Special indices of body composition as a criterion of somatic development of martial arts practitioners

Authors' Contribution:
- **A** Study Design
- **B** Data Collection
- **C** Statistical Analysis
- **D** Manuscript Preparation
- **E** Funds Collection

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Abstract

Background & Study Aim: The study of athletes' anatomic-morphological characteristics permits to estimate adaptation potentials that are required for prediction of successfulness and sportsmanship progress. The purpose of this work is the usefulness of special indicators in prognosticating the widely understood success of martial arts practitioners.

Material & Methods: In the research 29 athletes, divided into two groups, participated. The first group (n =12, age 18.58 ±0.38 years) were athletes, practicing Greco-Roman and free style wrestling, judo, sambo (conventionally: *gentle combat sports*). The second group (n = 17, age 18.12±0.26 years) were athletes practicing hand-to-hand fighting, karate, taekwondo (conventionally: *aggressive martial arts*). Sportsmanship level in both groups did not differ noticeably but varied from athletes-beginners to elite athletes. We registered 20 anthropometric indicators (body length and mass; chest circumference; width of shoulders; length and circumference of arm, forearm, thigh and shin). For comparative analysis we used 14 special indices.

Results: We confirmed the presence of certain distinctions in athletes' body composition. Quetelet index and shoulder width were confidently higher in **gentle** combat sports athletes. Index Vervek and index Piniet were lower in **gentle** combat sports athletes than in **aggressive** martial arts practitioners. Among **gentle** combat sports practitioners there was much less athletes with low index of Erisman. **Gentle** combat sports practitioners had relative body area much larger than other athletes, also greater relative arm and forearm length.

Conclusions: We proved possibility of physical condition indices' usage for analysis of body composition's specificities and prediction of athletes' successfulness. The found distinctions illustrate specific features of kind of sports and different body compositions of **gentle** combat sports athletes and **aggressive** martial arts practitioners. Indices of Quetelet, Erisman, Piniet and Vervek, relative body area witness about increase of muscular component of **gentle** combat sports athletes somatic type. Arm's and forearm relative lengths of **gentle** combat sports athletes permit to fulfill techniques more successfully. It is a positive factor of prediction. The used indices are simple, informative and accessible indicators. They can be recommended for selection, control over athletes' condition and successfulness prediction in particular martial arts.

Key words: achievement sport • anthropometry • hand-to-hand fighting • prediction • sambo

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INTRODUCTION

Intensive physical trainings (total training loads) can result in improvement of sportsmen's proportionality and harmonious development [1] but not only sport successfulness. The term "achievement sport" is not synonymous appellation "success-orientated" (see glossary). Successful – especially for martial arts practitioners as "sport of life" – has a multidimensional meaning.

Studies of athletes' anatomic-morphological characteristics permit to assess adaptation potentials. It gives the necessary information for prediction of successfulness and sportsmanship growth. Realization of this approach is possible with the help of tests, indices and functional tests. Such analysis permits to predict the presence of prenosological states in youth [2]. Pion et al. [3] studied information value of tests for body composition, physical fitness and coordination of athletes. The conducted discriminant analysis permitted to find the most important for different kinds of sports physical qualities. Cangur et al. [4] confirmed that anthropometric data are closely connected with psychological criteria of female athletes and determine their successfulness. Drywien et al. [5] note that correlation of body mass and length is an important indicator, characterizing athletes' physical condition.

Study of body composition is often used in sport games. Hencken and White [6] carried out wide anthropometric examination of football players. They showed importance of somatic type indicators for sportsmanship progress in this kind of sports and concluded that without consideration of these indicators successfulness of team reduces. Anthropometrical characteristics of handball players were analysed by Matthys et al. [7]. They found that the level of biological maturity and specific features of body composition should be considered in determination of game role. Anthropometric characteristics of female water polo players were studied by Martínez et al. [8]. The authors found indicators, determining game role. They are: shoulder width, arm and forearm length, arm and forearm circumferences. They proved correlation of these criteria and speed of throw. Rugby is a kind of sports, in which successfulness depends on muscular mass. Morehen et al. [9] offered application of anthropometric profile for individualization of rugby players' training. Pietraszewska et al. [10] studied anthropometric characteristics of female

volleyball players. Longitudinal and transverse indicators of female athletes were much higher than in control group. Female volleyball players had very balanced mesomorphic somatic type.

Specificity of power kinds of sports pre-conditions the relevance of body composition's study. Keogh et al. [11] studied somatic types of power-lifting athletes. They proved the importance of anthropometric indicators for successfulness prediction in this kind of sport.

Body composition characteristics are important in kinds of sport, which are connected with long term training loads. Knechtle et al. [12] regarded correlations between anthropometric criteria and run indicators of marathon runners. They proved the presence of significant correlations between speed and time of run, body mass, skin-fat fold and specific weight of fat tissue. Analysis of successfulness in bicycle marathon was fulfilled by Knechtle et al. [13]. The authors found correlation between anthropometric indicators and speed in race.

Maslyak and Krivoruchko [14] confirmed effectiveness of indices method for physical condition analysis of the youth, practicing cheerleading. Application of Quetelet, Robinson and Skibinskaya's indices permitted to adequately assess the dynamic of physical development. Research of elite female gymnasts' body composition was fulfilled by Claessens et al. [15]. Indices and the worked out anthropometric profiles were recommended for selection of female athletes and control over their condition. Analysis of gymnasts-acrobats' anthropometric profiles was carried out by Taboada-Iglesias et al. [16]. They found distinctions, which depended on sport role. Thigh circumference was regarded as criterion of prediction.

Durkalec-Michalski et al. [17] proved that components of combat sports athletes' somatic type correlate with aerobic ability. It conditions significant influence on bio-chemical adaptation and shall be considered in trainings. Similar results were received by Mirzaei et al. [18]. The authors confirmed that cadets wrestlers' body composition influences on their trainability. The presence of correlations between somatic type, anthropometric profile, and body composition, physiological and physical profiles of young wrestlers was proved by Jafari et al. [19]. These indicators shall be used in selection of promising wrestlers.

Andreato et al. [20] proved importance of body composition and somatic type study for success in Brazil jiu-jitsu. Poliszczuk et al. [21] created the model of taekwondo champion. They found characteristics, influencing on successfulness. They were: width of pelvis, arm's length and hand's width.

Thus, study of body composition characteristics, application of special tests and indices can be used for analysis of athletes' condition and for prediction of their successfulness.

The purpose of this work is the usefulness of special indicators in prognosticating the widely understood success of martial arts practitioners.

MATERIAL AND METHODS

Participants

In the research 29 athletes, divided into two groups, participated. The first group (n =12, age 18.58 ±0.38 years) were athletes, practicing combat sports qualifying to throws and grips of immobilisation of opponent's body: Greco-Roman and free style wrestling, judo, sambo (**conventionally:** *gentle combat sports*). The second group (n =17, age 18.12 ±0.26 years) were athletes practicing combat sports and martial arts based on hitting: hand-to-hand fighting, karate, taekwondo (**conventionally:** *aggressive martial arts*). Sportsmanship level in both groups did not differ noticeable but varied from athletes-beginners to elite athletes.

Design of the research

We registered 20 anthropometric indicators. The measurements were fulfilled in compliance with requirements of unified methodic of anthropometric studies. We registered: body length and mass; chest circumference; width of shoulders; length and circumference of arm, forearm, thigh and shin. For comparative analysis we used the complex of special indices.

Quetelet's index (body mass index) was determined as relation of body mass (kg) to body length (m) (in square). Values of 20 to 25 were regarded as norm.

Index of shoulder width was found as relation of this indicator to body length (in percent). 23-25% values were regarded as norm.

Erisman's index was determined as difference between chest circumference and half of body length. Proportional physical condition implies positive value of this indicator. In athletes it was not less than 5.8 cm.

Index of Vervek was found by the following formula:

$$IV = BL/(2{\times}BM + CC) \tag{1}$$

where: *BL* body length (cm); *BM* body mass (kg) and *CC* chest circumference in breathing pause (cm). If *IV* is within 0.75 to 0.85 (confidential units) body composition is considered to be hypersthenic; 0.85 to 1.25 normosthenic and 1.25 to 1.35 asthenic.

Piniet's index was found by formula:

$$IP = BL - (BM{+}CC) \tag{2}$$

where: *BL* body length (cm); *BM* body mass (kg) and *CC* chest circumference in breathing pause (cm). The less is the value, the better is the indicator (if no obesity). Index *IP* (confidential units) of less than 10 is regarded as strong body composition; from 10 to 20 good; from 21 to 25 satisfactory; from 26 to 35 weak and more than 36 means very weak body composition.

Index of Livy was found by formula:

$$IL = CC/BL \tag{3}$$

where: *CC* chest circumference in breathing pause (cm), *BL* body length (cm). Mean *IL* indicator (confidential units) equals to 50-55%.

Body area (by Isaakson) was found by formula:

$$S = 1+ [(BM + BL - 160)/100] \tag{4}$$

where: *S* area of body surface (m²); *BM* body mass (kg); *BL* body length (cm). By dividing body area value by body mass we found relative area of body surface.

We also found relative values of forearm, arm, shin, thigh length in respect to body length. Besides, we determined: arm index as correlation of arm and forearm circumferences; leg index, as correlation of shin and thigh circumferences. In connection with absence of noticeable

Oruzhiya, which literally translates as "self-defence without weapons". Sambo is relatively modern since its development began in the early 1920s by the Soviet Red Army to improve their hand-to-hand combat abilities It was intended to be a merger of the most effective techniques of other martial arts. The pioneers of Sambo were Viktor Spiridonov and Vasili Oshchepkov. Oshchepkov died in prison as a result of the Great Purge after being accused of being a Japanese spy. Oshchepkov spent several years living in Japan and training in judo under its founder Jigoro Kano [44].

Brazilian jiu jitsu – is a type of fight in which a uniform or gi is used; its main purpose is to project or take your opponent down. Once on the ground, you must seek to control your adversary with different techniques (immobilizations, chokes, joints locks). In the absence of submission at the end of the fight, the winner is declared by the number of points won [45].

Training load – "A simple mathematical model of training load can be defined as the product of qualitative and quantitative factor. This reasoning may became unclear whenever the quantitative factor is called 'workload volume' or 'training volume' interchangeably with 'volume of physical activity'. Various units have been adopted as measures i.e. the number of repetitions, kilometres, tons, kilocalories, etc. as well as various units of time (seconds, minutes, hours) (...) As in the real world nothing happens beyond the time, the basic procedure of improvement of workload measurement should logically start with separation of the time factor from the set of phenomena so far classified together as '*workload volume*'. (...) Due to the fact that the heart rate (HR) is commonly accepted as the universal measure of workload intensity, the product of effort duration and HR seems to be the general indicator of *training load* defined as the amount of workload. It is useful in analyses with a high level of generality. (...) In current research and training practice the product of effort duration and HR was referred to as conventional units' or further calculations have been made to convert it into points." [46, p. 238].

differences we used results also for right arm and leg. All indexes in confidential units.

Statistical analysis

Was fulfilled with the help of licensed Excel tables. The following descriptive statistic's indicators were determined: mean arithmetic, standard deviation and error of mean value. Confidence of differences was assessed with the help of Student's t-test (t) and non-parametric criteria of Wilcoxon-Manna-Whitney (U) and Rosenbaum (Q).

RESULTS

The results prove certain distinctions in body composition of gentle combat sports and aggressive martial arts athletes (Table 1). Quetelet's index is within norm in both groups. But in **gentle** combat sports athletes (1st group) it is at upper limit of the norm and in **aggressive** martial arts athletes it is practically at the lowest limit of the norm. It conditioned confident increase of this index in 1st group. Significance of distinctions was proved with Student's t-test (t = 2.88) and criterion of Rosenbaum (Q = 8, p<0.05).

Mean values of shoulder width index are also within norm, but there is its confident increase in 1st group athletes both by Student's t-test (t=2.39), and by criterion of Wilcoxon-Manna-Whitney (U = 32, p<0.01).

Mean values of Erisman's index differed more than 4 times in both groups. However, this indicator can have both positive and negative meaning. It resulted in increase of error in 2nd group and did not permit to determine differences by Student's t-test. At the same time analysis of individual data permitted to find significant differences. For example, in 1st group only 4.17% of participants had low value of this index. In 2nd group there were 80% of such athletes.

Analysis of Vervek index's mean values showed its confident increase in impact martial arts group by Student's t-test (t = −2.23, p<0.05) and by indicators of Wilcoxon-Manna-Whitney (U = 53, p<0.05). These mean values permit to regard body composition as hypersthenic in both groups. Individual data analysis confirmed the presence of certain distinctions. For example in 1st group 91.7% of participants had hypersthenic body composition and 8.3% normosthenic. In 2nd group specific weight of such

Table 1. Special indices of body composition of combat sport and martial arts athletes.

Indicator	Gentle combat sports (1st group) (n = 12)	Aggressive martial arts (2nd group) (n = 17)	Differences
Quetelet's index 2 (kg/m^2)	**25.06 ±0.99**	21.66 ±0.64	**3.4***
Shoulder width index (%)	**24.33 ±0.64**	22.70 ±0.23	**1.63***
Erisman's index (cm)	6.29 ±2.86	1.47 ±1.38	4.82
Vervek's index (cu)	0.72 ±0.03	**0.79 ±0.02**	**0.07**
Piniet's index (cu)	3.42 ±6.17	**18.85 ±3.23**	**15.43***
Livy's index (cu)	53.44 ±1.62	50.86 ±0.77	2.58
Body area by Isaakson (m^2)	**1.95 ±0.06**	1.85 ±0.05	**0.1**
Relative body area to body mass (m^2/kg)	**39.96 ±1.01**	36.63 ±0.69	**3.33***
Relation of arm's length to body length (%)	**20.03 ±0.29**	18.90 ±0.37	**1.13***
Relation of forearm's length to body length (%)	15.00 ±0.24	14.59 ±0.29	0.41*
Relation of thigh length to body length (%)	22.74 ±0.36	23.08 ±0.47	0.34
Relation of shin length to body length (%)	20.49 ±0.42	20.93 ±0.48	0.44
Index of arm's circumferences (cu)	0.85 ±0.01	0.89 ±0.02	0.04
Index of leg's circumferences (cu)	0.66 ±0.01	0.65 ±0.01	0.01

cu confidential units; *differences are confident at minimum (p<0.05)

athletes was accordingly 86.4% and 23.6%. That means that in impact martial arts athletes normosthenic body composition was found nearly three times oftener than in gentle combat sports athletes. No one of the participants had the values of Vervek's index, characteristic for asthenic body composition.

Piniet's index permits to assess the strength of athletes' body composition. The methodic of its determination makes possible to find its negative values. The results prove the made earlier assumptions about gentle combat sports athletes better somatic development. Mean value of the index in 1st group shows strong body composition and in 2nd group – good. Individual data analysis gave interesting results. In 50% of 1st group athletes the index was negative; in 2nd group specific weight of such athletes was nearly five times less (11.8%). Negative Piniet's index was intrinsic to athletes, practicing free style and Greco-Roman wrestling.

Livy's index did not have confident differences in both groups and related to mean values. In 2nd group it was at bottom limit of the norm and in 1st group it was closer to top limit. Specific weights of athletes with this index's value above average differed. In 1st group it was 25.0%, and in 2nd group 11.8%.

Mean values of body area did not differ significantly in both groups. At the same time its relative value in 1st group noticeably exceeded the results of aggressive martial arts athletes (t = 2.71, p<0.05). Besides, there were confident differences by Rosenbaum criterion (Q = 8, p<0.05).

Analysis of longitudinal sizes and circumferences of arms and legs also showed some distinctions. Gentle combat sports athletes had relative forearm length greater than aggressive martial arts athletes by Student's t-test (t = 2.41, p<0.05) and by indicators of Wilcoxon-Manna-Whitney (U = 37, p<0.01). Gentle combat sports athletes also had greater relative arm length by Student's t-test (t = 2.41).

Concerning relative lengths of lower limbs we registered no noticeable distinctions. In respect to circumferential sizes we also did not find differences between groups. These results can be interpreted as sufficient muscular condition.

DISCUSSION

The study of athletes' body composition permits to assess the level of their fitness; to predict sportsmanship. Effectiveness of analysis depends on informative value of the used indicators. They shall be chosen, considering specific features of kind of sports. Validity of such approach is confirmed by analysis of different sportsmanship synchronous swimmers' functional potentials [22]. Application of indices method for physical condition assessment is built on calculation of correlations between different indicators. Such modelling is widely used in martial arts [23, 24].

The studies of Kalina et al. [25] proved that body mass and based on it indices have strong correlation with successfulness in "testing fights in a vertical posture" (based on sumo formula). Arakawa et al. [26] analysed anthropometric characteristics of elite female wrestlers. The authors determined promising character of indices' usage, built on anthropometric indicators' correlation, for prediction of successfulness. A bit earlier Khor'yakov [27] notes that it is possible to distort the results of body composition assessment by indices method. It is offered to use different indices and verify the results. Our research included calculation and analysis of 14 physical condition indices. It ensured informative value of the data and verification of the data.

Validity of gentle combat sports athletes and aggressive martial arts athletes' comparison is proved by other researches. It was proved that there are certain specific features in body compositions of different types of martial arts athletes [28]. The wrestlers' increased circumferences of arm and forearm, grip strength in dynamic and static regimes reflect specific of wrestling, importance of reliable grip for success.

Results of psycho-physiological researches confirmed that athletes practicing combat sports and martial arts based on hitting have better mobilization ability, more optimal readiness for actions and more developed functions of differentiation [29]. Results of Osipov et al. [30] permit to regard body mass as integral criterion, determining physical condition and physical fitness. In this connection indices with these indicators have high prediction values. Fry et al. [31] substantiated usage of body mass index as a tool for screening for American elite junior weight lifters. Socha et al. [32] confirmed importance of

body mass index as the factor of successfulness in judo. Jagiello [33] stresses on consideration of physical condition indices and specificities of somatic type for choosing tactic and technique in taekwondo.

At present Quetelet's index (body mass index) is used the most often in medical practice and in physical education and sports. Its analysis permits to assume increase of somatic type muscular component of wrestlers. It shall be regarded as specificity of this kind of sports. Martinez-Rodriguez et al. [34] confirmed importance of body mass control for successfulness in wrestling. The dynamic of somatic type components- reduction of fat component and increase of muscular one is an important factor of prognostication.

Many years ago Housh et al. [35] proved significance of anthropometric indicators study in wrestlers. They confirmed high validity and information value of such indicators as body density, circumferences and diameters of torso and limbs, thickness of skin-fat folds. Housh et al. [36] stress on importance of anthropometric indicators (body mass, specific weight of different tissues) and indices for successfulness in wrestling. Shoulder width index that wrestlers have greater transverse sizes in respect to longitudinal. It illustrates differences between somatic types of wrestlers and athletes practicing martial arts based on hitting. Analysis of this index shows that it is possible to regard shoulder width as important indicators for analysis of body composition. Similar results are provided by Tumanian and Martirosov [37], who studied peculiarities of wrestlers body composition.

Analysis of Erisman's index shows that wrestlers (and other athletes practicing combat sports qualifying to throws and grips of immobilisation of opponent's body) have more developed torso muscles than athletes practicing combat sports and martial arts based on hitting. This indicator illustrates dependence between longitudinal and circumferential sizes. Chest circumference reflects condition of torso muscles. It is intrinsic to wrestlers due to specific of this kind of sports. Tumanian and Martirosov [37] also informed about wide chest of wrestlers and significant body mass relation to body length.

Study of Vervek index's results witnesses about tendency to prevailing of hypersthenic body

composition of gentle combat sports athletes, comparing with aggressive martial arts athletes. It proves one more assumption about greater specific weight of muscular component of 1st group athletes somatic type. Piniet's index permits to make the same conclusion. Results of this index in free style and Greco-Roman wrestlers reflects specific of these kinds of sports. It conditions importance of muscles' good development, especially torso muscles. Our data are similar with the results of Mirzaei et al. [38]. These authors fulfilled comparative analysis of physical fitness indicators and anthropometric indicators of free style and Greco-Roman wrestlers and found the closeness of physical condition indicators. Analysis of Livy's index permits to regard physical condition of most of participants to be harmonious, with sufficient muscular system.

Comparison of relative body surface proves one more the made earlier assumptions about greater specific weight of muscular component of wrestlers' somatic type. Tumanian and Martirosov [37] noted that increase of wrestlers' body surface means increase of aerobic potentials. It substantially raises their functional potentials. This index shall also be regarded as factor of successfulness in martial arts.

The validity of made by us conclusions is confirmed by results of Diaz-Lara et al. [39]. These authors found importance of specific weight of separate tissues for successfulness in Brazilian jiu jitsu. Relative elongation of forearm and arm in wrestlers coincides with results of Tumanian and Martirosov [37]. These authors thought that limbs' elongation in wrestlers increase the length of bio-mechanical levers and permits to fulfil throws more successfully.

The found similarity of limbs' circumferential sizes proves importance of muscles' training in martial arts. Zaccagni [40] uses indices of correlations of anthropometric indicators in study of Italian wrestlers' combined team. He proved high information value of body mass index; correlation of somatic type different components and limbs' circumferential sizes for prognostication. Similar results were received by Arakawa et al. [41]. They studied anthropometrical characteristics of Japan elite female wrestlers. They proved that good muscles' condition of upper limbs (especially forearms) is an important factor of successfulness.

Thus, the received results coincide to large extent with available literature data and confirm information value, validity and effectiveness of indices' application for analysis of combat sports and martial arts athletes' body composition characteristics.

CONCLUSIONS

The conducted research proved that it is possible to use physical condition indices for analysis of body composition characteristics and prediction of combat sports and martial arts athletes' successfulness. The found distinctions illustrate specific of kind of sport. They permit to speak about differences between body compositions of athletes practicing combat sports qualifying to throws and grips of immobilisation of opponent's body and athletes practicing combat sports and martial arts based on hitting. Increase of muscular component of 1st group athletes somatic type is witnessed by indices of Quetelet, Erisman, Piniet and Vervek; by relative surface of body. Relative elongation of arm and forearm length in these athletes permits to fulfil throws more successfully. It can also be regarded as positive factor of prediction. The used indices are simple, informative and accessible. They can be recommended for selection of athletes, control over their condition and prediction of successfulness in combat sports and martial arts.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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