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INDIVIDUAL-TYPOLOGICAL CHARACTERISTICS OF THE BODY COMPOSITION OF ATHLETES IN THE KICKING MARTIAL ARTS

Objective assessment of athletes' body composition is a crucial tool for enhancing athletes' performance. Collaboratively, the State Research Institute of Physical Culture and Sports, in conjunction with boxing, kickboxing (WAKO), taekwondo, and hand-to-hand combat federations, has conducted extensive research into the morphological characteristics of high-caliber martial artists' body structures. The body's compositional makeup plays a pivotal role in understanding the unique individual and typological traits of athletes competing in various weight divisions. Emphasizing the importance of optimizing body weight by managing the fat component is pivotal for success in competitive martial arts. The study has identified substantial variability in the fat-related metrics (such as fat content, fat mass, and visceral fat content) among martial artists in different weight categories. This variability is attributed to the athletes' distinctive constitutional characteristics, necessitating careful consideration when devising weight adjustment strategies.

This article aims to delve into the distinct aspects of body composition among martial artists specializing in striking disciplines and examine how these factors influence the utilization of functional reserves during strenuous physical activity.

Primarily focusing on mesomorphic body types among male and female martial artists, we observed the following trends: lightweight martial artists typically exhibit ectomorphic physiques with minimal fatty tissue and an elevated percentage of bone mass; medium-weight categories favor mesomorphic body types; athletes in heavyweight and super heavyweight categories tend to display mesomorphic body types with a tendency toward endomorphism, characterized by an increased fat component.

Analyzing body composition data reveals that, in most cases, martial artists' fat content aligns with reference values. However, the study's significant finding is that certain athletes in each weight category exceeded the recommended fat content levels. Consequently, relying solely on average data within specific weight categories to determine a pattern of increasing fat content with higher athlete weight, as suggested in existing literature, is insufficient.

Correlation analysis further supports these findings, highlighting a substantial relationship between fat content and overall body size, including body weight ($r = 0.84$; $p < 0.05$) and length ($r = 0.49$; $p < 0.05$). Simultaneously, the analysis of fat content variability within athlete groups categorized by weight challenges this assertion. The coefficient of variation (V,%) for fat content significantly exceeds normative values (12-14%) across all weight groups, underscoring that athletes exhibit significant variability in fat content regardless of body weight or weight category due to individual constitutional traits. Consequently, formulating bodyweight adjustment strategies should prioritize individual typological characteristics and body composition indicators, irrespective of the athlete's weight category.

Keywords: *Body composition; martial arts; fat content; adaptation; body functional reserves.*

Statement of the question and its connection with important scientific or practical tasks. The work was carried out in accordance with the thematic plan of research works of the State Research Institute of Physical Culture and Sports, financed from the state budget by the Ministry of Youth and

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Analysis of recent research and publications. In sports morphology, there is a high level of attention to the composition of the athlete's body due to the significant influence of anthropometric and somatometric indicators on the effectiveness of training and competitive activities in sports. Many scientific studies [1, 2, 3, 4] indicate the need to bring the physique in the selection and orientation of athletes, optimize the training system, nutrition, and recovery, etc.

Modern athletes and coaches are well aware of the importance of achieving and maintaining optimal body weight to achieve the highest results in a particular sport. It is known that despite the significant genetic determination of body composition, there is a possibility of influencing its characteristics by exercise, nutrition, thermal procedures, etc. Regulation of body weight is achieved by the following: a) increasing the number of force loads to affect the muscular component of the body composition; b) the use of diets and thermal procedures (sauna, bath) to influence the fat component of the body composition. Simultaneously, the wrong weight adjustment strategy can harm the athlete's health, the effectiveness of adaptation processes, and athletes' physical performance [2, 5, 7, 8].

One of the most common effects on the athlete's body composition is body weight regulation by reducing the fat component, which is constantly present in various sports, especially in martial arts. There are the weight categories regulated by the competition rules and the athlete's desire, with the help of permitted tools of weight adjustment, to gain a competitive advantage by moving to a more favorable weight category [6, 7, 9]. For martial arts athletes, the optimal body fat content is 5-12% for male athletes and 8-16% for female athletes (according to Kenney W.L. at al, 2012 [1]), indicates a significant reserve for optimizing body weight due to the impact on the fat component. At the same time, urgent weight loss carries the most significant risk of losing physical performance.

Hence, the examination of athletes' physiological peculiarities, along with the utilization of instrumental methods to ascertain somatotype, and an exploration into the mechanisms driving the development of an optimal physique as indicative of adaptive changes in an athlete's morphofunctional organization during sports activities, remains an aspect insufficiently addressed within the broader context of adaptive mechanisms in athletes' bodies. This underscores the pressing nature of this topic within the realm of sports biology.

The aim of this article is to explore the distinct aspects of body composition among athletes specializing in striking martial arts, considering how these factors impact the utilization of functional reserves during periods of physical exertion.

Methods. The research was conducted by the basic bioethical norms of the Helsinki Declaration of the World Medical Association on Ethical Principles of Scientific and Medical Research, as amended (2000, as amended in 2008), the Universal Declaration on Bioethics and Human Rights (1997), and the Council of Europe Convention on Human Rights and Biomedicine (1997). Written informed consent was obtained from each study participant.

The research was conducted based on the State Research Institute of Physical Culture and Sports with high-qualified athletes of Ukraine's national teams in boxing, kickboxing and taekwondo, and hand-to-hand fight. One hundred eighty-seven human surveys were conducted, in which 72 men and 26 women aged 17-36 took part.

According to the peculiarities of the modern distribution of athletes in both Olympic and non-Olympic types of martial arts by weight categories, the basis for the selection of these groups is selected Qualification Standards and Requirements of the Unified Sports Classification of Ukraine for Olympic Sports (Order of the Ministry of Youth and Sports of 17.04.2014 № 1258 with changes), Qualification norms and requirements of the Unified sports classification of Ukraine in non-Olympic sports (Order of the Ministry of Youth and Sports of 24.04.2014 № 1305 with changes), according to which athletes were conditionally divided into groups according to the declared weight category.

The following weight categories are allocated for male athletes who specialize in martial arts: lightweight - weight categories up to 60 kg; average weight - weight categories up to 75 kilograms; heavyweight - weight categories up to 91 kilograms; overweight - weight category over 91 kg.

The following weight categories have been identified for female athletes specializing in martial arts: lightweight - weight categories up to 51 kg; average weight - weight categories up to 60 kilograms; heavyweight - weight categories up to 75 kg; overweight - weight category over 75 kg.

Studies of the body composition were performed in the morning, on an empty stomach, by bioelectrical impedance meter on professional scales-analyzer of body composition "Tanita BC-545" based on the determination of current resistance passing through the human body. We were investigated followed indicators: body weight (kg); fat content (%); mineral mass of the skeleton (kg); water content (%); visceral fat content (RU).

Based on the received data, we calculated: the mass of fat (kg) according to the formula

$$Mass\ of\ fat\ (kg) = \frac{body\ weight\ (kg) \cdot fatcontent\ (\%)}{100};$$

and lean body mass (LBM, kg) according to the formula

$$LBM\ (kg) = body\ weight\ (kg) - mass\ of\ fat\ (kg).$$

The study of body length (cm) was performed by anthropometry using a medical anthropometer Martin's with the following rules: the subject stands upright, barefoot, on a flat surface, abdomen relaxed, arms lowered along the torso, heels together and touching the wall, head in a horizontal position Frankfurt (the conditional line connecting the lower edge of the orbit and the upper edge of the earlobe). The body length index was used to calculate the body mass index (BMI, $kg \cdot m^{-2}$) according to the formula

$$BMI = \frac{body\ weight\ (kg)}{body\ length^2\ (m)};$$

and the body surface index according to Mosteller (BSA, $м^2$) according to the formula:

$$BSA = \frac{\sqrt{body\ weight \times body\ length}}{60}.$$

Statistica 12 software (StatSoft) was used for statistical analysis of primary data. Methods of mathematical statistics carried out the research, and there are followed: the method of averages; correlation analysis according to the even linear Brave-Pearson correlation coefficient, to verify the significance of which Student's criterion was used; assessment of the significance of differences, which was performed by the non-parametric Mann-Whitney test (the choice of the measure is because individual samples by the criterion of martial arts contained a small number of cases (n <10) and can not be checked for ordinary data distribution law).

Results. Analysis of anthropometric indicators and body composition indicators of athletes specializing in martial arts indicates the absence of significant differences in body size and body composition according to the kind of sport. On average, male athletes specializing in martial arts are characterized by body length, as 178.4±8.5 cm, body weight, as 74.47±15,19 kg, and the ratio of LBM to fat mass was 85,7: 9,8% with significant variability in body weight (V=20,42 %), as well as indicators of body fat component by fat content (9,83±4,03%, V=40,98%), body fat mass (7,75±4,79 kg, V = 61,85%), visceral fat content (1,59±1,27 RU), V = 17,02%),

In the group of female athletes specializing in martial arts, anthropometric and body composition did not differ significantly according to the sport. It averaged body length - 167,6±6,55 cm, body weight - 61,05±8,83 kg, the ratio of LBM and fat mass 78,2:17,5%, As in the group of male athletes, females had significant variability in the indicators of the living component, namely: fat content (17,54±5,24, V = 29,84%), body fat mass (11,02±4,63 kg, V = 42,04%), content visceral fat (1,17±0,45 RU, V = 38,65%).

The considerable range of variability of the specified indicators of the sizes and body composition both at male and female is explained first of all by existence of the weight categories defined by rules of competitions that form requirements to anthropometry of athletes. Therefore, the initial analysis of body composition is rational to conduct following the athlete's affiliation with the appropriate weight category.

Correlation analysis showed no relationship between the composition of the body composition of male athletes with sports specialization (0,024 <r <0,16), age (0,04 <r <0,25) and qualification of the athlete (0,001 <r <0,19). In the group of females specializing in martial arts, a significant correlation was found between the qualifications of athletes with fat content (r = -0,58; p <0,05), water content (r = 0,51; p <0,05) and fat mass (r = -0,44; p <0,05). Therefore, the body's compositional components' initial analysis was carried out by the stated weight categories in which athletes compete.

Based on the declared weight categories, groups of athletes were formed, in which statistically significant differences in body weight and fat content were revealed (Table 1). "Declared weight category" meant the weight category that the athlete indicated as the one in which he plans to perform, so the actual bodyweight of the athlete at the time of the study did not always correspond to the declared weight category.

The smallest total body size characterized lightweight male athletes specializing in martial arts by followed indicators: body length averaged was 169,0±4,69 cm, body weight was 57,6±4,15 kg with variability in the group at 2,78 and 7,20%, respectively. BMI and BSA indices in lightweight athletes were also the lowest, significantly (p <0.05) differed from similar values in all other weight categories and amounted to 20,18±1,34 RU 1,64±0,07 m^2, respectively.

Naturally, with the increase in the weight category, there was a linear increase in the total body size, which reached the highest values in athletes of the super heavyweight category, Athletes competing in the medium weight categories had an average body length of 175,87±3,97 cm and a bodyweight of 68,6±4,79 kg. BMI and BSA indices in middleweight athletes significantly (p <0,05) differed from similar indicators of the super heavyweight category and amounted to 22,18±1,43 RU and 1,83±0,08 m^2, respectively.

Athletes competing in heavyweight categories had a body length - 184.63±5,32 cm, body weight - 82,95±4,41 kg. BMI and BSA indices in males of weight category significantly (p <0,05) differed from similar indicators of the lightweight types and amounted to 24,38±1,64 RU and 2,06±0,07 m^2, respectively.

A characteristic feature of lightweight athletes is the highest percentage of LBM (as the 87,48±2,31%), relatively lower fat content (as the 7,87±2,44% corresponding to a fat mass of 4,55±1,47 kg), the minimum range of visceral fat (about 1,0 RU), and the largest values of the mineral mass of the skeleton (4,66±0,14%). Lightweight athletes had, on average, the highest level of water content in the body; it was 67,81±5,01%. On the contrary, athletes in the super heavyweight category had the lowest percentage of LBM (81,07±3,92%) compared to other weight categories, as well as the highest indicators of the fat component: fat content was 14,78±4,13%, fat weight indicator was 15,23±5,43 kg, the visceral fat indicator was 4,19±0,25 RU.

In female athletes were also observed all these features and tendencies to increase or decrease in body composition. Lightweight female athletes were characterized by the presence of the smallest followed indicators: body length - 160,83±4,17 cm, body weight - 51,6±4,11, fat content - 15,02±3,74% (corresponds to a fat mass of 7,85±2,59 kg), visceral content fat (was about 1,0 RU), compared to other weight categories. Compared to different weight categories, LBM (80,56±3,6%; 41,48±2,18 kg), skeletal mineral mass (4,41±0,28%), and water content (65,0±3,84%) were the largest.

Table 1

Indicators of body composition of the athletes who specialize in martial arts, according to the stated weight categories

Weight categories		Bodyweight, kg	Fat, %	Water, %	Skeletal mineral mass, kg	Fat mass, kg	LBM, kg
Males (n=152)							
Lightweight, up to 60 kg (n=29)	$\bar{x}$	57,60	7,87	67,81	2,68	4,55	53,05
	s	4,15	2,44	5,01	0.18	1,47	3,81
	±m	4,15	2,44	5,01	0,18	1,47	3,81
	V,%	7,20	30,95	7,39	6,57	32,34	7,18
Medium weight, up to 75 kg (n=71)	$\bar{x}$	68,61	8,02	67,00	3,14	5,55	63,05
	s	4,79	2,54	3,29	0,18	1,99	3,96
	±m	1,00	0,53	0,69	0,04	0,41	0,83
	V,%	6,98	31,73	4,91	5,81	35,77	6,28
Heavyweight, up to 91 kg (n=27)	$\bar{x}$	82,95	11,81	64,20	3,58	9,85	73,10
	s	4,41	3,67	4,06	0,22	3,26	4,03
	±m	0,61	0,50	0,56	0,03	0,45	0,55
	V,%	5,32	31,05	6,33	6,25	33,10	5,52
Super heavyweight, over 91 kg (n=25)	$\bar{x}$	101,23	14,78	62,74	4,19	15,23	86,00
	s	9,02	4,13	3,68	0,25	5,43	5,27
	±m	1,92	0,88	0,78	0,05	1,16	1,12
	V,%	8,91	27,91	5,86	5,86	35,69	6,12
Females (n=36)							
Lightweight, up to 51 kg (n=6)	$\bar{x}$	51,60	15,02	65,00	7,85	2,27	43,75
	s	4,11	3,74	3,84	2,59	0,12	2,24
	±m	1,84	1,67	1,72	1,16	0,05	1,00
	V,%	7,96	24,89	5,90	32,96	5,34	5,12
Medium weight, up to 60 kg (n=11)	$\bar{x}$	55,59	15,14	63,99	8,50	2,39	47,09
	s	2,47	4,64	3,74	2,88	0,07	1,59
	±m	0,78	1,47	1,18	0,91	0,02	0,50
	V,%	4,44	30,63	5,85	33,93	2,93	3,38
Heavyweight, up to 75 kg (n=15)	$\bar{x}$	64,34	18,61	60,51	12,05	2,61	52,29
	s	3,64	5,02	3,81	3,64	0,14	3,40
	±m	0,97	1,34	1,02	0,97	0,04	0,91
	V,%	5,66	26,95	6,30	30,18	5,38	6,51
Super heavyweight, over 75 kg (n=4)	$\bar{x}$	78,75	24,20	56,00	19,14	2,98	59,61
	s	4,55	2,87	1,99	3,30	0,10	1,83
	±m	2,62	1,66	1,15	1,91	0,06	1,06
	V,%	5,77	11,87	3,56	17,25	3,22	3,07

Changes in these indicators with increasing weight category of athletes occurred similarly to the dynamics in the males. As a result, female athletes in the super heavyweight category had the lowest percentage of LBM (72,02±2,73%), compared to other weight categories, as well as the highest indicators of the fat component by followed indicators: fat content - 24,2±2,87%, fat weight - 19,14±3,3 kg, visceral fat - 1,75±0,96 RU.

Analysis of the peculiarities of the composition of male athletes' body allowed to identify five homogeneous groups in terms of fat content (%), which differed significantly according to this criterion (Table 2).

Table 2

Indicators of the physique of male athletes who specialize in martial arts, according to fat content (%)

Group (fat content, %)		Bodyweight, kg	Muscle mass,%	Fat content,%	Skeletal mineral mass,%	Water content,%	LBM, kg
A (5,0-6,9%) n=43	$\bar{x}$	63,89	89,74	5,54*	4,72	71,41	60,35
	s	6,80	0,62	0,65	0,08	3,72	6,41
	±m	1,05	0,10	0,10	0,01	0,57	0,99
	V,%	10,64	0,69	11,82	1,67	5,20	10,62
B (7,0-9,9%) n=48	$\bar{x}$	70,25	86,82	8,62*	4,55	66,50	64,21
	s	10,00	0,88	0,92	0,07	1,70	9,24
	±m	1,44	0,13	0,13	0,01	0,25	1,33
	V,%	14,23	1,02	10,62	1,55	2,55	14,39
C (10.0-12.9%) n=30	$\bar{x}$	78,63	84,20	11,42*	4,38	64,42	69,59
	s	15,54	0,90	0,97	0,11	0,91	13,41
	±m	2,89	0,17	0,18	0,02	0,17	2,49
	V,%	19,76	1,07	8,49	2,49	1,42	19,27
D (13.0-16.9%) n=22	$\bar{x}$	85,65	81,40	14,38*	4,22	61,80	73,33
	s	9,25	0,92	0,97	0,06	1,23	7,93
	±m	2,47	0,25	0,26	0,02	0,33	2,12
	V,%	10,80	1,13	6,73	1,44	1,99	10,81
E (>16.9%) n=9	$\bar{x}$	107,21	76,11	20,06*	3,84	58,09	85,61
	s	12,01	1,68	1,65	0,13	1,57	8,92
	±m	4,24	0,59	0,58	0,04	0,56	3,15
	V,%	11,20	2,21	8,24	3,26	2,71	10,42

Remark. * significantly at $p < 0,05$.

In statistically different athletes selected by fat content (%), there was homogeneity of most body composition indicators. It has also been established that among athletes who specialize in martial arts, signs of ectomorphic (low-fat percentage, relatively increased bone mass, low visceral fat, high water content) are characteristic not only of lightweight categories. Compliance of fat content with the reference value was observed in 73,6% of male athletes in all selected groups.

Thus, the selected group A, for athletes characterized by fluctuations in fat content at the lower limit of the reference values (about 5%), characteristic of martial arts was 28% of the total sample. Group A included 14 representatives of lightweight categories, 27 of the medium, and two representatives of heavyweight categories. Thus, it is established that shallow fat content is not a sign of only lightweight categories.

Group B with a fat content at the 7-9,9% of reference values included 32.0% of athletes (the largest group by number), including ten athletes of lightweight categories, 29 of the medium categories, eight athletes of heavy, and two representatives of super heavyweight category.

In the athletes with a fat content of 10-12,9% (group C; 20%), which corresponds to the upper limit of the reference values, the variability of body weight, fat mass, and LBM was the largest. This

is because half of this group included athletes who belonged to the light and medium weight categories (5 and 11 athletes, respectively). The other half were heavy and super heavyweight (9 and 5 athletes, respectively).

The largest number of representatives of group D (15 persons) were athletes competing in heavyweight categories. Also, the group included four representatives of medium and two representatives of the super heavyweight category. With their inherent excess fat presence, the total representation of group D was 14% of the full sample.

Athletes with a fat content of more than 16,9% had the lowest representation in martial arts (6% of the total sample), which confirms a particular limiting role of high-fat content for successful sports activities in martial arts. This level of fat content had two representatives of heavyweight categories and seven athletes competing in overweight.

The obtained results prompted to study the composition of the body in athletes who specialize in the striking kinds of the martial arts, by the fat content (%) in the body, which according to experts [2, 4, 6, 11], is the central reserve for weight adjustment without loss of superior performance for athletes. It was found that the fat content of athletes specializing in martial arts, regardless of the stated weight category in most cases, corresponds to the reference values or fluctuates at the upper limit of the reference values due to the peculiarities of adaptive morphofunctional adjustments of athletes under the influence of factor periodic adjustment of body weight, which intensifies lipid metabolism and often leads to the accumulation of excess fat [10]. Also, the maintenance of the body's optimal composition is essential for the manifestation of physical performance. The literature [7, 8] is known about the nonlinear relationship between the percentage of body fat on the one hand and the specific power and maximum oxygen consumption on the other. Thus, it was found that the highest values of the maximum specified load capacity and maximum oxygen consumption are achieved by male athletes with fatty tissue in the range from 11,0 to 14,0%, a further increase in the percentage of fat is accompanied by a decrease in these values [13].

Conclusions and prospects for further exploration in this direction.

1. Noting mainly mesomorphic body type athletes (both men and women) who specialize in martial arts, and there are followed: for lightweight athletes who specialize in martial arts, the composition of the body indicates signs of ectomorphic of the physique with a low content of fatty tissue, an increased percentage of bone mass; for medium weight categories are preferred the features of the mesomorphic body type; for athletes of heavy categories and super heavyweight categories, mesomorphic body type is accompanied by a "drift" towards endomorphism of the body, with a characteristic increase in the fat component's content.
2. Analysis of body composition suggests that the fat content of martial arts athletes has a wide range of fluctuations and, in most cases, corresponds to the reference values. At the same time, an actual result of the study is that athletes who had fat content exceeded each weight category's reference values. Therefore, based solely on the average data by weight category can be considered a confirmed pattern of increasing fat content with rising weight category of athletes in martial arts, which prevails in the literature, which is confirmed by correlation analysis, which also indicates a significant relationship between fat content and total body size - body weight ($r = 0,84$; $p < 0,05$) and its length ($r = 0,49$; $p < 0,05$).
3. Simultaneously, the analysis of the variability of the fat content indicator in the groups of athletes selected by weight category refutes this statement. The coefficient of variation (V, %) of the fat content in all groups by weight varies considerably, exceeds the normative values (12-14%), and indicates that a significant fat content, or, conversely, low content is inherent in athletes regardless of body weight and weight category by the individual typological features of the body constitution. Therefore, choosing a strategy for adjusting bodyweight should rely more on individual typological features of the body and individual indicators of the body's composition, regardless of weight category.

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