, more masculine physique and low fat content – apart from the heavy-weight category in judo [19, 28-34, 40, 42-43]. Research on the group of the world's best judokas [29] indicates that the level of endomorphy in top-level athletes remains in low ranges of the adopted standards and is characterized by very high values in athletes of the highest weight categories, where there is no upper limit to the body mass, and the large weight may be an asset.

Analysis of mutual proportions of factors of body composition among taekwondo-ITF athletes indicates high values of the intragroup variability index (from 1.53 in the light-weight category to 1.76 in the heavy-weight one). Such diversity in taekwondo-ITF athletes' composition is due to the extremely small contribution of the fat content in all weight categories with a simultaneously high contribution of the length factor heavy-weight and hyper-weight one and of stoutness in the light-weight and middle-weight category. Such a significant advantage of one factor of body composition over another one is characteristic of the highly qualified athletes [41]. Taking into account the code of internal proportions of body composition factors, athletes of light-weight and middle-weight categories (the code of internal proportions: 5-6-2), in this respect, are the most similar to Polish representatives in baseball – the code of „pitchers" internal proportions: 5-5-2 [36]. Athletes of the hyper- weight category (6-4-2) in their internal proportions are the most similar to Polish representatives in tennis: 6-3-3 [39]. Thus it can be concluded that taekwondo competitors significantly differ in terms of body composition from representatives of combat sports of a wrestling character and are more similar to representatives of team games.

The results of the present study correspond with the results research on Greco-Roman wrestlers [19] and judokas [40], which showed that those athletes are characterized by an advantage of the forearm perimeter over the shank perimeter and a greater elbow width in relation to the knee width. In all weight categories, wrestlers and judokas, similarly to taekwondo-ITF athletes, exhibit an advantage of the upper extremity length over the length of the lower one. The basic and the biggest difference in the internal proportions of somatic features within the composition factors is extremely low, in the case of taekwondo athletes, contribution of the knee width in the stoutness factor. This is probably related to the fact that hitting with legs and arms dominate in taekwondo, i.e. techniques that do not involve extensor muscles of the hips and knees to such an extent as in judo or wrestling. Overcoming heavy loads causes not only an increase in muscle hypertrophy but also thickening of the bone heads with which muscles are joined by tendons so that these muscles could perform their functions.

Taking into account other sport disciplines, among others, one could pay attention to modern pentathlon [37, 38]. These athletes, like taekwondo-ITF athletes, are characterised by an advantage of the forearm perimeter over the shank perimeter and a smaller knee width over the elbow width. Similarly to judokas and wrestlers, modern pentathletes exhibit a predominance of the upper extremity over the lower one. A feature differentiating them from competitors in the above combat sports (except heavy-weight categories), including taekwondo, is higher fat content (m_3 = 0.09).

In the latest study [44] on taekwondo athletes, authors state that correlations of somatic indicators with the sports level and training experience of Polish representatives in taekwondo-ITF are heterogeneous and largely dependent on a weight category. The shank perimeter and the shoulder-pelvis index (except for the heavy-weight category) highly correlate with the sports level in all weight categories (except the hyper-weight one). A high correlation with the training experience was noted for the lower extremity length (except for the hyper-weight category), the shoulder-pelvis index (apart from the hyper-weight category), the shoulders width (except the heavy-weight category) and the forearm perimeter.

Conclusions

The long-term impact of training together with the process of selecting the most predisposed athletes, have a significant influence on the somatic composition of athletes from the Polish national team in taekwondo-ITF. A characteristic feature of their body composition is an extremely small contribution of the fat content in all weight categories with a simultaneous considerable significance of the length factor in the heavy-weight and the hyper-weight categories and of stoutness in the light-weight and the middle-weight ones.

Although competitors of the Polish national team in taekwondo-ITF confirm the general trends in body composition revealed in other combat sports, in terms of internal proportions of factors of body composition they are more similar to representatives of some team sports games rather than sports of a wrestling nature. The results of studies on Polish representatives in taekwondo-ITF confirm the fact of closer correlations of the training experience with the somatic composition rather than with the sports level.

The choice of an appropriate technique (hitting with hands and feet and a combination of these elements) for the body composition and other components of a taekwondo-ITF athlete's personality will still remain an open problem. Such problems, as authors of previously published work emphasise, must be settled by coaches with reference to particular athletes on an individual basis.

Competing interests

The author declares that has no competing interests.

References

1. Barczyński BJ, Graczynski M, Kalina RM. Barriers Restricting the Free Dissemination of Scientific Achievements: Own Experiences in Crossing Walls and Bridges. J Hum Kinet 2009; 22(22): 7-14
2. Naglak Z. Trening sportowy. Teoria i praktyka. Wydanie III poprawione i uzupełnione. Warszawa-Wrocław: Państwowe Wydawnictwo Naukowe; 1979 [in Polish]
3. Wołkow LW. Sportiwnaja podgotowka dietiej i podrostkow. Kijev: Wieża; 1998 [in Russian]
4. Płatonov VN. Sistema podgotovki sportsmenov w olimpijskom sportie. Obszczaja teoria i jejo prakticzeskie priłożenija. Uczebnik trenera wysszej kwalifikacji. Kijów: Olimpijska literatura; 2004 [in Russian]
5. Jaskólski E, Wołkow L, Jagiełło W. Biologiczne i pedagogiczne podstawy systemu szkolenia sportowego. Warszawa: Biblioteka Trenera; 2005 [in Polish]
6. Platonov WN. Spiecialnaja fiziczeskaja podgatowka płowcow wysszich rasriadow. Kijev: Ėdorobja; 1974 [in Russian]
7. Platonov WN, Bulatowa M. Fiziczna podgatowka sportsmena. Kijev: Olimpijskaja litieratura; 1995 [in Russian]

8. Płatonow WN. Obszczaja teoria podgotowki sportsmienow w olimpijskom sportie. Kijev: Olimpijska literatura; 1997 [in Russian]
9. Jagiełło W. Przygotowanie fizyczne młodego sportowca. Warszawa: COS; 2000 [in Polish]
10. Kalina RM, Chodała A, Dadeło S et al. Empirical basis for predicting success in combat sports and self-defence. Kinesiology 2005; 37(1): 1-13
11. Kalina RM, Barczyński BJ. From "physical fitness" through "motor competence" to the "possibility of action" Arch Budo 2008; 4(4): 106-109
12. Schmidt RA, Wrisberg CA. Motor Learning and Performance. A Situation-Based Learning Approach. Fourth Edition. Human Kinetics; 2008
13. Jagiełło W, Wolska B, Sawczyn S et al. The similarity of training experience and morphofunctional traits as prediction criteria of the sports level in subsequent stages of long-term women's judo training. Arch Budo 2014; 10: 201-210
14. Claessens A, Beunen G, Lefevre J et al. Body structure, somatotype, and motor fitness of top-class Belgian judoists and karateka. A comparative study. Kinanthropometry III. Eds: Reilly T, Watkins J, Borms J, editors. London: E. & F.N. Spon 1986: 53-57
15. Baxter-Jones ADG, Helms P, Maffulli N et al. Growth and development of male gymnasts, swimmers, soccer and tennis players: a longitudinal stady. Ann Hum Biol 1995; 5: 381-394
16. Vardar SA, Tezel S, Ozturk L et al. The relationship between body composition and anaerobic performance of elite young wrestlers. J Sports Sci Med 2007; 6: 34-38
17. Kalina RM. Teoria sportów walki. Warszawa: COS; 2000 [in Polish]
18. Bujak Z. Wybrane aspekty treningu w taekwon-do. Biała Podlaska: Zamiejscowy Wydział Wychowania Fizycznego w Białej Podlasce; 2004 [in Polish]
19. Jagiello W, Kruszewski A. Somatic aspects of sports mastery of Polish national team representatives in Greco-Roman wrestling. Pedagogies, Psychology, Medical-Biological Problems of Physical Training and Sports 2009; 4: 150-153
20. Sterkowicz-Przybycień K, Franchini E. Demographic profile of combat sports athletes: A comparative analysis between genders and competitive achievement in London 2012. Arch Budo 2013; 9(2): 149-159
21. Drozdowski Z. Antropometria w wychowaniu fizycznym. Poznań: AWF. Seria: Podręczniki No 24; 1998 [in Polish]
22. Piechaczek H. Oznaczanie całkowitego tłuszczu ciała metodami densytometryczną i antropometryczną. Materiały i Prace Antropologiczne 1975; 89: 3-48 [in Polish]
23. Perkal J. O wskaźnikach antropologicznych. Przegląd Antropologiczny 1953, 19: 209-11 [in Polish]
24. Milicerowa H. Zastosowanie wskaźników Perkala do charakterystyki budowy ciała bokserów. Materiały i Prace Antropologiczne 1956: 20 [in Polish]
25. Piechaczek H, Lewandowska J, Orlicz B. Zmiany budowy ciała młodzieży akademickiej Politechniki Warszawskiej w okresie 35 lat. Wych Fiz Sport 1996; 3: 3-14 [in Polish]
26. Sheldon WH, Stevens SS, Tucker WB. The varieties of Human Physique. New York: Parper and Brothers; 1940
27. Heath B, Carter J E. Modified somatotype method. Am J Phys Anthrop 1967; 27: 57-74
28. Skład M, Krawczyk B, Majle B. Body build factors and body components in greco-roman and free-style wrestlers. Biol Sport 1995; 2: 101-105
29. Kuźmicki S, Jagiełło W. Niektóre różnice i podobieństwa w budowie ciała judoków. In: Kalina RM, Jagiełło W, editors. Wychowawcze i utylitarne aspekty sportów walki. Warszawa: Akademia Wychowania Fizycznego Józefa Piłsudskiego; 2000: 136-143 [in Polish]
30. Sterkowicz-Przybycień K, Sterkowicz S, Żarów RT. Somatotype, Body Composition and Proportionality in Polish Top Greco-Roman Wrestlers. J Hum Kinet 2011; 28: 117-130
31. Franchini E, Sterkowicz-Przybycien K, Takito MY. Anthropometrical profile of judo athletes: Comparative analysis between weight categories. Int J Morphol 2014; 32(1): 36-42
32. Ji-Woong Noh, Ju-Hyun Kim, Junghwan Kim. Somatotype analysis of elite judo athletes compared with nonathletes for health science research. Toxicol Env Health Sci 2014; 6(2): 99-105
33. Poliszczuk T, Jankowska E, Mańkowska M et al. Profile of an ITF Taekwon-do Female Champion Team in terms of somatotype and body composition. Arch Budo 2015; 11: 153-158
34. Marchocka M, Skibińska A. Budowa ciała zapaśników w stylu wolnym. In: Zapasy. Warszawa: INKF. Seria: Wyniki Badań; 1970: 19-38
35. Jagiełło W, Kruszewski A. Morphological Diversification of Competitors Training Greko-Roman Style of Wrestling. Arch Budo 2009; 5: 147-153
36. Jagiełło M, Jagieło W, Kozina ZhL. Differentiation of body composition of players of the polish national baseball team. Pedagogies, Psychology, Medical-Biological Problems of Physical Training and Sports 2014; 10: 72-76
37. Jagieło W, Kalina RM, Jagiełło M. Differentiation of the body composition in the Polish national team pentathletes. Balt J Health Phys Act 2011; 3(2): 105-111
38. Jagiełło M, Jagiełło W. Internal proportions of body composition in women practising modern pentathlon. Arch Budo Sci Martial Art Extreme Sport 2014; 10: 11-16
39. Jagiełło W, Jagiełło M. Internal proportions of body build of the Polish representatives in tennis. Pedagogies, Psychology, Medical-Biological Problems of Physical Training and Sports 2006; 5: 141-145
40. Jagiełło W. Differentiation of the body build in judo competitors of the men's Polish national team. Arch Budo 2013; 9(2): 117-123
41. Łaska-Mierzejewska T. Antropologia w sporcie i wychowaniu fizycznym. Warszawa: COS; 1999 [in Polish]
42. Jagiełło W, Kalina RM, Korobielnikow G. Morphological diversification of female judo athletes. Arch Budo 2007; 3(3): 27-34
43. Jagiello W, Krushevskiy A. Somatic Aspects of Sports Mastery of Polish Representatives in Wrestling. Pedagogies, Psychology, Medical-Biological Problems of Physical Training and Sports 2008; 5: 158-161
44. Jagiello W, Kozina ZhL, Jagiello M. Somatic aspects of sports championship in taekwon-do ITF. Physical Education of Students 2015; 4: 51-55

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