

PEDAGOGY

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Studying of physical development features of elite athletes of combat sports by means of special indexes

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Abstract

Purpose. The analysis of bodybuild features of elite athletes of combat sports with the application of special indexes.

Methods. 22 anthropometrical indicators were defined, 13 indexes of physical development were calculated on their basis. 29 elite athletes (Candidates Master of Sports and Masters of Sports) were divided into groups. 1 – 7 athletes (*judo, sambo, Greco-Roman wrestling, and freestyle wrestling*), (18,43±0,43 years). 2 – 9 kickboxing athletes, (18,22±0,52 years). 3 – 13 combat sports athletes (*karate, taekwondo, hand-to-hand fight*), (18,00±0,28 years).

Results. Higher body mass index in athletes demonstrates the prevalence of muscular component of somatotype. The Erismann and Pignier indexes, shoulders width index illustrate the best development of muscles in athletes and kickboxing athletes in comparison with karate athletes, and taekwondo. Increase in a relative body surface of athletes demonstrates the growth of their aerobic opportunities. Increase in the power index confirms the importance of grip strength for success in combat. Indexes of a ratio of segments of extremities reflect features of the technique of combat sports.

Conclusions. The existence of the features caused by combat sports is confirmed. The competency of special indexes application which is especially illustrated ratios of extremities segments in the monitoring of athletes' functional condition is also proved.

Introduction

The main task of sports science is ensuring the growth of skill and success of athletes. For this purpose, it is necessary to apply the criteria reflecting athletes' condition. The leading place among them is taken by indicators of physical development.

Increase in success in combat sports depends on optimum body structure, development of muscular force, the flexibility of anaerobic and aerobic potential [Mata-Ordóñez *et al.* 2018]. The offered strategies are based on constant control of body mass.

The complex technique of successful prediction in kickboxing [Podrigalo *et al.* 2018] includes anthropometrical indicators. It is confirmed by their informational content and the importance of the analysis of physical development for the forecast of sports skill.

The basis of a success kickboxers assessment technique were indicators of the general and special physical fitness [Podrigalo *et al.* 2017]. The level of training significantly influenced the tolerance to physical activities.

Pion *et al.* (2015) estimated the informational content of the tests studying features of bodybuild, physical fitness, and coordination of athletes. The carried-out discriminant analysis allowed to determine the physical qualities, the most important in different types of sport.

Studying bodybuild features is often applied in sports games [Kovalchuk 2017]. It is established that the level of a biological maturity and feature of bodybuild have to be considered at determining the game role of handballers [Matthys *et al.* 2013]. Anthropometrical indicators define success and are closely connected with psychological criteria in female athletes [Cangur *et al.* 2017]. Forecasting (predicting) of success in arm-wres-

ting presuppose the application of physical development indexes with high informational content [Podrigalo *et al.* 2017]. Assessment of interrelations of morphofunctional indicators by means of the correlation analysis can be used as the forecast tool for the success of elite judo athletes [Korobeynikov *et al.* 2017].

Calculating (estimating) of own body mass of Greco-Roman wrestling athletes allows reaching optimum development of force and speed [Nagovitsyn *et al.* 2017]. Indexes of physical development were applied for assessment of adaptation features to training conditions [Andres 2017]. The body mass index, the power index, indexes reflecting a condition of the cardiovascular system had high informational content. The battery of the indexes reflecting physical fitness and adaptation opportunities is applied for assessment of physical health dynamics under the influence of the multilevel system of the differentiated education [Masliak *et al.* 2018]. Modelling of long-term sports development is impossible without monitoring of athletes' condition [Lloyd *et al.* 2015]. The important place in the model is allocated to physical development indexes. Rugby belongs to sports in which development of muscle mass defines success. It is offered to apply an anthropometrical profile for individualization of rugby players training [Morehen *et al.* 2015].

The efficiency of indexes method for the analysis of the physical development of the youth practising cheerleading is confirmed [Maslyak *et al.* 2016]. Application of indexes allowed to estimate adequately the dynamics of physical development. In the review of the book "Physical Conditioning for Combat Sports", edited by Dr Emerson Franchini and Dr Tomas Herrera-Valenzuela the importance of physical development for success in combat sports is emphasised. The essential significance is attached to the general and special tests for control of a condition of the main physical qualities of athletes [Valdes-Badilla *et al.* 2018].

Thus, studying bodybuilding features, application of indexes could be used for the analysis of athletes' condition and will allow predicting their success. On the basis of the foregoing, the purpose of the research is the analysis of bodybuilding features of elite athletes of combat sports with the application of special indexes.

Methods

Participants. 29 elite athletes (Candidates Master of Sports and Masters of Sports) participated in research, were divided into groups. The first group – 7 athletes (*judo, sambo*, Greek-Roman wrestling and freestyle wrestling), age (18,43±0,43 years). The second group – 9 kickboxing athletes, age (18,22±0,52 years). The third group – 13 athletes of martial arts (*karate, taekwondo*, hand-to-hand fight), age (18,00±0,28 years). Average age and level of skill in groups did not significantly differ.

Measures

The design of a research presupposed the definition of 22 anthropometrical indicators. Measurements were performed according to requirements of the unified technique of anthropometrical research [International Standards for Anthropometric Assessment 2001]. Body length and mass, chest circumference, shoulder width, lengths and circumference of extremities and their segments, hands dynamometry were determined. The battery of special indexes was applied for the comparative analysis.

Procedure

The body mass index (BMI) was defined as the relation of the body mass (kg) to body length (m) in a square. The values 20-25 are taken as the norm.

Erismann index is the difference of chest circumference and a half of body length. Proportional physical development is characterised by the positive value of this indicator. Its value is not less than 5,8 cm in athletes.

Pignier index was determined by a formula:

$$IP = BL - (BM + CC), \quad (1)$$

where BL – is body length (cm), BM – is body mass (kg), CC – is chest circumference in a pause (cm). The less is the value, the better is an indicator (on condition of absence of obesity). The index value of less than 10 is estimated as a strong bodybuilding, 10-20 – as good, 21-25 – as an average, 26-35 – as weak, more than 36 – as very weak.

The index of shoulders is the relation of this indicator to body length expressed as a percentage. The value of 23-25% is taken as the norm.

The surface of a body according to Isaakson was defined by the formula:

$$S = 1 + \frac{BM + (BL - 160)}{100}, \quad (2)$$

where S – is body surface (m²); BM – is body mass (kg), BL – is body length (cm).

The relative body surface area was defined by the division of the body mass (kg) into the body surface (m²).

The power index was defined as the relation of hand dynamometry to body mass expressed as a percentage. The value 50-75% is taken as the norm.

It was determined the relative length values of a hand and leg to body length. It was defined as a ratio of segments of extremities: hands – as the forearm length relation to shoulder length, leg, respectively, to a shin to a hip. It has also defined the index of hand circumference as the relation of forearm and shoulder circumference.

Statistical analysis

The statistical analysis of the obtained data was carried out by means of the licensed Microsoft Excel. The following indicators of descriptive statistics were defined: arithmetic mean value, standard deviation, and error of the average mean. The significance of differences in groups was estimated by means of parametrical Student t-test (t) and nonparametric criterion of Wilcoxon-Mann-Whitney test (U).

Results

Results of calculations of physical development indexes are given in table 1. They prove certain differences in the physical development of athletes of single combats.

All participants had the normal level of BMI. This index was significantly higher in the 1st group than in 3rd. It is confirmed by Student t-test ($t = 2,38$, $p < 0,05$) and Wilcoxon-Mann-Whitney test ($U=15$, $p < 0,05$).

Establishing differences between groups on Erismann and Pignier indexes did not succeed. It is caused by the fact that these indexes can be both positive, and negative. It increases the error of the mean and does not allow to confirm differences. The carried-out individual analysis allows to speak about some tendencies of athletes' physical development. In the 1st group of 57,15% of athletes had the value of Erismann index of above the norm, and 42,85% – had the lower value than the norm. In the 2nd group, their specific weight was, respectively, 55,55% and 44,45%. In the 3rd group, respectively, 7,7% and 92,3%.

The individual analysis of the Pignier index has shown similar results. In the 1st group of 57,14% of athletes had a strong bodybuilding, 14,29% – good and 28,57% – weak. In the 2nd group 55,56% had a strong

bodybuilding, 11,11% – good, 22,22% – average and 11,11% – weak. In the 3rd group of 7,7% had a strong constitution, 30,77% – good, 7,7% – average and 53,83% – weak.

The value of shoulders width index in 1st and 2nd groups was in normal limits, and in the 3rd group it was lower. It is confirmed that there is a lack of essential differences between 1st and 2nd groups. In the 2nd group, the index of shoulders width was significantly larger in comparison with the 3rd group. It is confirmed by parametrical ($t = 3,60$, $p < 0,05$), and nonparametric criterion ($U=14$, $p < 0,05$).

The surface of a body in all groups was close and had no significant differences. The index of the relation of body mass to a surface was significantly higher in the 1st group compared with 3. The difference was confirmed with two used criteria ($t = 2,21$, $U=19$, $p < 0,05$).

The power index illustrates the relative force of the forearm and wrists muscles. In athletes, this indicator belonged to average values. Other athletes of combat sports had the level below average. This index for the right hand in the 1st group was more than in 2nd ($U=15$, $p < 0,05$). For the left hand, the increase is proved also by Student t-test ($t = 2,25$, $p < 0,05$), and Wilcoxon-Mann-Whitney test ($U=15$, $p < 0,05$).

Results of indexes calculation reflecting a ratio of segments of extremities were the most illustrative. The hand length relation to body length in the 1st group was significantly more than in the 3rd group ($t = 2,16$, $U=22$, $p < 0,05$). Kickboxers had this index more than *karateka* and athletes of *taekwondo* ($U=32$, $p < 0,05$).

Values of the relative length of a leg were different. The biggest values of this index were established in kickboxers, they were significantly higher than in athletes ($t = 2,05$, $U=32$, $p < 0,05$). The result of 2nd groups was higher than in the 3rd group, but only by Student t-test ($t = 2,15$, $p < 0,05$).

Table 1. The physical development indexes of combat sports athletes

Indicators	1 group (n=7)	2 group (n=9)	3 group (n=13)
Body mass index, kg/ m ²	24.91±1.34 ²	23.03±1.10	21.29±0.72
Erismann index, cm	5.07±4.39	4.36±1.95	0.65±1.48
Pignier index, ea	6.43±8.36	11.57±5.82	21.23±3.28
Surface of a body according to Isaakson, m ²	1.88±0.07	1.87±0.08	1.82±0.06
Relative surface to body mass, kg/m ²	39.60±1.37 ²	37.90±1.32	36.15±0.74
Shoulder width index, %	24.15±0.99	24.14±0.34	22.61±0.26
Power index of left hand, %	53.83±5.06 ¹	41.45±2.16	49.48±4.60
Relation of hands length to body length, %	34.78±0.43 ²	34.67±0.60	33.04±0.68
Relation of leg length to body length, %	44.64±1.09 ¹	47.62±0.95	44.50±1.10 ¹
Retaliation of forearm to right shoulder, ea	0.77±0.02 ¹	0.84±0.01 ²	0.76±0.02
Right hand circumferences index, ea	0.85±0.02 ^{1,2}	0.91±0.01	0.91±0.02
Left hand circumferences index, ea	0.84±0.02 ^{1,2}	0.90±0.01	0.90±0.02
Relations of lengths of a shin and hip, ea	0.92±0.01 ¹	1.07±0.03	0.91±0.02 ¹

Note. 1 – the difference with the 2nd group is significant ($p < 0,05$), 2 – the difference with the 3rd group is reliable ($p < 0,05$).

Certain differences of ratios of segments of extremities of athletes are established. The forearm length relation to shoulder length in kickboxers is more, than in athletes ($t = 2,90$, $U=8$, $p<0,0$) and *karateka* and athletes of *taekwondo*, etc. ($t = 3,78$, $U=17$, $p<0,05$). The similar dependence takes place in an assessment of the relations of lengths of a shin and hip. Kickboxers have this index more, than in athletes ($t = 5,07$, $U=0$, $p<0,05$) and athletes 3rd groups ($t = 5,15$, $U=1$, $p<0,05$).

The similar dependence is established at the assessment of ratios of segments of the lower extremities. The biggest relation of a shin to a hip at kickboxers is significant above, than in athletes ($t = 5,07$, $U=0$, $p<0,05$) and *karateka* and athletes of *taekwondo*, etc. ($t = 5,15$, $U=1$, $p<0,05$).

Athletes had a ratio of right hand circumference, than in kickboxers ($t = -2,09$, $U=15$, $p<0,05$). The similar dependence took place when comparing 1st and 3rd groups, but only by Student's criterion ($t = -2,14$, $p<0,05$). On the left hand the analysis of this index has shown the same results. Athletes had less, than kickboxers ($t = -3,12$, $U=7$, $p<0,05$) and athletes of martial arts ($t = -2,64$, $U=23$, $p<0,05$).

Discussion

Physical development is the powerful and informative criterion allowing to estimate the athletes' condition. Indicators of physical development are very important in the prediction of sports skill growth and success.

The applied criteria have to be valid, informative and reflect the specifics of the sport. The competency of such an approach is confirmed in the analysis of the condition of synchronised swimming female athletes with the different level of skill [Rovnaya *et al.* 2016].

The importance of specific tests for the monitoring of a functional condition of athletes is emphasised [Agostinho *et al.* 2018]. Authors have developed centile tables on the basis of results of tests performance and restoration of indicators after loads taking into consideration gender and age of athletes.

The specific of sport is the basic requirement for the choice of tests [Giovanis *et al.* 2017]. Thus, application of the tests specific to ski slalom for football players does not allow to receive a true picture.

Calculation of physical development indexes allows to define ratios between separate indicators, to establish interrelations and dependencies between them. Simplicity and availability of indexes predetermined their wide application in sports science and practice.

It is proved the informational content of physical development indexes for the prediction of success in studying anthropometrical characteristics of elite female athletes [Arakawa *et al.* 2015].

The applied design is the comparison of representatives of different combat sports and now it is applied

rather widely [by Romanenko *et al.* 2018; Volodchenko *et al.* 2017]. At the same time the specified works presupposed division of participants only according to sports. The groups consisted of athletes with a different level of skill and this fact made analysis a little bit complicated. Only elite athletes participated in this research. They have already reached the high level of skill. It allowed to consider the prediction of success realised and helped to determine the factors influenced by it.

The research of a condition of elite athletes allows increasing significantly the efficiency of the analysis [Sung *et al.* 2017]. It is confirmed at such *taekwondo* athletes that the termination of training influences significantly on metabolism's parameters. The important tool of condition control is the definition of physical development indexes, especially of somatotype. It is confirmed the presence of essential connections of psychophysiological qualities and emotional condition in elite athletes of Greek-Roman style [Reza *et al.* 2016; Korobeynikov *et al.* 2017].

The division of kickboxing athletes into separate groups is caused by the specificity of this combat sport. It has characteristic features both of boxing, and such combat sports as karate, *taekwondo*, etc. It results in differences in a functional condition of athletes. It is confirmed that there are the essential distinctions of psychophysiological features of kickboxing athletes in comparison with athletes of other martial arts [Volodchenko *et al.* 2017]. It is established the differences of goniometric indicators of extremities joints of kickboxing athletes in comparison with athletes [Podrigalo *et al.* 2017]. The established differences reflect specifics of sports.

Body mass is estimated as the integrated criterion of physical development and physical fitness [Osipov *et al.* 2016]. In this regard, the indexes including this indicator have high predictive value. 6 indexes including body mass of athletes are applied in this research.

Body mass monitoring is the most important in combat sports where athletes are divided into weight categories [Berkovich *et al.* 2016]. Observation of body mass dynamics, calculation of the corresponding indexes allows to optimise the athletes' condition.

It is emphasised the importance of constant control of the body mass index [Fernandez-Arguelles *et al.* 2018; Greier *et al.* 2018]. This indicator is in interrelation with sports activities duration. It is confirmed the existence of the bidirectional synergetic connection between the body mass and motor skills. The applied model of monitoring was based on mass control of and body length, motor skills.

The body mass index is the most often applied in modern medical practice, and for solving problems of physical culture and sport. The received results reflect big massiveness of athletes due to the prevalence of a muscular component of a somatotype. It reflects specifics of combat as a sport.

The Erismann index illustrates dependence between the longitudinal and circumference parameters of athletes' body. Its value demonstrates that athletes of the 3rd group more often have the worst body muscles development. The specific weight of persons with sufficient and insufficient body muscles development in kickboxing athletes is almost identical.

Comparison of Pignier index confirms the established tendency. Among kickboxing athletes, the persons with strong bodybuilding are more than a half, and in the 3rd group persons with a weak bodybuilding prevail. It also reflects specifics of sports. In combat and kickboxing strength qualities are very important for the achievement of success. In karate and taekwondo, the technical training is more important in which smaller significance is attached to muscles development.

Shoulders width is an indicator of shoulder muscles development. Differences of this index have to be interpreted as confirmation of the assumptions done before. Kickboxing athletes have the best level of muscles development in comparison with representatives of shock single combats. The received results confirm the available data on the importance of shoulders width and indexes on the basis of this criterion for the success prediction [Tumanian *et al.* 1976].

The stated differences of a relative body surface reflect the higher aerobic potential of athletes in comparison with *karateka* and *taekwondo* athletes. Increase in the body surface of athletes reflects the growth of their aerobic opportunities [Tumanian *et al.* 1976]. Authors connect this with the increase in body length of athletes. However, the received results demonstrate lack of essential differences between groups on this indicator. It is possible to presuppose that increase is caused by the increase in a muscular component of somatotype. It is one more confirmation of the assumptions made earlier. This index is also estimated as a success factor in single combats.

Results of the power index confirm the importance of grip strength for success in combat. It coincides with the available data [Podrigalo *et al.* 2016]. The victory in kickboxing, karate, taekwondo requires striking which does not depend on forearm and wrists muscles. Thus, the power index has to be recognised as a specific indicator for the prediction success in combat. Similar results are received in the analysis of anthropometrical characteristics of elite Japanese female athletes [Arakawa *et al.* 2015]. The conclusion is drawn on the importance of forearms muscles force for success in combat.

The analysis of indexes of extremities ratio and their segments allows to draw a conclusion on their importance for the physical development analysis and the prediction of success in combat sports. The received results confirm the available data [Tumanian *et al.* 1976]. Authors determined that in athletes the lengthening of hand increased the lever shoulder force, and, there-

fore, it promotes demonstration of additional efforts. It allows to perform holds with smaller effort. Relative lengthening of hands in kickboxers reflects a possibility of striking at a bigger distance. It also is an illustration of specifics of this combat sports in comparison with karate and taekwondo.

Athletes are characterised by rather short legs in comparison with representatives of other combat sports. It will also be coordinated with the available data concerning features of elite athletes bodybuilding [Tumanian *et al.* 1976]. Lengthening of the lower extremities also allows to strike with more power of legs in a combat and at a bigger distance. It has to be estimated as a success factor in martial arts and, especially, in kickboxing.

Thus, the received results in many respects will be coordinated with the available literary data and confirm informational content, validity, and efficiency of the applied indexes for the analysis of features of a combat sports athletes' bodybuilding.

Conclusion

Thus, the performed analysis of elite athletes bodybuilding of combat sports has confirmed the existence of the features caused by specifics of combat sports. The higher index of body mass in athletes reflects the prevalence of a muscular component of somatotype. The Erismann and Pignier indexes, shoulders width index illustrate the best development of muscles in athletes and kickboxers in comparison with athletes of karate, taekwondo. Increase in a relative body surface of athletes reflects the growth of their aerobic opportunities. Higher rates of the power index confirm the importance of grip strength for success in combat. Indexes of a ratio of segments of extremities reflect features of the technique of a single combat. It also has to be estimated as a positive factor of the prediction. It is confirmed that there is the competency of application of the special indexes which are especially illustrating ratios of segments of extremities in the monitoring of a functional condition of athletes.

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Zastosowanie specjalnych indeksów w badaniu cech rozwoju fizycznego elity zawodników uprawiających sporty walki

Słowa kluczowe: sztuki walki, rozwój fizyczny, wskaźniki, monitorowanie

Abstrakt

Cel. Analiza cech budowy ciała za pomocą specjalnych indeksów najlepszych sportowców uprawiających sporty walki. Metody. Wyznaczono 22 wskaźniki antropometryczne, na ich podstawie obliczono 13 wskaźników rozwoju fizycznego. 29 najlepszych sportowców (kandydatów na Mistrza Sportu i Mistrzów Sportu) podzielono na grupy. 1 – 7 zawodnicy (*judo, sambo, zapasy klasyczne i zapasy stylu wolnego*), ($18,43 \pm 0,43$ lat). 2 – 9 zawodnicy kick-boxingu, ($18,22 \pm 0,52$ lat). 3 - 13 zawodnicy sportów walki (*karate, taekwondo, walka wręcz*), ($18,00 \pm 0,28$ lat).

Wyniki. Wyższy wskaźnik masy ciała u sportowców pokazuje przewagę składnika mięśniowego somatotypu. Wskaźniki Erismana i Pigniera, wskaźnik szerokości ramion wskazują na najlepszy rozwój mięśni u zawodników i zawodników kick-boxingu w porównaniu z zawodnikami uprawiającymi *karate* i *taekwondo*. Wzrost względnej powierzchni ciała sportowców pokazuje wzrost ich możliwości aerobowych. Wzrost indeksu siły potwierdza znaczenie siły chwytu dla odniesienia sukcesu w walce. Wskaźniki proporcji segmentów kończyn odzwierciedlają cechy techniki sportów walki.

Wnioski. Potwierdza się istnienie cech, do których przyczyniają się sporty walki. Udowodniono kompetencję zastosowania specjalnych indeksów, czyli szczególnie zilustrowane proporcje segmentów kończyn w monitorowaniu kondycji funkcjonalnej sportowców.